THE UNIVERSITY OF ZAMBIA UNIVERSITY
FIRST AND SECOND SEMESTER 1996
SCHOOL OF ENGINEERING

1.	Statics and introduction to strength of materials	–	CE 213
2.	Statics and introduction to strength of materials	–	CE 219
3.	Statics and introduction to strength of materials	–	CE 219
4.	Civil engineering drawing	–	CE 302
5.	Civil engineering drawing	–	CE 302
6.	Strength of materials	–	CE 311
7.	Strength of materials	–	CE 311
8.	Theory of structure	–	CE 312 ✓
9.	Soil Science, roads and hydraulics	–	CE 365
10.	Fluid mechanics	–	CE 369 ✓
11.	Civil engineering materials and practices		CE 381
12.	Structural engineering	–	CE 431
13.	Highway and traffic engineering	–	CE 442
14.	Public health engineering	–	CE 452
15.	Hydrology	–	CE 461
16.	Hydrology	–	CE 461
17.	Structural dynamics	–	CE 512
18.	Structural dynamics	–	CE 512
19.	Steel design	–	CE 532
20.	Water management and hydraulic structures		CE 565 ✓
21.	Def/Sup	–	CE 565 ✓
22.	Construction techniques and management	–	CE 582 ✓
23.	Farm machinery design	–	EA 512
24.	Principles of electricity	–	EE 209
25.	Principles of electricity	–	EE 209
26.	Principles of electricity II	–	EE 309
27.	Electronic engineering	–	EE 311
28.	Electromechanic and electrical machines	–	EE 321
29.	Electronic engineering I	–	EE 342
30.	Electronic engineering	–	EE 381
31.	Electrical engineering practice	–	EE 392
32.	Electromagnetic fields	–	EE 411
33.	Electrical machines 1	–	EE 422
34.	Electrical and electronic engineering	–	EE 441/431
35.	Electric power systems	–	EE 452
36.	Electrical instrumentation	–	EE 462
37.	Electrical engineering Def/Sup	–	EE 471
38.	Computer engineering	–	EE 481
39.	Electrical machines II	–	EE 521
40.	Power electronics	–	EE 532
41.	Electrical and electronic engineering	–	EE 541
42.	Electrical power systems II	–	EE 552
43.	Control systems	–	EE 561
44.	Control systems	–	EE 562
45.	Electrical and electronic engineering	–	EE 572
46.	Communications principles	–	EE 581
47.	Engineering workshop technology	–	EG 212
48.	Introduction to computing	–	EG 279
49.	Introduction to computing	–	EG 279
50.	✓ Engineering management and society I	–	EG 475
51.	Engineering management and society I	–	EG 475

52. Engineering management and society II - EG 575
53. Engineering management and society II - EG 575
54. Engineering mathematics I - EM 211
55. Engineering mathematics - EM 212
56. Mathematics - EM 311
57. Mathematics and statistics - EM 312
58. Engineering drawing - ME 209
59. Engineering drawing I - ME 209
60. Engineering drawing I - ME 209
61. Engineering materials I - ME 252
62. Engineering drawing II - ME 302
63. Strength of materials I - ME 332
64. Strength of materials I - ME 332
65. Thermodynamics I - ME 341
66. Fluid mechanics and thermodynamics - ME 365
67. Fluid mechanics and thermodynamics - ME 365
68. Dynamics - ME 375
69. Machine design I paper I - ME 405
70. Production technology - ME 415
71. Strength of materials II - ME 431
72. Heat engines - ME 442
73. Engineering materials science - ME 452
74. Fluid mechanics II - ME 461
75. Machine design and production management ME 501
76. Production technology II - ME 515
77. Production technology II paper I - ME 515
78. Refrigeration and air conditioning - ME 525
79. Refrigeration and air conditioning - ME 525
80. Vibrations and control engineering - ME 571
81. Vibrations and control engineering - ME 571
82. Automobile engineering - ME 585
83. Def/Sup - ME 585
84. Cartography I - SE 321
85. Land, law, cadastre and survey regulations SE 352
86. Principles and methods of surveying I - SE 371
87. Principles and methods of surveying I - SE 371
88. Surveying mathematics - SE 411
89. Numerical methods and programming for surveyors - SE 412
90. ✓Cartography II - SE 422
91. Photogrammetry II. - SE 431
92. Geodesy I - SE 441
93. Remote sensing - SE 462
94. ✓Principles and methods of surveying II - SE 472
95. Introduction to surveying - SE 481
96. Photogrammetry III - SE 531
97. Geodesy II - SE 542
98. Geographic information systems - SE 561
99. Land resource planning - SE 562
100. Engineering surveying - SE 571

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER SUPPLEMENTARY/
DEFERRED EXAMINATION - JULY 1996

CE 213: STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS

TIME: THREE (3) HOURS

ANSWER: ANY THREE from Section A and Any TWO from Section B

SECTION A

Q1. Calculate the magnitude of the force supported by the pin at B for the bell crank loaded and supported as shown in Fig. 1.

Q2. Locate the centroid of the two plates welded together in Fig. 2, with respect to the co-ordinate system shown.

Q3. A stone crusher consists of two large cylinders, each of radius r = 600 mm, rotating in opposite directions. The distance d is set equal to the maximum size of crushed aggregate. If d = 25 mm and coefficient of friction = 0.35, determine the size S of the largest stone which will be pulled through the crusher by friction alone. The self weight of the stone may be neglected. (Fig.3).

Q4. The maximum and minimum moments of inertia of the shaded area in Fig. 4 about principal axes passing through the centroid G are 25×10^6 mm ^{4} and 5×10^6 mm^4 respectively. The product of inertia with respect to the X-Y axes is -8×10^6mm^4. Calculate the moments of inertia (I_x and I_y) and the orientation (angle α) of the major principal axis from the X-axis by:-

(a) constructing the Mohr's circle of Inertia,
(b) using the appropriate equations from Inclined Axis Theorem.

SECTION B

Q5. A punch press can work safely up to a compressive stress of 400 N/mm^2. Calculate the maximum thickness of the mild steel plate having an ultimate shear strength of 200 N/mm^2 through which a hole of 40 mm diameter can be punched.

Q6. The rigid bar AD is pinned at A and attached to a steel bar ED and a brass bar BC as shown in Fig.5. The cross-sectional area of ED and BC are respectively $100\ mm^2$ and $200\ mm^2$. The system is initially stress-free and the self weight of all bars may be neglected. Determine the stresses in bars ED and BC, if the temperature of the bar ED is raised by 20°c and that of bar BC is simultaneously lowered by 20°c.

Given: $E_S = 205\ kN/mm^2$, $E_b = 80 kN/mm^2$
$\alpha_s = 1.1 \times 10^{-6}/^\circ c$, $\alpha_b = 1.89 \times 10^{-6}/^\circ c$

Q7. (a) State (with proof) the relationship betwen load intensity (p), shear force (V) and bending moment (M) at a cross-stion of a beam subjected to a continuously distributed load p=f(x). Define the sign conventions associated with these relations.

(b) Using these relations, determine the shear force V_x and bending moment M_x as functions of x for a simply supported beam of span L, subjected to a sinusoidal loading $p = p_o \sin(\pi x/L)$. Refer to Fig. 6.
Draw Shear Force and Bending Moment diagrams for this beam showing relevant values.

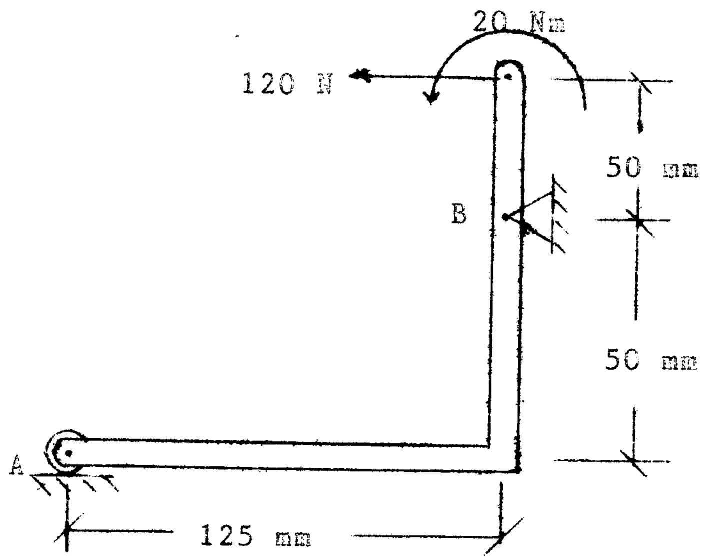

FIG: 1

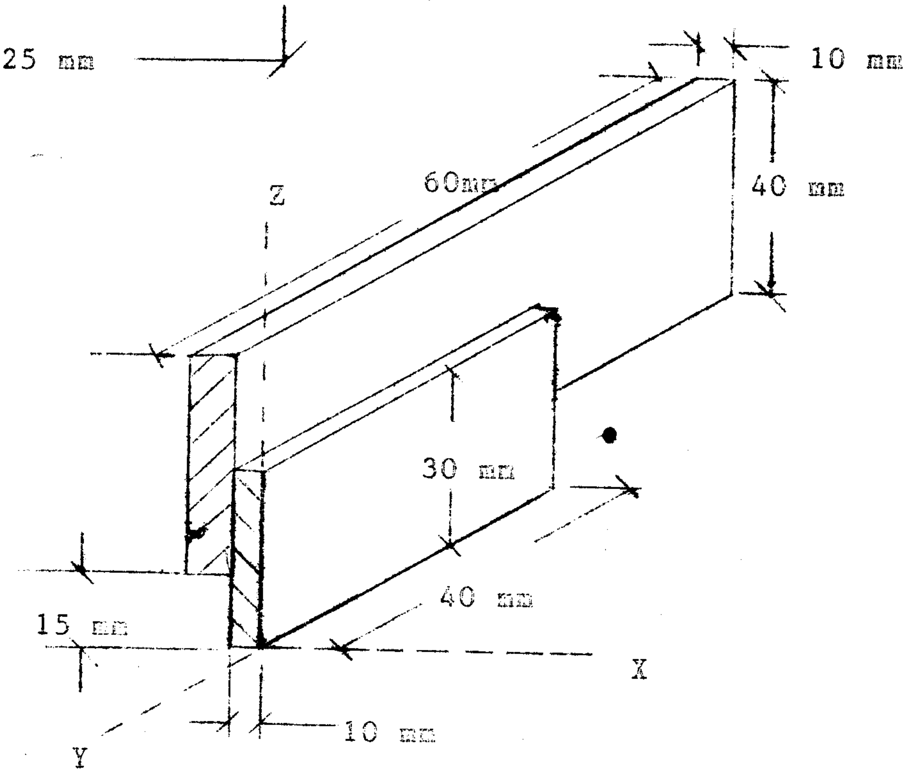

FIG: 2.

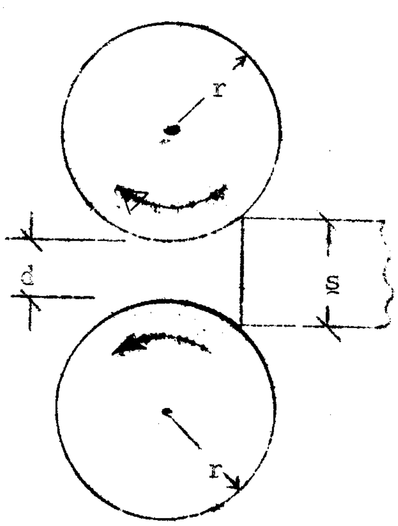

FIG: 3

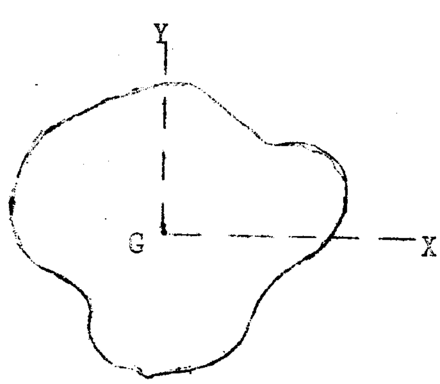

FIG: 4

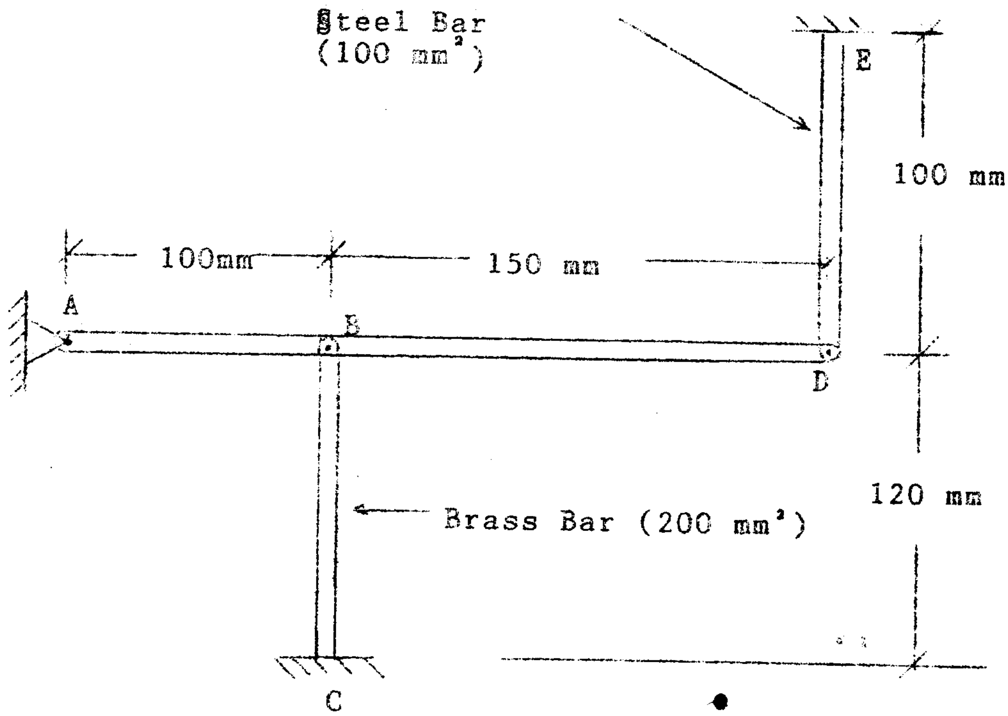

FIG: 5

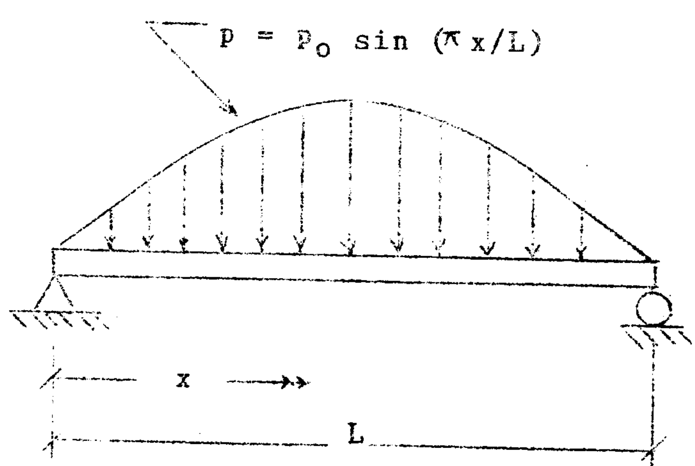

FIG: 6.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1997

CE 219

STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS

TIME: THREE HOURS

ANSWER: ANY THREE FROM SECTION A, AND ANY TWO FROM SECTION B.

SECTION A

Q1. Calculate the magnitude of the force supported by the pin at A for the angle bracket subjected to the two forces and the couple shown in Fig: 1.

Q2. Determine the forces in members BF, AF, CE and BE for truss shown in Fig: 2 under the action of the 20- and 40- kN horizontal loads.

Q3. A screw jack with square threads having a mean radius of 25 mm supports a load of 5 kN. If the coefficient of friction is 0.25, what is the greatest lead L (advancement per turn) of the screw for which the screw will not unwind by itself? For this condition what torque M applied to the screw would be required to raise the load?

Q4. Calculate the product of inertia Iuv of the rectangle shown in Fig: 3 if G is the centroid of the rectangle.

SECTION B

Q5. A reinforced concrete column 300 mm x 300 mm has four reinforcing bars of 28 mm diameter, one in each corner. The column is subjected to an axial load and the stress in concrete is found to be 5 N/mm^2. If Es/Ec = 18, Determine:

a) the axial load acting on the column, and
b) the corresponding stress in steel

Q6. Determine the normal and shear stresses acting on plane AB shown in Fig: 4. What are the principal stresses and the maximum shear stress?

Q7. A steel tube, 500 mm long, 20 mm in external diameter and 15 mm in internal diameter encloses a copper rod of the same length and 12.5 mm in diameter. The tube is firmly joined to the rod at both ends and its temperature is raised by 150°C. Calculate the stresses in steel and copper. Find the increase in length of this composite system and the external axial force P which must be applied to prevent this increase in length. (Fig: 5).

GIVEN:

$Es = 200 \text{ kN/mm}^2$ $\qquad$ $Ec = 100 \text{ kN/mm}^2$

$\alpha s = 10 \times 10^{-6}/^{\circ}C$ $\qquad$ $\alpha c = 15 \times 10^{-6}/^{\circ}C$

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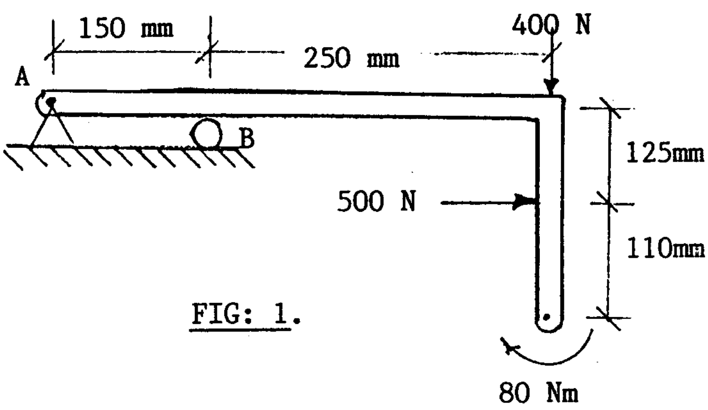

FIG: 1.

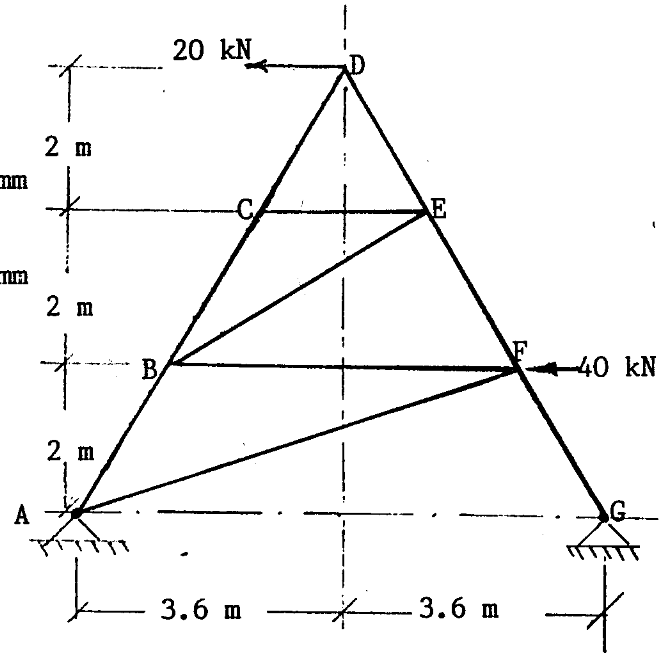

FIG: 2.

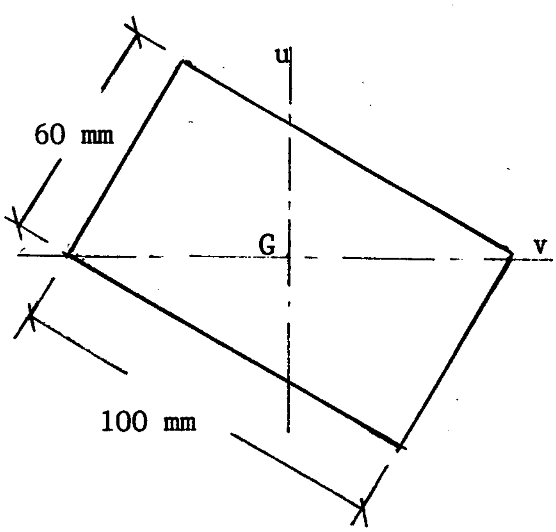

FIG: 3.

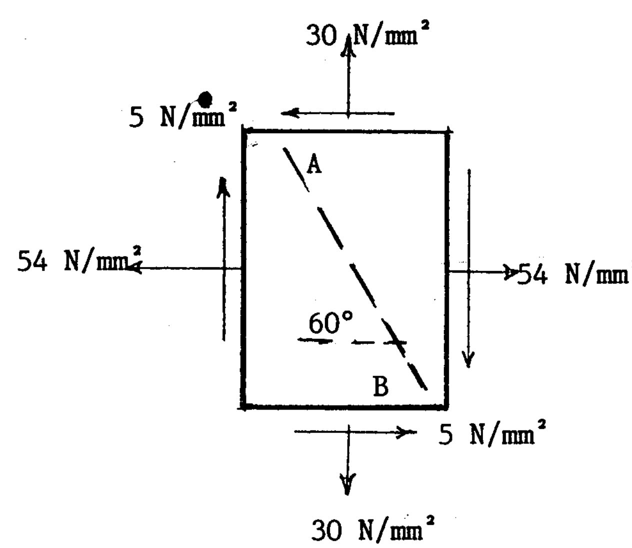

FIG: 4.

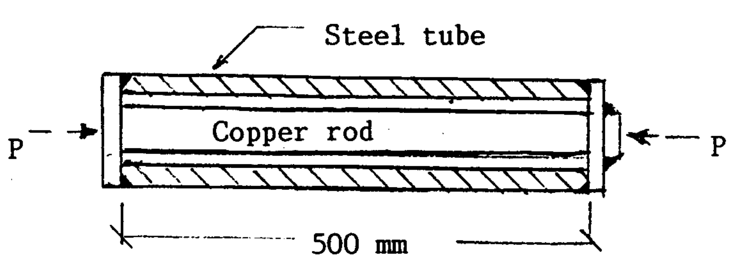

FIG: 5.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JUNE 1996

CE 219

STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS

TIME: THREE HOURS

ANSWER: ANY THREE FROM SECTION A AND ANY TWO FROM SECTION B.

Section A

1. A prismatic bar AB of weight Q and length L rests at A against a smooth horizontal floor, and under the action of its gravity force Q presses against smooth supports at C and D. Determine the magnitude of reactions at A, C and D. (Fig.1).

2. Calculate the force in each member of the truss shown in Fig.2. The length of each member is 1.5 m.

3. A uniform semicircular rod of radius r is supported by a smooth bearing at its upper end and is free to swing in the vertical plane. Calculate the angle θ made by the diameter with the vertical for the equilibrium position. [Fig.3]

4. An anticlockwise moment M = 150 Nm is applied to the flywheel shown in Fig.4. If the coefficient of friction between the brake band and the wheel is 0.2, compute the minimum force P to be applied at the brake handle in order to prevent the wheel from rotating.

Section B

5. A steel rod of circular cross-sections is loaded as shown in Fig.5. Determine:

   (a) the maximum stress and where it occurs;
   (b) total change in length;
   (c) change in external diameter at each section.

   Given, E = 200 kN/mm^2, Poisson's Ratio = 0.3

6. A composite bar of aluminium and steel shown in Fig.6 is firmly held between unyielding supports at A and C. An axial load of 200 kN is applied at B at 50°C. Find the stress in each material when the temperature is 100°C. Given:

E_a = 70 KN/mm^2 $\qquad$ α_a = 24 x 10 /°C

E_s = 210 KN/mm^2 $\qquad$ α_s = 11.8 x 10 /°C

7. Direct stresses of 100 N/mm^2 tension and 80 N/mm^2 compression are applied to a material at a certain point, on planes at right angles (Fig.6). If the major principal stress is limited to 140 N/mm^2 (tension), determine:

(a) The shearing stress τ which may be applied to the given planes;

(b) The maximum shearing stress at the point;

(c) The minor principal stress;

(d) The orientation of the principal planes.

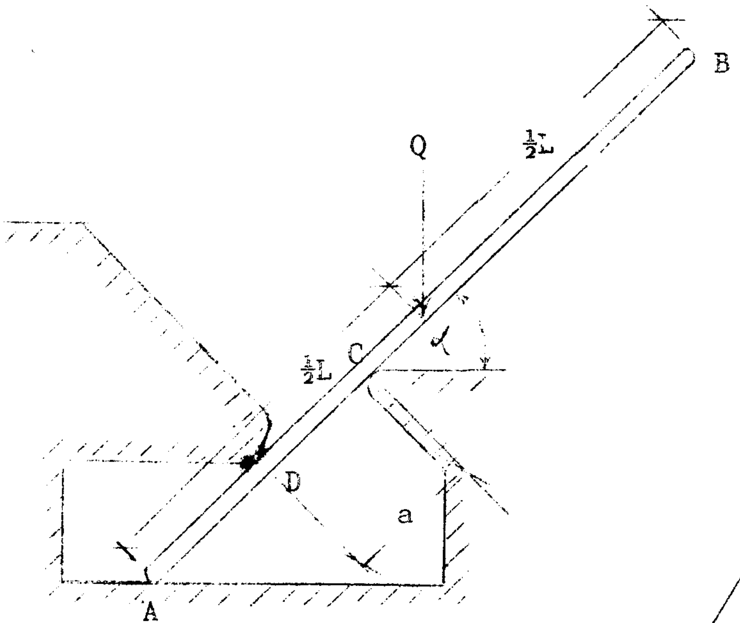

FIG: 1

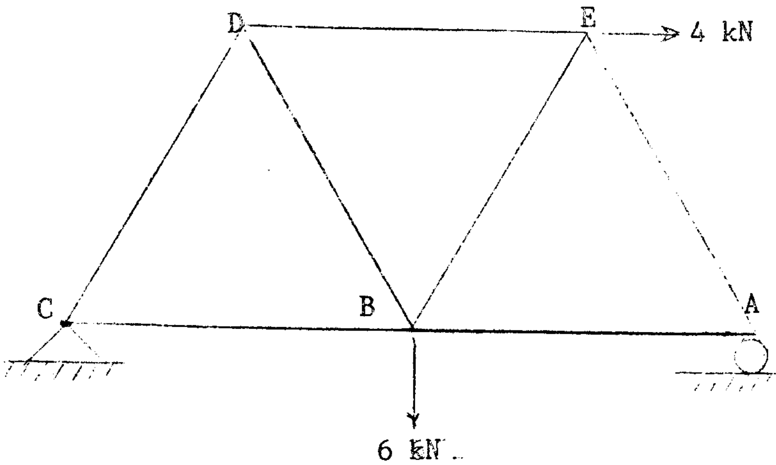

FIG: 2

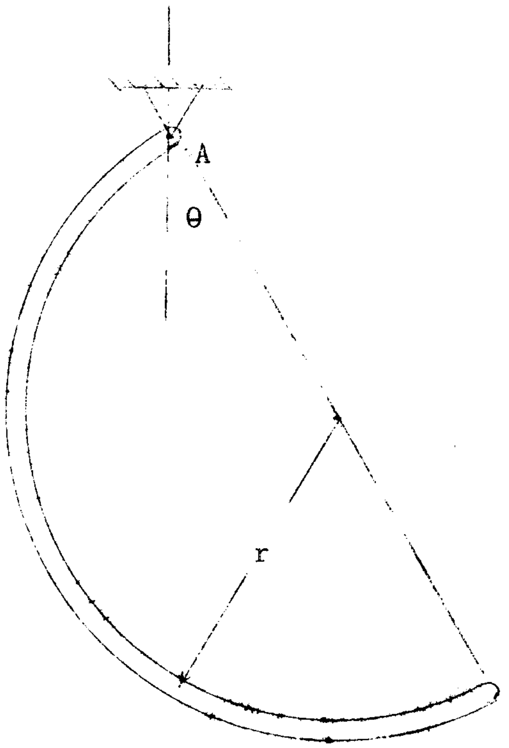

FIG: 3

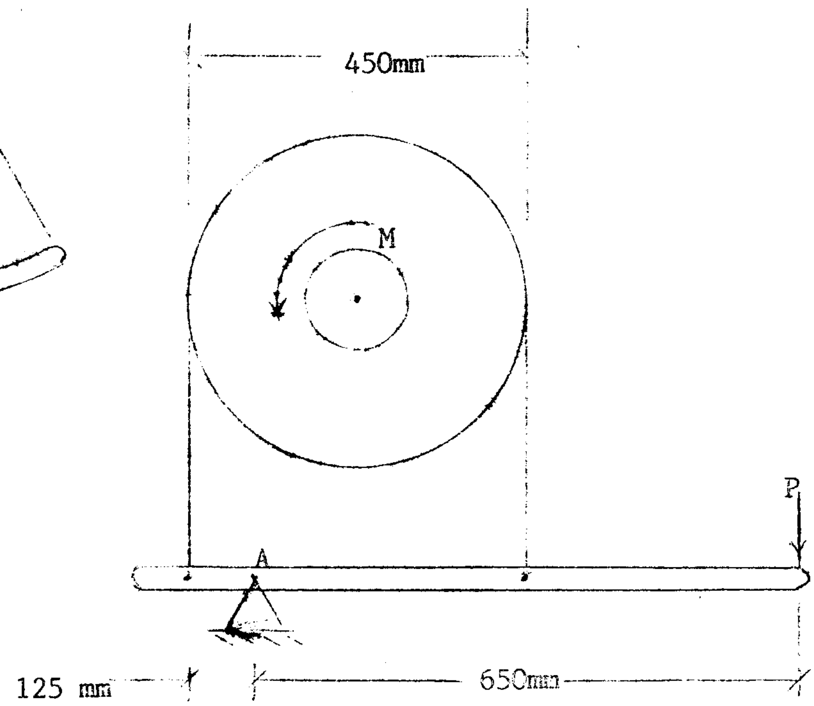

FIG: 4

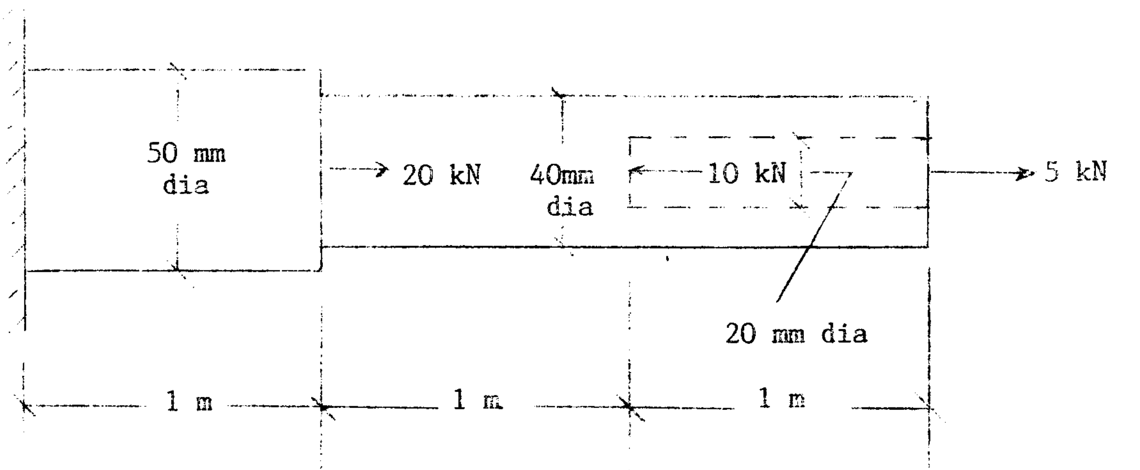

FIG: 5

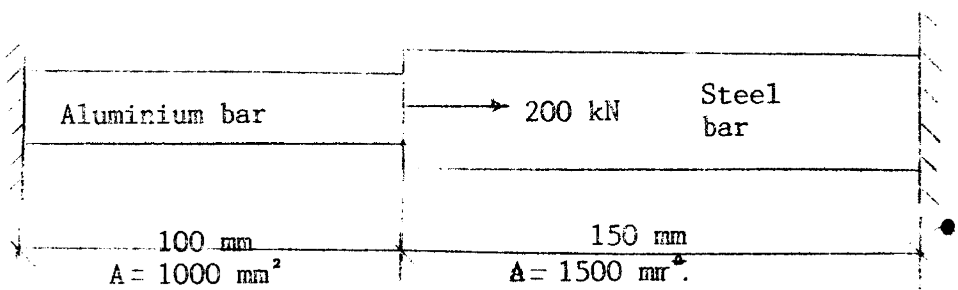

FIG: .5

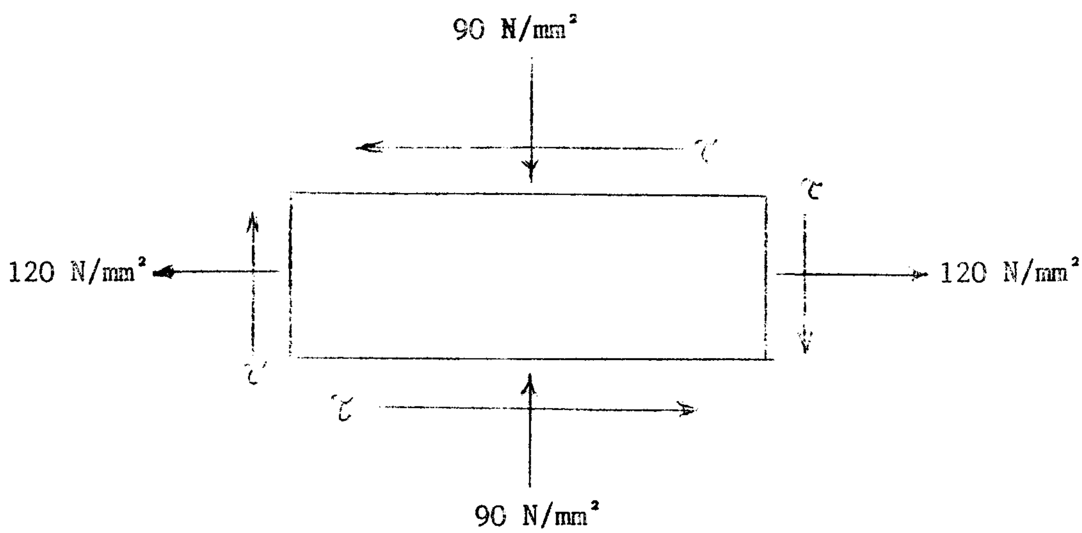

FIG: 7

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1997

CE 219

STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS

TIME: THREE HOURS

ANSWER: ANY THREE FROM SECTION A, AND ANY TWO FROM SECTION B.

SECTION A

Q1. Calculate the magnitude of the force supported by the pin at A for the angle bracket subjected to the two forces and the couple shown in Fig: 1.

Q2. Determine the forces in members BF, AF, CE and BE for truss shown in Fig: 2 under the action of the 20- and 40- kN horizontal loads.

Q3. A screw jack with square threads having a mean radius of 25 mm supports a load of 5 kN. If the coefficient of friction is 0.25, what is the greatest lead L (advancement per turn) of the screw for which the screw will not unwind by itself? For this condition what torque M applied to the screw would be required to raise the load?

Q4. Calculate the product of inertia Iuv of the rectangle shown in Fig: 3 if G is the centroid of the rectangle.

SECTION B

Q5. A reinforced concrete column 300 mm x 300 mm has four reinforcing bars of 28 mm diameter, one in each corner. The column is subjected to an axial load and the stress in concrete is found to be 5 N/mm^2. If $Es/Ec = 18$, Determine:

a) the axial load acting on the column, and
b) the corresponding stress in steel

Q6. Determine the normal and shear stresses acting on plane AB shown in Fig: 4. What are the principal stresses and the maximum shear stress?

Q7. A steel tube, 500 mm long, 20 mm in external diameter and 15 mm in internal diameter encloses a copper rod of the same length and 12.5 mm in diameter. The tube is firmly joined to the rod at both ends and its temperature is raised by 150°C. Calculate the stresses in steel and copper. Find the increase in length of this composite system and the external axial force P which must be applied to prevent this increase in length. (Fig: 5).

GIVEN:

$E_s = 200\ kN/mm^2$ $\quad\quad$ $E_c = 100\ kN/mm^2$

$\alpha_s = 10 \times 10^{-6} /°C$ $\quad\quad$ $\alpha_c = 15 \times 10^{-6} /°C$

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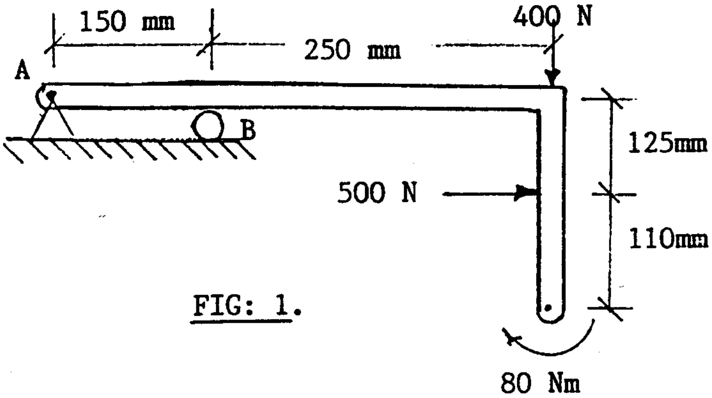


FIG: 1.

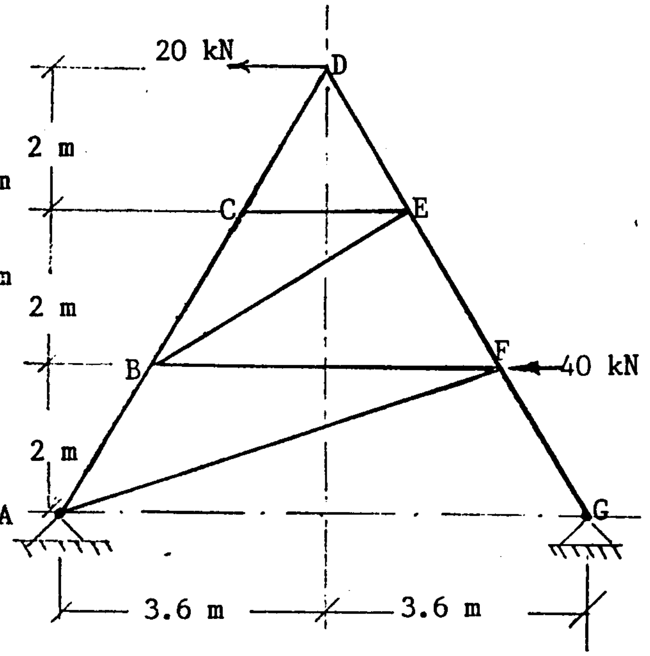


FIG: 2.

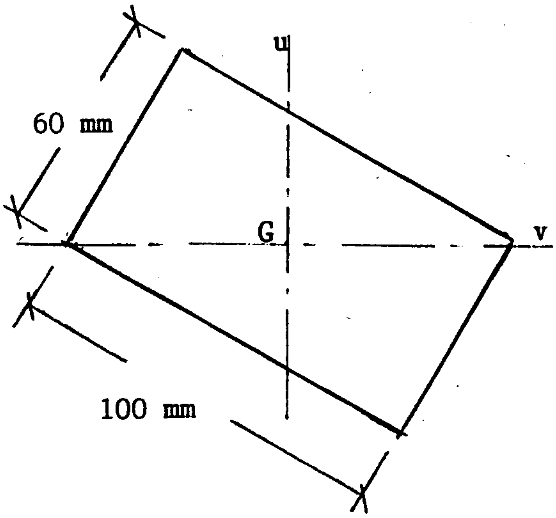


FIG: 3.

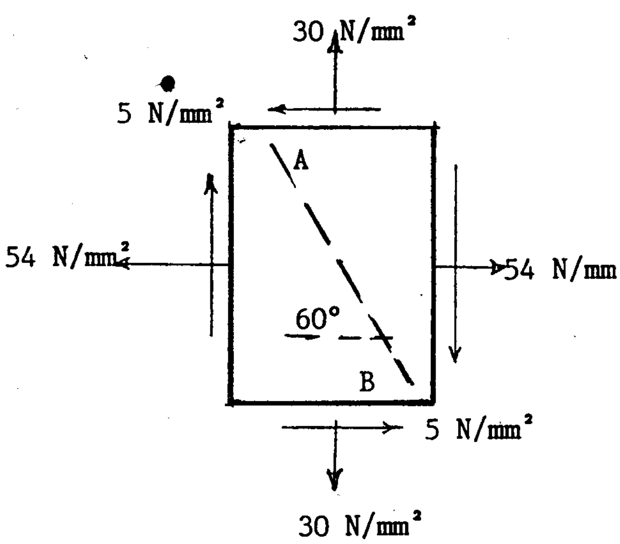


FIG: 4.

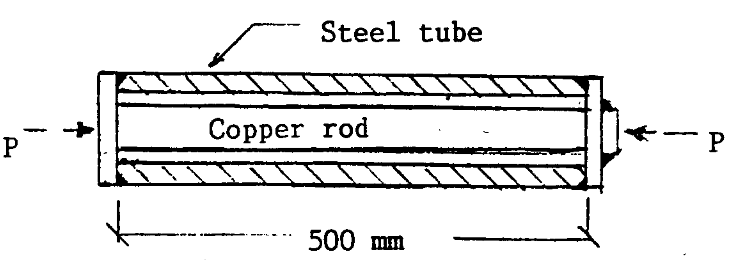


FIG: 5.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - NOV/DEC, 1996

CE219

STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS

TIME: THREE HOURS

ANSWER: ANY THREE FROM SECTION A AND ANY TWO FROM SECTION B

SECTION A

1. A heavy prismatic beam of weight 100N is supported horizontal between two fixed fulcrums A and B as shown in Fig: 1. If the coefficient of friction between the beam and each fulcrum is 1/3, find the magnitude of a horizontal force P applied as shown that will cause impending sliding of the beam to the right.

2. The vertical position of the 100 kg block in Fig: 2 is adjusted by the screw-activated wedge. Calculate the torque M which must be applied to the handle of the screw to raise the block. The single threaded screw has square threads with a mean diameter of 30 mm and advances 10 mm for each complete turn. The coefficient of friction for the screw threads is 0.25 and that for all mating surfaces of the block and wedge is 0.4.

3. Determine the coordinates of the centroid of the shaded area shown in Fig: 3.

4. (a) Where $I_x = I_y$ for an area which is symmetrical about either the x- or the y- axis, prove that the moment inertia is the same for all axes passing through the origin.

   What happens to the Mohr's circle of inertia in this case?

(b) Use this knowledge to calculate the base b and the altitude h of an isosceles triangle with an area of 1600 mm² if the moments of inertia about all axes through vertex of the triangle are the same.

(It is given that the moment of inertia of a triangle about its centroidal axis parallel to the base is $\frac{bh^3}{36}$

SECTION B

5. A member ABCD is subjected to point loads P_1, P_2, P_3 and P_4 as shown in Fig: 4. Calculate the force P_2 necessary for equilibrium, if P_1 = 45 kN, P_3 = 450 kN and P_4 = 130 kN. Determine the total elongation of the member if E = 210 kN/mm².

What is the largest stress in this member and where does it occur?

6. (a) A rigid horizontal beam ACB is supported by a hinge at C and pin connected to two vertical bars at A and B as shown in Fig: 5. A load P acts downward on AB at the indicated position. If the bar at A is subjected to a temperature rise of 20°C, determine the load P so that the rigid beam AB remains horizontal even after the temperature rise.

For bar at A: A = 400 mm², E = 2×10^5 N/mm²
$\alpha = 12.5 \times 10^{-6}$/°C

For bar at B: A = 300 mm², E = 1.25×10^5 N/mm²
$\alpha = 7.8 \times 10^{-6}$/°C

(b) If the load P is absent, determine the stresses in the two vertical bars and the tilt of the beam ACB.

7. Draw the Shear Force and Bending Moment Diagrams for the beam shown in Fig: 6

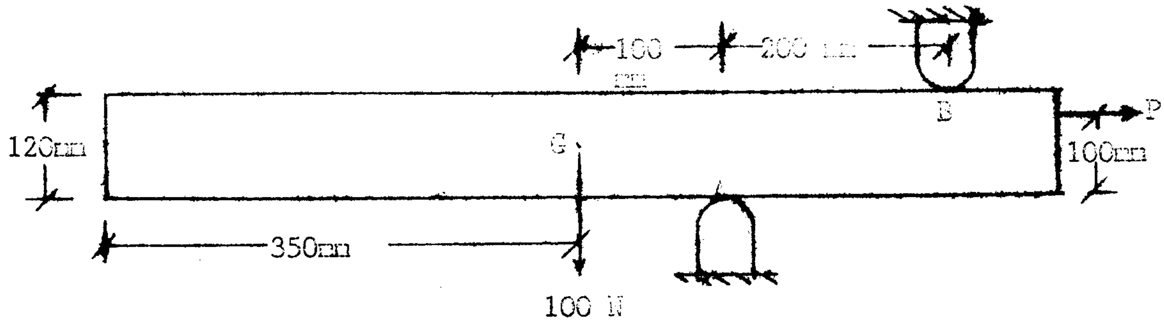


FIG: 1.

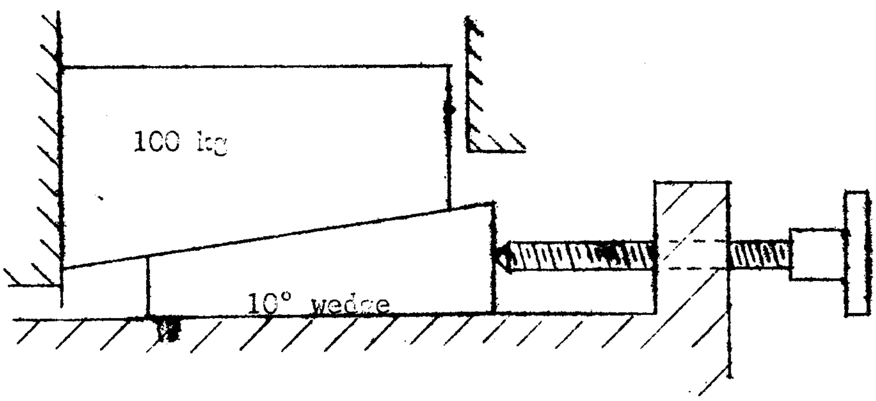


FIG: 2.

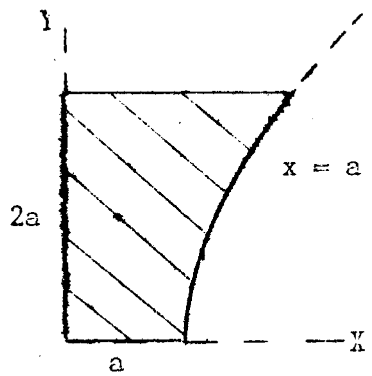


FIG: 3

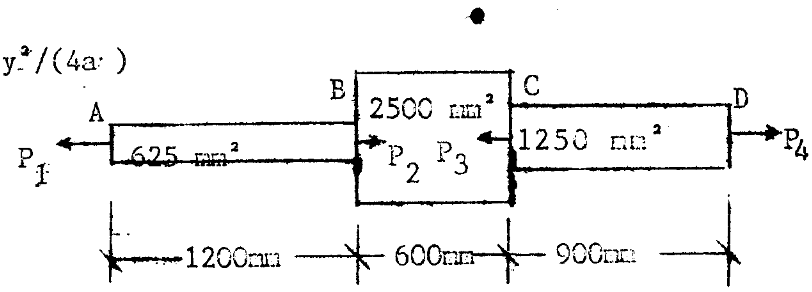


FIG: 4

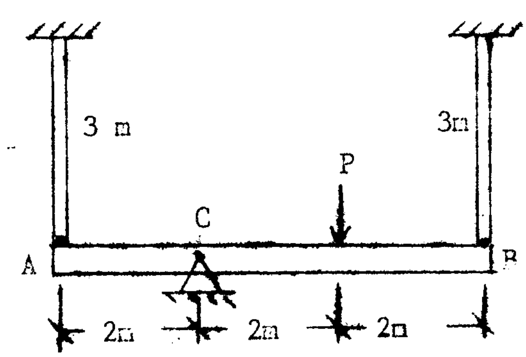


FIG: 5

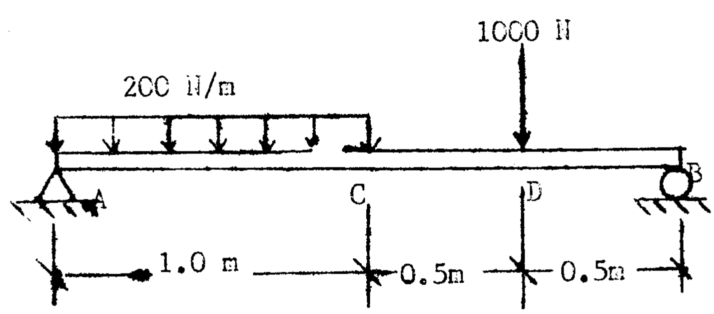


FIG: 6.

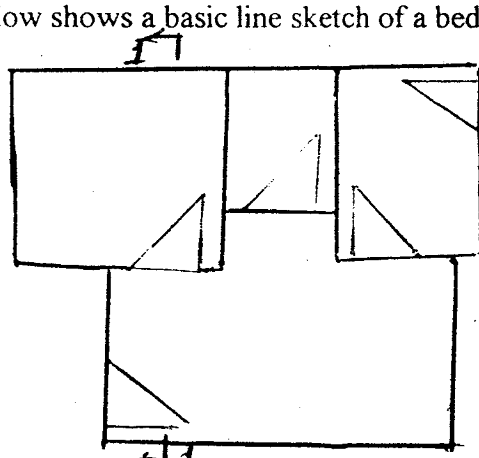
END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JAN., '96
CE 302
CIVIL ENGINEERING DRAWING

TIME : FOUR (4) HOURS
ATTEMPT : ALL QUESTIONS **OPEN BOOK**

QUESTION ONE

The figure below shows a basic line sketch of a bedsitter flat.



Draw a fully annotated FLOOR PLAN and SECTION **1 -1** for the flat.

NOTE : Where specific information is not given, make reasonable assumptions.

(25 + 15 MARKS)

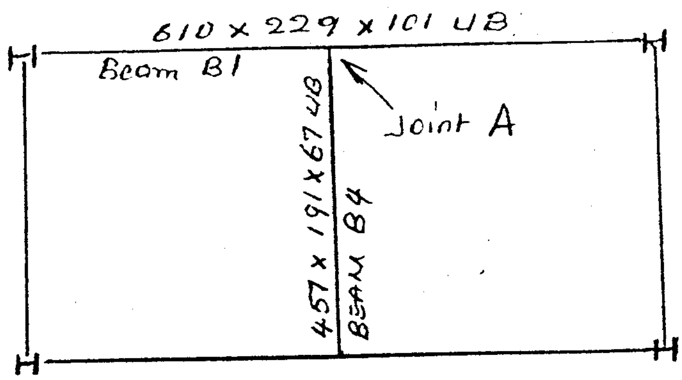
QUESTION TWO

Detail and prepare a bar bending schedule for a 6.0 m span, 400 x 300 reinforced concrete beam, simply supported on 150 mm thick masonry walls. The main bottom steel should be at least 1% of the cross - sectional area of concrete. Top steel is 50% of the main bottom steel. Links are R8 at 260 mm centres throughout. Cover to main steel is 30 mm.

(20 MARKS + 10 MARKS)

QUESTION THREE

The figure below shows the general arrangement for a floor.



You are required to detail a joint A using 2 angle cleats (90 x 90 x10 each) welded to beam B4 and bolted with a total of 6Nos. M20 bolts to beam B1. The tops of the two beams are at the same level.

NOTE : Only two view are necessary (**15 + 15 MARKS**).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS JUNE 1996
CE311
STRENGTH OF MATERIALS

TIME: THREE HOURS

INSTRUCTIONS TO CANDIDATE

(a) Candidates must ensure that their computer numbers are clearly written on each answer booklet used and that the number of questions answered are entered in the space provided on the front cover of the answer booklet.
(b) Answer **FIVE** questions only.
(c) All questions carry equal marks (20). Marks of sub-questions are indicated at the end of each sub-question.
(d) Mathematical gadgets and drawing instruments are allowed.

MAXIMUM SUM OF MARKS: 100 **CLOSED BOOK**

Q.1 What should be the cross section dimensions of a rectangular wooden beam to carry the load as shown in **figure 1**. The height to width ration is to 2.5:1.0. The allowable bending stress is 10MPa and the allowable shearing stress is 1 MPa. Neglect the self weight of the beam. (20)

Q.2 Determine the location and magnitude of maximum defection for the beam shown in **figure 2**. E = 200 GPa, I = 30 x 10^{-6} mm^4. (20)

Q.3 The frame shown in **figure.3**, supports a force **F** at the joint B as shown. Member BC is of cross section area 75 x 50 mm and the Elastic Modulus of the material is 50 000 N/mm^2. Allowable compression stress is 10.5 N/mm^2.

(i) What value of **F** in kN will the member support? (16)

(ii) Will the member fail by crushing or buckling? (2)

(iii) For a safety factor of 1.5, what value of F should be specified?(2)

Q.4 An I - beam has a width of 100 mm and a depth of 175 mm. The flanges and the web are of 12 mm thickness. Calculate the maximum pure torque which could be applied to this beam if the yield shear stress is 240 MN/m^2. Assume a safety factor of 2.5. (20)

Q.5 A simply supported beam of rectangular cross section 600 x 250 mm and spans over 8 meters carries a uniformly distributed load of 1.25 kN/m. In order to have NO longitudinal stress at the bottom surface of the beam at the mid-span section, the beam is pre-loaded with a compression load of 800 kN at an eccentricity from the X-X axis e, at both ends as shown in **figure 4**.
(i) Calculate the amount of eccentricity, e, to achieve this requirement.(15)

(ii) What is the longitudinal stress at the top surface of the beam. (5)
Note- indicate for stress if compression or tension.

Q.6 Compute the vertical deflection of the joint D due to the load, for the truss shown in **figure 5** . The area of each bar cross section in 10^3 square millimetres are shown in parentheses. (20)

Q.7 A built in steel T-beam is supporting a point load at the mid span as shown in **figure 6**.

(i) What is the value of the ultimate load in terms of plastic moment, $\mathbf{M_p}$ and length, **L**, for a plastic collapse to occur? (8)

(ii) For the cross section given what is the plastic moment for the area about an axis parallel to the x-x axis? Yield stress of the material is 250 N/mm^2. (8)

(ii) What is the shape factor of the cross section. (4)

Q.8 For the beam shown in **figure 7**, using the Conjugate - Beam method determine

(i) the vertical deflection at point D in millimetres; (8)

(ii) the location and value of the maximum deflection in millimetres between B and C. (12)

E= 200 x 10^3 MPa and I = 50 x 10^{-6} m^4.

FIGURES

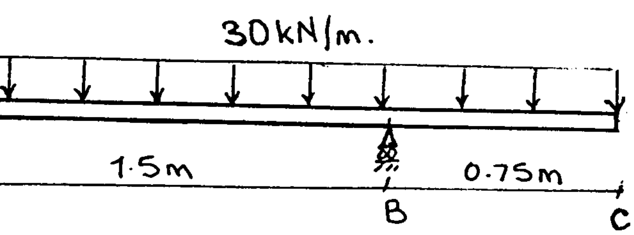


Figure. 1.

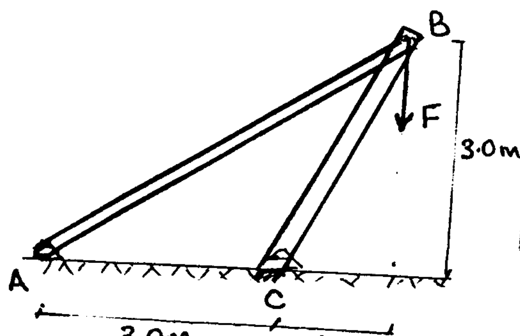


Figure 3.

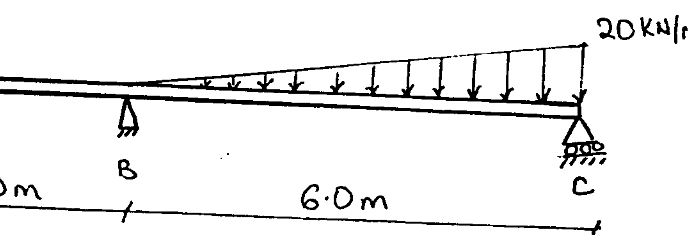


Figure 2.

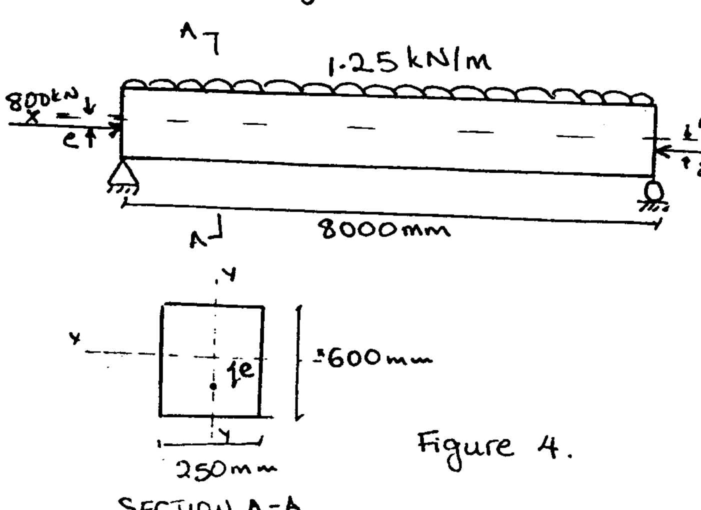


Figure 4.

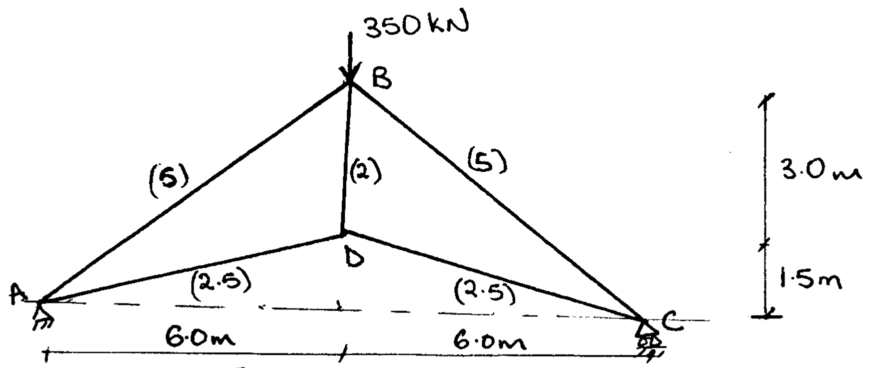


Figure 5

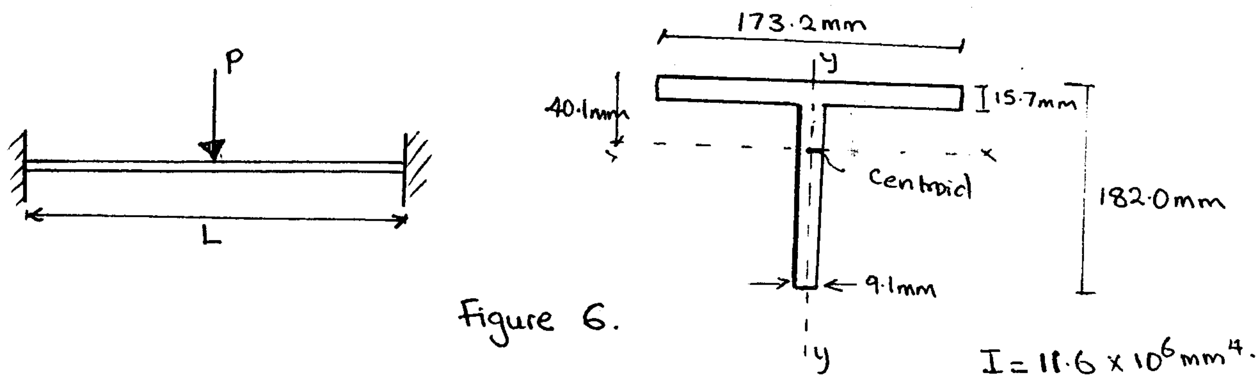


Figure 6.

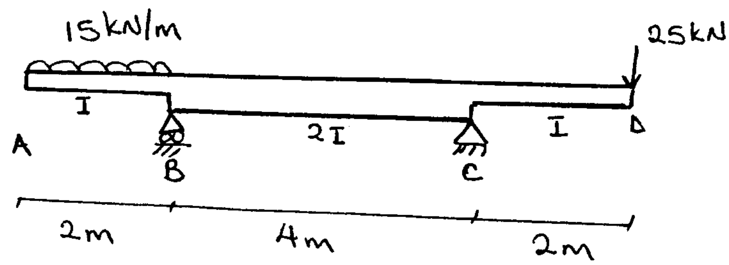


Figure 7.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS
JULY 1996
CE311
STRENGTH OF MATERIALS

TIME: THREE HOURS

INSTRUCTIONS TO CANDIDATE

(a) Candidates must ensure that their computer numbers are clearly written on each answer booklet used and that the number of questions answered are entered in the space provided on the front cover of the answer booklet.
(b) Answer FIVE questions only.
(c) All questions carry equal marks (20). Marks of sub-questions are indicated at the end of each sub-question.
(d) Mathematical gadgets and drawing instruments are allowed.

MAXIMUM SUM OF MARKS: 100 **CLOSED BOOK**

Q.1 What should be the cross section dimensions of a rectangular wooden beam to carry the load as shown in **figure 1**. The height to width ration is to **2.0:1.0**. The permissible stresses are, bending stress, **8.0 N/mm^2** and shear stress, **2.4 N/mm^2**. Neglect the self weight of the beam. (20)

Q.2 For the beam shown in **figure 2**

(a) Determine the location and magnitude maximum defection between B and C; (8)

(b) Does point A deflect up or down? (8)

(c) What is the maximum deflection on the beam? (4)

E = 70 GPa, I = 50 x 10^{-6} mm^4. ~~(20)~~

Q.3 A pin-ended wooden member *AB,* shown in **figure 3**, with effective length 3m acts in compression in the planar arrangement shown in the figure. The cross section dimensions of the member are 60 x 100 mm. Let the Elastic Modulus, E= 1.2 x 10^{10}Pa and permissible compression stress, 8.5 MPa..

(a) Show whether the member fails by buckling or crushing? Use the Euler's formula for member AB. (8)

(b) If the factor of safety against buckling of 2 is to be maintained, what can be the maximum value of applied force **F** be? (12)

Q.4 Determine the angle of twist per unit length and the maximum shear stress in the channel section of web 150mm long and 3mm thick and flanges of 75 mm long and 2 mm thick. (20)

Q.5 A timber beam simply supported over the span of 6 m, is to be strengthened by additional steel flitches fixed as shown in **figure 4**.

With the original timber beam a load of 3 500 N/m gave a maximum stress of 4 N/mm^2. If the flitched beam is to carry an additional 900 N/m with maximum stress in the steel of 55 N/mm^2, the timber stress remaining the same, find the dimensions. $E_s/E_t = 20$. (20)

Q.6 Compute the vertical deflection of the joint D due to the load, for the truss shown in **figure** 5 . The area of each bar cross section in 10^3 square millimetres are shown in parentheses. (20)

Q.7 The **figure 6** shows the section of a beam which is subjected to pure bending moment of such a magnitude that yielding occurs at the lower part of the web over a depth of 2 cm. The yield stress of 280N/mm^2 may be assumed constant over the yielded area, while over the remainder of the section the stress is proportional to the distance from the neutral axis. Determine:

(a) the position of the neutral axis, (6)

(b) the stress at the top of the section, (6)

(c) the moment of resistance of the section. (8).

Q.8 For the beam shown in **figure** 7, use the moment-area method to determine

(a) the slope in radians at A; (8)

(b) the location and maximum vertical deflection between A and C. (12)

E= 70 GPa and I= 20 x 10^{-6} m^4.

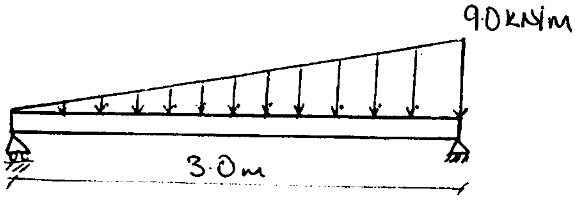


Figure 1.

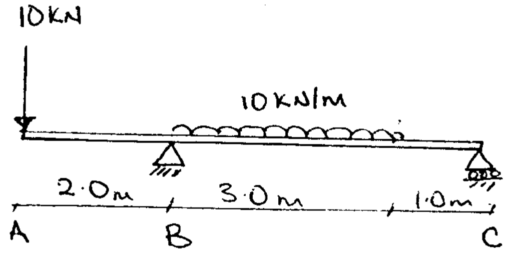


Figure 2.

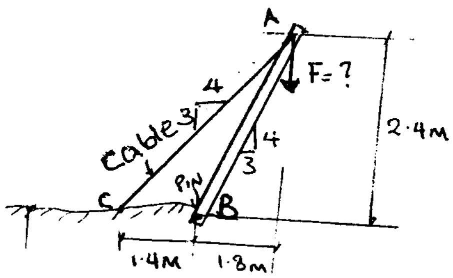


Figure 3.

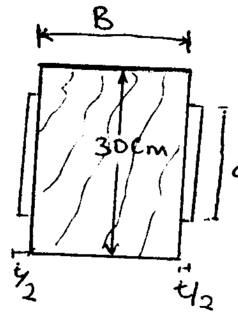


Figure 4.

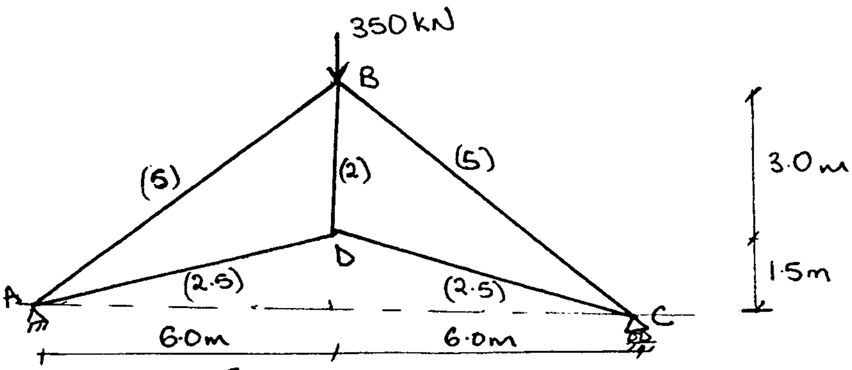


Figure 5

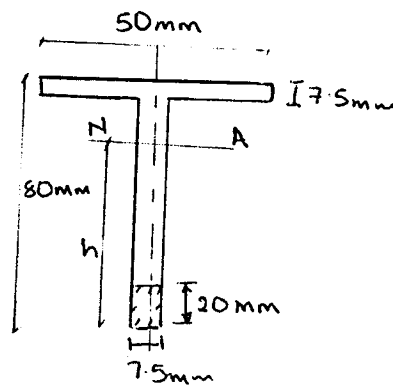


Figure 6

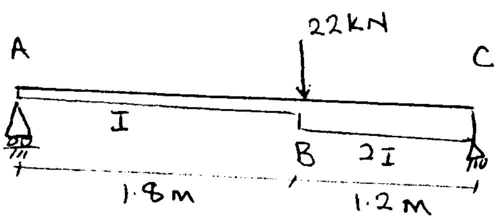


Figure 7.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - NOV/DEC, 1996

CE 312

THEORY OF STRUCTURES

TIME: THREE HOURS

ANSWER: TOTAL FIVE QUESTIONS, FOUR FROM PART A AND ONE FROM PART B. ALL QUESTIONS CARRY EQUAL MARKS (20%).

PART A

1. (i) Sketch the shear and bending moment diagrams for the beam show in Fig. 1.1. State whether it is statically determinate or indeterminate. If it is statically indeterminate, give its degree of indeterminacy. Sketch its deflection shape. Indicate the approximate location of the inflection point. (10%)

   (ii) For the frame shown in Fig. 1.2.

   (a) determine the reactions; (6%)

   (b) construct the bending moment diagram. (4%)

2. The mild steel pin-joint truss is shown in Fig. 2. All members have a cross-section of 2000 mm². The modulus of elasticity of steel is E = 200kN/mm². A 30kN vertical load is applied at Joint C as shown. Determine:

   (i) the horizontal displacement of the joint E; (12%)

   (ii) the vertical displacement of the joint C; (8%)

3. The frame is shown in Fig. 3. Determine:

   (i) the reactions; (15%)

   (ii) the slope at point E. (5%)

4. For the frame shown in Fig. 4, determine:

   (i) the values of the moments at the member ends; (15%)

   (ii) the values of the reaction components at A. (5%)

   E is the same for all the members.

5. (i) Determine the plastic moment of resistance about the x-x axis for the section shown in Fig. 5.1, $\sigma_y = 250 N/mm^2$. (8%)

   (ii) Determine the collapse loads for the frame shown in Fig. 5.2. (12%)

PART B

6. (i) For a unit load moving from A to B on the truss shown in Fig. 6.1, construct influence lines for the numbered members. (8%)

   (ii) For the beam shown in Fig. 6.2, construct the influence lines for

   (a) the shear force at A; (4%)

   (b) the bending moment at A; (4%)

   (c) the bending moment at C. (4%)

7. A simply supported beam with a span of 24m is transversed by a train of four loads, viz: 10, 15, 10, 5 kN, spaced 2 m apart. The train may travel in either direction, with the 10 kN load leading. Use the influence lines to determine:

   (i) the maximum value of the shear force 8 m from the left hand support; (10%)

   (ii) the absolute maximum bending moment in the beam. (10%)

END OF EXAMINATION

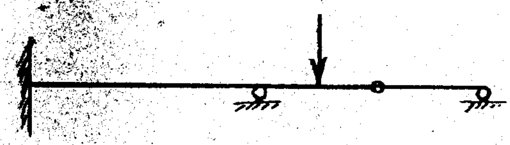


Fig. 1.1

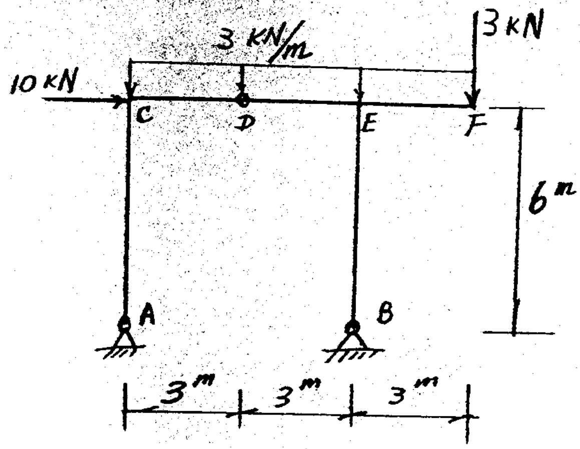


Fig. 1.2.

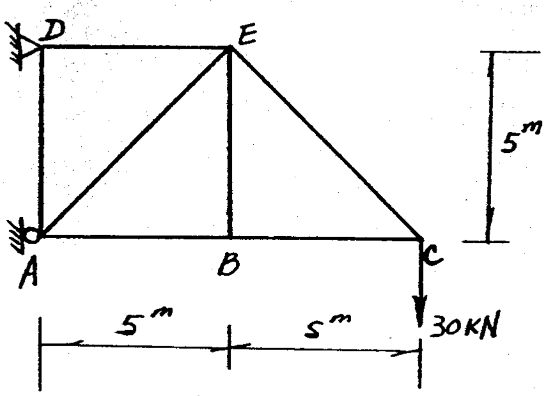


Fig. 2.

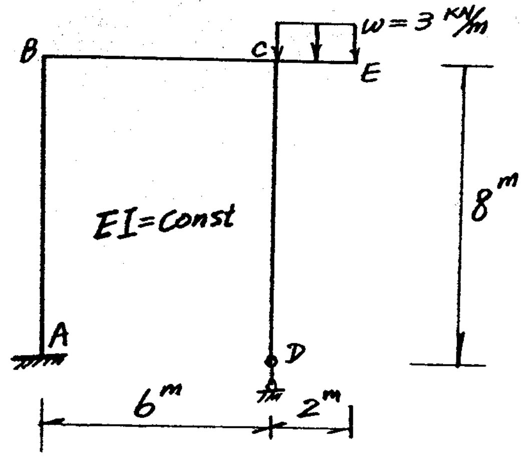


Fig. 3.

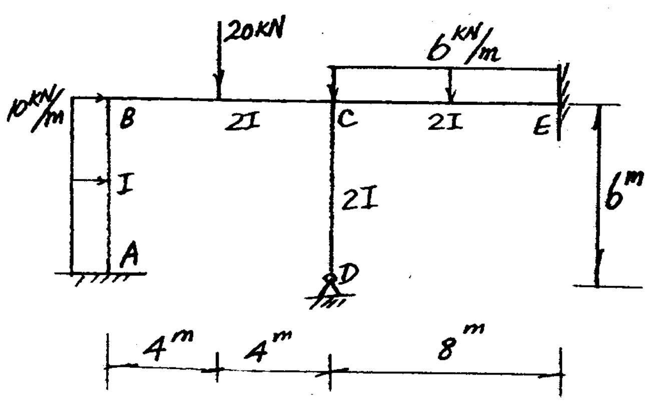


Fig. 4

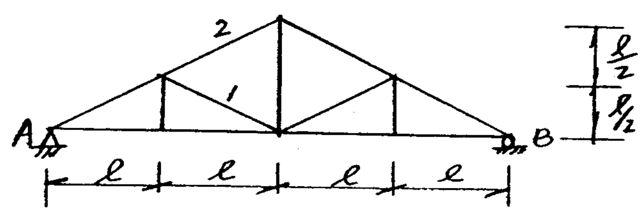


Fig. 6.1

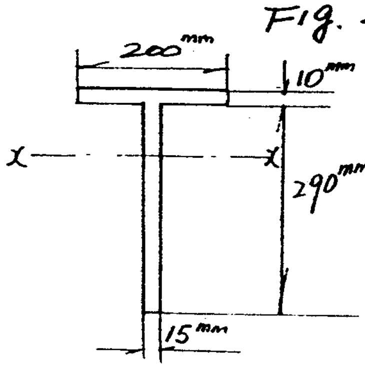


Fig. 5.1

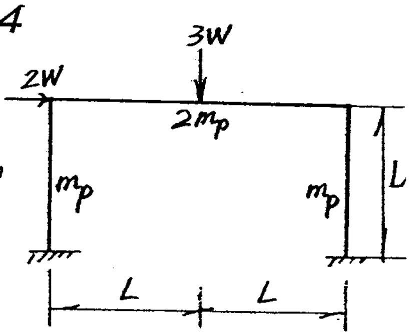


Fig. 5.2

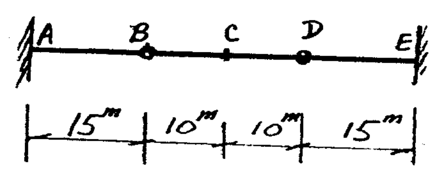


Fig. 6.2

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FINAL EXAMINATION - JUNE 1996

CE 365 - SOIL SCIENCE, ROADS AND HYDRAULICS

TIME: **THREE HOURS**

ANSWER: **FIVE QUESTIONS AND AT LEAST ONE QUESTION FROM EACH OF PART I, II AND III. ALL QUESTIONS CARRY EQUAL MARKS (20%).**

INSTRUCTIONS: **In all calculations take γ_{ω} = 10 kN/m^3 .**

PART I

Q1. (a) Explain the terms: (5 marks)
Liquid limit
plastic limit
plasticity index

(b) Draw the soil phase diagram. (5 marks)
(c) A sample of saturated clay had a volume of 98 cm^3 and a mass of 205 g. When completely dried out the volume of the sample was 87 cm^3 and its mass is 171 g.
Find:
(i) the initial water content of the clay. (5 marks)
(ii) the specific gravity of the solid particles. (5 marks)

Q2. (a) Point out the broad rock groups on the basis of their origins. Give one example for each group of rocks. (10 marks)

(b) What is the rock cycle? Draw a sketch to show it. (10 marks)

PART II

Q3. Figure **a** shows the section of Great East Road from Munali traffic lights to the University of Zambia bus stop. Figure **b** shows a longitudinal profile of the same road. The road section is a highly accident prone area.

(i) List three types of studies you would need to carry out in order to assess the performance of the road. (5marks)

(ii) What factors would you take into account in determining the economic justification of constructing the proposed bypass? (10 marks)

(iii) Recommend a design speed for the road section assuming a perception reaction time of 2.5 seconds and a coefficient of friction of 0.30.
(5 marks)

Q4. (a) "There are more than 30 design procedures for flexible pavements used around the world."
Discuss the causes and implications of the above statement for any highway engineer.
(8 marks)

(b) What rationale/principle is used in design of flexible pavements in

(i) Emperical methods based on soil classification
(ii) Emperical methods based on soil strength (6 marks)

(c) With the help of a clearly labelled sketch identify the different layers of a typical flexible pavement and indicate their functions. (6 marks)

PART III

Q5. (a) The following total rainfall data were collected from a rain gauge sited close to the downstream border of the catchment area of a stream. The depth of surface runoff for this particular rainfall is estimated at 35 mm.

TIME (hrs)	0	1	2	3	4	5	6
RAINFALL (mm)	0	25	15	10	5	25	0

(i) Define the ϕ-index method and give the basic assumption underlying this method.

(ii) Determine the ϕ-index for this rainfall event.

(b) For the catchment area of the stream mentioned above, the 1 mm 1 hour Unit Hydrograph has been given below.

TIME (hrs)	0	1	2	3	4	5	6	7
UH (m^3/s)	0	2.0	5.0	4.0	3.0	2.0	1.0	0

(i) What is the total surface area of this catchment?

(ii) Estimate the peak flow at the downstream border of the catchment area and its time of occurrence, assuming that the baseflow in the river is a constant 20 m^3/s (Take the ϕ-index determined above into account. In case you could not determine the ϕ-index ,assume the ϕ-index to be 5.0 mm/hr).

(c) (i) Determine the percentage of the total amount of water infiltrated into the soil and the percentage of water discharged by the stream for this rainfall event.

(ii) Calculate the surface runoff depth and check if the one you have calculated is accordance with the estimated figure given under (a).

Q6. (a) (i) Define hydrology and with a neat sketch give a description of the hydrological cycle.

(ii) With the aid of a diagram explain the differences between a confined and an unconfined aquifer.

(b) A well is 0.30 m in diameter and penetrates 40 m into an unconfined aquifer.

fter a long period of pumping at a rate of 30 l/s, the drawdown in two observation wells situated at 20 and 45 m from the pumped well are 3.75 and 2.50 m respectively.

(i) What is the coefficient of permeability (K) of the acquifer?
(ii) What is the drawdown in the pumped well?

(c) Well A is 750 m due North of well B. Well C is 500 m south-East of well A. The static levels are 265 m, 260 m and 255 m in wells A, B and C, respectively.

(i) Determine the direction of the groundwater flow.
(ii) Determine the slope of the groundwater table
(iii) Discuss the factors that might cause errors in the values of the parameters above.

END OF CE 365 EXAMINATION

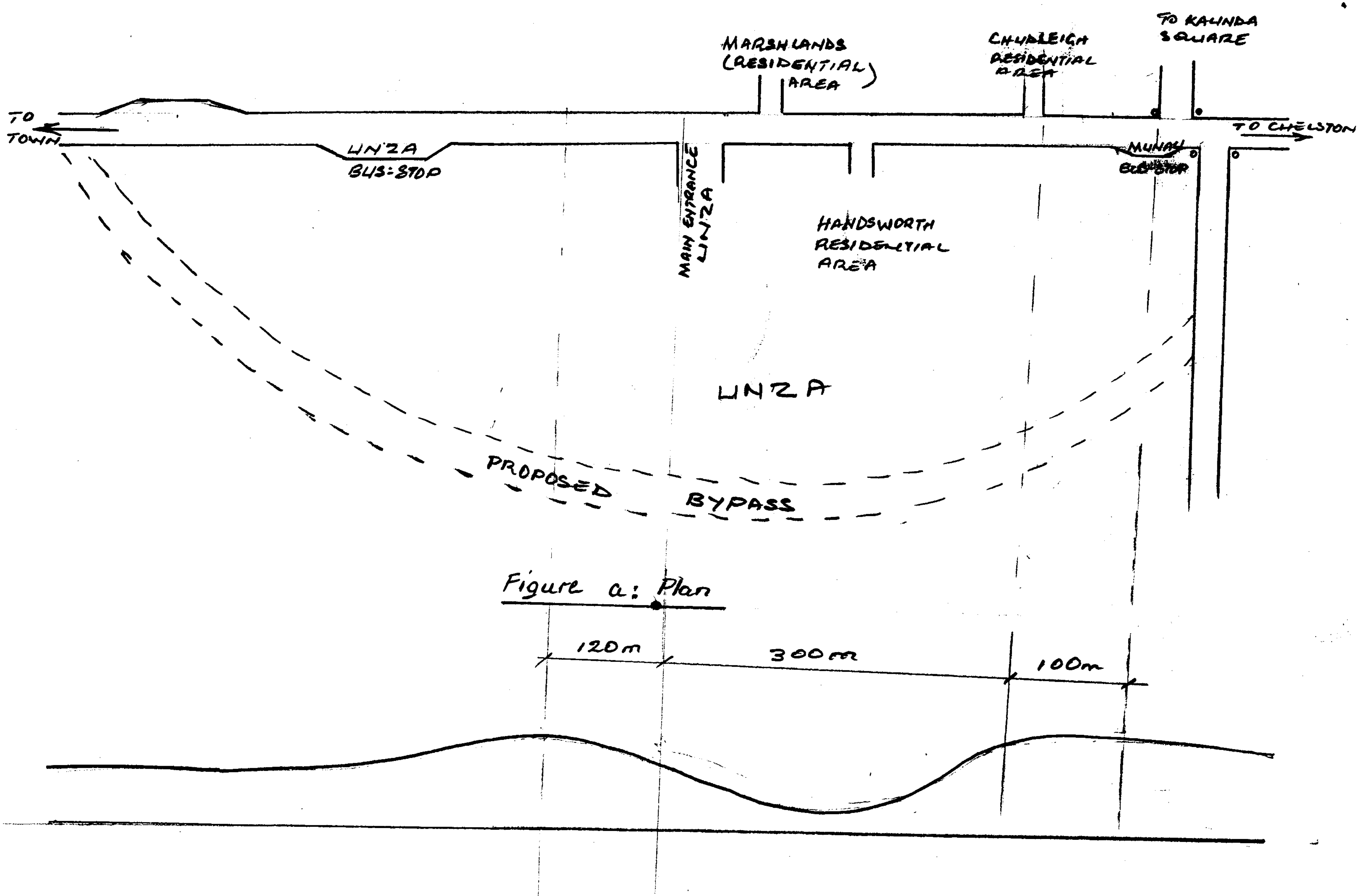


Figure a: Plan

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JUNE, 1996

CE 369

FLUID MECHANICS

TIME: THREE (3) HOURS

INSTRUCTIONS: ATTEMPT ANY FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Q1. (a) Define Fluid Mechanics. How does fluid mechanics differ from "solid-body" mechanics?

(b) What is meant by the viscosity of a fluid? A fluid has absolute viscosity 0.0010 Pas and relative density 0.913. Calculate the velocity gradient and the intensity of shear stress at the boundary and at points 1cm, 2cm and 3cm from the boundary, assuming a straight line velocity distribution.

(c) A mercury U-tube manometer is used to measure the pressure above atmospheric of water in a pipe, the water being in contact with the mercury in the left-hand limb. Sketch the arrangement and explain its action.

(d) If the mercury is 30cm below A (Fig. 1) in the left limb and 20cm above A in the right-limb, what is the gauge pressure at A? Relative density of mercury = 13.6. (5+5+5+5)

Q2. (a) Show that for fluids at rest there can be no shear stresses in the fluid.

(b) State and prove Pascal's law.

(c) A circular lamina 125cm in diameter is immersed in water so that the distance of its perimeter measured below the water surface varies between 60cm and 150cm.

Find the total force due to the water acting on one side of the lamina, and the vertical distance of the centre of pressure below the surface.

(4+8+8)

Q3. (a) What is meant by continuity of flow and under what conditions does it occur?

(b) Oil flows through a pipeline (Fig. 2) which contracts from 450mm diameter at A to 300mm diameter at B and then forks, one branch being 150mm diameter discharging at C and the other branch 225mm diameter discharging at D If the velocity at A is 1.8m/s and the velocity at D is 3.6m/s, what will be the discharges at C and D and the velocities at B and C?

(c) A fluid is flowing in a tapering pipe (Fig. 3). At section AB, the area of cross-section is a_1 and the velocity v_1 and at section CD the corresponding values are a_2 and v_2. Derive an expression for the rate of change of momentum of the fluid between the two sections. (4+8+8)

Q4. (a) Distinguish between steady and unsteady flow; and between uniform and non-uniform flow.

(b) Write down Bernoulli's equation in its usual form and list the conditions under which it is applicable.

(c) Explain how provision can be made in Bernoulli's equation for loss of energy occurring between two points in a stream of liquid.

(d) A conical tube is fixed vertically with its smaller end upwards. The velocity of flow down the tube is 4.5m/s at the upper end and 1.5m/s at the lower end. The tube is 1.5m long and the pressure head at the upper end is 3m of the liquid. The loss in the tube expressed as a head is $0.3(v_1-v_2)^2/2g$ where v_1 and v_2 are the velocities at the upper and lower ends. What is the pressure head at the lower end?

(3+5+3+9)

Q5. (a) Two distinct types of flow can be distinguished in the flow of a real fluid. State and describe these two types of flow.

(b) Show that the loss of head when a pipe undergoes a sudden increase in diameter is given by $(v_1-v_2)^2/2g$ where v_1 is the velocity in the smaller pipe upstream of the enlargement and v_2 that in the larger pipe.

(c) A pipe increases suddenly in diameter from 0.5m to 1m. A mercury U-tube has one leg connected just upstream of the change and the other leg connects to the larger section a short distance downstream. If there is a difference of 35mm in the mercury levels, the rest of the gauge being filled with water, find the discharge.

(4+8+8)

Q6. (a) A pipeline connecting two reservoirs having a difference of level of 6m is 720m long, and rises to a height of 3m above the upper reservoir at a distance of 240m from the entrance before falling to the lower reservoir. If the pipe is 1.2m in diameter and the frictional coefficient f = 0.01, what will be the discharge and the pressure at the highest point of the pipeline?

(b) Water is discharged from a reservoir into the atmosphere through a pipe 39m long. There is a sharp entrance to the pipe and the diameter is 50mm for 15m from the entrance. The pipe then enlarges suddenly to 75mm in diameter for the remainder of its length. Taking into account the loss of head at entry and at the enlargement, calculate the difference of level between the surface of the reservoir and the pipe exit which will maintain a flow of $2.8 \times 10^{-3}\,m^3/s$. Take f as 0.0048 for the 50mm pipe and 0.0058 for the 75mm pipe.

(10+10)

Q7. (a) What is meant by open channel flow? State Chezy's equation for open channel flow. To what type of open channel flow is the Chezy equation applicable?

(b) A rectangular open channel has a width B of 4.5m and a slope of 1 vertical to 800 horizontal. Find the mean velocity of flow v and the discharge Q when the depth D of water is 1.2m, if C in the Chezy formula is 49 in SI units.

(c) An open channel (Fig. 4) is V-shaped, each side being inclined at 45° to the vertical. If the rate of flow Q is 45dm^3/s when the depth of water at the centre is 225mm, calculate the slope of the channel using the Chezy formula, assuming that C is 49 in SI units.

(4+8+8)

END OF EXAMINATION

CE 369

FIG. 1
Q1.

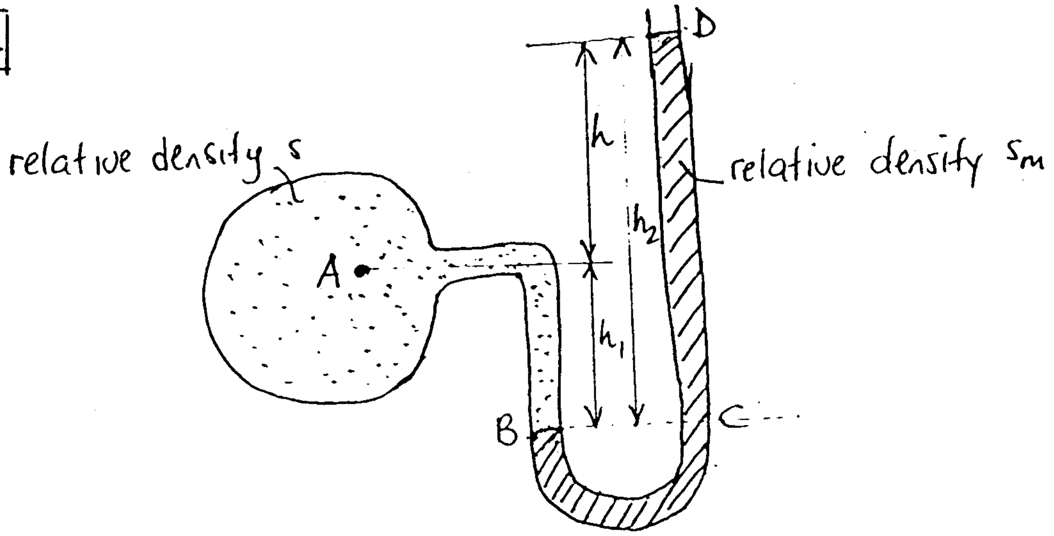


FIG. 2
Q3.

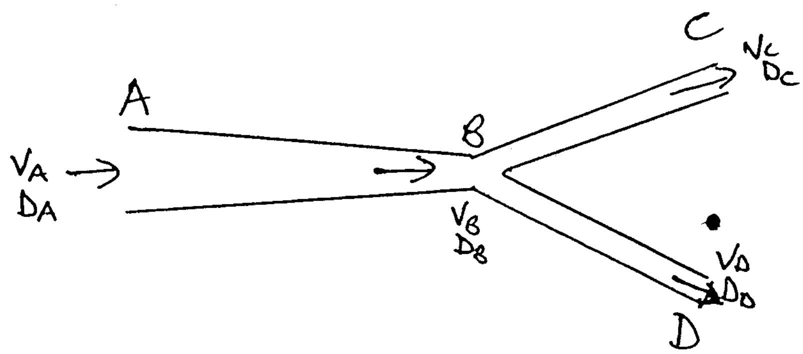


FIG. 3
Q3.

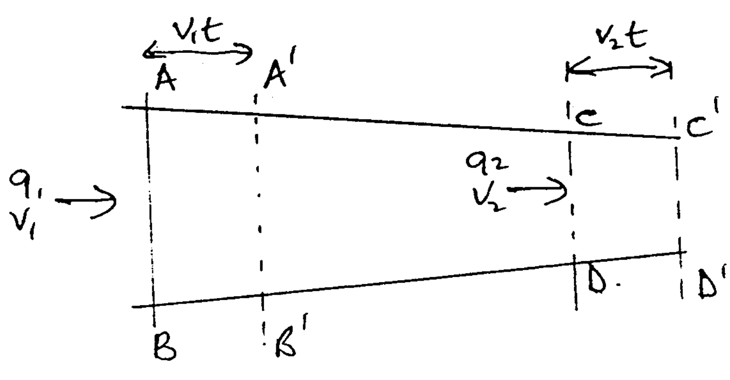
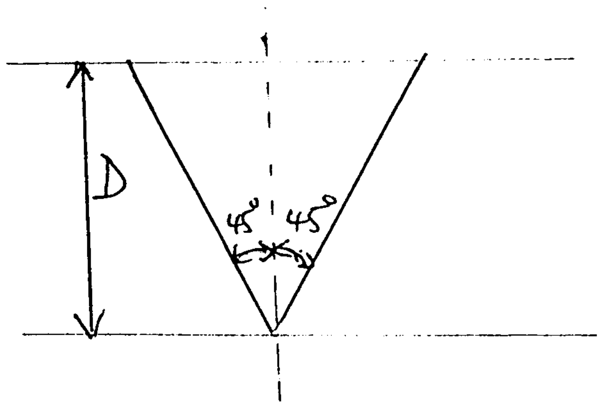


FIG. 4.
Q7.



THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JUNE 1996

CE 381

CIVIL ENGINEERING MATERIALS AND PRACTICES

TIME: THREE HOURS

ANSWER: 5 QUESTIONS, CHOOSING AT LEAST ONE QUESTION FROM EACH SECTION.

NOTE: CLOSED BOOK

SECTION A: CIVIL ENGINEERING MATERIALS

1. (a) Briefly discuss the various types of additives to alter or improve the properties of freshor hardened concrete or both. (10 marks)

   (b) Write short notes on the following:
   - (i) Hydration
   - (ii) Setting times of Cement
   - (iii) Flash set
   - (iv) False set (5 marks)

   (c) List the various factors that influence strength of hardened concrete. Why is curing of Concrete important? (5 marks)

2. (a) Discuss the various procedures for formation of clay bricks indicating the appropriate raw materials for each. (10 marks)

   (b) What types of blocks are commonly manufactured in Zambia? In terms of size and form, what types are common in Zambia? (8 marks)

   (c) Why are the nominal dimensions for blocks different from the work sizes? (2 marks)

3. (a) In terms of source of timber in Zambia, name the two broad categories giving two examples (names) of each source. (5 marks)

(b) What is meant by the following terms?
   (i) Conversion of Timber
   (ii) Seasoning

   Explain the importance of seasoning in practice. (5marks)

(c) List and give an example for each use of Timber. For Low Cost housing in Zambia, what is the major use for Timber? (5 marks)

(d) Briefly discuss the major advantages of using timber in Civil Engineering practice compared to other materials for construction. (5 marks)

PART B: CONSTRUCTION

4. List the main types of stonework and give brief explanation for each of them. (5 marks)
   (a) Draw sketches to show three types of stone work. (5 marks)
   (b) Give the general requirements for laying of stone masonry. (10 marks)

5. What is the main function of waste piping system in a building? (5 marks)
   (a) Draw a sketch to show the main components of the waste piping system in a building. Give brief explanation to the functions of each component. (10 marks)
   (b) What are used to determine the pipe size of the waste piping system? (5 marks)

PART C: ORGANISATION

6. Describe four (4) types of contracts. (20 marks)

7. (a) Give two main purposes of the Bill of Quantities.
   (b) List the steps involved in the preparation of a Bill of Quantities.
   (c) Take off the concrete in the 30 m long retaining wall and foundation shown in fig. Q7.

(4+4+12 marks)

END OF THE EXAMINATIONS

MASS CONCRETE RETAINING WALL

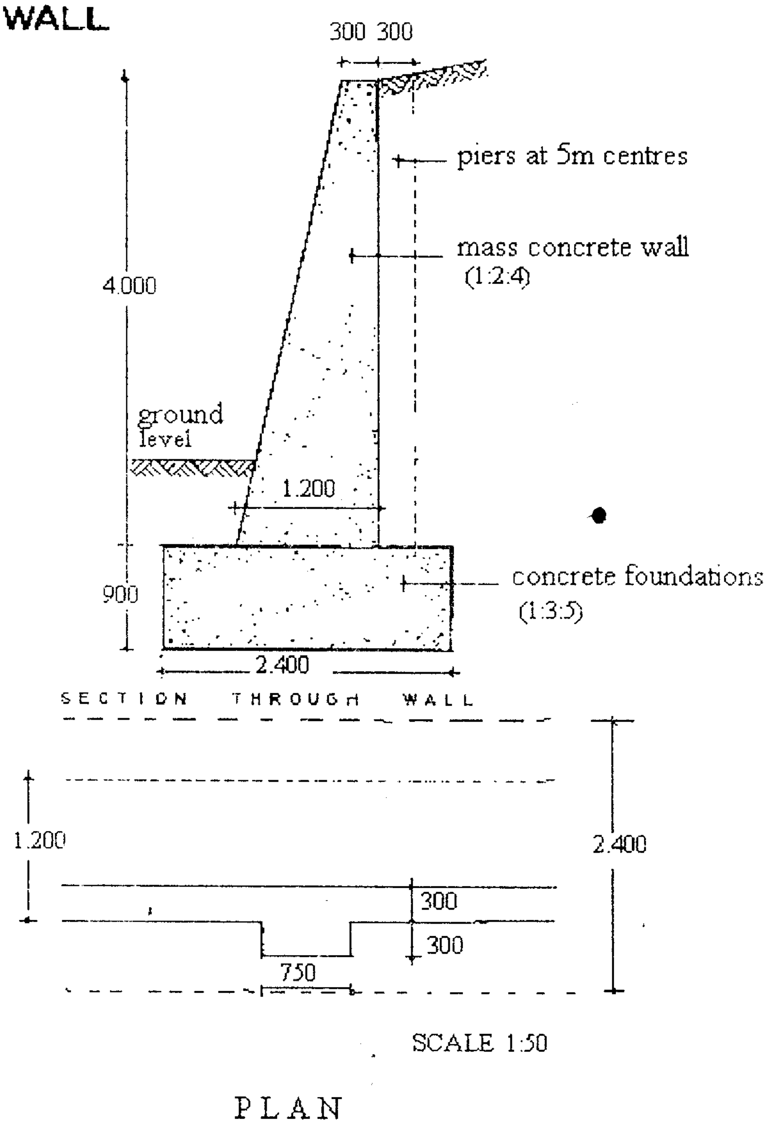


Figure Q7

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JUNE, 1996

CE 431

STRUCTURAL ENGINEERING

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS, CHOOSING AT LEAST TWO QUESTIONS FROM EACH SECTION.

NOTE: OPEN BOOK

SECTION A: STRUCTURAL MASONRY

Q1. The cavity wall shown in Fig. 1 is 1.5m long. The unfactored loading details are as follows:

Loading of inner leaf (kN/m run of wall)	G_k	Q_k
Load from above and self load	15	15
Load from floor slab	10	5

Calculate the block/mortar combination required. (20)

Q2. A single storey structure is loaded as shown in Fig. 2. Assuming mortar designation iii is available, obtain the compressive strenth required for the un grouted concrete block pilaster A-A. Assume density of un grouted 200mm thick ~~block~~ wall is 2.1kN/m². Loading from the truss is assumed ~~1.5~~ 15 kN/m length of wall. Assume live load on the flat roof is ~~1.5~~ 15 kN/m². Neglect flexural strength enhancement (20)

Q3. (a) The panel shown in Fig. 3 is a load bearing cavity wall using modular clay bricks. It is well supported on its two vertical edges but is simply supported on top and rests on damp proof course at the bottom. Both leaves carry the roof loads equally W_k for the exposed ~~face~~ site is 1.2kN/m² suction. Water absorption for the bricks is between 7 and 12% and mortar type ii is used. Assume μ = 0.35. (10)

(b) Assuming a single wall was constructed instead, using 200mm concrete blocks of compressive strength 7.0N/mm² and mortar designation ii and vertical construction joints are located at 5.6m centres; what would be the lateral load resistance of the wall? Assume flexural strength enhancement. (10)

Q4. (a) What is meant by progressive collapse and list what types of loads may lead to this. (5)

(b) A transverse section of a six storey building is shown in Fig. 4. The clear height of each storey is 2.4m and bay spacing is 5.0m. The walls are 200mm grouted concreted block walls. The dead (G_k) and imposed (Q_k) loading on each floor is 3.6 and 1.5kN/m² respectively. Assuming the characteristic strength of reinforcement is 250N/mm², compute:

(i) The amount of peripheral ties.

(ii) The external wall ties.

(iii) For the 4th floor, check the shear resistance at the contact surfaces assuming mortar type iii and the design vertical load at that floor. Slabs are 150mm thick. (15)

SECTION B: TIMBER ENGINEERING

Q5. The truss shown in Fig. 5 is loaded as shown (selfload, sheeting, access). The truss fabricated using standard grade pine is in an inside location. The sheeting is asbestos and the trusses are spaced at 5m centres. The purlins are standard grade Eucalyptus grandis spaced at 1.2m centres. Assume, services and ceiling hang from the bottom chord at nodes contribute 0.5kN/m² length of bottom chord.

(a) Neglect the wind loading, obtain a suitable section for the bottom and top chords. Available timber depths are 150mm. (12)

(b) Obtain a suitable section for the purlins, if the available depth is ~~75~~ 125mm. **(8)**

Q6. For installation within a domitory floor, check the suitability of a sawn Eucalyptus grandis, common grade timber beam on a clear span of 3.0m. The beam of size 100 x 250 is loaded by incoming beams spaced at 0.6m centres. The dead loading is $0.35kN/m^2$ inclusive of the beam self weight. The imposed loading is $1.5kN/m^2$. The incoming beams have a span of 4.5m on each side of the beam and laterally restrain the beam. **(20)**

Q7. For a long term load of 120kN design a suitable box column of height 4.0m. The species for the timber is standard grade Eucalyptus grandis in an outside location. Only ~~100~~ 125mm ~~thick~~ deep planks are available. Design the necessary spacer blocks and choose suitable nail sizes giving reasons. **(20)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - NOVEMBER 1996

CE 442
HIGH WAY AND TRAFFIC ENGINEERING

TIME: THREE (3) HOURS

ANSWER: QUESTION ONE AND ANY OTHER FOUR

Q1.(a) Define the following:

(i) Stopping Sight Distance (SSD)
(ii) Passing sight Distance
(iii) Meeting Sight Distance

(b) A sag vertical curve joins a -3% and a + 3% grade. If the PVI of the grades is at station (435+050) and has an elevation of 1200 m, determine the station and elevation of the BVC and EVC for a design speed of 100 km/hr. Use coefficient of tangential friction = 0.23.

Q2. (a) Show the following joints by means of stetches:

(i) Contraction joints
(ii) Longitudinal joints (full width construction)

(b) Show how superelevation can be attained by rotating a pavement about the centre line.

(c) Why are horizontal circular curves widened - show curve widening by means of a sketch.

Q3.(a) What are the criteria used to determine the lengths of sag curves?

(b) The deflection angle of a 2° curve is 6°. If the PC is located at station (150+080), determine the length of the curve and the station of the PT. Also determine the deflection angle for setting out.

Q4. (a) Describe the following test procedures:

(i) DCP
(ii) ACV
(iii) Marshal Test design procedure

Indicate their significance in highway engineering

(b) Make comparisons between tar and bitumen binders.

Q5.(a) What is consolidation?

(b) The material from a borrow pit gave the following bulk-unit weight relationship.

W.C.(%)	11.4	12.3	15.5	18.6	19.8
Density (kN/m^3)	19.0	19.6	20.7	20.6	20.3

If the average specific gravity of the solids is 2.7,

(i) Plot the dry unit weight versus the moisture content curve and determine the maximum dry unit weight and O.M.C.

(ii) If the compaction specification stipulates 95% proctor maximum dry unit weight, what is the probable range of moisture contents to which the compacted soil can be subjected without a volume change occuring.

Q6.(a) Design a ditch cross section which can carry a design flow of $4m^3/s$.
$S = 0.04\%$, trapezoidal side slopes
2:1, $n = 0.022$, $V_{max} = 0.66$ m/s.

(b) What factors affect the run off from an area?

(c) What advantages do V-shaped and trapezoidal drains have, respectively.

(d) Calculate the pipe size you would need to drain 18 km^2.
Use Talbot's constant = 0.11.

Q7. Write brief notes on the following:

(i) Practical capacity
(ii) Elongation Index (Shape Test)
(iii) Electrical and thermal methods of stabilization.
(iv) Factors which affect cement - soil mixtures.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - NOVEMBER 1996

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THE UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS - NOVEMBER/DECEMBER 1996

CE 452

PUBLIC HEALTH ENGINEERING

TIME: THREE HOURS

INSTRUCTIONS: ANSWER 5 OUT OF 7 QUESTIONS. QUESTIONS 4 AND 7 ARE COMPULSORY.
ALL QUESTIONS CARRY EQUAL MARKS (MAXIMUM 20).

---

1. a. What is a 'mechanical vector' and what is a 'biological vector' of disease transmission? Explain and give one example of each. [6]

   b. What approximate numbers of faecal coliforms you expect to find in deep groundwater, shallow groundwater and surface (river) water? What is the reason for the difference and what does it mean for the provision of public water supply? [6]

   c. (i) Why is turbidity objectionable for drinking water?

   (ii) Point out the principles of the BOD-test and discuss its suitability for various types of wastewater. [8]

2. a. The following data are given for a certain town:

   - future population 10,000 inhabitants of which:
     - 60% lives in high density areas (with an average daily water demand of 50 lcd);
     - 30% lives in medium density areas (with an average daily water demand of 100 lcd); and
     - 10% lives in low density areas (with an average daily water demand of 250 lcd);
   - a public/commercial water demand equaling 20% of the domestic water demand;
   - an industrial water demand of 650 m^3/d;
   - water losses estimated at 30% of the actual demand;
   - peak factors:
     - monthly peak factor: 1.1
     - daily peak factor: 1.2
     - hourly peak factor: 1.67

   (i) Determine the design capacity of the treatment works to satisfy future water demand.

   (ii) Determine the design capacity of the distribution network to satisfy future water demand. [8]

   b. For a city of 10,000 inhabitants the following hourly water demand figures are given:

0 - 2 hours:	40 m^3/h	12 - 14 hours :	160 m^3/h
2 - 4 hours:	60 m^3/h	14 - 16 hours:	200 m^3/h
4 - 6 hours:	80 m^3/h	16 - 18 hours:	120 m^3/h
6 - 8 hours:	150 m^3/h	18 - 20 hours:	100 m^3/h

8 - 10 hours:	200 m^3/h	20 - 22 hours:	80 m^3/h
10 - 12 hours:	190 m^3/h	22 - 24 hours:	60 m^3/h

To balance the fluctuating hourly demand with the continuous and constant supply a service reservoir is planned.

(i) Determine the volume of the service reservoir as a percentage of the total daily demand.

(ii) Assume the water losses to be a constant 20 m^3/h throughout the day. What will happen to the storage volume if the water losses are reduced to 0 m^3/h? [8]

c. Briefly discuss the design procedure for a looped network. [4]

3. a. Explain why the removal efficiency for a suspension of discrete particles is smaller for an upflow sedimentation tank than for a horizontal sedimentation tank. [7]

b. In a horizontal settling tank it is observed that re-suspension of particles start to take place when the horizontal velocity (v_0) equals 7 cm/s. The critical scour velocity (under laminar flow conditions) is given by the following equation:
$v_s = 0.49 \cdot ((\rho_s - \rho_w)/\rho_w)^{1/4} \cdot s^{1/4}$.
What will be the diameter of the particles going into suspension, assuming the particles have a specific weight (ρ_s) of 2,650 kg/m^3; and the water having a temperature of 20°C (the kinematic viscosity (ν) being 1.01 x 10^{-6} m^2/s). [7]

c. Describe the factors due to which the removal efficiency of an ideal horizontal settling basin may be influenced. [6]

4. a. Name and briefly describe the five (5) mechanisms of filtration. [6]

b. Discuss the differences between slow sand filtration and rapid sand filtration in terms of:
- filtration rate;
- characteristics of filter material;
- penetration of suspended matter;
- filter run lengths between cleanings; and
- method of cleaning. [7]

c. The results of rapid sand filtration can be expressed in two parameters:
- the filter run length (T_q) during which the effluent quality satisfies the set standard;
- the filter run length (T_r) during which the filter resistance is less than the maximum allowable value.

(i) Discuss the actual filter run length (T_{actual}) used under operational conditions in relation to the above mentioned parameters.

(ii) Discuss the impact in relation to the above mentioned parameters when instead of uniform sand with a grain size of 0.8 mm
- uniform sand with a grain size of 0.7 mm is used;
- uniform sand with a grain size of 0.9 mm is used. [7]

5. a. Name and briefly describe the influence of the four basic design parameters governing the effectiveness of chlorination. [7]

b. (i) Which conditions are required to keep the chlorine dose in chlorination practice as low as possible?

(ii) When is it necessary to disinfect water supply facilities (as opposed to drinking water) and how is it carried out? [7]

c. For a given water it is observed that the chlorine demand after 20 minutes equals 0.7 mg/l. To ensure a chlorine residual of 0.3 mg/l, the gas flow of a gas chlorinator treating 100 m^3/h of this water is set at 40 g/h. Assess whether this gas flow is set correct. [6]

6. a. (i) Briefly describe (use sketches) the kinetics governing the absorption an release of a gas.
   (ii) Name and briefly describe four types of aerators used in gas transfer practice. [7]
   b. (i) Give the mean reasons why softening is applied in water treatment?
   (ii) Name and briefly describe the two main processes used in water softening practice. [7]
   c. (i) What is the definition of the equilibrium pH and what is its meaning in water treatment?
   (ii) Briefly describe pH adjustment practice as applied in water treatment. [6]

7. a. (i) Give the main purpose of an aerobic pond in a waste stabilization ponds system.
   (ii) Compute the volume (V) and the retention time (t) of an anaerobic pond using the following data: the daily sewage flow (Q) = 3,600 m^3/d; the BOD-concentration of the sewage (L) = 500 mg/l; and the volumetric BOD loading rate (r) = 275 mg BOD/(l·d). [7]
   b. (i) Briefly describe the processes that take place in a facultative pond in a waste stabilization ponds system.
   (ii) Compute the volume (V) and the retention time (t) of a facultative pond using the following data: the daily sewage flow (Q) = 3,600 m^3/d; the BOD-concentration of the (pretreated) sewage (L) = 250 mg/l; the surface BOD loading rate (s) = 25 g BOD/(m^2·d); and the depth (H) = 1.2 m. [7]
   c. (i) Give the main function of maturation ponds in a waste stabilization ponds system.
   (ii) Compute the number and the area of each maturation pond using the following data: the daily sewage flow (Q) = 3,600 m^3/d; the number of faecal coliforms of the (pretreated) sewage (N_0) = 6.655 * 10^6 FC/100ml; the desired number of faecal coliforms of the effluent (N_R) = 5,000 FC/100ml; the retention time in each maturation pond (R) = 5 days; and the depth of each maturation pond (H) = 1.2 m. [6]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SUPPLEMENTARY EXAMINATIONS - JULY 1996
CE 461 HYDROLOGY

TIME : THREE (3) HOURS
ANSWER : ANY FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

---

1. Measurements of stage and discharge for a particular site on a stream are given in the table below.

discharge (m^3 / s)	stage (m)
79.1	0.701
91.2	0.769
126.6	0.939
188.5	1.235
238.9	1.402
267.9	1.475
317.4	1.725
333.2	1.782
355.6	1.887
421.5	2.000
476.9	2.219
506.0	2.258
588.5	2.554
685.2	2.844
702.1	2.897
756.9	2.984
823.9	3.195

Using the equation of the form:

$$Q = a\,(z - z_o)^b$$

a) Calculate the values of a, b and z_o

b) What would the discharge be if the maximum stage observed during a flood was 4.216 m

Hint: $z_o = (z_1 z_3 - z_2^2) / (z_1 + z_3 - 2 z_2)$

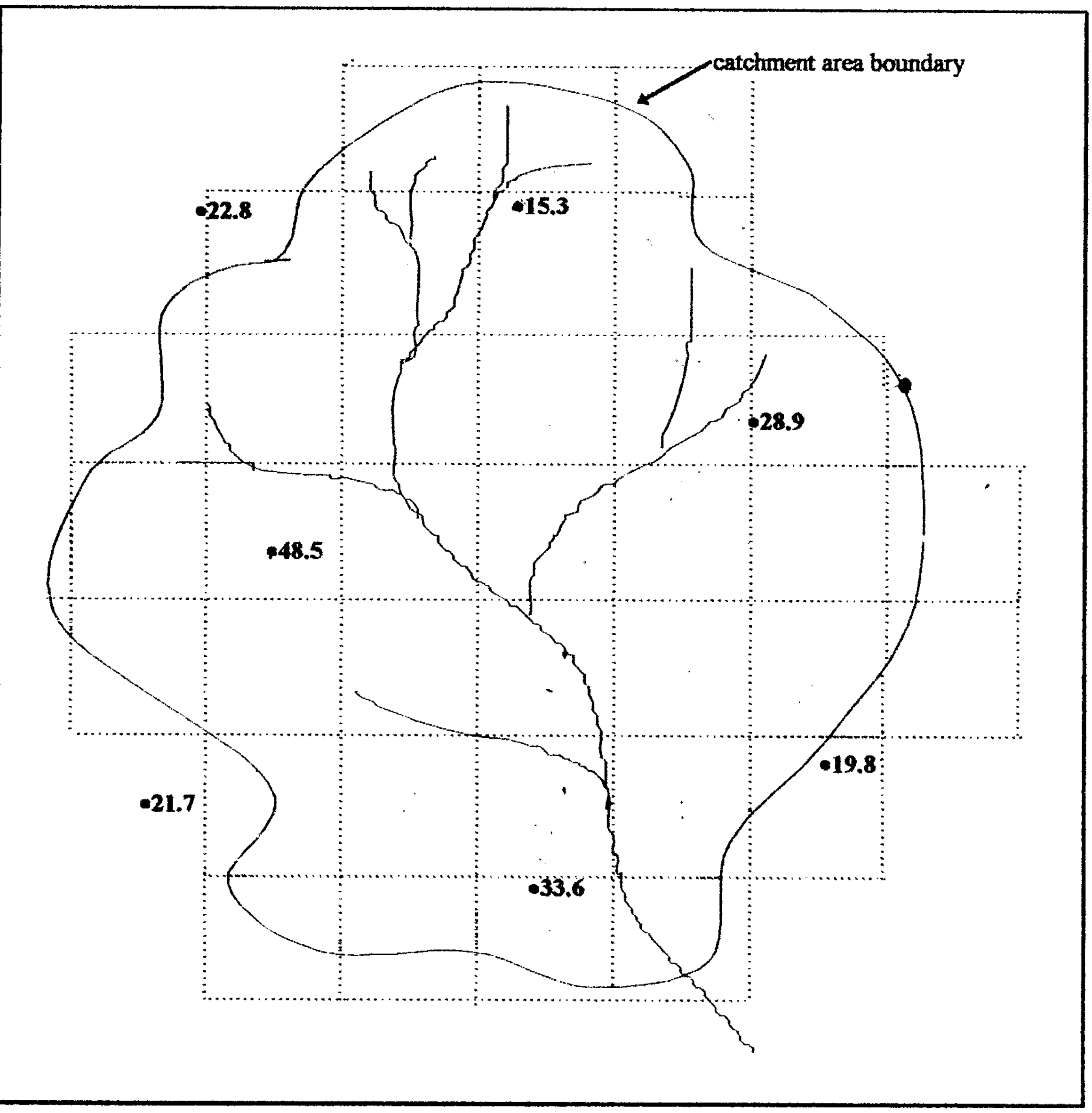
c) What errors could arise in the extrapolated discharge value by using this method.

d) How can the errors in (c) above be reduced by using other methods.

(10+3+4+3)

2. a) One of four monthly-read rain gauges on a catchment area develops a fault in a month when the other three gauges record 39, 45 and 53 mm respectively. If the average annual precipitation amounts of these three gauges are 726, 752 and 840 mm respectively and of the broken gauge 694 mm, estimate the missing monthly precipitation at the latter.

b) For the catchment shown below, determine the average precipitation using
(i) the arithmetic mean
(ii) the Theissen method
Each square grid represents 10 Km^2
Rainfall amounts are in mm



(6+14)

1.6 litres of tracer solution was suddenly added to a small turbulent stream. Downstream the change in tracer concentration (C_t) was measured and gave the following results:

time (min)	0	6	9	12	15	20	25
C_t (g / l) (x 0.00001)	75	81	160	137	100	80	75

a) If the concentration of the injected tracer solution was found to be 200 g / l, calculate the discharge of the river.

b) On which of the following rivers was the above discharge measurement likely to have been carried out:
i) Zambezi River downstream the Victoria Falls
ii) Kafue River near Kafue Gorge
iii) Ngwerere River in Roma Township, Lusaka
Why?

c) What are the advantages of this method compared to the constant rate injection method

(10+6+4)

Consider a catchment of 24.8 Km^2.
The data of a rainfall storm and of the corresponding discharge at the outlet of the basin are given in the table below.

time (min)	rainfall (mm)	discharge (m^3 / s)
0		17
30	6.6	14
60	45.8	30
90	66.4	73
120	52.8	168
150	19.2	277
180	28.7	319
210	7.4	240
240		129
270		89
300		58
330		42
360		27
390		18
420		17
450		15
480		13

a) Use the logarithmic plot to find the time when storm runoff ceases.
b) Determine the Φ - index for the catchment.
c) Determine the net rainfall hyetograph.
d) Using the Φ - index calculated in (c) above, determine the volume of direct runoff (m^3 / s) that would result from the following storm

time (min)	0	30	60	90	120	150
rainfall (mm)	0	14.5	29.3	37.1	30.3	9.2

(4+8+4+4)

5. Given below are the observed flows from a storm of 4 - hr duration on a stream with a drainage area of 36.2 Km^2 and the baseflow.
   a) Derive the 4 - hr Unit hydrograph.
   b) Find the peak flow resulting from two successive 4 - hr periods of rainfall producing 4.0 and 5.0 cm of runoff. Ignore baseflow.

Hour	Total flow (m^3 / s)	Baseflow (m^3 / s)
12.00	11	11
14.00	160	12
16.00	244	13
18.00	168	14
20.00	87	15
22.00	41	16
24.00	17	17

(12+8)

6. a) Explain what the factors x and K are in river channel routing
   b) Why is it necessary to determine the values of these factors.
   c) Tabulated below is the inflow to a river reach where the storage constants are K = 10 hours and x = 0. Find the outflow peak in time and magnitude.

Time (h)	inflow (m3 / s)
0.00	62.0
5.00	133.0
10.00	152.0
15.00	90.6
20.00	53.8
25.00	34.0

(4+4+12)

7. Two boreholes 90 m deep (A and B) penetrate a confined aquifer of thickness 28 metres. They are sited 100 metres apart. If the water is being pumped from each at a rate of 20 l / s, estimate the drawdown at point C, 30 m from A and 70 m from B.

<u>DATA</u> K = .0001 m / s Radius of A = 0.3 m Radius of B = 0.2 m
original piezometric surface was 20 m below the ground. The drawdown in borehole A, when only A is pumped is 14 m. The drawdown in borehole B, when only B is pumped is also 14 m.

(20)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FINAL EXAMINATION

CE 512 STRUCTURAL DYNAMICS

TIME: Three hours.

SECTION A: Select 3 from four. (20 marks for each)

1, A water pipe is located as shown in fig.1. The velocity of the water in the pipe u=10m/sec, if the diameter of the pipe is 1000 mm, determine the force of the water on the foundation.

2, A point mass M is placed on top of a weightless rod of length L and restrained by two springs of stiffness K each shown in fig.2. At neutral position the springs are unstretched. Using the energy method, calculate the natural frequency including the effect of gravity.

3, A rigid beam with mass M at one end can pivot about the other end. It is supported by three equally spaced springs as shown in fig.3. What is the natural frequency?

4, A rigid beam is hinged at the left end and supported by two springs shown in fig.4. A mass, M=10 kg, is suspended to the right end of the beam with a spring. K=1000 n/m, if the vertical displacement of the mass y_o=0.04 m and velocity v_o=0.6 m/sec at t=0, determine the displacement at t=1 sec. Assume no damping and neglect the effects of the mass of the beam.

SECTION B: Select 2 from three. (20 marks for each)

5, A two-story building frame is to be considered as a shear building. For the first mode, natural circular frequency ω_1=10.64, the characteristic shape a_{11}=1, a_{12}=1.528. Determine the characteristic shape and the natural circular frequency of the second mode.(Fig. 5)

6, A two-degree system shown in fig.6 has the following parameters: M_1=5 kg, M_2=2 kg, K_1=5000 n/m, K_2=2500 n/m. Using direct determination, obtain the natural frequencies and characteristic shapes of both modes. Demonstrate orthogonality of the modes.

7, A simply supported beam shown in fig.7 is subjected to a uniformly distributed static load p which is suddenly released. Write the series expression for the resulting free vibrations and determine the amplitude of the first mode in terms of p. L=12m, EI=1.5x10 n-m^2, M=30 kg/m.

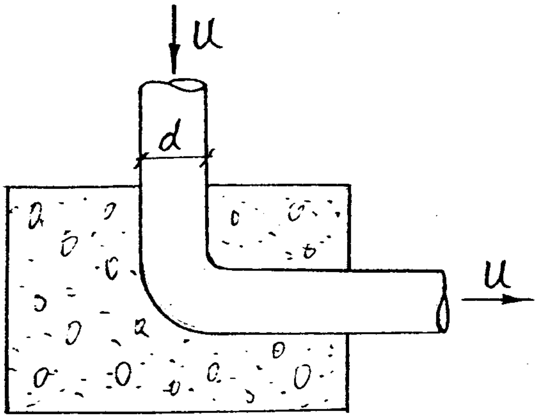


Fig. 1

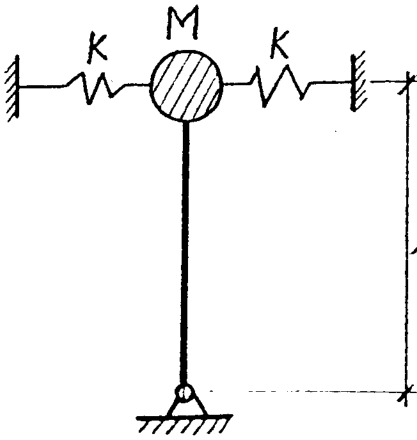


Fig. 2

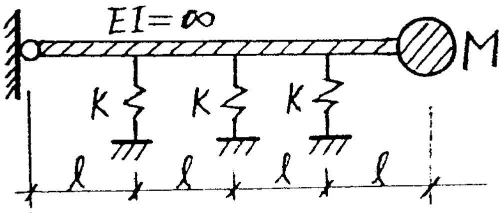


Fig. 3

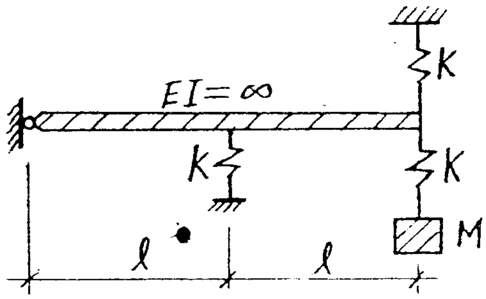


Fig. 4

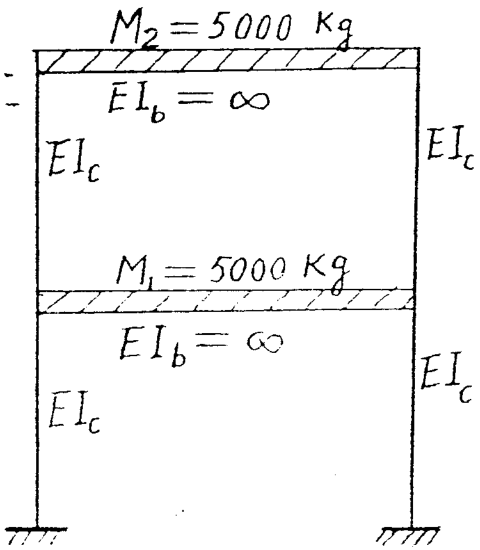


Fig. 5

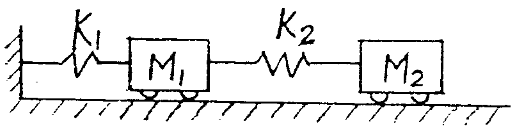


Fig. 6

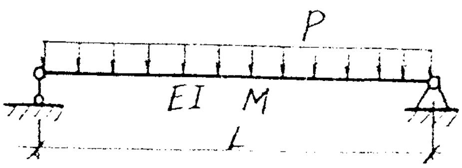


Fig. 7

UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER DEFERRED AND
SUPPLEMENTARY EXAMINATIONS - JANUARY 1997
CE 512
STRUCTURAL DYNAMICS

ANSWER: FIVE QUESTIONS, CHOOSING THREE QUESTIONS FROM SECTION A AND TWO FROM SECTION B. ALL QUESTIONS CARRY EQUAL MARKS.

TIME: THREE HOURS

SECTION A:

Q1. A stone M rests on the top of a smooth hemispherical dome of radius R as shown in fig.1. It is given an initial horizontal velocity Vo. At which point will the stone leave the surface of the dome?

Q2. A point mass M is placed at the bottom of a weightless rod of length L and restrained by two springs of stiffness K each shown in fig.2. At neutral position the springs are unstrainched. Using the energy method , calculate the natural frequency including the effect of gravity.

Q3. A rigid beam with mass M as shown in fig.3 can pivot about the right end. It is supported by three springs. What is the natural frequency?

Q4. It is observed that the amplitude of free vibration in the fundamental mode of a certain structure decreases from 1 to 0.5cm in 10 cycles. What is the percentage of critical damping?

SECTION B

Q5. For the two-degree system as shown in fig.4. determine the fundamental frequency of the system using Rayleigh method. M1=4 kg, M2=2 kg, $EI=50 \times 10^3 N.m^{2}$ (It is known that the deflection of a cantilever under concentrated load p acting at the tip of the beam is $y=p(Lx^2/2-x^3/6)/EI$.

Q6. The massless beam supports two concentrated weights, suppose that the masses are at 1/3 points of the span as shown in fig.5. $EI=6 \times 10^8$ $N.cm^2$, M1=M2=4000 kg. Determine the natural frequencies and characteristic shapes. It is known that D11=D22=4L /243EI, D12=D21=3L /243EI.

Q7. A simply supported beam is subjected to a uniformly distributed load over one-half the beam as shown in fig.6. $L=10m$, $EI=2x10^5 N.m^2$, $m=50kg/m$. Write the series expression for the resulting free vibrations and determine the amplitude of the first mode in terms of p. Suppose the load is applied suddenly and remains on the beam.

END OF EXAMINATION

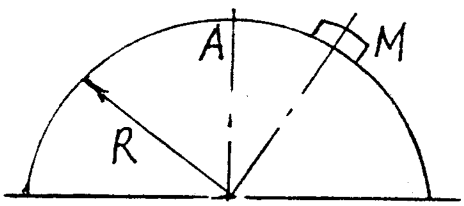


Fig. 1

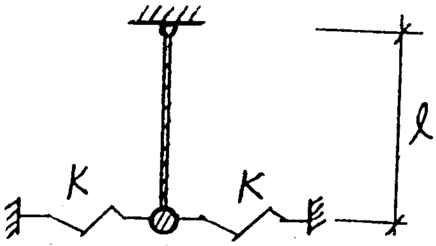


Fig. 2

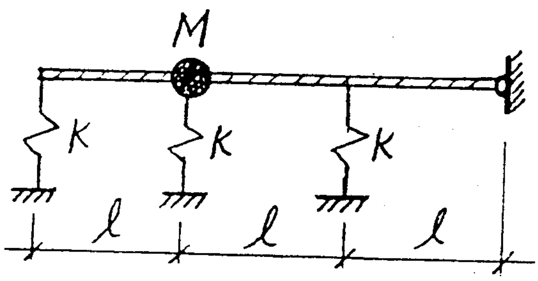


Fig. 3

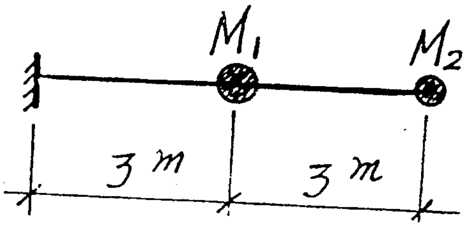


Fig. 4

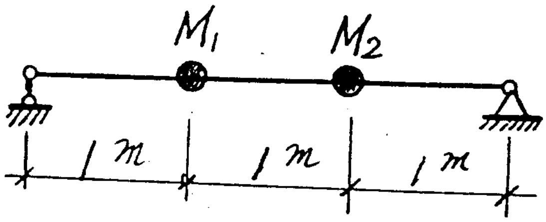


Fig 5

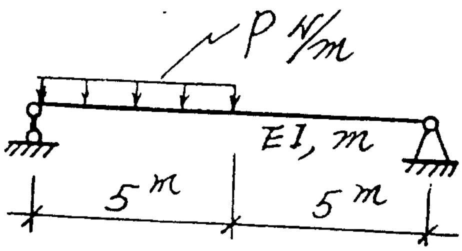


Fig. 6

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS NOVEMBER 1996
CE532(5)
STEEL DESIGN

TIME: FOUR HOURS

INSTRUCTIONS TO THE CANDIDATES

(a) Candidates must ensure that their computer numbers are clearly written on each answer booklet used and that the numbers of the questions answered are entered in the space provided on the front cover of the answer booklet.
(b) Answer **all questions in Section A** and **one question in Section B**.
(c) Maximum marks possible for each question are indicated.
(d) Mathematical gadgets and drawing instruments are allowed.
(e) **All clauses** given below are taken from **BS5950** unless stated otherwise.

MAXIMUM SUM OF MARKS: 100 **OPEN BOOK**

SECTION A

Q1. For steel ties, what is the difference between **Net Area** and **Effective Area**? (4)

Q2. What advantage is gained when rows of bolts at a joint of two ties are **staggered**? (4)

Q3. Why is it important to classify a steel section as given in **clause 3.5**?(4)

Q4. Why does the **Clause 4.7.5**, suggest that when calculating the compressive strength of sections made of welded plates, the design strength p_y should be reduced by 20 N/mm^2? (4)

Q5. Why is deflection due to imposed load only checked?(Clause 2.5.1)(4)

SECTION B

Q6 The plan and elevation shown in figure 1 are for a two storey school constructed using Simple Construction Method. If the floor slab is 150 mm thick and is made of reinforced concrete and supported as shown. Using an imposed load of 3.0 kN/m^2 and partitions of negligible weight on the slab, design for the following:

(a) **Beam 1**(30)

(b) **Column A** assuming a factored axial force from **column Á** is 250 kN.(20)

(c) Provide a connection for column A and beam 1 to meet the simple construction assumption.(30)

Q7 Figure 2 shows a floor plan and an section. The upper floor is used for office accommodation.

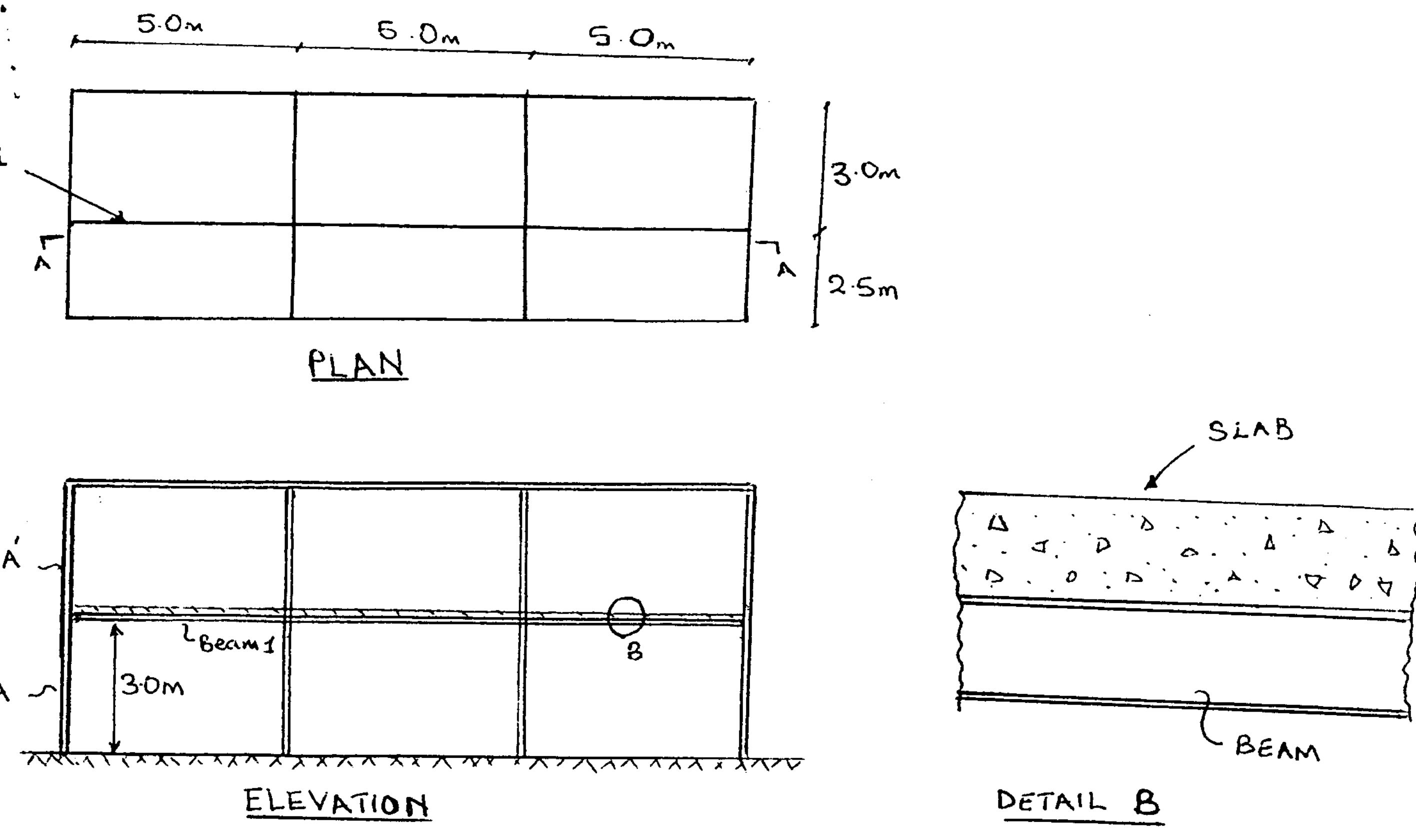
(a) Design for **Beam B** if the loads on the slab are as follows;

(i) Imposed load for office accommodation is **5.0 kN/m^2**

(ii) Slab is 200 mm thick

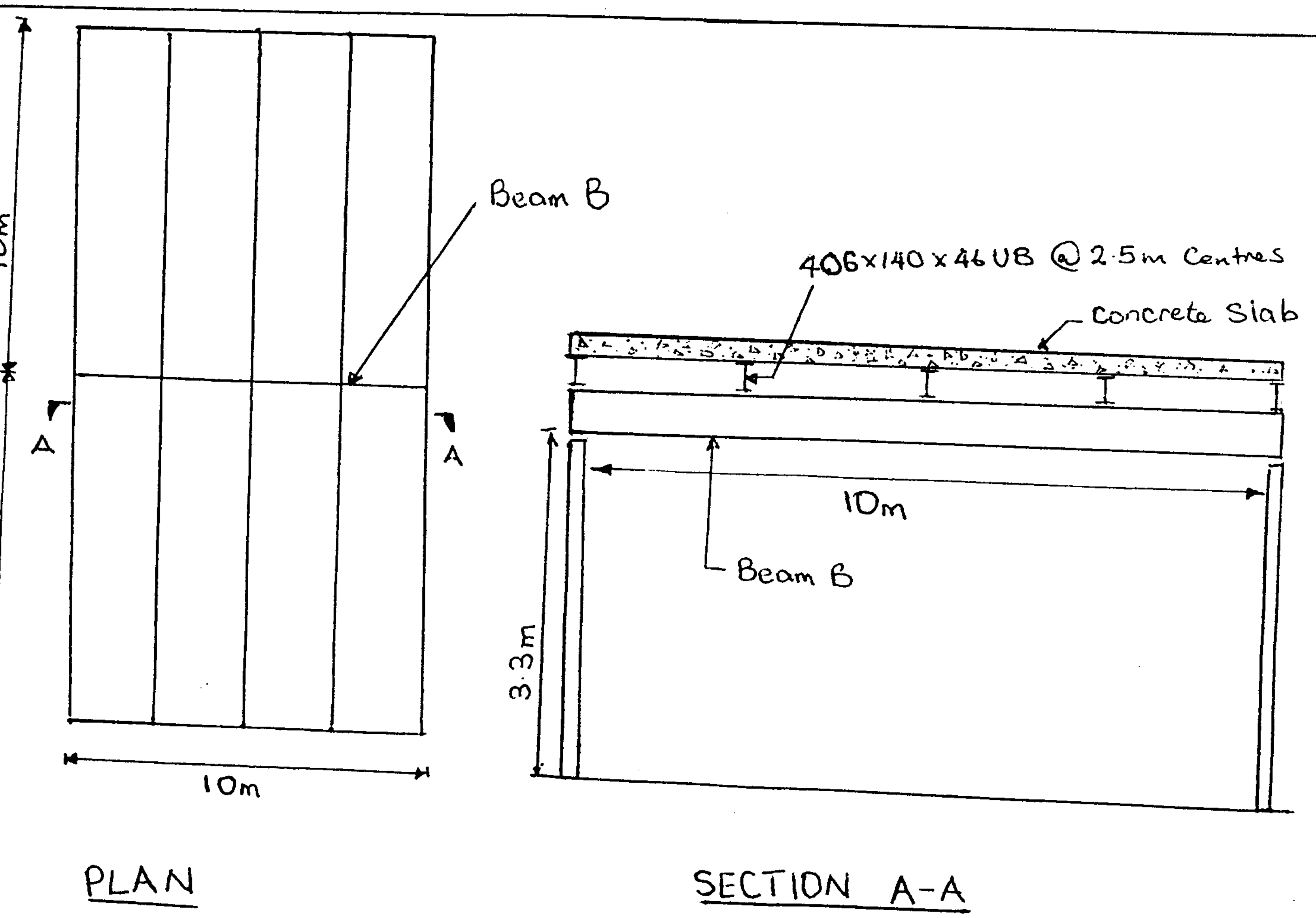
(iii) **406 x 140 x 46 UB** are used as secondary beams placed at 2.5 m centres.(40)

(b) The columns in shown in the section are to be made from channels placed back to back. Provide either battened or laced columns and check that they (columns) will be able to support their loads. Design and detail the joints of the end tie panels to the main column members, and that of the lacing or batten to the main column member.(40)



SECITION A-A

Figure 1



The University of Zambia

Final examination CE 565
Water Management and Hydraulic structures

26th of November 1996, 14:00 - 17:00

OPEN BOOK Examination

Instructions to candidates:
1. Candidates must ensure that their computer numbers are clearly written on each answer used booklet and that the numbers of questions answered are entered in the space provided on the front of the answer booklet.
2. Please answer any FIVE questions out of SEVEN.
3. All questions carry equal mark (20 %). Marks of subquestions are indicated at the end of each subquestion.
4. Textbooks, lecture notes, mathematical gadgets and drawing instruments are allowed.

Question 1

a. Determine the factor of safety and the factor of stability for reservoir full conditions for the upper part and for all dam's body of the gravity dam given in figure 1. The specific weight of concrete $\gamma_c = 24$ kN/m³, the density of water $\rho_w = 1000$ kg/m³ , $g = 9.81$ m/s², $\tau_{max} = 1.75$ MPa , $\sigma_{max} = 20$ MPa and the coefficient of friction $\mu = 0.6$. Check the stresses parallel to the face of the dam as well. (12 %)

b. What measures would you recommend to improve the design in such a way that safety and stability are guaranteed ? Explain by means of calculations what the effect of the proposed measures is. (8 %)

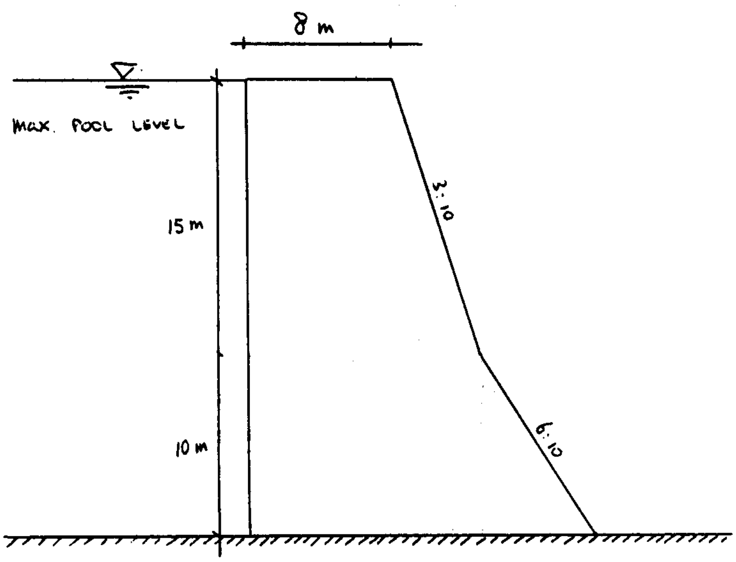


Figure 1. Gravity dam at full reservoir condition

Question 2

Calculate the period of time (T_{tot}) during which 60 % of the reservoir capacity will be filled with sediments. Do so, when:

a. the time period is not divided into a number of intervals, i.e. the only "time interval" is the time when 60 % of the initial capacity is filled with sediment (8 %)

b. the period of time $T_{tot} = T_1 + T_2 + T_3$, where T_n is the time interval when 20 % of the reservoir's capacity is filled with sediment , i.e. the period of time is divided into three intervals. (8 %)

c. Compare the results of the two calculations. (4 %)

Given data: The initial reservoir's capacity is 100 * 10^6 m^3, the average annual flood inflow is 250 * 10^6 m^3, the average annual sediment inflow is 5 * 10^5 tonnes, g = 9.81 m/s^2 and the specific weight of the sediment γ_{sed} = 12.5 kN/m^3. The relationship $\eta = f$ (Capacity/inflow) is given in table 1.

Capacity/inflow	0.1	0.2	0.3	0.4	0.5	0.6	0.7
η	87	93	95	95.5	96	96	96.5

Table 1

Question 3

a. Determine the design head (h) on an uncontrolled spillway if the design (maximum) flow is 200 m^3/s. The width of the overflow spillway L = 30 m, the height of the spillway H_{sp} = 25 m. The weir coefficient can be found in figure 2 (h = head to be calculated, h' = design head and $H_d = H_{sp}$ =height of the spillway). (6 %)

b. If the overflow spillway would be a controlled spillway with the same design flow and the same design head as found in subquestion 3a, what would be the necessary width of the sections ? The maximum width of one section is 15 meters. The width of a pier b_n = 5 meters. The coefficient of local losses K = 0.75, C_D = 0.45, the height of the spillway H_{sp} = 25 m. See figure 3 for a sketch of the overflow spillways. (10 %)

c. Compare the results of the two foregoing questions and explain which solution has your preference. (4 %)

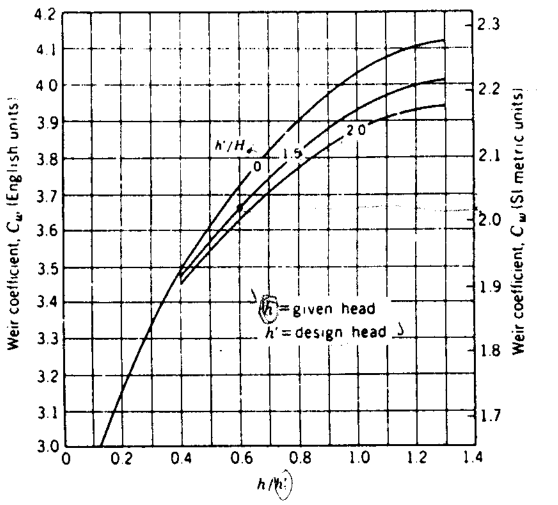


Figure 2 Variation of weir coefficient with head for an spillway crest

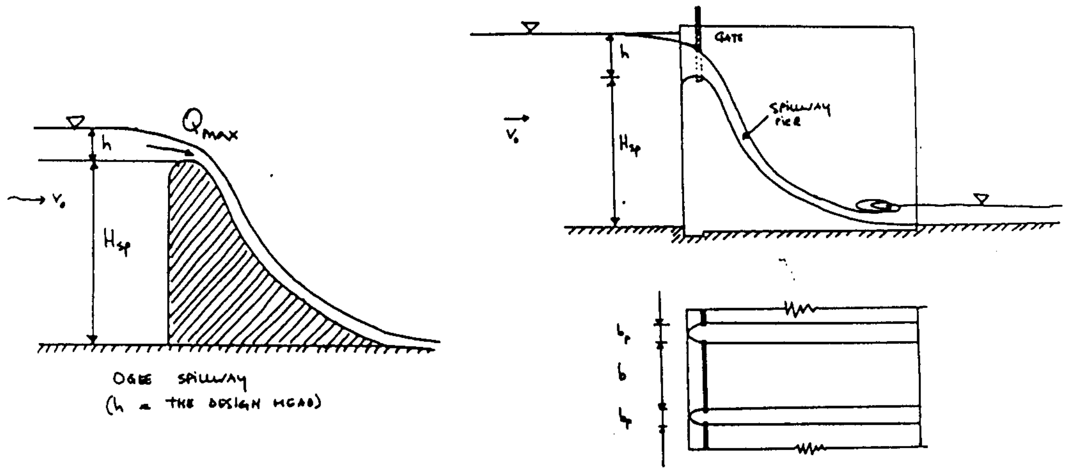


Figure 3 Uncontrolled and controlled overflow spillway

Question 4

a. Using the data given in table 2, calculate the cumulative inflow, plot the Ripple diagram and determine the necessary reservoir's capacity to guarantee water supply. The water demand from the reservoir is $70 * 10^6$ m^3 per year. (8 %)

b. Using the Ripple diagram, determine the safe yield in case the reservoir's capacity is $160 * 10^6$ m^3. (8 %)

c. Indicate when specific levels are reached, for example the minimum and maximum pool level, when the reservoir is spilling water, etc. (4 %)

Year	1970	1971	1972	1973	1974	1975
Inflow ($* 10^6$ m^3)	120	40	30	30	80	160
Year	1976	1977	1978	1979	1980	1981
Inflow ($* 10^6$ m^3)	60	30	40	110	150	35

Table 2

Question 5

Two types of crops can be grown on a particular irrigated farm of area 80 ha. each year. Each 50 Kg quantity of crop A can be sold at K30 000 and requires 5 ha. of land, 3 pockets of fertilizer and 1 farm worker as labour. Similarly, crop B can be sold at K25 000 and requires 2 ha of land, 2 pockets of fertilizer and 2 farm workers as labour. The farm is located along the Kafue River and the Water Board has given the farmer water rights of 60 m^3/day. The irrigation requirements are 16 and 24 m^3/day for 50 kg of crops A and B respectively and are assumed to remain constant over the 100 days growing season. The farmer uses an irrigation system whose conveyance and application efficiencies are 84 and 95.2 % respectively. The farmer has in stock 60 pockets of fertilizer and a total labour force of 40.

a) Structure a linear programming model for estimating the quantities of each of the two crops that should be produced in order to maximize the total income. (12 %)

b) solve the problem preferably graphically. (4 %)

c) Are there any inactive constraints? If so give your comments on how future management could be improved. (4 %)

Question 6

It is required to study the flow and sediment discharge of the given river by constructing a physical model in the laboratory hall of 72 m x 36 m (see figure 6). The dimensions of the river are given below:

DATA
Prototype
$L = 20$ km; $W = 10$ km; $B = 1000$m; $i = 7 \times 10^{-5}$; $h = 10$ m; $Q = 16.000$ m^3/s; $T_p = 1$ year.

Design a physical model which reproduces water movement only. The model has to be also physically reasonable and economical.

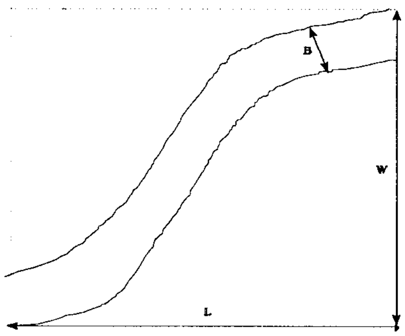


Figure 6

Question 7

A farmer proposes to use sprinkler irrigation on a silt-loam piece of land 1140 by 580 m adjacent to a river from which he can pump water (see figure 7.1). For the crops which he intends to grow, one of the three types of sprinklers given in table 7.1 will be suitable, and from a study of the climatic and soil conditions he has found that he will need a maximum application depth of 76 mm every 7 days. The maximum intake rates of different soils for overhead irrigation are given in table 7.2. The application efficiency of the system is 80 %. The worst friction position of laterals is also given in figure 7.2. The distance from the water source to the lateral is 50 m. Assume the land is completely flat. For the calculation of head losses along the pipelines, use table 7.3.

Sprinkler Type	A	B	C
operating pressure, atmospheres	5	2	1
nozzle diameter	10	6	4
discharge per sprinkler (Q) l/s	4	1	0.6
sprinkler spacing along lateral (m)	40	15	10
lateral shift distance (m)	30	20	12
application rate (mm/h)	11.6	12.4	12.8

Table 7.1 Sprinkler Specifications

Soil Type	Intake rate (mm/h)
clay	4
clay-loam	7.4
silt-loam	9.6
sandy-loam	12
sand	24

Table 7.2

Design a sprinkler irrigation system for the farmer. Ignore the sprinkler operating head and riser height. You should include the following:

a) number of sprinklers;
b) number of lateral positions;
c) minimum time of application;
d) number of settings over a day;
e) number of days required for complete irrigation;
f) day on which the next irrigation cycle begins;
g) diameters of pipes;
h) maximum pump discharge and pump head.

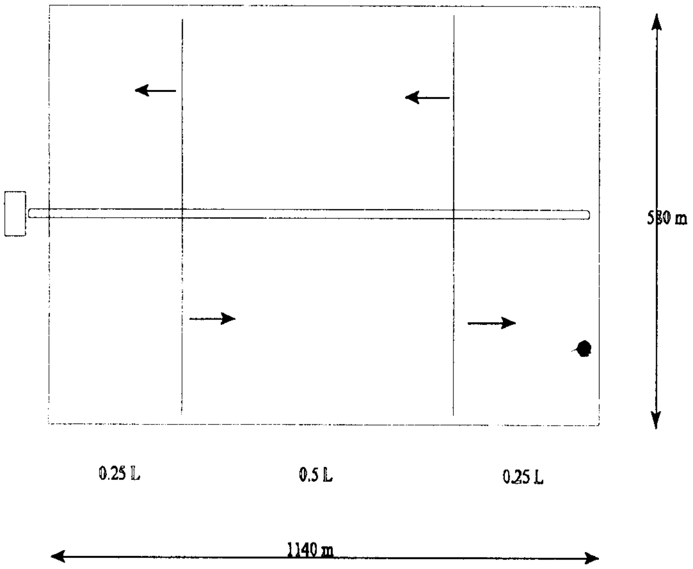


Figure 7.1

Flow (litres/sec)	Nominal pipe diameter (mm)			
	75	100	125	150
4	1·60			
5	2·44			
6	3·45			
7	4·59	1·06		
8	5·88	1·38		
9	7·34	1·73		
10	8·91	2·12		
15	19·45	4·61	1·53	
20	33·70	7·98	2·61	1·08
25		12·10	3·95	1·65
30		17·01	5·51	2·31
35		22·80	7·31	3·10
40		29·10	9·50	4·00
45		36·10	12·2	5·00
50		44·05	14·9	6·05
55		52·50	17·7	7·25
60			20·8	8·54
65			24·1	9·95

TABLE 7.3 Typical sprinkler line head loss table. Friction losses in m head per 100 m of line. (For design use manufacturers' charts)

The University of Zambia

Deferred examination CE 565
Water Management and Hydraulic structures

January 1997

OPEN BOOK Examination

Instructions to candidates:
1. Candidates must ensure that their computer numbers are clearly written on each used answer booklet and that the numbers of questions answered are entered in the space provided on the front of the answer booklet.
2. Please answer any FOUR Questions
3. All questions carry equal mark (25 %). Marks of subquestions are indicated at the end of each subquestion.
4. Textbooks, lecture notes, mathematical gadgets and drawing instruments are allowed.

Question 1

a. Determine the factor of safety and the factor of stability if the maximum water level is 5 meters below the top of the dam, for all the dam's body of the gravity dam given in figure 1. Check the maximum pressures as well. The specific weight of concrete γ_c = 24 kN/m^3, the density of water ρ_w = 1000 kg/m^3 , g = 9.81 m/s^2, τ_{max} = 1.75 MPa , σ_{max} = 20 MPa and the coefficient of friction μ = 0.6. (15 %)

b. If in the future the water demand is higher, will it be possible to raise the water level inside the reservoir until the top level, i.e. 5 meters higher than the actual level, in such a way that safety and stability will be guaranteed ? Explain your answer by means of calculations !! (10 %)

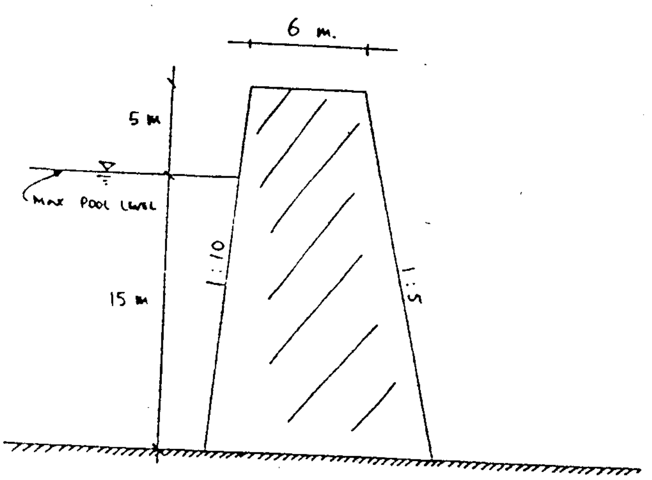


Figure 1. Gravity dam at full reservoir condition

Question 2

Calculate the period of time (T_{tot}) during which 80 % of the reservoir capacity will be filled with sediments. Do so, when:

a. the time period is not divided into a number of intervals, i.e. the only "time interval" is the time when 80 % of the initial capacity is filled with sediment (10 %)
b. the period of time $T_{tot} = T_1 + T_2 + T_3 + T_4$, where T_n is the time interval when 20 % of the reservoir's capacity is filled with sediment , i.e. the period of time is divided into four intervals. (10 %)
c. Compare and discuss the results of the two calculations. (5 %)

Given data: The initial reservoir's capacity is $100 * 10^6$ m^3, the average annual flood inflow is $250 * 10^6$ m^3, the average annual sediment inflow is $6 * 10^5$ tonnes, $g = 9.81$ m/s^2 and the specific weight of the sediment $\gamma_{sed} = 12.5$ kN/m^3. The relationship $\eta = f$ (Capacity/inflow) is given in table 1.

Capacity/inflow	0.05	0.1	0.2	0.3	0.4	0.5	0.6
η	79	86	92	94	95	95.5	96

Table 1

Question 3

Two types of crops can be grown on a particular irrigated farm of area 80 ha each year. Each 25 Kg quantity of crop A can be sold at K30 000 and requires 5 ha of land, 3 pockets of fertiliser and 1 farm worker as labour. Similarly, 25 Kg of crop B can be sold at K25 000 and requires 2 ha of land, 2 pockets of fertiliser and 2 farm workers as labour. The farm is located along the Kafue River and the Water Board has given the farmer water rights of 8000 m^3/day. The irrigation requirements are 7.2 and 10 mm/day for 25 kg of crops A and B respectively. The farmer uses an irrigation system whose conveyance and application efficiencies are 84 and 95.2 % respectively. The farmer has in stock 72 pockets of fertiliser and a total labour force of 50.

a) Structure a linear programming model for estimating the quantities of each of the two crops that should be produced in order to maximise the total income.

(15%)

b) solve the problem preferably graphically (5%)

c) Are there any inactive constraints? If so give your comments on how future management could be improved.

(5%)

Question 4

Consider the scales for a model of 7.2 Km of ~~wazzu~~ a river having a roughness typified by n = 0.02. The model is to be constructed in a tank with a working length of 24m and it will be assumed that the Reynolds number, based on a prototype mid-stream depth of 3.4m and a mean velocity of 0.8 m / s, must be greater than 1000 to ensure rough turbulent flow.

a) What values of velocity, mid-stream depth and Manning's n of the model satisfy the desired conditions?

b) Are there any problems that you notice in your model in (a) above?

c) If the answer in (b) above is YES, apply a technique that overcomes the problems and recalculate the parameters mentioned in (a) above.

(25%)

Question 5

A farmer proposes to use sprinkler irrigation on a silt-loam piece land 820 by 380 m adjacent to a river from which he can pump water (See Figure 7.1). For the crops which he intends to grow, only one of the three types of sprinklers given in Table 7.1 will be suitable, and from a study of of the climatic and soil conditions he has found that he will need a maximum application depth of 80 mm every 5 days. The maximum intake rates of different soils for overhead irrigation are given in Table 7.2. The application efficiency of the system is 80 %. The worst friction position of laterals is also given in Figure 7.1. The distance from the water source to the main is 150 m.

Sprinkler Type	A	B	C
operating pressure, atmospheres	5	2	1
nozzle diameter	10	6	4
discharge per sprinkler (Q) l/s	2	0.5	0.3
sprinkler spacing along lateral (m)	40	15	10
lateral shift distance (m)	30	20	12
application rate (mm/h)	12.0	12.8	13.2

Table 7.1 Sprinkler Specifications

Soil Type	Intake rate (mm/h)
clay	4
clay-loam	8
silt-loam	10
sandy-loam	12
sand	24

Table 7.2

Design a sprinkler irrigation system for the farmer. Assume the land is completely flat. For the calculation of head losses along the pipelines, use Table 7.3. You should include the following:

a) type of sprinkler you have selected
b) number of sprinklers
c) number of lateral positions
d) minimum time of application
e) number of settings over a day
f) number of days required for complete irrigation
g) day on which the next irrigation cycle begins
h) diameters of pipes
i) maximum pump discharge and pump head

(25%)

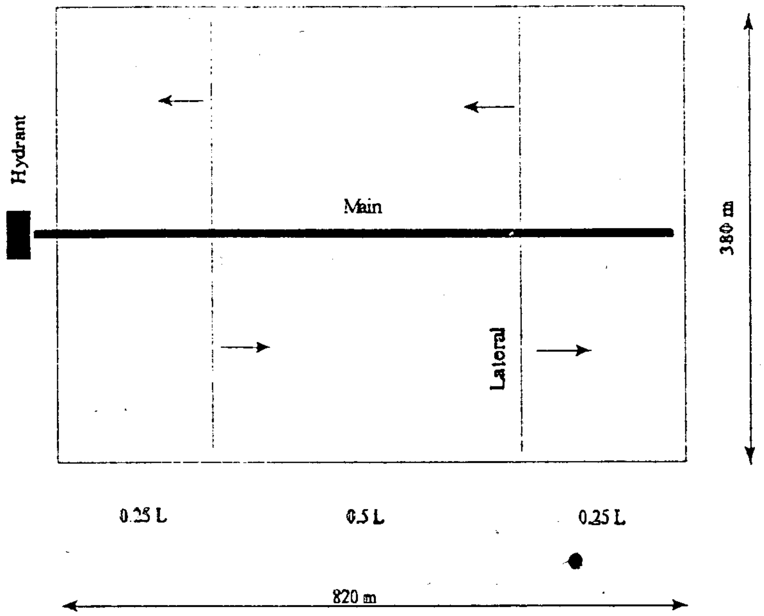


Figure 7.1

Flow (litres/sec)	Nominal pipe diameter (mm)			
	75	100	125	150
4	1·60			
5	2·44			
6	3·45			
7	4·59	1·06		
8	5·88	1·38		
9	7·34	1·73		
10	8·91	2·12		
15	19·45	4·61	1·53	
20	33·70	7·98	2·61	1·08
25		12·10	3·95	1·65
30		17·01	5·51	2·31
35		22·80	7·31	3·10
40		29·10	9·50	4·00
45		36·10	12·2	5·00
50		44·05	14·9	6·05
55		52·50	17·7	7·25
60			20·8	8·54
65			24·1	9·95

TABLE 7.3 Typical sprinkler line head loss table. Friction losses in m head per 100 m of line. (For design use manufacturers' charts)

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT

UNIVERSITY EXAMINATIONS - NOVEMBER, 1996
CE 582 - CONSTRUCTION TECHNIQUES & MANAGEMENT

<u>TIME</u>: **THREE HOURS**

<u>ANSWER</u>: **FIVE QUESTIONS FROM THE GIVEN SEVEN**
NO CREDIT WILL BE GIVEN WHERE INTERMEDIATE STEPS IN THE CALCULATIONS ARE NOT SHOWN.

Q1. Give the various phases of a construction project from inception to completion. Indicate also the actors in each phase, their roles and the end product of that phase. [20]

Q2.(a) In a construction project list five elements that require supervision and in each case elaborate.

(b) Identify four methods used in project supervision and explain each. [10+10]

Q3.(a) Give six potential reasons why losses may occur on a construction project.
(b) Give two fundamental points when devising a cost control system.
(c) Describe three cost control systems you know. [6+2+12]

Q4.(a) Give four advantages of using equipment in the construction industry.
(b) List six general factors considered in the selection of construction equipment.
(c) List three cost components making up the operating costs of equipment.
(d) Outline the seven essential factors considered as developed by Kepner and Tregoe in the systematic plant selection procedure. [4+6+3+7]

Q5. Figure Q5 shows the construction plan of a house. Table Q5.1 gives the Man hours required and the team size for each operation.

Prepare a line of balance schedule for a contract of 30 houses using a target rate of build of four houses per week and each team working at their natural rate. Assume a minimum buffer time of five days between operations and five 8-hour days per week.

What is the overall duration of the project and when will the first team of bricklayers (superstructure operation) leave the site?

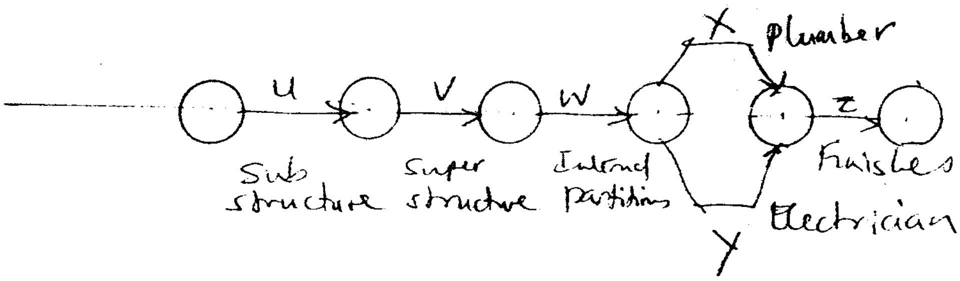


Figure Q5 Construction Plan for one house

Q5.

Table Q5.1 Manhours and team size

Operation	U	V	W	X	Y	Z
Manhours per house	120	290	250	40	30	220
Men per team	3	6	4	3	2	5

Use Table Q5.2 provided for calculations. [20]

Q6 (a) List the five methods of depreciation.

(b) Arken Enterprises purchases a mechanical excavator for £42,000.00 to work an average 2000 hours per year. The life of the machine is expected to be ten years after which time the salvage value will be £2 000.00. Using the declining balance depreciation method, show how Arken enterprises will charge depreciation for the first five years.

For declining balance depreciation,

percentage depreciation (d) = $[1 - \sqrt[n]{(L/P)}] \times 100$

where n = Life of asset

L = Salvage value and

P = Purchase price

(c) Arken Enterprises have for hire an ARB-38 crane, from the information given below, calculate the marginal hourly hire charge.
Use straight line depreciation method and capital recovery factor (CRF) = 0.199 at 15% p.a for 10 years. [2.5+7.5+10]

Initial Cost	£44 050.00
Resale Value	£ 2 050.00
Average working hours per year	2 000
Years of life of machine	10
Insurance premiums per year	£ 200.00
Licences and tax per year	£ 100.00
Fuel at 20 litres per hour	£ 0.10 per litre
Oil and grease	10% of fuel cost
Repair and maintenance	15% of initial cost per year
Required rate of return on capital	15%

Q7. (a) Figure Q7 shows a network based on activity on arrow. Calculate the times and show the critical path.

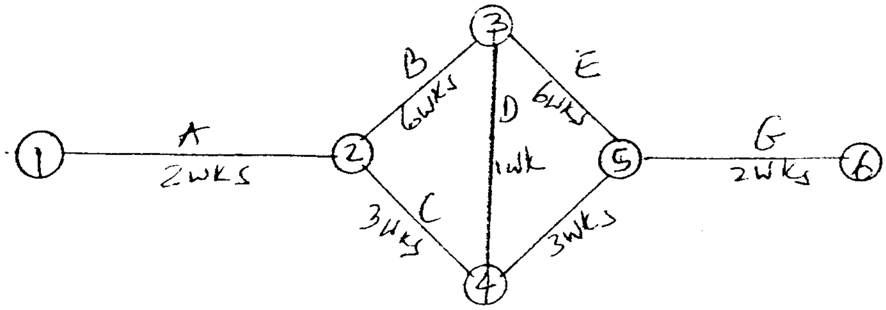


Figure Q7.1 Construction network

(b) For the precedence diagram shown in figure Q7.2.
Calculate:

(i) Earliest start times
(ii) Earliest Finish times
(iii) Latest start times
(iv) Latest Finish times.

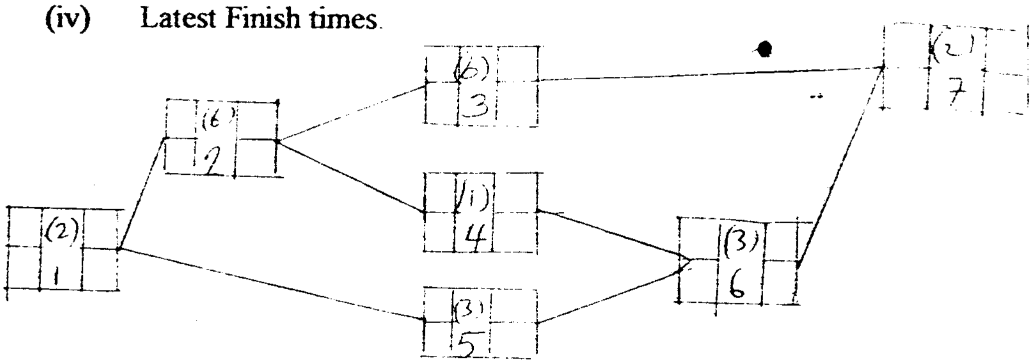


Figure Q7.2 Precedence diagram

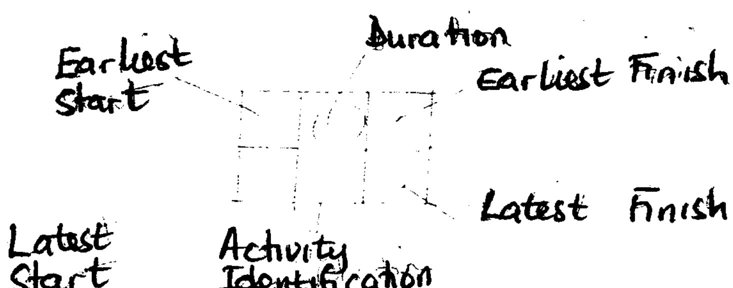


Figure Q7.2

[8+12]

Table Q5.2 Calculation [illegible] gang and rates of build ([illegible] [illegible]et rate of build = 4)

Operation	Man hours per/ house (M)	Theoretical gang size ($G = \frac{4 \times M}{40}$)	Men per house (Q)	Actual gang size (in multiples of Q) (g)	Actual rate per week ($U = \frac{g}{G} \times 4$)	Time in days for one house ($U = \frac{M}{8 \times Q}$)	Time between start of first and last hous[illegible] (days) $S = \frac{(n - 1) \times 5}{U}$
U							
V							
W							
X							
Y							
Z							

The university of Zambia

SCHOOL OF ENGINEERING
AGRICULTURAL ENGINEERING DEPARTMENT
EA512 FINAL EXAM
Farm Machinery Design

Time : 3 hours

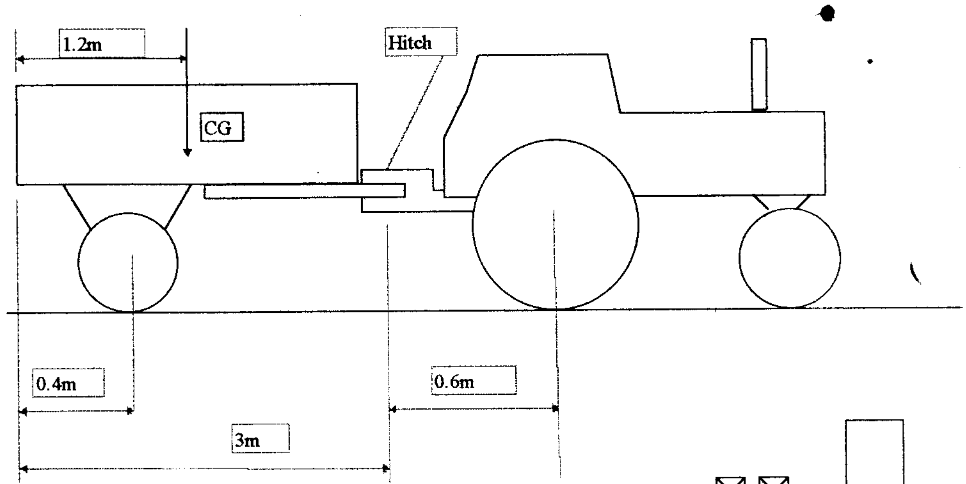
Instructions

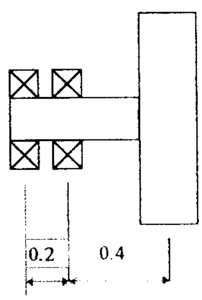
1. **Open book exam**
2. **Attempt all the three questions**
3. **Question 1 has 50 marks while question 2 and 3 have 25 marks each.**

Question 1

A two wheel drive tractor is pulling a 2 wheeled trailer up a 15% slope . The coefficient of resistance is 0.04 for the drive wheels and 0.1 for the rest of the wheels (tractor front wheels and trailer wheels). The total mass of the trailer is 3 tons the center of gravity as indicated in fig Q1
Take the gravitational acceleration as 9.81 m/s2

a) Determine the draw bar force and the force acting normal (on the hitching point) to the draw bar force. **13marks**
b) Calculate the force on the driving wheels of the tractor **12marks**
c) Find the maximum normal and shear stress on the 15 cm diameter tractor axle. **10marks**
d) Determine the factor of safety of the fine machined axle against fatigue failure with reliability of 95%, if the ultimate tensile strength of the shaft material is 880Mpa. Assume the concentration factor is unity. **15marks**





Bearing arrangement of rear wheel of tractor

Not drawn to scale All dimension in m

FIG Q1

Additional information

Tractor:

- Front wheels diameter=0.787m
- Rear wheels diameter=1.696m
- Wheel base= 2.268m
- Draw bar height = 0.379
- Weight front= 1198Kg
- Weight rear=1570kg
- Center of gravity is 0.5m above the ground

Trailer:

- Height of center of gravity of trailer with load =1.3m
- draw bar height may be assumed to be equal to that of the tractor.

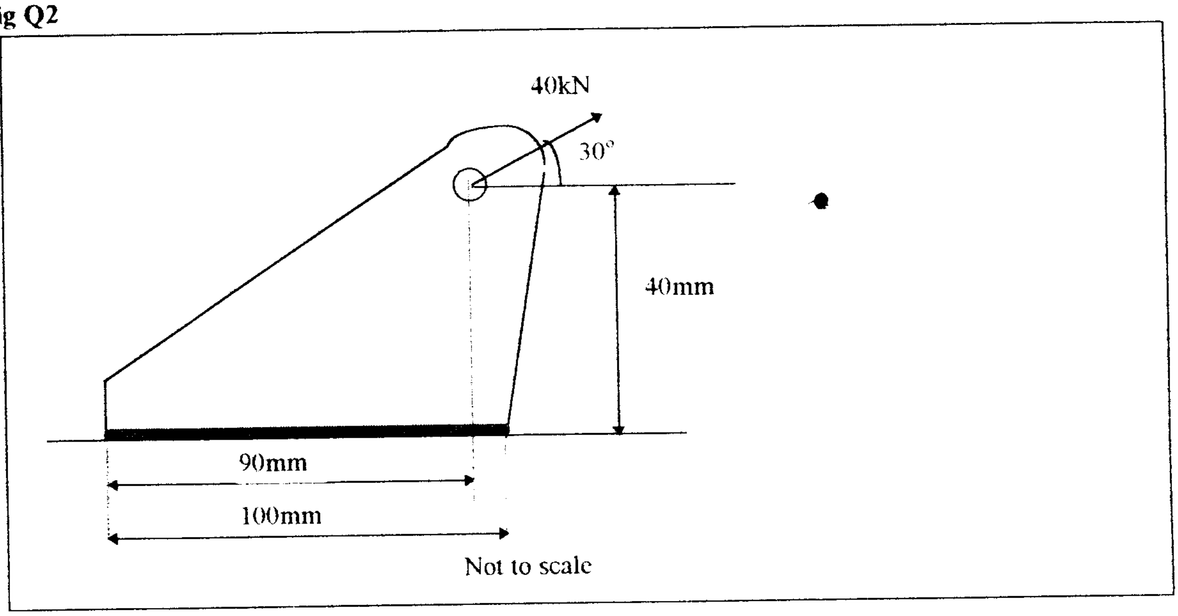
Question 2

A of 12mm thick steel plate bracket used in mooring (anchoring) a boat of a farmer used on his fishing ponds is subjected to a force of 40 kN. as shown in fig Q2. The bracket is welded to the support with two fillet welds, 100m long with a throat thickness a=5mm.

(a) Calculate the effective stresses at the middle and the ends of the welds. 15marks

(b) What will be the factor of safety when the pemissible stress equals 140 MPa 10marks?

fig Q2



Question 3

A flat belt used in transmission of power between an electric motor and a water pump is 160mm wide and is running at a speed of 28 m/s. The belt has a mass of 1.9kg/m of belt length and transmits 45 KW of power. The belt is used in an open configuration to connect a 250mm diameter driving sheave to an 800mm diameter pulley at a shaft spacing of 3m.

(a) Calculate the belt length and the angles of wrap. **5marks**

(b) Compute the belt tensions passed on a coefficient of friction of 0.32. **5marks**

(c) What is the maximum contact pressure between belt and pulley. **5marks**

(d) Calculate the minimum belt thickness when the permissible tensile strength is 1.9MPa. 5marks

(e) What should have been the initial belt tension in order to transmit the given power (45 kw) for the given pulley system. 5marks

Prepared by Chileshe J.M

University of Zambia

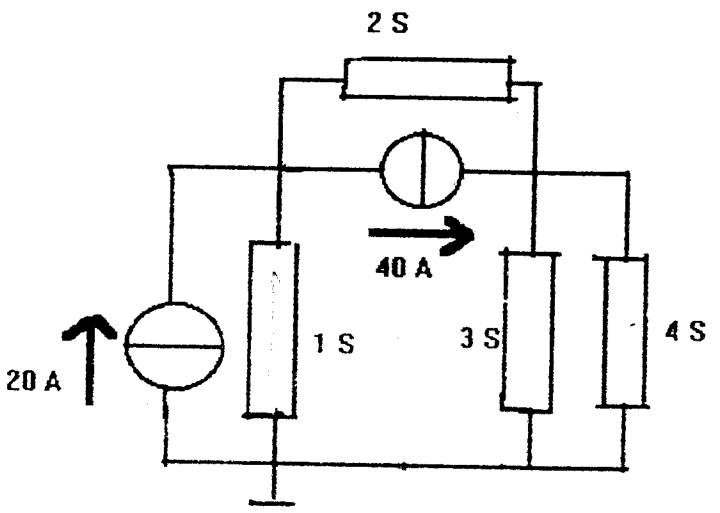
School of Engineering
Dept of Electrical and Electronic Engineering

Examination
EE209-PRINCIPLES OF ELECTRICITY
November 1996

Time :Three hours

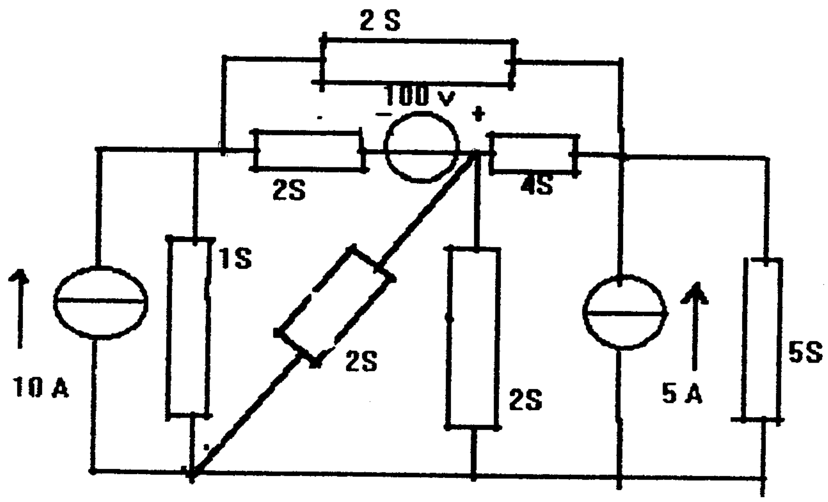
Anwer only 5(five) questions

Question # 1(20points)



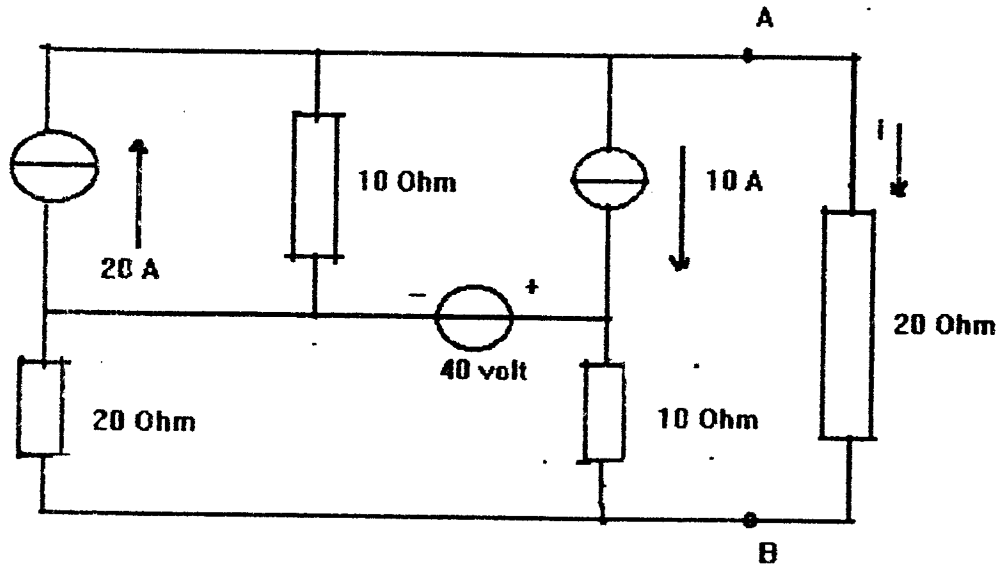
Use the Nodal Analysis Method to calculate
the total power dissipated by each source.
How much power is dissipated in the entire circuit?

Question # 2(20points)



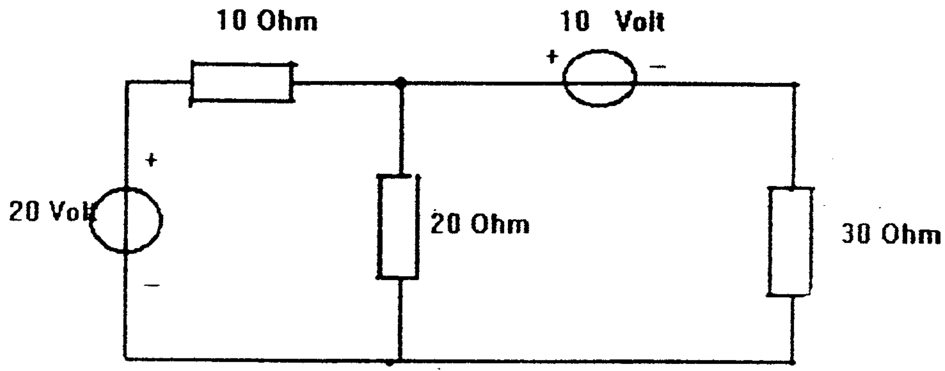
Calculate the voltages at the nodes .
Any method is allowed.

Question # 3(20points)



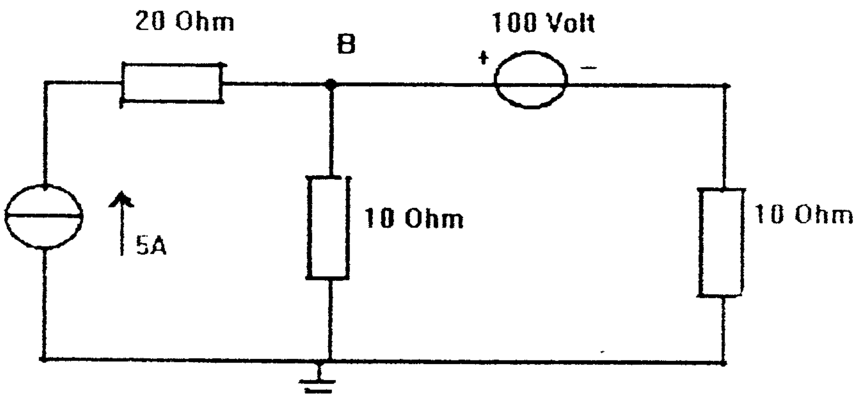
Use Thevenin to calculate the current i through AB(20 Ohm)

Question # 4(20points)



Calculate the current through the 20 Ohm resistor using the mesh-method.

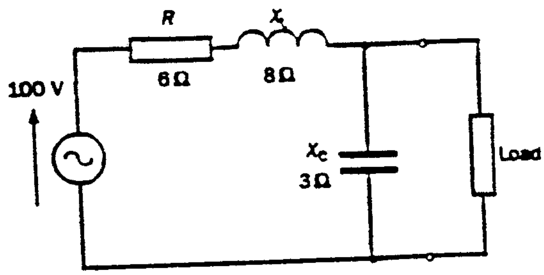
Question #5(20 points)



Calculte the votage V_B using superposition theorem.

Question # 6(20points)

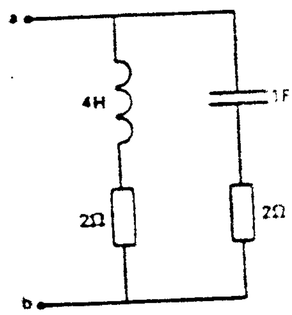
Consider the circuit with an AC voltage source of 100V. The inductive reactance of the coil X_L= 8 Ohm ,the capacitive reactance of the capacitor is X_C=3 Ohm. Determine the Thevenin equivalent circuit supplying the load. For which value of the load will there be a maximum power transfer to the load?



Question # 7(20points)

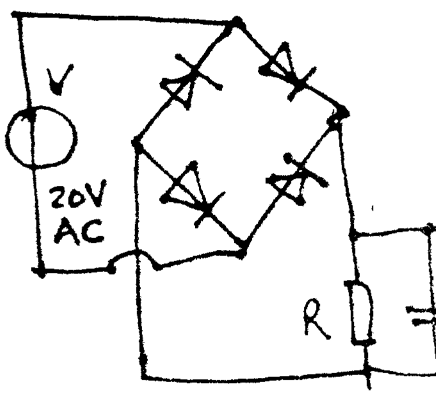
Consider the circuit with an inductance L= 4H and a capacitor C=1F and two resistors R= 2 Ohm .In the first case we apply a voltage source with ω=1.

In the second case we change ω =100. Calculate in both cases the impedance of the circuit between the nodes a and b.



Question # 8 (20 points)

The circuit has a ripple factor f_r = 0.01.
The frequency is 50 Hz.
The maximum current in each diode is 50mA.
Calculate R and C.



University of Zambia

Supplimentary and Deffered Examinations
EE209

Schooı uı ɛngineering
Dept of Electrical and Electronic Engineering

EE209-PRINCIPLES OF ELECTRICTY

Answer : five questions only
Time :Three hours

Question # 1(20points)

(a) Determine the voltage across,the currents through,three resistances of R1= 5 Ohm, R2= 10 Ohm ,R3= 20 Ohm all connected in parallel and across a 100V DC-source.
(b) Find the current and power drawn from the source.

Question # 2(20points)

(a) Obtain the equivalent capacitance of two capacitors connected in series and in parallel.Generalize the results to the case of n series and n parallel capacitances.
(b) Obtain the equivalent inductance of two inductors connected in series and in parallel.Generalize the results to the case of n series and n parallel inductors.

Question # 3(20points)

(a) Draw a bridge circuit consisting of resistance branches:
R12= 3 Ohm , R24= 4.5 Ohm , R43= 3 Ohm , R31= 6 Ohm and R23= R32= 9 Ohm.
The input terminals of the bridge circuit are terminals 1 and 4.

(b) The bridge at balance conditions has zero voltage drop across branch R23 . Find the voltage across branch R13 using the potential divider rule if the input terminals are connected to a 20V DC source.

Question # 4(20points)

A particular DC circuit has the following mesh equations:

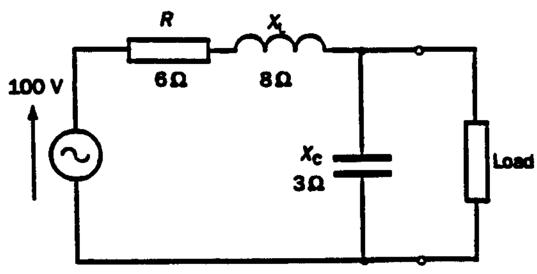
$$7 I_1 - 1 I_2 - 0 I_3 = 10\text{ V} \quad \text{LOOP 1}$$
$$-1 I_1 + 6 I_2 - 3 I_3 = 0\text{ V} \quad \text{LOOP 2}$$
$$0 I_1 - 3 I_2 + 13 I_3 = -20\text{ V} \quad \text{LOOP 3}$$

(a) Build the particular circit and label all voltage sources and resistances in each loop.

(b) Determine I_3 from the mesh equations.

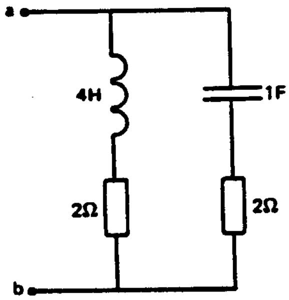
Question # 5(20points)

Consider the circuit with an AC voltage source of 100V. The inductive reactance of the coil X_L= 8 Ohm ,the capacitive reactance of the capacitor is X_C=3 Ohm. Determine the Thevenin equivalent circuit supplying the load. For which value of the load will there be a maximum power transfer to the load?



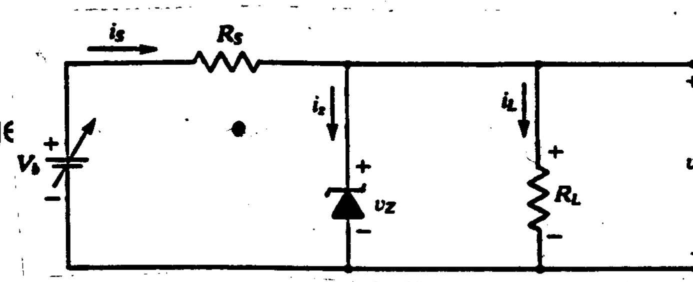
Question # 6(20points)

Consider the circuit with an inductance L= 4H and a capacitor C=1F and two resistors R= 2 Ohm .In the first case we apply a voltage source with ω=1.
In the second case we change ω =100.
Calculate in both cases the impedance of the circuit between the nodes a and b.



Question # 7(20points)

A variable DC voltage source Vb is connected to a source resistor Rs.
A zener-diode Z with a zener-voltage V_Z is placed paralle to the load resistor RL.
The properties of the zenerdiode are Vz = 12V if 10 mA < i_Z < 250 mA.
The source Vb will vary between 16 V and 20V. The value of the load resistor is 240 Ohm.



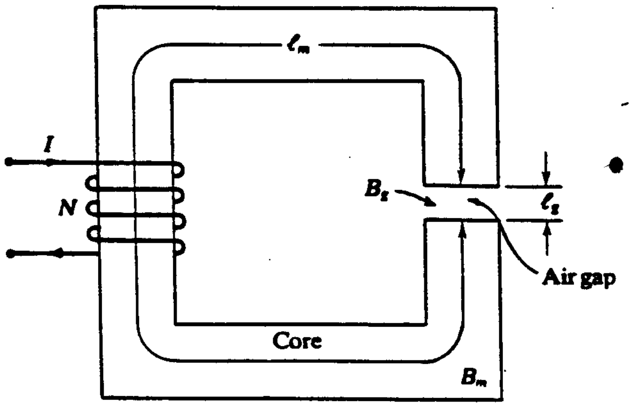
A)(8points) Calculate the value of Rs that will allow a stable voltage across the load of 12V.
B)(8points) Calculate the value of i_Z if the load resistor is removed from the circuit.Will regulation be continued?
C)(4points) Calculate the value of i_Z if an extra load resistor R2= 240 Ohm is placed parallel to RL
Will regulation be continued?

Question # 8(20points)

The magnetic circuit shown has N=200 turns, l_g=0.1mm,l_m=300mm.

A)(10 points) Calculate the flux density B_g in the gap,
if the current I=4A and the relative permeabilty
μ_r =1000(of the core)
the permeability of air can be set to
$\mu_0 = 4\pi\ 10^{-7}$

B)(10 points) Calculate the inductance L of the circuit.



End of exam

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

EXAMINATION - JUNE 1996

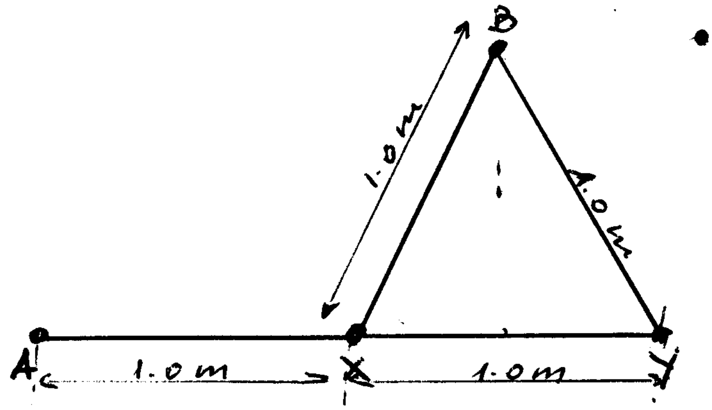
EE 309 PRINCIPLES OF ELECTRICITY II

TIME : Three hours .
Answer only five questions
(Closed book)

Question 1 (20 *marks*)

Find the potential and field strength (magnitude and direction) at points A (with positive charge) and B ~~A~~(with positive charge), fig.1., due to two small spheres X and Y, 1.0 m apart in air and carrying charges of $+2 \times 10^{-8}$ C and - 2×10^{-8} C respectively. Assume the permttivity of air $= \varepsilon_0$ and $1/4\pi\varepsilon_0 = 9 \times 10^{9}$ Nm^2C^{-2}..

Fig.1.



Question 2 (20 *marks*).

A capacitor is made up of two metal plates, each having an area of 0.02 m^2 and spaced 2,5 mm apart. A potential difference of 250 V across the plates establishes a charge of 1000 μC. Calculate :
a) the electric field strenngth ;
b) the electric flux density ;
c) the absolute permittivity of the dielectric ;
d) the energy stored the capacitor ;
e) the time for which the lamp of 10 W would be illuminated, if that energy could be discharged at a constant rate into.

Question 3 (20 ***marks***).

A/5 kVA, 200/400 V, 50 Hz, single phase transformer on domestic load, which can be taken as of unit power factor, has an efficiency of 98 % at full load, and its maximun efficiency occurs at 2/3 full load unity p.f.
Thas transformer gave the following test results,

- Open Circuit Test, perfomed from the l.v. side : 200 V, 0.7 A, 60 W
- Short Circuit Test, performed from the h.v.side : 22 V, 16 A, 120 W.

Calculate:
a) the iron losses and the maximum efficiancy;
b) the equivalent parameters referred to the h.v.side and indicate these quantities on an approximate equivalent circuit complete with all voltages and currents ;
c) the percentage voltage regulation at full load and 0.9 p.f. lagging;
d) the maximun percentage voltage regulation at full load and the power factor at which it occurs;
e) the all-day efficiancy if during one day it is loaded as follows:

- 12 hours - 4 kW at 0.5 p.f.
- 8 hours - 12 kW at 0.8 p.f.
- 4 hours - 9 kW at 0.9 p.f.

Question 4 (20 ***marks***).

A shunt excited machine is connced to 240 V d.c.bus - bars.The machine's particulars are as follows:

Number of poles = 6;
Flux per pole = 50 mWb;
Resistance of the coil winding = 120 Ohms;
Resistance of the commutatorl winding includingbrushes, etc. = 0.1 Ohm.

The commutator winding is composed of 864 conductors in lap.
Calculate:
a) the speed and the torque which the prime - mover must impart to the machine in order that it supplies 50 A to the d.c. bus - bars ;
b) the speed and torque the machine would produce working as a d.c. motor taking 50 A from the bus - bars.
All losses other than resistive are to be neglected. The current connections for a generator and a motor operation are shown in fig. 2.

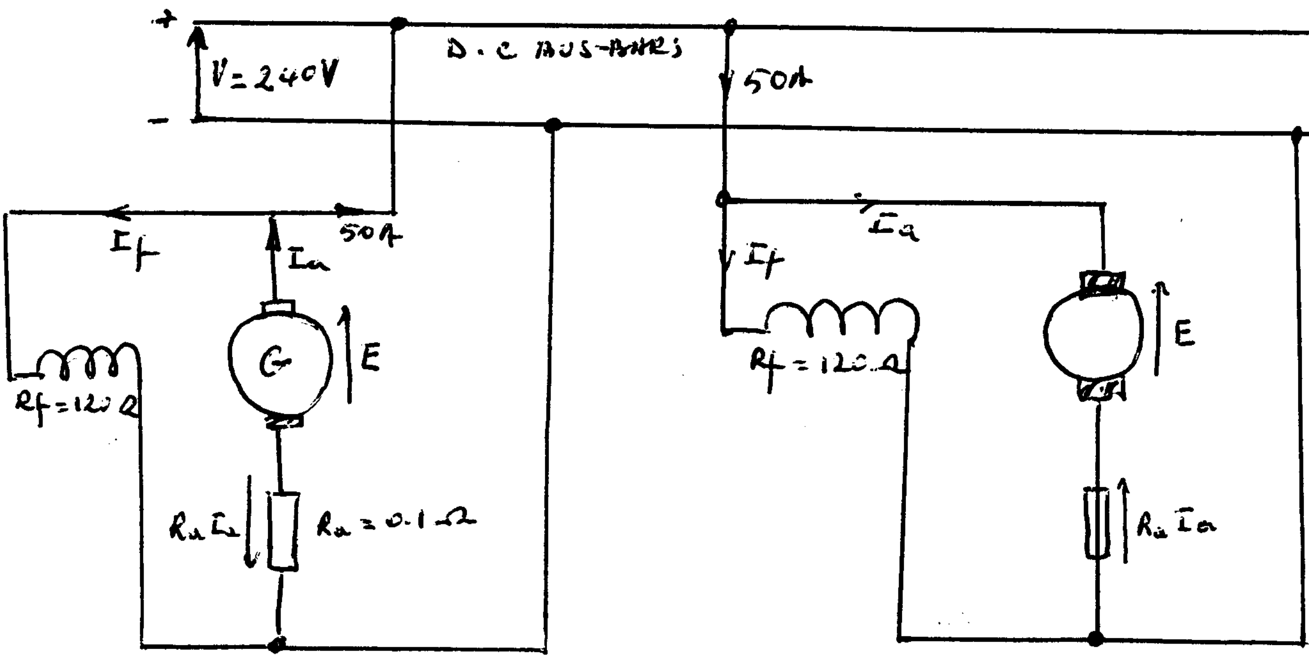


Fig 2. Operation as a generator Operation as a mot

Question 5 (20 *marks*).

A 3 - phase , 4 - wire, 11 - kV, 50 Hz is connected to a 3 - phase induction motor whose out put is 800 kW at efficiency of 93% and p.f.of 0.8 lagging.
Calculate :
a) supply power;
b) line current ;
c) neutral current
d) wattmeter reading (one - wattmeter method)
e) neutral current ;
d) wattmeter readings (two - wattmeter method).

Question 6 (20 *marks*).

A permenent-magnet moving - coil instrument has an air - gap magnetic flux density of 0.3 T , a coil of 200 turns and resistance of 100 Ohms , length of coil side 20 mm , and width of coil 20mm.
If it has a full - scale deflexion of 100^o for a current of 10 mA , calculate :
a) control spring consntant ;
b) resistance of shunt so that FSD corresponds to 1 A ;
c) series resistance so that FSD corresponds to100 V;
d) discuss the importance of the terms in the equation for a moving - coil mete

Question 7 (20 *marks*)..

a)write the Boolean expression for the logic circuit shown in fig. 3.and draw the truth table for it (**5*marks***) :

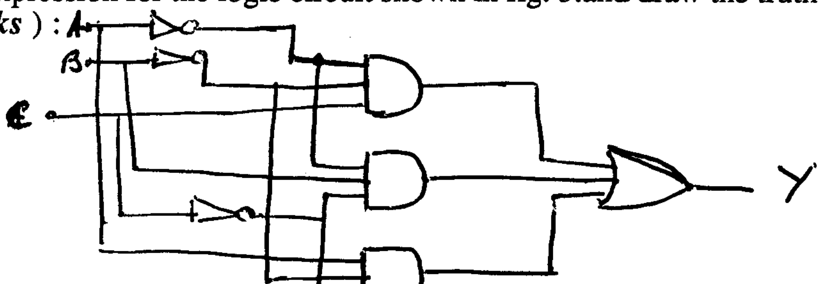


Fig. 3

b) realise the the fonction in AND/OR and OR/AND forms , the invertors being avalaible (**7.5 *marks***):

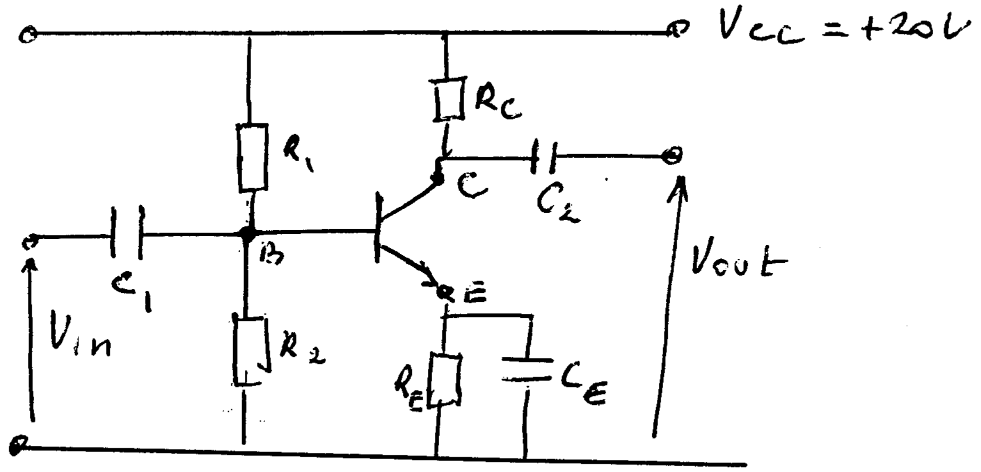
$F = A\bar{B} + \bar{A}B$, where F represents a lamps being lit.

c) minimise and plott, using the Karnaugh map, the fonction (**7.5 *marks***):

$F = \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}CD + \bar{A}B\bar{C}D + \bar{A}BCD$

Question 8 (**20 *marks***)

a) define h_i, h_f, h_r and h_o for a n-p-n transistor (**2*marks***) ;
b) draw three BJT configurations (**3*marks***) ; (BJT : BIPOLAR JUNCTION TRANSI
c) give three ways of biasing a transistor stage in a common -emiter connection and discuss briefly the advantages and disadvantages of the differnt methods (**7.5 *marks***)
d) calculate the approximate value of the gain of the transistor stage shown in figure below and draw its circuit model (**7.5 *marks***)



$R_1 = 10\,K\Omega$

$R_2 = 1\,K\Omega$

$R_C = 2.7\,K\Omega$

$R_E = 330\,\Omega$

h_{ie} : $2.5\,K\Omega$

h_{fe} : 120

C_1, C_2, C_E are very Large capacitors.

<u>END OF FINAL EXAMINATION EE309.</u>

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

University Examination June 1996

EE 311

Time: Three hours

Answer: Five questions

Laplace transform table will be distributed.

Q1. a) Give the voltage - current relation for a resistor $i_R(t)$, $v_R(t)$

b) Give the equation that describes the current and voltage in an ideal capacitor, $i_C(t)$, $v_C(t)$

c) Give the equation that describes the voltage in an ideal inductor, $i_L(t)$, $v_L(t)$,

d) Describe in detail the physical implications of the equation on the behaviour of the passive elements.

e) Repeat (a) to (c) the transformed expressions and draw their circuit representation.

Q2.

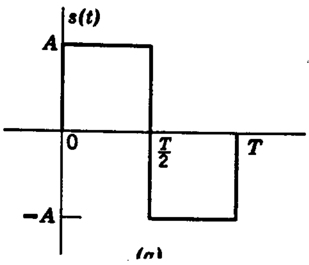


Fig 2

Consider figure 2

a) Use the complex form of the fourier series and derive the complex coefficient β_n.

b) Using impulse method evaluate the same coefficients β_n

Q3.

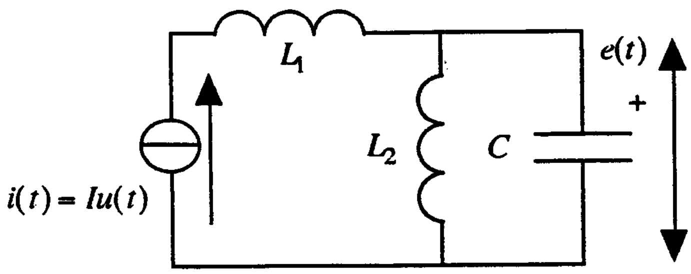


fig3

a) Find the voltage e(t)

b) Calculate the total impedance Z_{total}.

c) If $E_{tot}(s) = \frac{I}{S} Z_{tot}$
derive an expression for $e_{tot}(t)$

Q4.

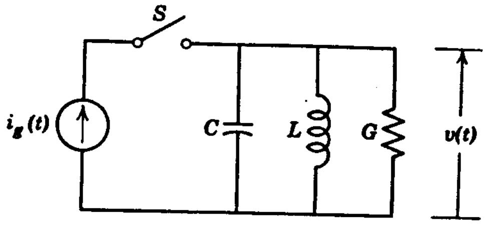
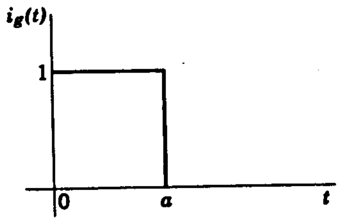


fig 4

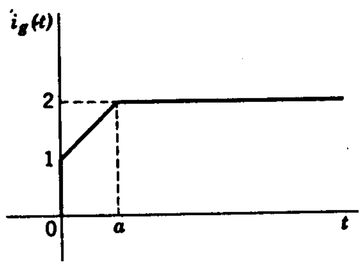
Consider the network of fig 4. The excitation is current ig(t) and the response is the voltage v(t). The network is initially inert when the switch is closed at t = 0. Find the response V(s) for the excitation:

a) ig(t) = Sin(ω_0t) U(t)

b) ig(t) a square pulse as shown



c) ig(t) the waveform given below .



Q5. Consider the network

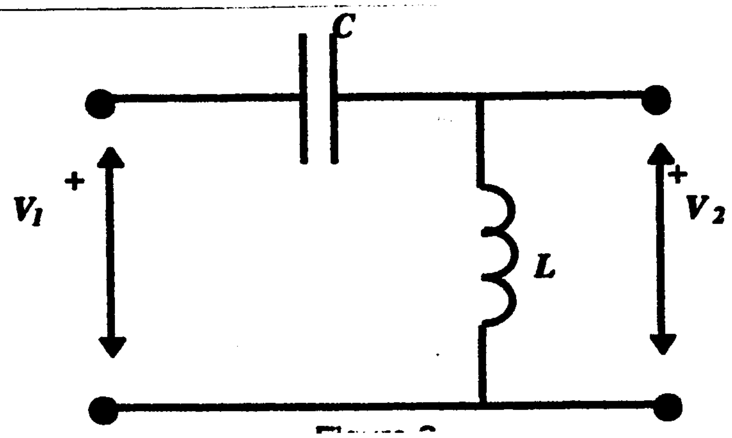


fig. 5

a) Find the transfer function $H(s) = \dfrac{V_2(S)}{V_1(S)}$

b) Find the step response from the network in the time domain

c) Find the impulse response of the network in the time domain.

Q6. Consider the 3 different pole zero plots in the s-plane

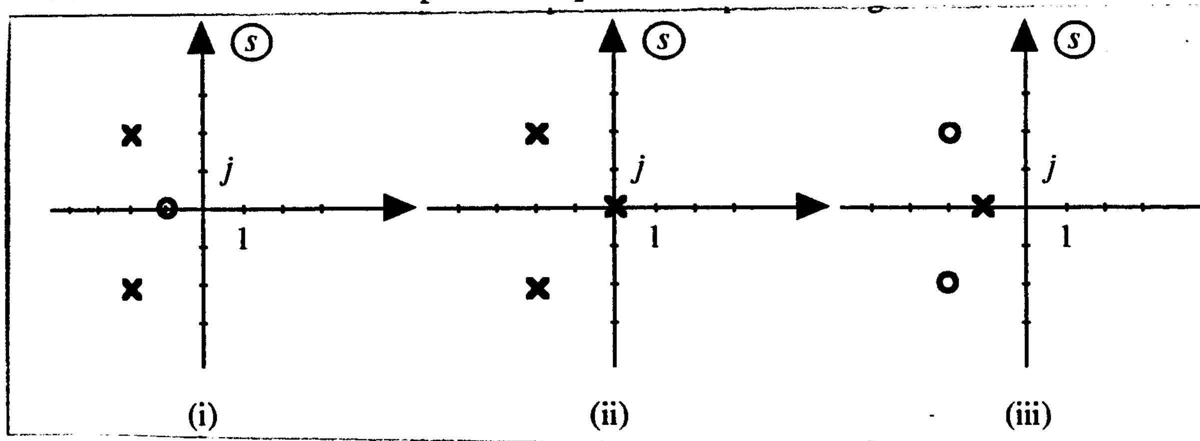


fig. 6

a) Find the transfer functions H(i), H(ii) and H(iii).

b) If the systems are driven by steps, what responses will we get for (i), (ii) and (iii) respectively?

c) Which transfer function (i, ii or iii) performs an integration.

Q7.

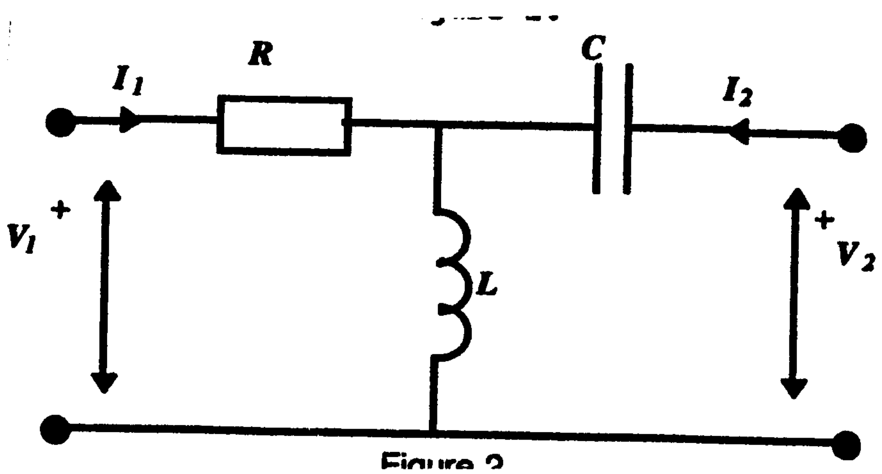


Figure 2

Consider the network in Figure 7.
Find the open circuit parameters
Z11, Z12, Z21 and Z22

Q8. In this question you should answer true of false. You should attach the reasoning behind your answers. Wrong answers will be penalised.

		True	False
a.	The integral of the δ - function is the step function		
b.	The voltage over an ideal capacitor cannot change instantaneously unless the driving function is an impulse.		
c.	The solution, x(t), of a differential equation of the type $Ax''(t) + Bx'(t) + cx(t) = U(t)$ has to contain an impulse.		
d.	For a system to be stable the laplace equation has to have its zeros in the left part of the S-plane		
e.	$\int_{\infty}^{\infty} f(t)\delta(t-T_1)dt = f(T_1)$		

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
Department of Electrical & Electronic Engineering
University Examinations June 1996

EE321
Electromechanics & Electrical Machines

Time: **Three hours.**
Answer Five questions.

Permeability of free space $\mu_0 = 4\pi x\ 10^{-7}$ *H/m*
Permittivity of free space $\varepsilon_0 = 8.85\ x\ 10^{-12}$ *F/m*

1.

Calculate, after deducing the appropriate formula, the capacitance of 20 km of cable if the radius of the inner conductor is 6 mm and the dielectric between the central core and the outer conductor has a thickness of 6 mm. The relative permiitivity of the medium is 3.5.

[15 marks]

What will be the maximum voltage gradient in the dielectric when a sinusoidal ac voltage of 10 kV is applied on the conductor?

[5 marks]

2.

Discuss the analogy between magnetic fields and electric fields, giving examples from magnetostatics, electrostatics and electric conduction.

[12 marks]

An iron ring of cross-sectional area 0.4 m² has a circumference of 5 m. A coil of 200 turns is uniformly wound on the ring to give negligible leakage flux. Calculate the stored energy when the coil is energise with a current of 10 A, if the B-H characteristic can be represented in the relevant region by $\mu H = B^3$, where $\mu = \mu_0 \mu_k$ and $\mu_k = 100$ in appropriate units.

[8 marks]

3.

Show that reluctances in series and in parallel combine in the same way as resistances.

[8 marks]

The relay shown in Fig. 1 has a linear magnetic circuit. When energised with a current of 4 A the flux is 0.5 mWb in the open position and 1.5 mWb in the closed position. Find the air gap length in the open position and calculate the amount of work done when the relay is closed by energising the coil with a constant current of 4 A. [12 marks]

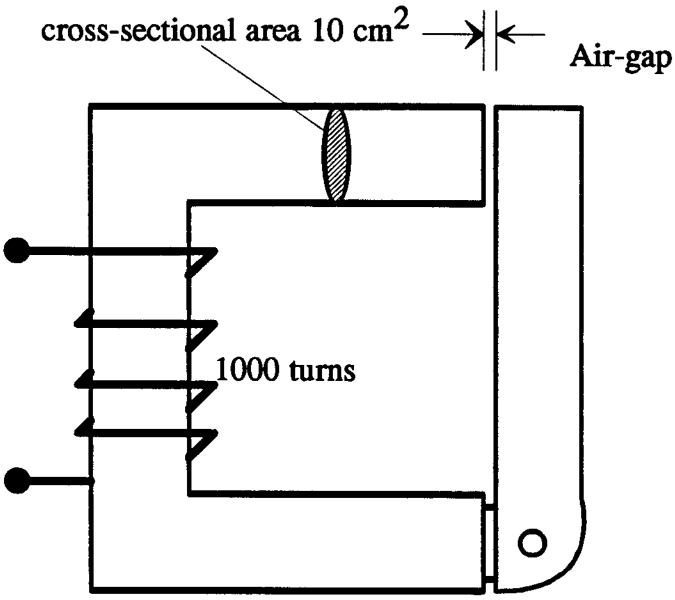


Fig. 1

4.

What effect does the non-linearity and saturation of the magnetic circuit have on the waveform of the no-load current of a transformer? Describe which elements in the equivalent circuit of the single-phase transformer account for the power losses, and show how they appropriately do so.

[12 marks]

A 200-kVA, single-phase, 6600/660-V, 50-Hz transformer has a high voltage winding resistance of 1.56 Ω and a low voltage winding resistance of 0.016 Ω. No-load current is 0.96 A at 0.26 power factor lagging. Calculate the load current which gives maximum efficiency.

[8 marks]

5.

Describe the circuit that would be used to measure reactive power in a balanced three phase circuit and prove that such a circuit measures reactive power.

[10 marks]

Find the readings of the two wattmeters used to measure real power on a 3-wire, 240-V system with a balanced delta-connected load of $20\underline{/80^{\circ}}$ Ω.

[10 marks]

6.

Starting with $v = Blu$, where v is the induced voltage, l is the length of the conductor and u is the conductor speed in a magnetic field of density B, show that the expressions for the brush terminal voltages for the commutator and slip ring machines are $V = \frac{2pZ}{c} n\varphi$ and $V = 2.22 Z_s f\varphi k$, respectively, explaining the symbols used.

[10 marks]

The magnetic characteristic obtained for a dc generator at 1200 rpm is as follows.

Field current (A)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	5.5
Generated emf (V)	120	240	360	480	540	600	660	696	738	744

The generator is shunt excited and is driven at 1000 rpm. If its field resistance is 120 Ω, what is its no-load generated voltage? If the load resistance is 5 Ω and the armature resistance is 1 Ω, find the terminal voltage and load current.

[10 marks]

7.

Assuming no power loss and no magnetic saturation, show that the torque-speed characteristic of a dc series motor reduces to an inverse square relationship. Contrast this with the torque-speed characteristic of the dc shunt motor.

[12 marks]

A dc series motor operates at 750 rpm with a line current of 80 A from a 230-V source. The series field has a total resistance of 0.11 Ω and the armature circuit resistance is 0.14 Ω.

Determine the motor speed when the line current is 20 A.

[8 marks]

8.

Show how a constant speed "rotating" magnetic field of fixed magnitude is produced from a set of balanced 3-phase sinusoidal ac currents. Hence develop a simplified equivalent circuit of a synchronous machine.

[14 marks]

With the use of phasor diagrams distinguish the modes of operation of a synchronous machine as generator and as a motor, and between leading and lagging reactive power handling.

[6 marks]

END OF EE321 EXAMINATION

The University of Zambia
School of Engineering

Final Examinations - November, 1996

EE342 - Electronic Engineering I

TIME: **THREE Hours**
Answer: **FIVE Questions**

Boltzmann's constant	$k=1.38 \times 10^{-23}$ J/K
Electronic charge	$q = 1.6 \times 10^{-19}$C
Ambient Temperature	$T = 300$ K

Q1. (a) Briefly describe the formation of the space-charge region in a p-n junction. By use of sketches explain what is meant by: forward biasing a p-n junction, reverse biasing a p-n junction, injection of minority carriers, conduction and valence bands, energy level diagrams, acceptor and donor impurities and a process called dopping.

(b) Describe the mechanisms involved in the breakdown diodes. For an ideal p-n junction diode the current I is related to the voltage V by an expression known as diode equation. State or write down this equation and explain all the parameters contained in it. A diode is operating in a circuit where the diode current is I_D and the voltage across the diode is V_D. If the current in the diode is doubled, calculate the increase in diode voltage V_D. Assume $V_T = 25$mV

(c) Explain avalanche multiplication and avalanche breakdown in diodes. Explain with the aid of a sketch the term dynamic resistance of a diode.

Q2. (a) State the Ebers-Moll equations for a p-n-p bipolar junction transistor (BJT).

(b) A bipolar junction transistor can operate in three regions namely; active, saturation and cut-off regions. Describe in detail the operations of a transistor in these three regions.

(c) For a common-emitter transistor configuration, there is a relationship between its *h* and *hybrid* – π parameters. Show the approximate relationship between the two parameters.

Q3. (a) Sketch the *hybrid* $-\pi$ and h parameter models for a common-emitter configuration and derive the relationship between the models.

(b) Show that the expression for low frequency common-emitter forward current gain with output shorted is

$$\beta = \frac{g_m - g_\mu}{g_m + g_\mu} \quad \text{where}$$

g_m is the conductance independent of the transistor used and varies linearly with collector current.

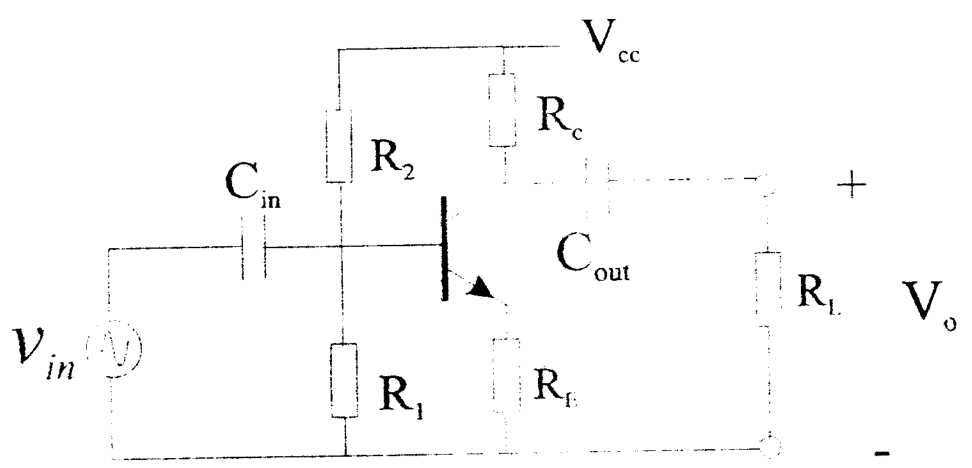
g_μ is the conductance, that accounts for the feedback effect between output and input of a bipolar junction transistor.

(c) Show that the ratio of the frequency f_T at which the common-emitter forward current gain with output shorted equals 1 to cut-off frequency f_β at which gain $\beta(w)$ is equal to 0.707 β_0 is

$$\frac{f_T}{f_\beta} = g_m r_\pi = \beta_0$$

Give good interpretation of the relationship $f_T = \beta_0 f_\beta$

Q4. (a) Derive expressions for input resistance, current gain, voltage gain and output resistance for the common-emitter amplifier whose circuit diagram is shown below.



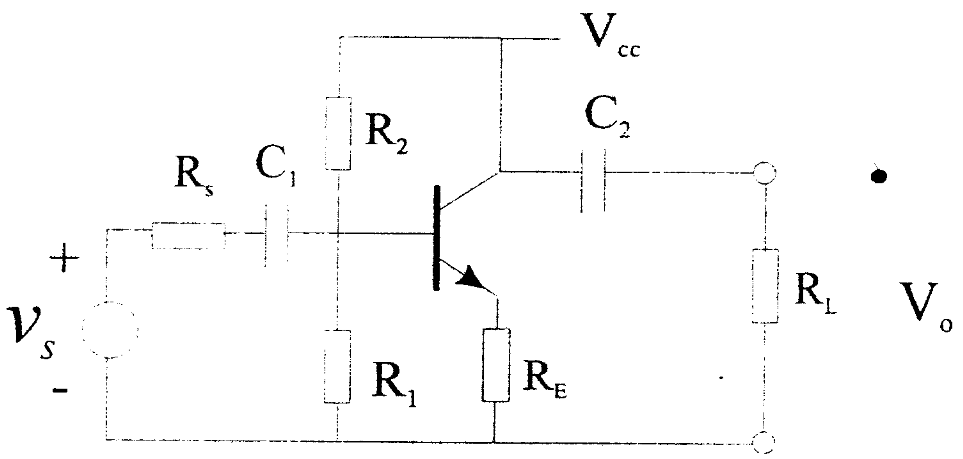
(b) Explain the role and use of coupling capacitors C_{in} and C_{out}. What criteria is normally used in selecting values of the above mentioned capacitors?

(c) Explain as to what the difference is between circuit analysis and design. A transistor can be used as a switch in which case it operates in two distinct regions. Name these regions and describe how a bipolar junction transistor operates in these two regions.

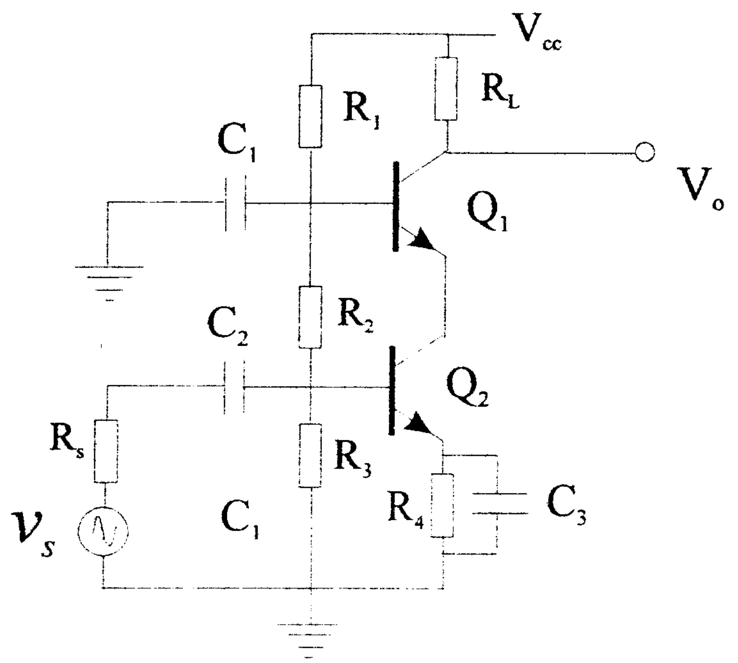
Q5. With the help of an equivalent circuit for low varying small signal find the voltage gain A_v, current gain A_i, input resistance R_i and output resistance R_o for a given single stage ***npn*** common-collector (CC) amplifier whose circuit diagram is shown below, with

$\beta = 60 \;\; V_{BE} = 0.7V, \quad R_s = 1k\Omega, \quad R = 13.8k\Omega_1 \quad R_2 = 1.68k\Omega,$

$R_E = R_L = 100\Omega, \; r_\pi = 25k\Omega, \; g_m = 40mA/V$ and $r_b = 01k\Omega$



Q6. The circuit diagram below shows a cascade configuration consisting of a common-emitter (CE) amplifier direct-coupled to a common base (CB) amplifier. Given that $g_m = 40$ mA/V $R_s = 1k\Omega$, $R_L = 2k\Omega$, $\beta = 100$, $r_b = 0.1k\Omega$ and $r_\pi = 2.5k\Omega$. Calculate with the help of general low varying small signal equivalent circuit, the second and first stage equivalent circuits, the overall voltage and current gain.



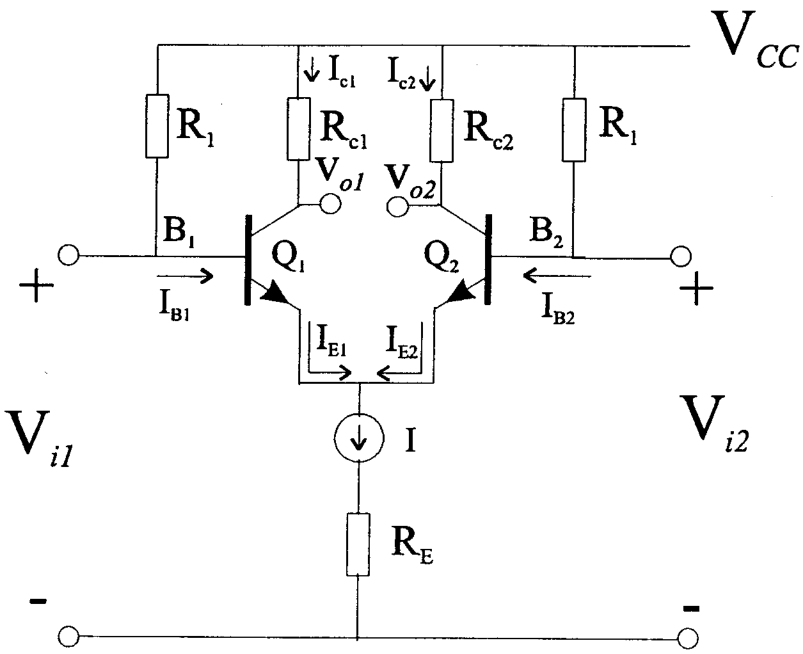
Q7. The basic functions of a differential amplifier, the basic stage of an integrated operational amplifier with differential input, is to amplify the difference between input signals. The need for differential amplifiers arises in many physical measurements where response from dc to megahertz is required.

Find an expression for output voltage $V_o = V_{o1} = V_{o2} = f(v_{i1}, v_{i2})$ and an expression for input impedance at each input if

i) $v_{i1} = v_{i2} = v_{ic}$

ii) $v_{i1} = -v_{i2} = \frac{1}{2} v_{id}$

for a circuit diagram of a differential amplifier shown below:

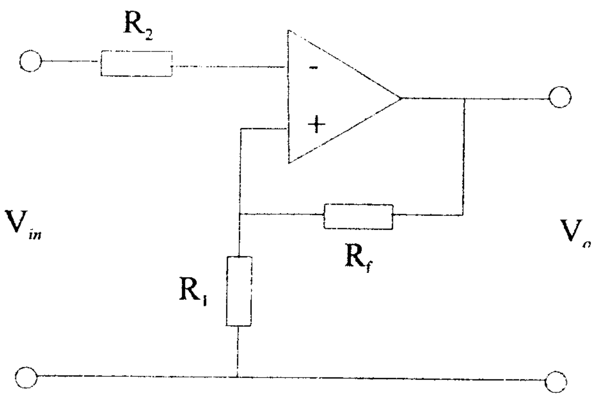


Note that

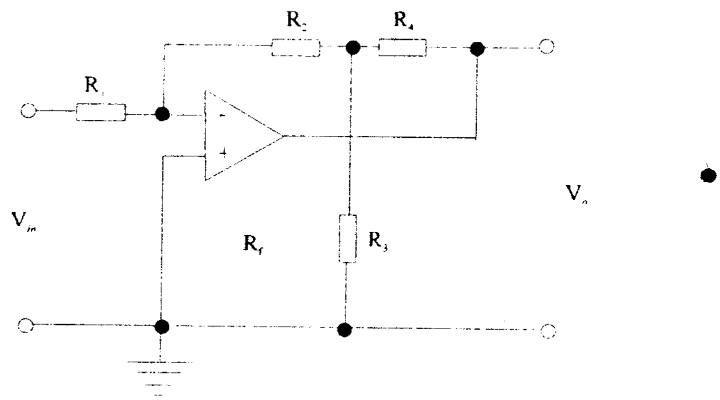
$$I_{c1} = I_{c2} = \frac{I}{2}$$
$$r_{\pi 1} = r_{\pi 2} = r_{\pi}$$
$$R_{c1} = R_{c2} = R_c$$
$$r_{b1} << r_{\pi 1}$$
$$r_{b2} << r_{\pi 2}$$
$$r_{b1} = r_{b2} = r_b$$
$$v_{ic} = \frac{v_{i1} + v_{i2}}{2}$$
$$v_{i1} - v_{i2} = v_d$$
$$v_{i1} = v_{ic} + \frac{v_d}{2}$$
$$v_{i2} = v_{ic} - \frac{v_d}{2}$$

Q8. Given the non-inverting amplifier shown below with $R_1 = 1k\Omega$, $R_f = 4k\Omega$ and $V_s = 1V$. Vin = 1 volt

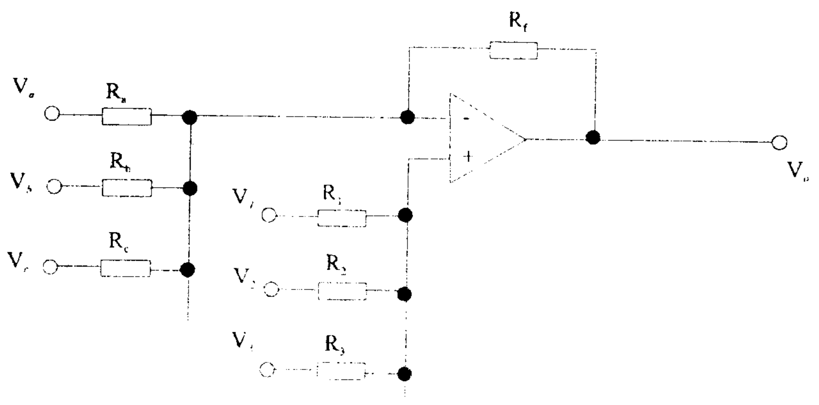
(a) Find V_o when the amplifier is assumed to be ideal.



(b) Calculate the voltage gain given
$R_1 = 150k\Omega$, $R_2 = 120k\Omega$, $R_3 = 12k\Omega$ and $R_4 = 180k\Omega$ for a given ideal operational amplifier whose circuit diagram is shown below.



(c) Derive an expression for the output voltage of an operational amplifier whose circuit diagram is given below.



THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

EE381 FINAL EXAMINATION - June, 1996

TIME: **Three** hours
Answer **FIVE** Questions.

Q1. a) You are already well aware of the fact that the true complement of a number for a given number system is formed by subtracting each digit of the number from the radix minus one of the number system and then adding one to the least significant digit of the number formed.

Form the twos, threes, fives, eights and tens (2's, 3's, 5's 8's and 10's) complement of the number 125_8 in binary, ternary, quinary, octal and decimal notations respectively.

b) Convert the following numbers to equivalent decimal numbers:

(i) ~~1223_3~~ 12223_3
(ii) 465_8
(iii) 11011_2
(iv) 413_5

c) Show how you would add together two binary numbers A and B where

$A=0101_2$
$B=0011_2$

(i) When both A and B are positive quantities
(ii) When A is positive and B is negative (expressed in 2's complement form).
(iii) When A is negative (expressed in two's complement form) and B is positive.
(iv) When both A and B are negative (both expressed in 2's complement form).

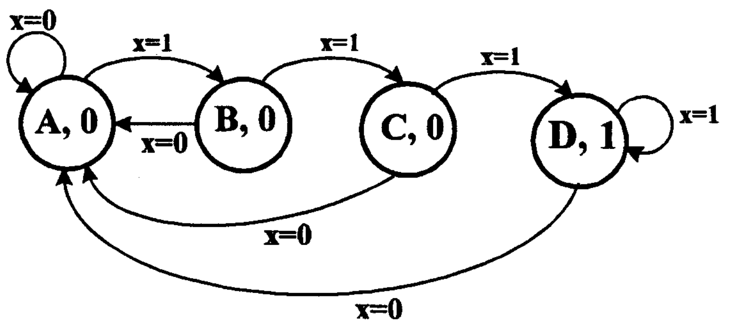
Q2. a) Draw a diagram of a typical microprocessor. The diagram should include all the major and necessary components among which are Arithmetic Logic Unit, Accumulator, Controller Sequencer, Instruction Decorder, Data

Register, Programme Counter and Address Register. Describe the functions of all the components mentioned above in a microprocessor.

b) Given the instruction set for the 8085 in the appendix, write a program using mnemonics and machine code. The program should accept immediate inputs using register B and A. The two values are added and the result is stored in memory at the absolute location 20C0H. Assume the value of the Program Counter (PC) = 2000H. Your program should follow the format below.

Address	**Data (machine Code)**	**Mnemonic**	**Comments**
•	•	•	•
•	•	•	•
•	•	•	•
•	•	•	•
•	•	•	•

Q3. A binary sequence detector which realizes three consecutive 1s realizes the following state diagram.



a) What do circles represent in the state diagram?
b) What do letters A, B, C and D stand for?
c) What does X signify?
d) Display the state table and final design of the sequence detector.

Q4. Design a counter using three RS flip-flops X_1, X_2, and X_3 and whatever gates you would like which counts as follows:

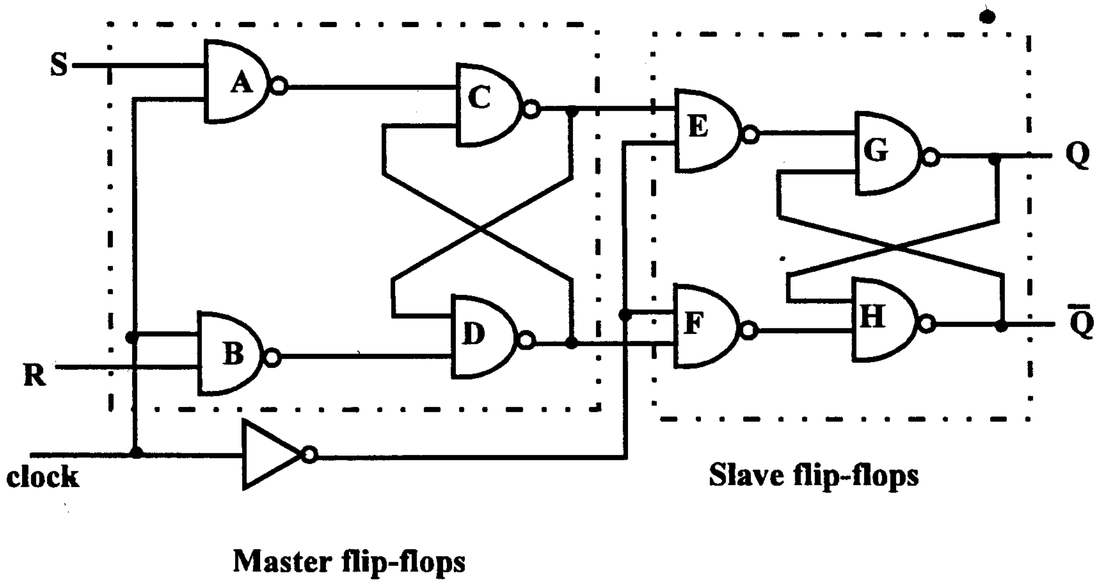
X_1	X_2	X_3
0	0	0
1	1	1

1	0	1
1	1	0
0	0	1
0	1	0

Q5. Simplify by use of Karnaugh maps, the following expressions in your variables A, B, C and D:

a) $F_1=m_1+m_3+m_4+m_6+m_9+m_{11}+m_{12}+m_{14}$
b) $F_2=m_2+m_6+m_8+m_{10}+m_{14}$
c) $F_3=m_0+m_2+m_4+m_8+m_9+m_{10}+m_{11}+m_{12}+m_{13}$
d) $F_4=m_0+m_2+m_{10}+m_8$
e) $F_5=m_0+m_4+m_8+m_{12}$

Q6. The basic flip-flop design of Master-Slave flip-flop and its clock signal are given below:



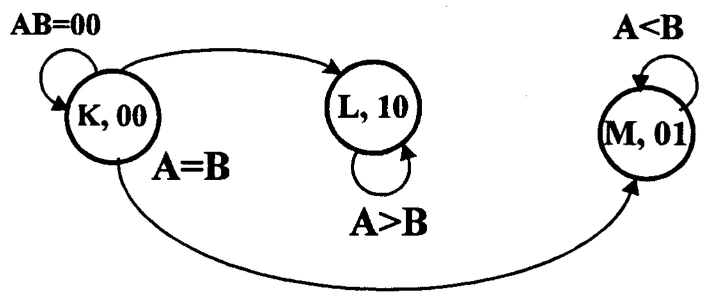
Describe in detail how the above circuit functions, by considering two clock pulses and 4 different inputs given below.

a) S=0, R=0
b) S=1, R=0
c) S=0, R=1
d) S=1, R=1

What is a possible remedial modification to the circuit to enable it handle inputs **d** (i.e. S=1, R=1)?

Q7. A state machine with two binary input numbers A and B and two outputs Z_1 and Z_2 whose main function is to determine which of the two inputs is larger than the other is commonly known as magnitude comparator.

Design a magnitude comparator whose state diagram is shown below.



In the design of the magnitude comparator clearly show construction of state table and karnaugh maps involved in minimisation of boolean Algebraic expressions.

Q8. Design a synchronous modulo 10 counter on JK bistables. The counter has four flip-flops X_1, X_2, X_3, and X_4. In your design show clearly the design table, truth table and Karnaugh Maps involved in minimisation of Boolean Algebraic expressions for each and every input to various flip-flops.

JUMP

C3	JMP	
C2	JNZ	
CA	JZ	
D2	JNC	
DA	JC	
E2	JPO	Adr
EA	JPE	
F2	JP	
FA	JM	
E9	PCHL	

CALL

CD	CALL	
C4	CNZ	
CC	CZ	
D4	CNC	
DC	CC	
E4	CPO	
EC	CPE	
F4	CP	
FC	CM	

RETURN

C9	RET
C0	RNZ
C8	RZ
D0	RNC
D8	RC
E0	RPO
E8	RPE
F0	RP
F8	RM

MOVE IMMEDIATE

06	MVI	B,	
0E	MVI	C,	
16	MVI	D,	
1E	MVI	E,	
26	MVI	H,	D8
2E	MVI	L,	
36	MVI	M,	
3E	MVI	A,	

Acc IMMEDIATE*

C6	ADI	
CE	ACI	
D6	SUI	
DE	SBI	
E6	ANI	D8
EE	XRI	
F6	ORI	
FE	CPI	

LOAD IMMEDIATE

01	LXI	B,	
11	LXI	D,	
21	LXI	H,	D16
31	LXI	SP,	

DOUBLE ADD†

09	DAD	B
19	DAD	D
29	DAD	H
39	DAD	SP

INCREMENT**

04	INR	B
0C	INR	C
14	INR	D
1C	INR	E
24	INR	H
2C	INR	L
34	INR	M
3C	INR	A
03	INX	B
13	INX	D
23	INX	H
33	INX	SP

DECREMENT**

05	DCR	B
0D	DCR	C
15	DCR	D
1D	DCR	E
25	DCR	H
2D	DCR	L
35	DCR	M
3D	DCR	A
0B	DCX	B
1B	DCX	D
2B	DCX	H
3B	DCX	SP

LOAD/STORE

0A	LDAX	B
1A	LDAX	D
2A	LHLD	Adr
3A	LDA	Adr
02	STAX	B
12	STAX	D
22	SHLD	Adr
32	STA	Adr

RESTART

C7	RST	0
CF	RST	1
D7	RST	2
DF	RST	3
E7	RST	4
EF	RST	5
F7	RST	6
FF	RST	7

ROTATE†

07	RLC
0F	RRC
17	RAL
1F	RAR

CONTROL

00	NOP
20	RIM
30	SIM
76	HLT
F3	DI
FB	EI

SPECIALS

EB	XCHG
27	DAA*
2F	CMA
37	STC†
3F	CMC†

INPUT/OUTPUT

D3	OUT	D8
DB	IN	

STACK OPS

C5	PUSH	B
D5	PUSH	D
E5	PUSH	H
F5	PUSH	PSW*
C1	POP	B
D1	POP	D
E1	POP	H
F1	POP	PSW*
E3	XTHL	
F9	SPHL	

MOVE

40	MOV	B,B	60	MOV	H,B
41	MOV	B,C	61	MOV	H,C
42	MOV	B,D	62	MOV	H,D
43	MOV	B,E	63	MOV	H,E
44	MOV	B,H	64	MOV	H,H
45	MOV	B,L	65	MOV	H,L
46	MOV	B,M	66	MOV	H,M
47	MOV	B,A	67	MOV	H,A
48	MOV	C,B	68	MOV	L,B
49	MOV	C,C	69	MOV	L,C
4A	MOV	C,D	6A	MOV	L,D
4B	MOV	C,E	6B	MOV	L,E
4C	MOV	C,H	6C	MOV	L,H
4D	MOV	C,L	6D	MOV	L,L
4E	MOV	C,M	6E	MOV	L,M
4F	MOV	C,A	6F	MOV	L,A
50	MOV	D,B	70	MOV	M,B
51	MOV	D,C	71	MOV	M,C
52	MOV	D,D	72	MOV	M,D
53	MOV	D,E	73	MOV	M,E
54	MOV	D,H	74	MOV	M,H
55	MOV	D,L	75	MOV	M,L
56	MOV	D,M			
57	MOV	D,A	77	MOV	M,A
58	MOV	E,B	78	MOV	A,B
59	MOV	E,C	79	MOV	A,C
5A	MOV	E,D	7A	MOV	A,D
5B	MOV	E,E	7B	MOV	A,E
5C	MOV	E,H	7C	MOV	A,H
5D	MOV	E,L	7D	MOV	A,L
5E	MOV	E,M	7E	MOV	A,M
5F	MOV	E,A	7F	MOV	A,A

ACCUMULATOR*

80	ADD	B	A0	ANA	B
81	ADD	C	A1	ANA	C
82	ADD	D	A2	ANA	D
83	ADD	E	A3	ANA	E
84	ADD	H	A4	ANA	H
85	ADD	L	A5	ANA	L
86	ADD	M	A6	ANA	M
87	ADD	A	A7	ANA	A
88	ADC	B	A8	XRA	B
89	ADC	C	A9	XRA	C
8A	ADC	D	AA	XRA	D
8B	ADC	E	AB	XRA	E
8C	ADC	H	AC	XRA	H
8D	ADC	L	AD	XRA	L
8E	ADC	M	AE	XRA	M
8F	ADC	A	AF	XRA	A
90	SUB	B	B0	ORA	B
91	SUB	C	B1	ORA	C
92	SUB	D	B2	ORA	D
93	SUB	E	B3	ORA	E
94	SUB	H	B4	ORA	H
95	SUB	L	B5	ORA	L
96	SUB	M	B6	ORA	M
97	SUB	A	B7	ORA	A
98	SBB	B	B8	CMP	B
99	SBB	C	B9	CMP	C
9A	SBB	D	BA	CMP	D
9B	SBB	E	BB	CMP	E
9C	SBB	H	BC	CMP	H
9D	SBB	L	BD	CMP	L
9E	SBB	M	BE	CMP	M
9F	SBB	A	BF	CMP	A

D8 - constant, or logical/arithmetic expression that evaluates to an 8 bit data quantity.

* - all Flags (C, Z, S, P, AC) affected

New instructions
RIM 20
SIM 30

D16 = constant, or logical/arithmetic expression that evaluates to a 16 bit data quantity.

† = only CARRY affected 8085 only

Adr = 16 bit address

** = all Flags except CARRY affected: (exception: INX & DCX affect no Flags)

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

EXAMINATION - NOVEMBER 1996

EE 391: ELECTRICAL ENGINEERING PRACTICE

TIME : Three hours .

ANSWER - Any two questions from each section.
- Each section must be answered in separate set of answer booklets.

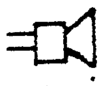
SECTION I : Drawing and Design.

Question 1 (20 *marks*).

i) Indicate six methods of mounting components.

ii)Draw thea circuit diagram for the push - pull amplifier shown below.

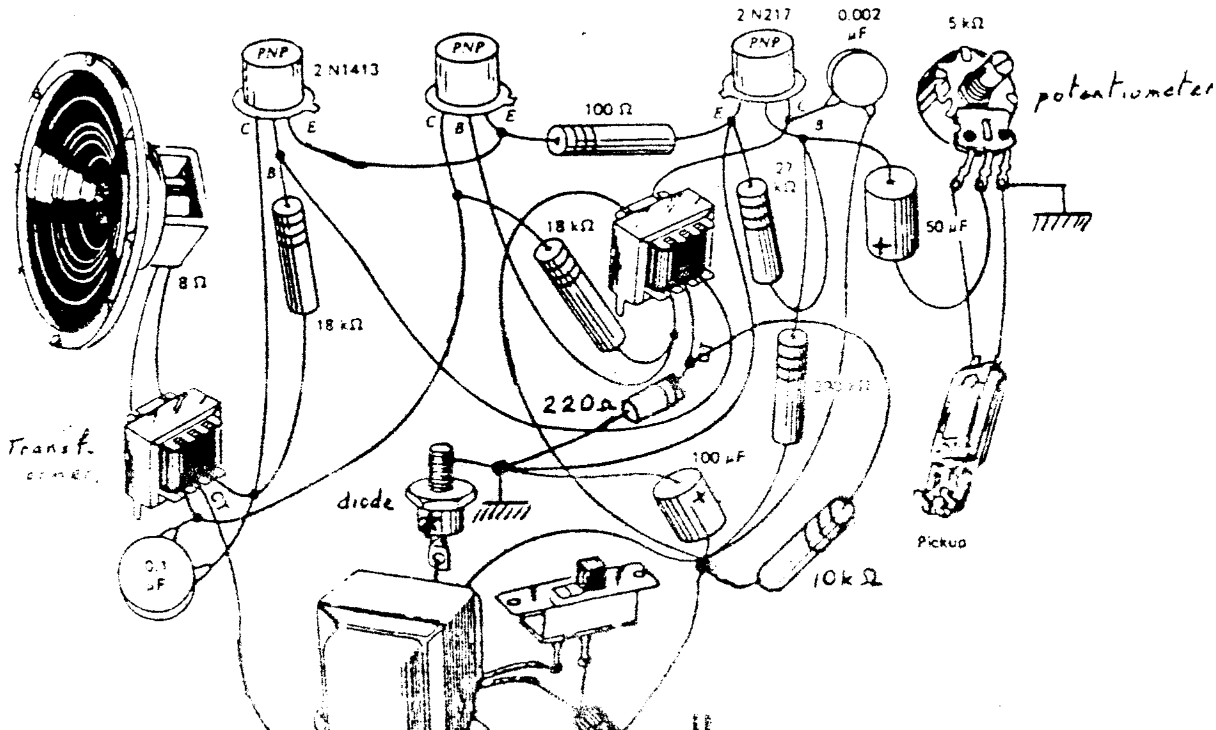
The circuit layout should be in accordance with the guide lines and use the standard symbols (the 50 µF and 100 µF capacitors are polarised electrolytics).

Note : (i) Loudspeaker 

Stylus operating record head 

(ii) The amplifier has a common emitter stage which is transformer coupled to a push-pull output stage.

(iii) CT means centre-tap not current transformer



Question 2 (20 *marks*):

Neatly sketch in multiline , the circuit described below :

- A 3 -phase synchronous generator has been connected to its outputs via a circuit breaker and an isolator, a 3 - phase delta - transformer and a 3- phase rectifier *(5 marks)*
- The transformer which has a dust core, has its secondary winding star point grounded . Between two of the secondary phases, a variabble autotransformer is connected and between the third phase and the ground, an a.c. synchronous motor is connected via a circuit breaker , an isolator and a thyristor. Between the isolator and the anode of the thyristor there is a current transformer . The cathode of the thyristor is connected to the motor and the gate is connected to one terminal of a one port.. *(5 marks)*
- The auto- transformer has its movable terminal connected to a bulb via a fused switch and a separable link. The other side of the transformer is connected straight to the other terminal of the bulb. The positive output of the 3- phase rectifier is connected to a series d.c. motor via a circuit breaker , a non linear resistor and an ammeter. The negative output is connected straight to the other side of the motor. *(5 marks)*
- The generator is excited through a d.c. field winding which is connected to an a.c source via a single - phase full wave rectifier. The a.c. source supplying the rectifier consists of a single phase transformer with laminated core. The secondary winding is connected to the rectifier and the primary winding is open. *(5 marks)*

Question 3 (20 *marks*).

Fig.3 is a wiring diagram for a lighting circuit;

i) give the name of this type of switching; *(2.5 marks)*
ii) how many switch points can you switch on / off the bulb from; *(2.5 marks)*
iii) define wiring diagram, single line wiring diagram , multiline wiring diagram and schematic wiring diagram; *(5 marks)*
iv) draw the multiline wiring diagram and schematic wiring diagram of that switching; *(5 marks)*
vi) draw the single line wiring diagram so that you can switch the bulb from 4 switch points and how many junction -boxes will you need
(5 marks)

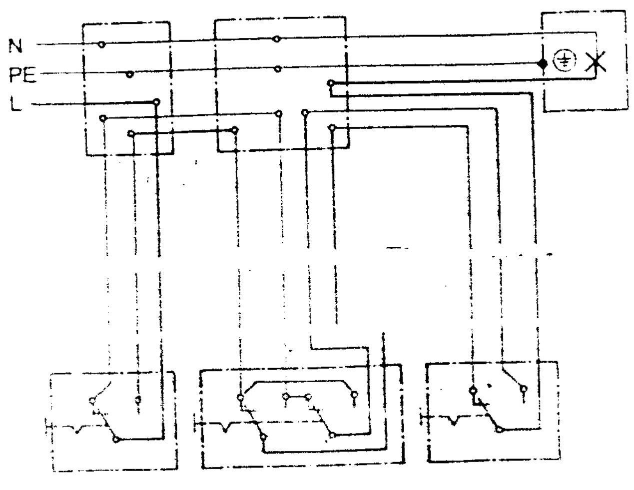


Fig. 3

SECTION II : Instrumentation and Fault Finding.

Question 4 (20 *marks*).

i) Assume that the inductance of a certain moving - iron ammeter varies with deflection at the constant rate of $2.0\ \mu H/^{\circ}$. If the control spring constant is $5 \times 10^{-7}\ N.m/^{\circ}$, calculale the deflection for a current of 1.0 A. *(5 marks)*

ii) A dynamometer instrument designed for use as a wattmeter is rated for 10 A, 200 V, the resistance of the voltage coil circuit being 20 kΩ. The mutual inductance between the coils varies sinusoidally according to $M = 1.0 \sin(\theta - 45^{\circ})$ mH, where θ is the angle of of deflection in degree from the rest position. Ful - scale deflection $\theta = 90^{\circ}$ is obtained under rate current and voltageat unity power factor

(a) calculate the control spring constant (consider full scale deflection) *(5 marks)*

(b) complete the following table : *(7.5 marks)*

Deflection θ	0 °	15 °	30 °	45 °	60 °	75 °	90 °
$dM/d\theta$, mH/rad.							
Control torque, Nm							
Power, W							

** $\sin(A - B) = \sin A \cos B - \cos A \sin B$

iii) Consider the simple potential divider circuit shown in Fig .4 a & b. A voltmeter with a sensitivity of 2 kΩ/V is used to measure the voltage between A and E. When the meter is set to the 10 V range, calculale the meter reading and the error.
(7.5 marks)

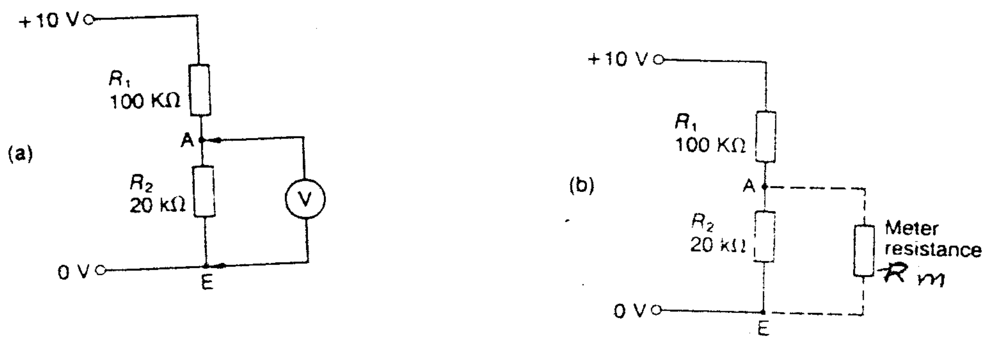
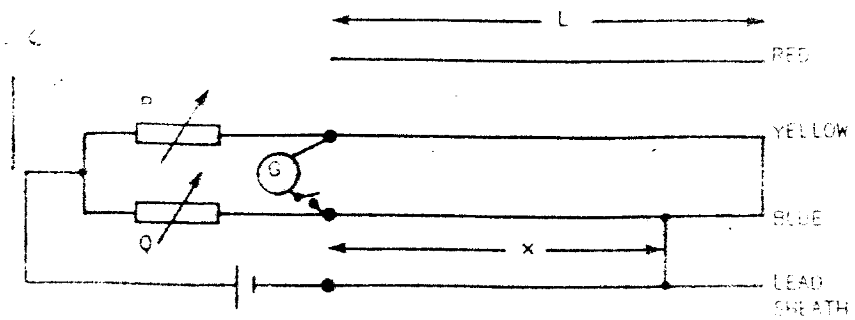


Fig 4 a & b

Q 6 Fig. 6



Question 5 (20 *marks*).

i) Indicate the more probable types of failure for various types of electronic components; *(5 marks)*

ii) The complete circuit of most elctronic instruments can be broken down into series of functional blocks . By treating an intstrument in blocks, rather than as a whole, ,its is possible to narrow down the search for a faulty component.Indicate the methods used to decide which block is faulty. *(5 marks)*

iii) The circuit shown in Fig.5 is a common base amplifier. With this type of amplifier the input is applied at the emetter and the output taken from the collector. The bais circuit is identical in operation to the potential diveder bias of common emetter. Calculate the voltage you would expect to measure with a 20 kΩ/V meter between the test points and 0 V. Then determine which component or components could cause the following fault conditions*(10 marks)*

	1	2	3
Fault			
A	0	0	12
B	0	3	12
C	3·8	3	3·8
D	1·1	1·7	1·1
E	5·2	5·9	5·9
F	3·7	4·4	3·8

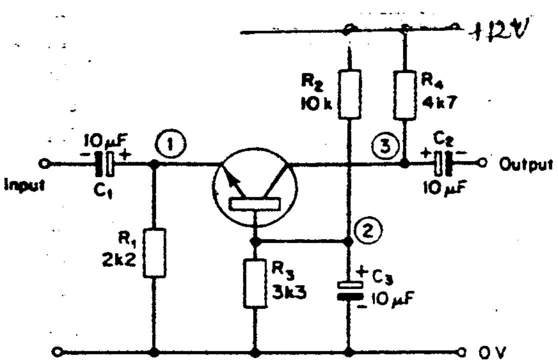


Fig. 5 Common base amplifier

Question 6 (20 *marks*).

i) Explain how to determine the polarity of a particular multirange meter you are using if you do not know its connections. *(5 marks)*

ii) Having establisded the ohmmeter lead polarity, how can identify by using the ohmmeter the base lead of a transistor *(5 marks)*

iii) How can you test in circuit *(5 marks)*

- a leaky electrolytic capacitor ;

- an open capacitor.

Using a low frequency generator at 1 kHz and two meters, make a simple laboratory set- up to messure a capacitance

iv) One phase of a three - phase cable is found to be short circuited to the lead sheath at distance x metres from the near end . Let the cable resistance be R Ω/metre

Find the distance x using a Wheastone Brige as shown in Fig. 6. *(5 marks)*

SECTION C: STATICS AND DYNAMICS

ANSWER ANY TWO(2) QUESTIONS ONLY

Q7(a) A simply supported beam of span 20m carries two concentrated loads 4kN at 8m and 10kN at 12m from one end. Calculate the maximum deflection given that $E = 200{,}000 N/mm^2$ and $I = 10^9 mm^4$.

(b) A close-coiled helical spring has to absorb 50Nm of energy when compressed 5cm. The coil diameter is eight times the wire diameter. If there are ten coils, estimate the diameters of the coil and the wire and the maximum shear stress ($G = 85{,}000 N/mm^2$).

Q8(a) A,B,C and D are four masses attached to a rotating shaft with their centres of mass lying at radii of 100, 125, 200 and 150mm respectively. The planes in which the masses rotate are spaced 0.6m apart and the magnitudes of A,C and D are 15, 10 and 8kg respectively. Find the value of the mass B and the relative angular settings for the shaft to be in complete balance.

(b) Determine the ratio of the mass of a solid shaft to that of a hollow one of the same length which will be required to transmit a given torque for the same maximum shear stress if the inside diameter of the hollow shaft is two-thirds (2/3) of the outside diameter.

Q9(a) An air compressor of mass 450kg operates at a constant speed of 1750rpm. The rotating parts are well balanced. If the reciprocating parts produce a harmonic forcing function $F = 3400\cos wt$ in kN, and the damper for the mounting introduces a damping factor $z = 0.15$.

(i) Determine the natural frequency of vibration of the system and specify the spring stiffness for the mounting such that only 20% of the resultant force is transmitted to the ground and

(ii) Determine the magnitude of the transmitted force.

(b) An unbalanced disc lying on a plane inclined at 30° to the horizontal is released from rest. The centre of mass is on the line perpendicular to the inclined plane and 12cm from the point of contact between the disc and the plane. If the wheel is of diameter 24cm, mass 14.5kg and has a radius of gyration of 6cm about the centre of mass, find the velocity of the centre O after the wheel has rolled through two complete revolutions. Assume no slippage.

END OF SECTION C
Dr A N Ng'andu

END OF EXAMINATION EE392

THE UNIVERSITY OF ZAMBIA
School of Engineering, Dept of Electrical & Electronic Eng.
UNIVERSITY EXAMINATION JUNE 1996
ELECTROMAGNETIC FIELDS EE411
time: 3 HOURS
ANSWER 5 QUESTIONS OUT OF 8
ALL QUESTIONS CARRY 20 POINTS

Question 1.

Given $\vec{\mathbf{A}} = x^2\bar{\mathbf{a}}_x + xy\bar{\mathbf{a}}_y + yz\bar{\mathbf{a}}_z$
Verify the divergence theorem over a cube one unit on each side.
This cube is situated in the first octant of the Cartesian coordinate system with one corner at the origin as shown in figure Q1.

Question 2.

The capacitor shown in figure Q2 consists of two parallel conducting disks separated by 5 mm, and contains a dielectric for which $\epsilon_r = 2.2$ ($\epsilon_0 = 8.85 \times 10^{-12}$ F/m)
The lower disk is kept at a constant potential of +100 V and the upper disk at +250 V.
Determine the charge density on the upper disk.

Question 3.

The electrostatic field intensity $\bar{\mathbf{E}}$ is derivable as the negative gradient of a scalar electric potential **V**; that is $\bar{\mathbf{E}} = -\nabla \mathbf{V}$.
Determine $\bar{\mathbf{E}}$ (give magnitude and direction) at the point (1,1,0) if $\mathbf{V} = \mathbf{V_0 e^{-x} \sin(\pi y/4)}$.

Question 4.

Find the voltage across each dielectric in the capacitor, shown in figure Q4, when the applied voltage is 200 V.
There is a 1mm layer with relative permittivity 5 and the remaining 3mm space is filled with air.
The parallel conducting plates both have an area of $1m^2$.

Question 5.

Determine the resistance of the insulation in a length **L** of coaxial cable as shown in figure Q5.
Assume a current **I** from the inner conductor (radius $\mathbf{r_i}$) to the outer conductor (radius $\mathbf{r_o}$).

Question 6.

Find $\bar{\mathbf{H}}$ at the centre of a square current loop of side **L**.
The steady current in the loop equals **I** as shown in figure Q6.

See next page for questions 7 and 8.

Question 7.

The rail gun.

The bar **AA'** in figure Q7 serves as a conducting path for the current **I** in two very long parallel lines.

These lines have a radius **b** and are spaced at a distance **d** apart.

Find the direction and the magnitude of the magnetic force on the bar.

Question 8.

N turns of wire are wound around a toroidal core of a ferromagnetic material with permeability $\boldsymbol{\mu}$.

The core has a mean radius $\mathbf{r}_0$, a circular cross section of radius **a** ($\mathbf{a} \ll \mathbf{r}_0$), and a narrow air gap of length $\mathbf{L}_g$ as shown in figure Q8.

A steady current **I** flows in the wire.

Determine:

(i) the magnetic flux density $\bar{\mathbf{B}}_f$ in the ferromagnetic core. (6 points)

(ii) the magnetic field density $\bar{\mathbf{H}}_f$ in the core.(6 points)

(iii)the magnetic field density $\bar{\mathbf{H}}_g$ in the gap.(8 points)

END

Figures Q1, Q2, Q4, Q5, Q6, Q7 and Q8 associated with the corresponding questions of EXAMINATION 1996 in Electromagnetic Fields (EE411).

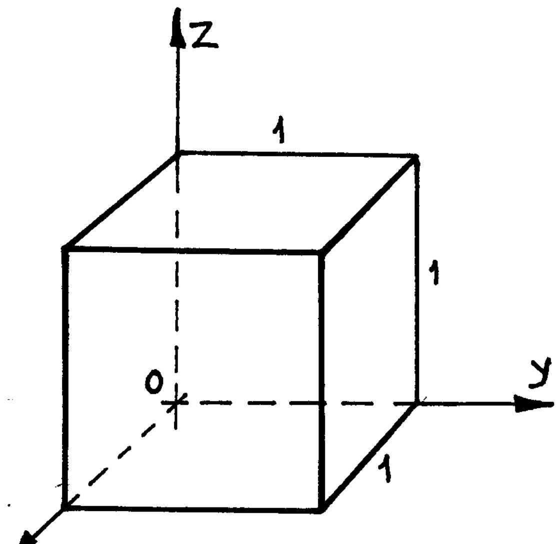


figure Q1

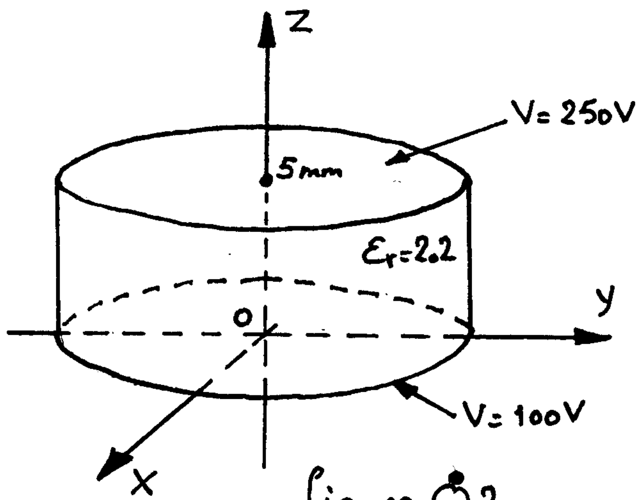


figure Q2

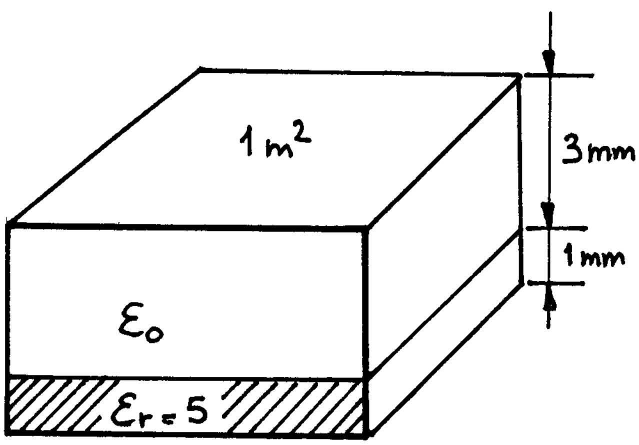


figure Q4

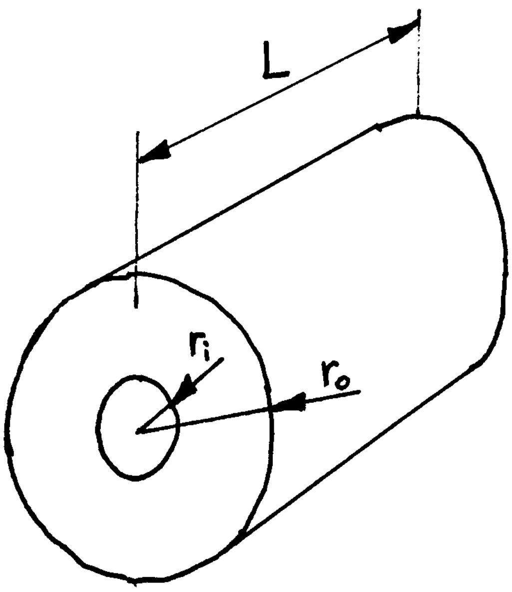


figure Q5

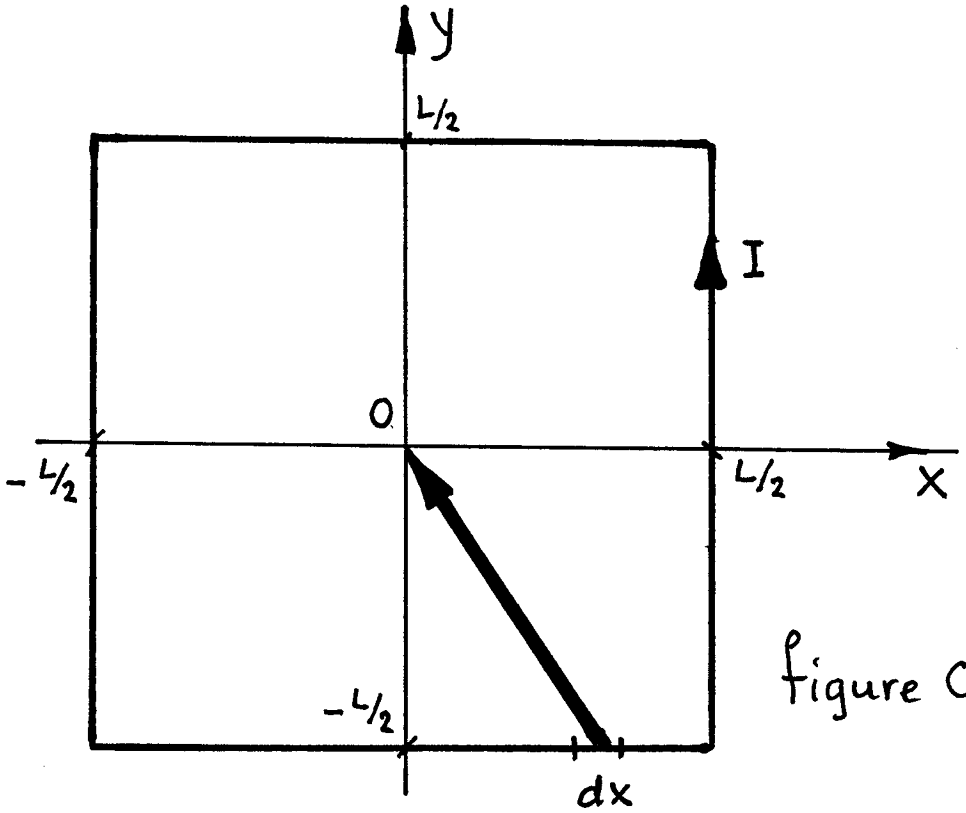


figure Q6

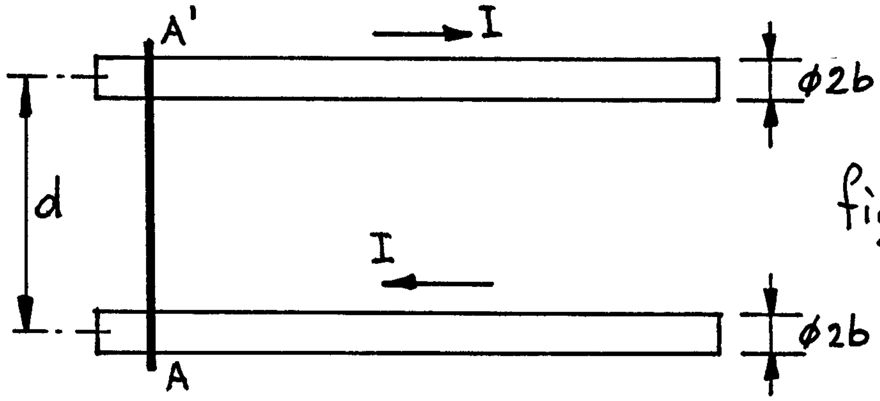


figure Q7

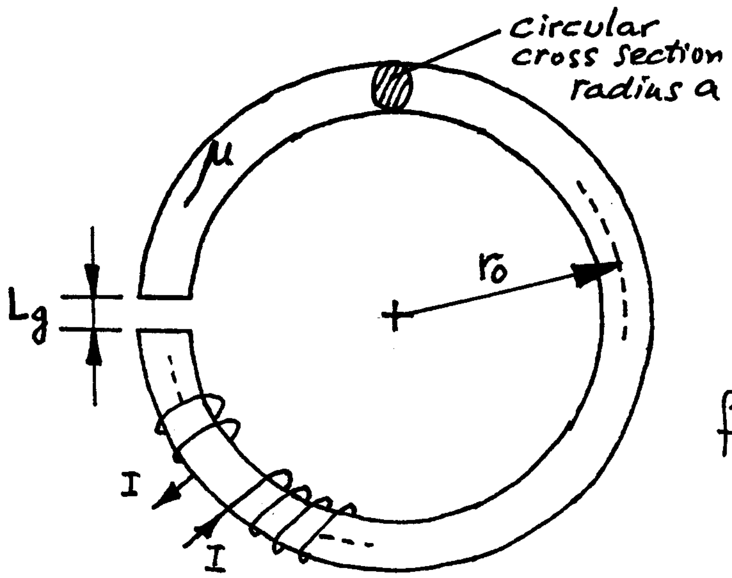


figure Q8

THE UNIVERSITY OF ZAMBIA
ELECTRICAL & ELECTRONIC ENGINEERING DEPT.

EE422 ELECTRICAL MACHINES I
SECOND SEMESTER

FINAL EXAMINATION NOVEMBER 1996

ANSWER: **FIVE** QUESTIONS
ALL QUESTIONS CARRY **20 POINTS**

Q1 A 1000kVA, 11kV, three-phase, star-connected alternator has a resistance per phase of 1.03Ω, a core loss of 28kW, a field copper loss of 7,2kW and a combined friction and windage loss of 9.5kW. Calculate the full-load efficiency at pf 0.9lag.

Q2. A 380V, 50 Hz, four-pole, three-phase induction motor develops 4.0 kW when running at 1425 rev/min. The friction and windage losses are 250 W. Calculate the rotor copper loss and power crossing the air-gap from stator to rotor.

Q3.(a) Derive from first principles the torque, and voltage performance equations of a dc machine.

(b) A 20-hp, 250-V shunt motor has an armature-circuit resistance(including brushes and interpoles) of 0.22Ω and a field resistance of 170Ω. At no-load and rated voltage, the speed is 1200 rpm and the armature current is 3.0A. At full-load and rated voltage, the line current is 55A, and the flux is reduced 6% (due to the effects of armature reaction) from its value at no-load. What is the full-load speed?

Q4 A 10 kVA distribution transformer has a half-load efficiency at unity power of 0.96 pu. Its copper and iron losses are equal at one-half of full load. On a particular day it is loaded as follows: no load for 8 hours, one-third of full load for 6 hours, two-thirds of full load for 5 hours, and full load for 5 hours. Calculate its all-day efficiency, assuming loads have a power factor of unity.

Q5. Tests on a 10 kVA, 11 000/240 V, 50 Hz single-phase transformer gave the following results:

Open-circuit test 240 V	(applied to low-voltage winding)	70 W 1.0A
Short-circuit test 310 V	(applied to high-voltage winding	80 W 0.9A

Calculate the equivalent circuit parameters referred to the high-voltage winding and mark these on a sketch of the equivalent circuit. Determine the maximum efficiency and the load at which it occurs when the transformer is delivering at pf 0.8 lag.

Q6. With an aid of a sketch describe the design and constructional features of a rotating machine. Give a qualitative description of computer aided design and role of motor starting studies.

Q7. (a) Describe the action of an ideal synchronous machine with the aid of rotor angle sketches and phasor diagrams.

(b) An ideal 1.5 MW, 50Hz, 3-ph, 8-pole synchronous machine with a reaction reactance of 1.25p.u. runs on 6.6 kV infinite busbars. The moment of inertia of the rotor and its mechanical attachments is 3 100 kg-m^2.

The machine operates

(a) on no load with 1.0p.u excitation
(b) as a compensator with 2.0p.u. excitation
(c) as a motor on full load (1.0p.u) at power factor 0.87 leading;
(d) as a generator on 0.75p.u. active power at an output power factor of 0.78 lagging

For each case estimate the load angle, synchronizing power and torque, and the natural frequency of hunting oscillation; for case(d) find the voltage regulation.

Q8. (a) Given a motor and a mechanical load, state the relation that can be used to estimate the motor starting time. Stating the moment of inertia conversions per IEC 34-12.

(b) Sketch the acceleration torque areas for a lift, fan, piston

pump, and flywheel.

(c) Give a 6 pole, 1000 rpm, 50 Hz motor with K_1 = 104, T(motor) = 1040 Nm, Tmax = 2912 Nm, J(motor) = 2.5 kgm^2, J(Load) = 80 kgm^2 at 500 rpm and T(Load) = 1600Nm at 500 rpm for a lift motion. Calculate the starting time in seconds.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

Department of Electrical and Electronics Engineering

Final exam EE441 and EE431 first semester 1996.

Prof. A.J. Mouthaan

Time: 3 hours, answer any 5 questions.

All questions 20 points.

The following constants and equations may be used

Constant	Symbol	Unit	Value
Thermal voltage	kT/q	mV	25 (room temperature)
Bandgap silicon	E_g	eV	1.12

Diode equation: $\mathbf{J} = \mathbf{J_p} + \mathbf{J_n} = \mathbf{n_i^2 q}\left(\frac{\mathbf{L_e}}{\mathbf{N_A \tau_e}} + \frac{\mathbf{L_p}}{\mathbf{N_D \tau_p}}\right)\left(\mathbf{e}^{\frac{\mathbf{V}}{\mathbf{V_{th}}}} - \mathbf{1}\right)$, if it is assumed that the length of the neutral regions is larger than the diffusion lengths, $\mathbf{L_{e,p}}$, in the p- and n-material resp.

MOST current equation, linear region: $\mathbf{I_D = K(V_{GS} - V_{th})V_{DS}, K = \frac{W}{L}\mu C_{ox}},$

saturation: $\mathbf{I_D = K\frac{(V_{GS} - V_{th})^2}{2}}.$

(Use the appropriate signs for n- and pMOST).

Q1. Solid state physics.

a) Sketch in one graph of temperature against resistance, the curve of the resistance of a piece of metal, a piece of intrinsic silicon and a piece of extrinsic silicon. Use a temperature range of 0 °K to 500 °K. Explain the shape of the three curves. (8points).

b) Sketch the response of the resistance of a piece of intrinsic semiconductor to the light flashes produced by a stroboscope as function of time. Take the time interval between the flashes to be larger than the life time of carriers. Explain the shape of the curve. In a second graph do the same for the resistance of a piece of heavily doped semiconductor. (12 points).

Q2. Solid state physics.

a) Give a definition of the Fermi energy level and describe its importance in view of semiconductor devices. (8 points).

b) In a semiconductor doped with donor atoms draw the position of the Fermi energy level as function of temperature starting from 0 °K to 500 °K and explain the curve. (12 points).

Q3. PN diodes.

a) For a pn diode, explain that the width of the depletion region increases when the reverse biasing is increased, and explain the phenomenon of junction breakdown. (4 points).

b) Explain why the minority carrier life time is an important factor for the high frequency behavior of a diode. (4 points).

c) Give an ac equivalent circuit diagram of a junction diode and explain the origin of all components and indicate the way they can be calculated. (12 points).

Q4. Bipolar transistors.

Given is a npn transistor with doping concentrations N_{De}, N_{Ab}, N_{Dc}, in emitter, base and collector resp. and with a base width, W_B, operating at room temperature, T. When one parameter at the time is increased, while the others are kept at their set values, complete the table below to indicate the effect that will have on the indicated transistor parameters. As an example the effect of increasing W_B is indicated. Briefly explain each entry. (20 points). Material parameters like μ, τ, L can be considered constant.

	effect on I_C	**effect on I_B**	**effect on β**
increase N_{De}			
increase N_{Ab}			
increase N_{Dc}			
increase W_B	*I_C reduces*	*no effect*	*β reduces*
increase T			

Q5. MOS transistors.

Given is a nMOST with oxide thickness, t_{ox}, and doping concentrations in the source, drain and bulk resp., N_{Ds} , N_{Dd} and N_{Ab} operating at room temperature, T. When one parameter at the time is increased, while the others are kept at their set values, complete the table below to indicate the effect that will have on the indicated transistor parameters. For an example entry see Q4. Briefly explain each entry. (20 points).

	effect on K	**effect on V_{th}**	**effect on g_m**
increase t_{ox}			
increase N_{Ds}, N_{Dd}			
increase N_{Ab}			
increase T			

Q6. **CMOS transistors.**

a) Make a sketch of a cross section of a CMOS transistor pair fabricated in an n-type substrate. Explain the working a CMOS inverter by showing and explaining the plot of V_{in} against V_{out}. (10 points).

b) For a CMOS inverter to behave 'symmetrically' (the same transient for switching on as for switching off) both n- and pMOS transistors must roughly have the same I-V characteristics. If both transistors have the same value of L, what should roughly be the ratio of their widths; W_n:W_p? (10 points).

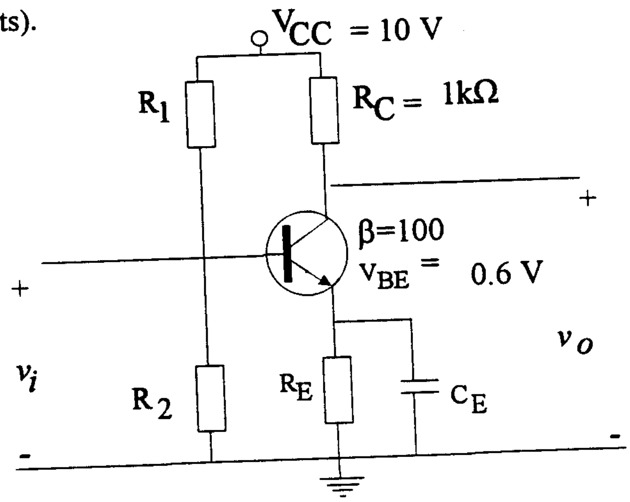
Q7. **Transistor circuit.**

Given below is a circuit configuration for a npn transistor.

a) Name the configuration and explain why it is thus named. This circuit leads to a stable biasing situation, even when e.g. the temperature changes. Explain why. (5 points).

b) For the given values of the voltages and components, determine the missing values of components when it is required that the output voltage swing must be 5 V. (10 points).

c) What is the function of C_E? (5 points).



Q8. **Thyristors.**

a) Sketch the basic construction of a SCR and explain the working of the device. (12 points).

b) How can the gate cuirrent control the breakover voltage? (8 points).

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
UNIVERSITY EXAMINATIONS NOVEMBER/DECEMBER 1996

EE452: ELECTRIC POWER SYSTEMS

Answer four questions.
Time: Three hours
Take $\mu_0 = 4\pi \times 10^{-7}\ H/m$ and $\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$

1.

Derive the power transfer equations between the receiving-end and the sending-end of a transmission system in terms of the ***ABCD*** constants. Explain how these equations can be used to construct the receiving-end and sending-end power chart, clearly indicating the implications of varying and keeping constant the receiving-end and sending-end voltages. [12]

A three phase transmission line, with a sending-end voltage of 132 kV is connected to a load of 20 MW at 0.8 power factor lagging. If the voltage at the load is 125 kV and a synchronous capacitor supplying 10 MVA is connected to the load busbar, determine the voltage, power and reactive power at the sending-end.

The constants of the line are:
$A = D = 0.916\angle 2.3^\circ$
$B = 240\angle 67.5^\circ\ \Omega$
$C = 7.36\times10^{-4}\angle 90^\circ$ S [13]

2.

Given that the general expression for flux linkages to a conductor i in a group of parallel conductors is $\lambda_i = \frac{\mu_o}{2\pi}\sum_{j=1}^{n} I_j \ln\frac{1}{d_{ij}}$, where I_j is the current in conductor j and d_{ij} is the geometric distance between conductors i and j, derive the expression of inductance per unit length per phase for a symmetrical three-phase transmission line. Using the technique of transposition, show that the inductance per phase per unit length of a general unsymmetrical three phase line is $L = \frac{\mu_o}{2\pi}\ln\frac{d_{eq}}{r'}$, where d_{eq} is the equivalent symmetrical conductor spacing. In your derivation clearly define d_{eq} and r'. [15]

A 200-km, 50-Hz, three-phase transmission line has each phase made up of a two-conductor composite phase with all the system conductors in a horizontal arrangement and the material of effective resistivity 0.025 μΩm. The diameter of each conductor is 3 cm and the distance between the centres of composite conductors in a phase is 12 cm. The effective phase spacings are 8.5, 8.5 and 17 m between the phases *Red* and *Yellow*, *Yellow* and *Blue*, and *Red* and *Blue*, respectively. Find the ***ABCD*** constants of the line [10]

3.

Describe the main considerations in the design of an overhead line concerning the conductors, insulators and towers, and the range of materials that can be used. In your discussion include the classification of these considerations under electrical, mechanical or other concerns.

[15]

An overhead transmission line is supported between two points on a hillside separated by a horizontal distance of 400 m at heights of 1125 m and 875 m above sea-level, respectively. The weight of the conductor is 9.5 N/m and the tension is 40000 N. Determine the vertical clearance between the conductor and a point on the hillside at 955 m above sea-level and a horizontal distance of 172 m from the lower support. [10]

4.

(a) Explain how the bus impedance matrix of an electric network can be used in the systematic method of evaluating faults, accounting for both solid short-circuits and short-circuits through an impedance, and stating the important assumptions. [8]

(b) A 20-MVA, 11-kV, 3-phase generator with a subtransient reactance of 12% supplies two identical synchronous motors, which have a combined load of 16 MW at 6.6 kV and unity power factor, through a 20-MVA 11/6.6-kV transformer. The leakage reactance of the transformer is j0.08 p.u. based on its own rating. The subtransient reactance of each motor is 16% based on 8 MVA and 6.6 kV.

Find, for a symmetrical three-phase short-circuit on the terminals of one of the motors, the sub-transient fault current in the generator and in each of the motors. [17]

5.

Distinguish between unit and non-unit protection schemes, and describe the principle behind the schemes that are defined as being purely time graded and purely current graded.

[8]

A 3-phase, 11-kV cable supplying Munali, Chainama and Chelstone in a radial connection, and fed at Munali, has fault levels during maximum load conditions of 250, 225 and 200 MVA at Munali, Chainama and Chelstone, respectively. The 11-kV circuit breaker at Chelstone, controlling the 11-kV / 415-V, 1-MVA transformer, is of the direct acting type with time-limit fuses which can be assumed to blow in 0.1 s for a 200 MVA fault on the hv side of the transformer. At Chainama, in the Chainama-Chelstone section and at Munali in the Munali-Chainama section are fitted 400/5 A CTs and IDMTL relays. Assuming a discriminative time margin of 0.5 s and relay plug settings such that for a 3-phase fault immediately on the remote side of the relay, the relay PSM has to be less than 20 by as small a margin as possible, calculate the plug settings and time setting multipliers of the relays at Chainama and Munali. IDMT relay characteristic is given by $t = \dfrac{0.14}{PSM^{0.02} - 1}$

[12]

If the maximum loads in the sections Munali-Chainama and Chainama-Chelstone are 2 and 1 MVA, respectively, check that the protection will not operate during maximum load conditions.

[5]

6.

(a) With the help of amplitude comparator circuits derive the marginal operating characteristic equation for a plain impedance relay. Hence show how the operating characteristic can be directionized to form the offset-mho relay. [9]

(b) Describe the arrangement and the operating principle of a power direction balance scheme as applied in unit protection schemes to protect a transmission line which has circuit breakers at both ends. [7]

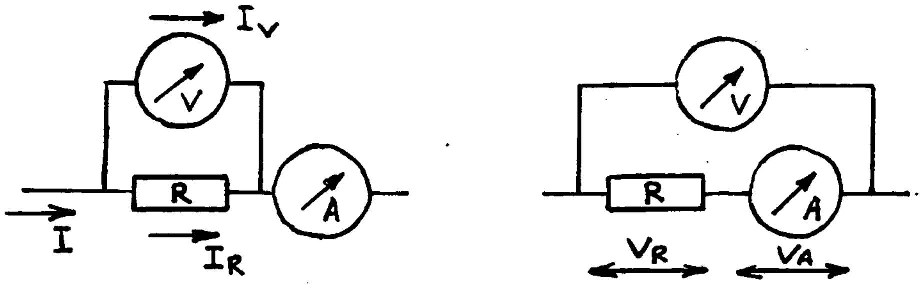
(c) Derive the operating characteristic of an IDMT relay explaining how in this relay current sensitivity and operating time can be varied. [9]

END OF EE452 EXAMINATION

THE UNIVERSITY OF ZAMBIA
School of Engineering, Dept of Electrical & Electronic Eng.
UNIVERSITY EXAMINATION SEMESTER 2 1996
ELECTRICAL INSTRUMENTATION EE462
time: 3 HOURS
ANSWER 5 QUESTIONS OUT OF 8
ALL QUESTIONS CARRY 20 POINTS

Question 1.

Consider two ways of measuring an unknown resistor **R**.



CIRCUIT A **CIRCUIT B**

Given:

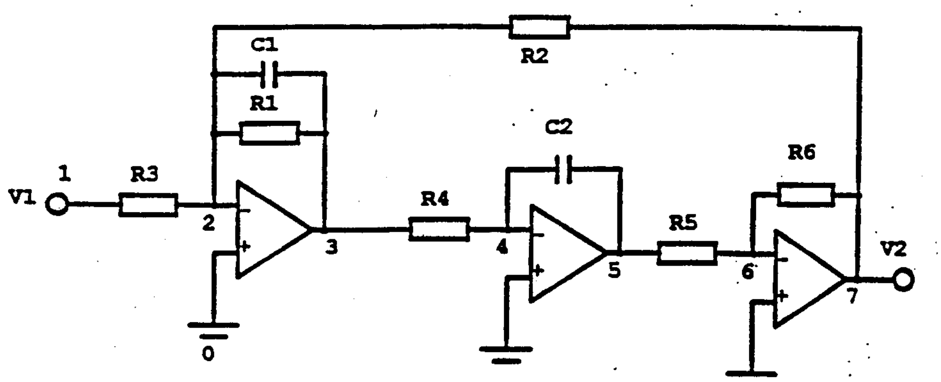
$R_{voltmeter} = R_V = 20k\Omega$
$R_{ampmeter} = R_A = 1k\Omega$
$R_{measured} = R_m = V/I$ (both circuits)
$R_{exact} = R_e = V/I_R$ (circuit A)
$R_{exact} = R_e = V_R/I$ (circuit B)

$$\text{Error} = E = \frac{|R_m - R_e|}{R_e} \times 100\%$$

a) Which circuit gives the best accuracy for high values of **R**? (4 points)
b) Derive the two graphs of the accuracy as a function of R/R_V and R/R_A. (8 points)
c) Find the break-even value of **R**. (8 points) That is the value for which the accuracies using circuit A or circuit B are the same.

Question 2.

Given is the following schematic:



$$T(s) = \frac{-1/R_3R_4C_1C_2}{s2 + s/R_1C_1 + 1/R_3R_4C_1C_2}$$

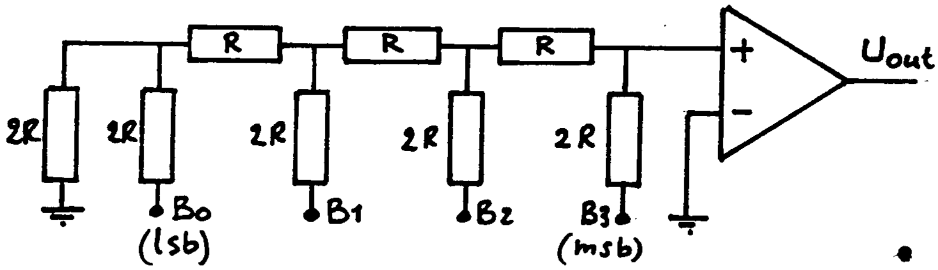
It can be proved that the relation between V_2 and V_1 can be normalised to:

$$V_2 = \left[\frac{-HV_1}{s + 1/Q} + \frac{-V_2}{s + 1/Q}\right](-1/s)(-1)$$

Prove that the quality vector **Q** and the central frequency **ω** and the gain **H** are orthogonal to each others operations. (10 points) Show the components that vary these variables in such a way.(10p.)

uestion 3.

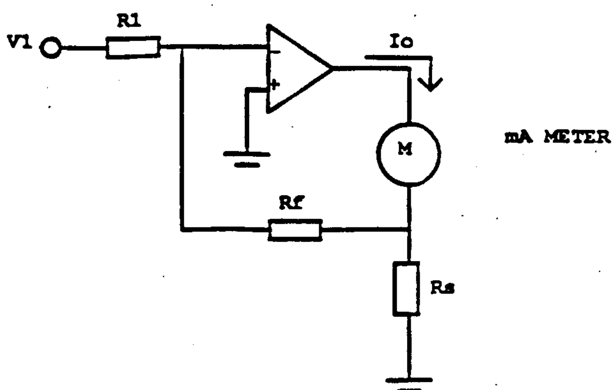
Given is an **R - 2R network** plus amplifier with gain 10.



The input bits are either 0 volt or +5 volt.

a) Find U_{out} if only B_0 (least significant bit) is connected to +5 volt while the others are grounded
b) The same for B_1.
c) The same for B_2.
d) The same for B_3.
Questions a) through d) carry 1 point each.
e) What digital input shall be applied for U_{out} = 15,625 volt (2 points)
f) What digital input must be applied for 40 volt output? (4 points)
g) How close to 40 volts can we come? (5 points)
h) How big is the relative error? (5 points)

estion 4.



The circuit above is used to measure 0 to 10 mV.
The input resistance of this circuit Rin = 1 MΩ.
Derive the values of the resistors if the mA meter has a range of 0 to 1 mA.

Question 5.

Given is a pressure transducer with following specifications:

Range 0.02 to 5 bar corresponding with an output voltage of -0.5 volt to +15 volt respectively.

Maximum pressure is 7.5 bar without damage.

This transducer is connected to a signal translator (transmitter), adjusted to give an output from 4mA to 20mA, when used to measure 0.8 to 4.0 bar respectively.

a) Describe for the transducer input the Upper and Lower operating limits, Upper and Lower Range, Overrange and Span. (2 points)
b) Calculate the transducer output for pressures of 1.15 bar and 2.81 bar. (6 points)
c) Find the transmitter outputs for these pressures. (6 points)
d) Explain why the standard describes 4mA as the lower limit in stead of 0mA? (3 points)
e) Why is a current signal from a transmitter usually preferred to a voltage signal? (3 points)

Question 6.

Give the three independent quantities in measurement. (10 points)
Mention the 7 base units in the International System. (5 points)
Explain why eg power and capacitance are derived units. (5 points)

Question 7.

General Purpose Interface Bus.

a) How many lines does the GPIB contain? (2 points)
b) How are the signals 0 and 1 defined? (2 points)
c) Give the names and describe shortly the function of the lines in the COMMAND BUS. (4 points)
d) Do the same for the CONTROL BUS. (4 points)
e) Make a time diagram and explain shortly how the handshaking procedure is performed. Assume there is only one talker and one listener. (8 points)

Question 8.

Describe a temperature measurement using analog transmission and also describe the hardware implementation and requirements. Use a circuit diagram to support your description. Give a detailed description of every component used in the diagram.

END

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

COMPUTER ENGINEERING
EE481

UNIVERSITY EXAMINATIONS, JUNE 1996.

TIME : **3 HOURS**

ANSWER : **QUESTION ONE IS COMPULSORY**

: **SELECT FOUR OTHER QUESTIONS FROM Q2 - Q8.**

: **ALL QUESTIONS CARRY EQUAL MARKS.**

Q1. You decide to computerise your electronic stores by keeping an inventory that can tell you what components you have, how many, and the cost. Write a program that reads and writes to the file "**device.dat**" of one hundred records, lets you input data concerning each component, enables you to list all your components, and update any information. The component ID number is used as the key. Use the information below to start your file (assume indexed file):

Record#	Component	Quantity	Unit_Cost
3	Capacitors	43	50.00
20	Diodes	50	100.00
43	Trans(BC108)	3	120.00

[20 points]

Q2. a). Describe segmentation as used in Intel 8086 processor, and state its advantage in a multitasking environment.

b). What is segment overlap as applied to the Intel 8086 processor? Explain why during segment overlap, each segment starts at an address that is divisible by 16_{10} i.e. in base ten.

Question 2 Cont..

c). Describe (with examples) how the effective address is obtained in the following addressing modes:

- register relative,
- based indexed,
- relative based indexed,
- intersegment indirect branch addressing.

d). What is the advantage of relocatable code and how can relocatability be implemented using a microprocessor with memory segmentation?

Q3. a). **Explain the difference between memory-mapped** I/O **and** I/O**-mapped** I/O.

b). Given the 8086 microprocessor system shown in **appendix-B.** Design around the processor buses, a fully decoded interface logic given the following: Assume an 8-bit data system,

-DRAM (The 6287 chip)
 with base address at 20000H-3FFFFH
-EPROM (The 2716 chip)
 with base address at 00000H-01FFFH

Show all the necessary connections to the processor. For the I/O ports only 10 address lines are required.

Show the memory map for the system.

Q4. The I/O channel, shown in the **appendix-C,** has interrupt request inputs indicated by IRQ3, IRQ4 ... . Internally these are connected to the system's programmable interrupt controller the 8259 which is internally decoded at I/O potrs 20H and 21H. In all cases, acknowledgement is done by interrupt service routines.

An A/D converter requests to transfer converted data though the 8255 (at 2F8H) chip's INTR line which is connected to the I/O channel's IRQ4.

(a) Decode the I/O devices and show the connection of the 8255 to A/D converter and I/O channel.

Question 4 Cont...

(b) Write an assembly code that programs the 8259A in the following mode(refer to **Appendix A**):
- a base interrupt vector at 8H with normal EOI, and edge-sensitive interrupts.

(c) If the interrupt service routine is at absolute address of 24231H, assume an IRQ4 is generated, determine interrupt number, the vector location and its contents. Describe the sequence of events that will occur from the time of request to transfer data to the end of data transfer.
- Include a sketch of the interrupt vector table.

Q5. Two computers communicate using serial ports (USART chip 8251A). The control port address is at 3A1H and data port at address 3A0H . Given the mode instruction format, command instruction format and status byte format as shown in **Appendix A;**

(a) Decode the 8251 and show (with the help of an assembly code) how you would program the 8251 to meet the following requirements:
- asynchronous mode of operation, 7 data bits (ASCII),even parity check,one stop bit, command instruction to enable only the receiver and transmitter and other functions ignored.

(b) Write an assembly program segment to program the 8251 as given above in (a) to read an ASCII character from the receiver and store it in register AL. (Hint: Utilise the status register).

(c) Refer to the I/O channel in the **appendix C.** The DRQ1 indicates a DMA request and the DACK1 represents acknowledgement to the DMA from I/O channel.
Given an I/O device that transfers data into memory using the DMA controller (chip 8257). Show how the device can be connected to the I/O channel using the system's internal DMA controller. Describe DMA single byte transfer using a single inactive processor cycle and assume a single wait state in DMA cycle.

Q6. **a).** Describe the steps required in a software development process.

b) What is structured programming?
- Discuss the principles of coupling, cohesion as applied to structured programming.
- Why is the principle of Egoless programmning encouraged

Q7. **a)** Describe the characteristics, operation and possible applications of the following data structures:
(include sketches for illustrations)

- Stack,
- queue,
- linked list.

b) Given the following declaration in C language:

```
#define          n   10
typedef          int   *ptr;
ptr         q ,  r[n] ,  *s ,   *t[n] ;
```

describe the variables q, r, s, and t.

Q8. **a).** Describe briefly the functions of an operating system (OS).

b). Describe briefly the following types of operating systems and give examples of implementations:
- single-user, single-tasking
- single-user, multitasking
- multiuser-user, single-tasking
- multiuser-user, multitasking
- multiprocessing
- networking

Question 8 Cont...

c) Assume that a DOS DEBUG program is used to trace through the program below. Describe in an annotated form or commented form the effect on the registers and memory location.

```
mov ax,1111
mov bx,2222
push ax
add ax,bx
push ax
pop cx
pop ax
mov [00],ax
mov [00+2],bx
mov ax,0
mov bx,0
push [00]
push [00+2]
pop ax
pop bx
add ax,bx
```

END OF EE481 EXAMINATIONS

APPENDIX A

7	6	5	4	3	2	1	0

Number of Stop bits (bits 7, 6)
00 - invalid
01 - 1 bit
10 - 1.5 bits
11 - 2 bits

Parity (bit 5)
0 - odd
1 - even

Parity enable (bit 4)
0 - disable
1 - enable

Character length (bits 3, 2)
00 - 5 bits
01 - 6 bits
10 - 7 bits
11 - 8 bits

Baud Rate (bits 1, 0)
00 - sync mode
01 -x 1 clock
10 - x 16 clock
11 - x 64 clock

8251 Mode instruction format.

EH	IR	RTS	ER	SBRK	RxE	DRT	TxE

8251 Command instruction format

DSR	SYNDET	FE	OE	PE	TxEMPTY	RxRDY	TxRDY

8251 Status byte

A_0								
0	0	0	0	1	LTIM	1	SNGL	IC4

8259 Initialisation Command Word 1

A_0								
1	T_7	T_6	T_5	T_4	T_3	X	X	X

8259 Initialisation Command Word 2

A_0								
1	0	0	0	SFNM	BUF	M/S	AEOI	1

8259 Initialisation Command Word 4

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
EE521 ELECTRICAL MACHINES II
SEMESTER I EXAMINATIONS
JUNE 1996

TIME: THREE HOURS
ANSWER FIVE QUESTIONS ONLY
EACH QUESTION CARRIES 20 POINTS

Q1.

From basic principles using: the specific electric loading (ampere conductor/meter); the specific magnetic loading (Tesla; rotor diameter(meter); and rotor length (meter) show that the VA rating of a polyphase induction machine is 111% that of a DC machine

Q2.

a) Given that the winding factor is the product of the winding distribution and coil-span factors only, define the nth harmonic voltage in terms of: numbers of coils/phase (slots/phase/pole); slot pitch = 180 Degrees/No.phases x coils/phase); conductor phase; and angle of departure from full-pitch of coil-span. Then explain how higher order harmonics and the nth harmonics can be eliminated using the slot-pitch and angle of departure from full pitch.

(b) The air gap flux distribution of a three phase, 50Hz, 1000 RPM alternator contains third and fifth harmonics of magnitudes 10% and 5% of the fundamental respectively.
Calculate the instantaneous voltage/phase generated, if the machine has a single-layer stator winding housed in 72 slots with 4 conductors/slot. The coil span is 120 Degrees (Electrical) and the fundamental flux/pole is 0.05 Wb.

Q3

(a) Given a voltage and current oscillogram from a slip test of a synchronous machine, how can the direct and quadrature axes reactances be calculated. In addition, how can the quadracture axis reactance be verified using the pull-out or maximum-lagging-current Test.

(b) What are the four necessary conditions for synchronism of two three phase ac supplies.

(c) Sketch the rms symmetrical a.c current and the dc component of current of an alternator under a sudden three-phase short circuit. Indicate on the current decrement curve envelope the three distinct stages with their respective current intercepts and time constants. What is the rms short circuit current and at what angle is the dc off-set a maximum.

If r_k = damper winding resistance; x_k = damper winding reactance; r_a = armature resistance; x_a = armature leakage reactance; r_f = field resistance; x_f = field leakage reactance; and x_m = direct - axis magnetizing reactance. Then define T_a, T_d (subtransient) and T_d (transient).

Q4

(a) A separately excited, four pole dc generator has its armature connected to a 190 Ohm resistive load. The machine is driven at 1200 RPM with the field unexcited. Find the equation for the variation of load current with time when 240 Vdc supply is suddenly connected to the field winding. The machine has the following parameters:

$K_f = (P/2)\ M_d\ i_f$, P=4
$E = K_f w_m$, M_d = 2.32H, R_a = 0.9Ohm,
L_a = 43mH, R_f = 440 Ohm and L_f = 39.6 H.

(b) Draw the torque and power characteristics of dc motors, indicating the regions for armature voltage control and field voltage control.

Q5.

(a) Draw schematic connection diagrams and phasor diagrams for: the split-phase motor, capacitor start motor and the shaded pole motor.

(b) Give a qualitative description of the starting of the above single phase motors in terms of the creation of a rotating magnetic field and the typical torque speed characteristic and starting torque parameters.

(c) A polyphase induction motor has a maximum (pull-out) torque equal to three times the gross full load value at rated voltage. The ratio of the rotor standstill leakage reactance to resistance is 3. What is the full-load slip? Calculate the ratio of starting torque to full-load torque for the cases of direct-on-line starting, star-delta starting, and autotransformer starting with a 60% tapping.

Q6

(a) With harmonic sources connected to a power system, harmonic currents will flow in the ac system, provided a path exists. List at least seven harmonic related problems that might occur in a power system. Give mathematical definitions for the current and voltage total harmonic distortion at a point of common coupling.

(b) Under what conditions can neutral inversion and neutral oscillation occur in three phase transformers? Demonstrate your answer using phasor diagrams.

(c) Give two methods of grounding delta connected transformer windings. Demonstrate your answer with schematic diagrams.

Q7.

(a) Briefly describe how maximum starting times of motors can be determined. Demonstrate your answer with torque speed characteristics.

(b) In view of temperature rise, when a motor is subjected to frequent starting it must be derated. State by way of a formula the major factors in determining the permitted output of a motor.

(c) Qualitatively describe the performance of motors as a function of altitude and duty type.

Q8.

(a) Given that the flux linkage and torque are functions of current and angular displacement. From first principles derive general torque equations in terms of stored energy and co-energy.

(b) Assuming a linear saturation curve, express the stored energy and co-energy in terms of inductance and reluctance as a function of angular displacement.

(c) Given a reluctance machine whose reluctance is a minimum at angular positions (0, PI, 2PI, etc), and a maximum at (PI/2, 3PI/2 etc). Plot the reactance as a function of angular displacement. Using a Fourier series expansion of the reluctance find the instantaneous values of torque as a function of angular position.

<u>END OF EE 521 EXAMINATION</u>

THE UNIVERSITY OF ZAMBIA
1995/96 SEMESTER II - FINAL EXAMINATIONS
NOVEMBER 1996

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EE 532 - POWER ELECTRONICS

ANSWER: FIVE QUESTIONS
TIME: THREE HOURS

ALL QUESTIONS CARRY EQUAL MARKS

Q1 (a) With the aid of suitable diagrams define the following terms in relation to a converter:
(i) natural commutation;
(ii) commutation delay;
(iii) commutation overlap;

(b) State and explain two conditions that are necessary for a naturally commutated converter to operate in the inversion mode and explain why, in practice, such a converter cannot operate with a delay angle of 180 degrees.

(c) Draw the circuit diagram of a naturally commutated three-phase bridge converter and, with the aid of voltage and current waveforms, carefully explain the conduction sequence of the semiconductor switches.

Q2 A three-phase half-controlled thyristor bridge rectifier supplies a load of resistance16 ohms in series with ~~and~~ an inductance that may be assumed to be infinite. A free-wheeling diode is connected across the load. The supply voltage is 380 V and commutation overlap may be neglected.

(a) Explain the significance of the free-wheeling diode;
(b) carefully sketch, with salient values, the voltage at the dc terminals for a firing angle of 90 degrees;
(c) sketch the current in the free-wheeling diode and determine the average and rms values;
(d) sketch the current in one thyristor

Q3 A three- phase, half -wave thyristor converter supplies a dc current of 15 A at 670 V when the firing angle is 30 degrees. The converter is supplied from a delta-star transformer energised from a source of 2.2 kV. Commutation overlap may be neglected.
Determine
(a) the turns ratio of the transformer;
(b) the r.m.s. current in the secondary and primary windings, and in the supply

lines and sketch the waveforms of all the three currents showing salient values;

(c) the peak-to-peak value of the ripple voltage and sketch its waveform with salient values.

Q4 The basic circuit of a single-phase bridge inverter is shown in Figure Q4. Explain the operation of this circuit over a complete cycle and sketch the load voltage and current waveforms, making clear the conduction intervals for all the semiconductor switches

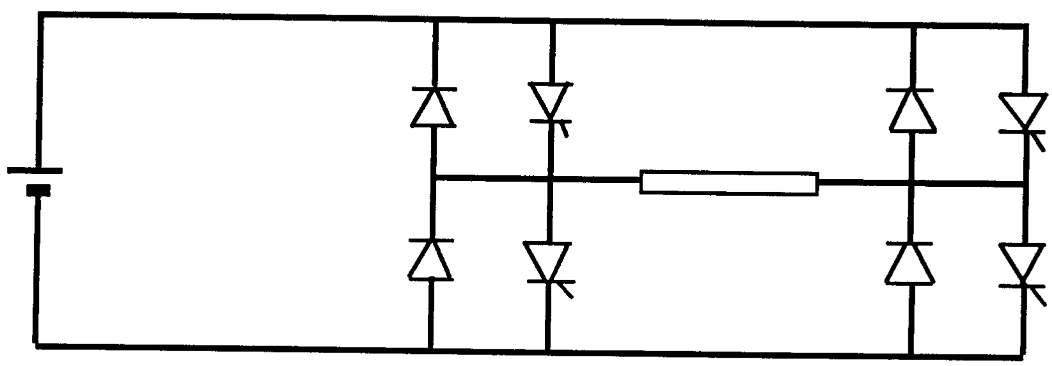


FIGURE Q4

Use the circuit of Figure Q4 to illustrate the use of pulse-width modulation to vary the load voltage of the inverter.

Q5 A separately-excited dc machine controlled by a three-phase bridge dual converter is in the regenerative braking mode. Using suitable diagrams explain the mechanical conditions at the motor and the electrical conditions in the dual converter during this mode.

In such a system, the machine is rated at 230 V, 11 A, 1500 rev/min and has an armature resistance of 2.1 ohms. The machine is coupled to a load whose torque varies as the square of the speed. The converter is supplied from a source of 380 V and, due to commutation, the converter dc voltage regulation is 0.08 V/A. Determine the firing angle of the converter when

(a) the machine motors at rated voltage and rated current;

(b) the machine generates at 80% of the rated voltage at rated flux with rated current;

(c) the machine motors at 800 rev/min with rated flux.

Q6 The load of a half-bridge inverter may be represented by an RLC series circuit. Sketch the waveforms of the load voltage and current when the circuit is (a) underdamped and (b) overdamped, and hence explain the conditions under which force commutation may not be required.

In such a circuit the load parameters are: R=10.9 ohms, L = 1.1 mH and C = 20 uF. Draw the circuit diagram and, neglecting the load current harmonics, sketch the load voltage and current, and the current in one feedback diode showing all salient values when the battery voltage is 240 V and the switching frequency is 1 kHz. If the minimum turn-off time of the thyristors is 50 microseconds, does the circuit require force commutation? Explain your answer.

Q7 For a naturally-commutated converter of pulse number m, derive, from basic principles, an expression for the current in an incoming device as a function of the supply voltage and the source parameters. Assume that the source impedance is predominantly reactive and state any other assumptions.

A three-phase controlled converter, capable of positive dc voltage output only and, connected to a source of 550 V, 50 Hz, supplies 120 A to a highly inductive load when the commutation delay angle is 15 degrees. Draw the configuration of the circuit and calculate the load resistance. Sketch to scale the variation of the average output dc voltage with respect to the firing angle in the range zero to 180 degrees.

Q8 Answer <u>THREE</u> of the following:

(i) Briefly discuss the advantages and disadvantages of hvdc transmission.

(ii) As a consultant, prepare short notes for a client who has to choose between an ac and dc drive, indicating important considerations in the operating environment.

(iii) Describe <u>three</u> effects of converter current harmonics on supply systems and explain the significance of the distortion factor with respect to the power factor.

(iv) Briefly explain the turning ON and turning OFF problems of a valve and describe three requirements of the firing signal for successful triggering.

END OF EXAMINATION EE532

University of Zambia

School of Engineering
Dept of Electrical and Electronic Engineering

Examination EE541
November 1996

All questions 20 points.
Answer only 5 questions.

Question # 1

In this differential amplifier the transistors T1 and T2 have the same properties. hfe=200 ,hre=0 , hie=4k, 1/hoe =50k.
Further R1=R2=10k and Vcc=15Volt.
The DC values of v1 and v2 may be set to zero.
The DC value of Vout =5 Volt.
A)Draw the circuits to measure the differential mode amplification Ad and the common mode amplification Ac
B)Prove that the only way to improve the common mode rejection rate CMRR is to increase the resistance R.
C)Calculate CMRR

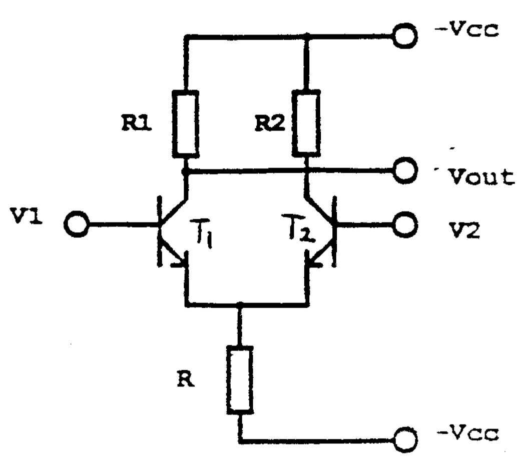


fig 1

Question # 2

In this circuit all transistors have the same properties.
hfe=200, hie=4k, hre=0, 1/hoe=50k.
The Zenerdiode has Vz=10 V and Iz= 1mA.
The supply voltage ic Vcc=15volt.
A)Calculate R1 and R2 to make the current in both T1 and T2 to be 100 uA.
B)The current-sink in the long-tail has a high Norton-resistance Rn.
Calculate the value of Rn
Calcultate the CMRR

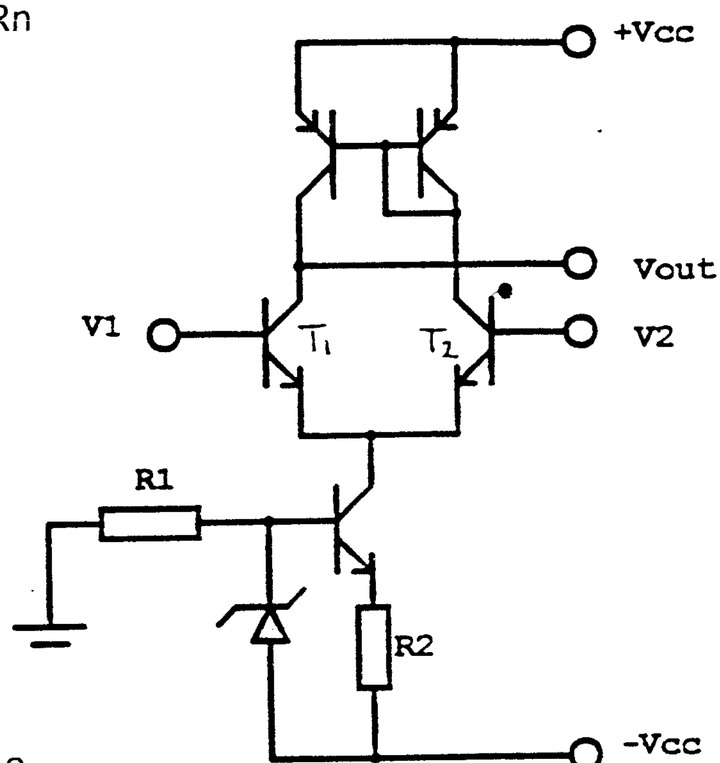


fig 2 .

Question #3

Calculate the output impedance in fig 2 .And try to improve the result by modifying the circuit without affecting the CMRR.

Question #4

The feedback circuit is in fig 3 using the simpified opamp-model in fig 4.
Calculate the input and output impedance if R1 =200k and R2=500k and Rl=100 Ohm,using the method used by Blackman.

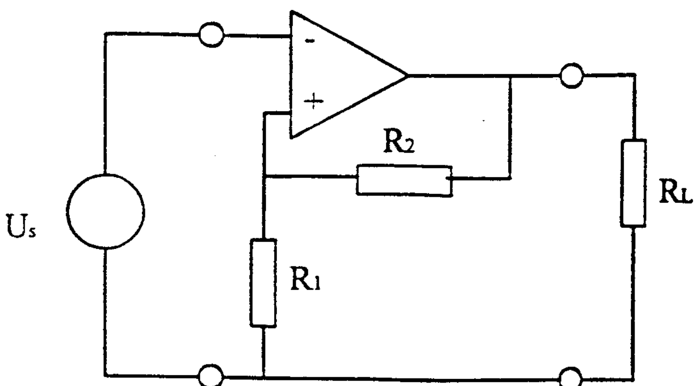


fig 3

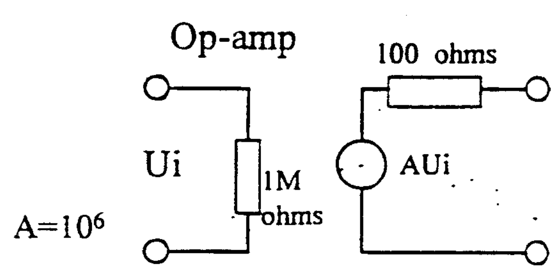


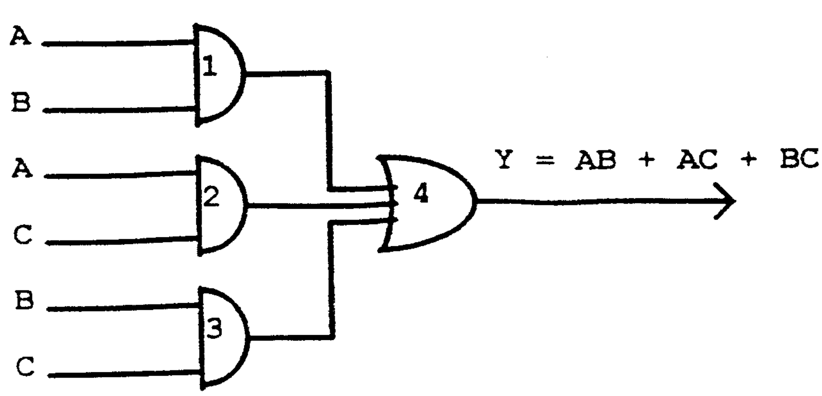
fig 4

Use the asymptotic gain model to calculate the feedback gain Af.
The formula to be used is

$$Af = A_{\infty} \times (-L)/(1-L) + \rho/(1-L)$$

Question # 5

Given the circuit that will test the majority between A, B and C.
Y=AB + BC +BC.
Calculate the testvectors that will show a stuck at zero error at the input B by usin the algebraic method of the Boolean difference.



Question #6

(a) Draw a clearly labelled artificial (simple) model of a neuron having three inputs x1, x2 and x3 and output y.

(b) Given eight input patterns and the corresponding desired outputs (y) shown in table 1 below, determine the complete weight vector. Use the delta learning for adapting the weights. Take $w=[-1,1,-1,1]^T$ as the initial weight vector.

	x_1	x_2	x_3	y
1.	0	0	0	0
2.	0	0	1	0
3.	0	1	0	0
4.	0	1	1	1
5.	1	0	0	1
6.	1	0	1	1
7.	1	1	0	1
8.	1	1	1	1

Table 1.

(c) A single neuron binary perceptron to perform the **AND** Boolean operation is to be designed. The perceptron should have two inputs. Given the initial weights as w_1=-1, w_2=1 and θ = -1.5, adapt the weights of the perceptron using the perceptron learning rule. Show your working clearly.

Question #7

(a) Explain the limitations of the single layer perceptron. Illustrate your answer with the **EXOR** function.

(b) Draw a basic multi-layered feed-forward neural network structure. The structure must show clearly the input, hidden and output layers.

(c) Briefly describe the back-propagation learning rule. And describe its significance

(d) A multi-layered neural network structure is a good function approximator. Describe a possible application of an artificial neural network structure in approximating a non-linear (optimal) controller.

(e) Apart from control, name two other areas where artificial neural network structures are being applied.

Question #8

(a) What is the difference between global learning and local learning? Illustrate your answer with the ***re-enforcement*** learning rule.

(b) Neural network structures are very useful for function approximation. However, they are not perfect approximators and usually have an approximation error after training. Name and explain three factors which determine this approximation error.

(c) What is meant by network ***overtraining***? Illustrate your answer.

(d) Explain what network validation means and why it is necessary.

THE UNIVERSITY OF ZAMBIA
School of Engineering, Dept of Electrical & Electronic Eng.
UNIVERSITY EXAMINATION JUNE 1996
CONTROL SYSTEMS EE561
time: 3 HOURS
ANSWER 5 QUESTIONS OUT OF 8
ALL QUESTIONS CARRY 20 POINTS

Question 1.

A. Given is the response of a certain system to a unity step input function. See figure Q1A.
a. Derive the time constant of this system. (5 points)
b. Find the location(s) of pole(s) and zero(s). (5 points)

B. Given is a controlled process (transfer function H_p), a proportional controller (H_c) and a feedback sensor (H_s). Fig Q1
a. Give the total transfer function **C/R**. (5 points)
b. Derive the system gain. (5 points)

Question 2.
Given is the transfer function of an open system:

$$H_s = \frac{K'(s+4)}{s(s+2)(s+20)}$$

This system is applied with a unity feedback.
a. What part(s) of the real axis (s-plane) belong(s) to the root locus? (2 points)
b. What is the number of asymptotes? (2 points)
c. What angles do the asymptotes make with the positive real axis? (3 points)
d. Where is the point of intersection of asymptotes with the re axis? (3 points)
e. Where about does the root locus leave the real axis (breakaway point)? Motivation requested. (5 points)
f. Give a sketch of this root locus. (5 points)

Question 3.
A simple mechanical accelerometer consists of a case with a mass spring-damper configuration as shown in figure Q3.
The position **y** of the mass with respect to the case is proporti to the horizontal acceleration of the case.
a. Determine the transfer function $\mathbf{H_1(s)}$ that relates **Y(s)** to a horizontal input acceleration **A(s)**. (2 points)
b. Determine $\mathbf{H_2(s)}$ that relates **Y(s)** to the input displacemen **X(s)**. (2 points)

Now assume **M** = 1 kg. **F** = 2 kg/sec. **K** = 4 N/m.
c. Determine the undamped frequency ω_n. (3 points)
d. Determine the damping ratio **z**. (3 points)
e. Position the pole(s) and zero(s) of $\mathbf{H_1(s)}$. (2 points)

This accelerator will receive a unity step input acceleration o **a(t) = 1(t).**
f. What will be the final value of **y(t)**? (2 points)
g. Find t_{peak}. (3 points)
h. Find the maximum overshoot. (3 points)

Question 4.

Given is a non-minimum-phase system represented by its poles and zero as shown in figure Q4. The system gain **K** = 1.

A. Unity step input.

a. Find **Y(s)**.

b. Find **y(t)**.

c. Derive the angle of departure in the time domain, (t=0) direc ly from **Y(s)**.

d. Check the value found in c purely based on **y(t)** only.

e. Plot **y(t)** graphically. (2 points each)

B. Impulse input (Dirac pulse).

Same set of questions as in **A.** (2 points each)

Question 5.

Given are the poles and zeros of output signal **Y(s)** as shown in figure Q5.

a. Derive the transfer function **H(s)** if the input is a unity step and the system gain **K** = 1. (2 points)

b. Give the transfer function if the input is an impulse functi (Dirac pulse) and **K** = 1. (2 points)

c. Give the components of the output signal **y(t)** related to ev individual pole. (3 points)

d. Same question as c, now for the zeros. (3 points)

e. Find the final value of **y(t)**. (3 points)

f. Find the initial value of **y(t)**. (3 points)

g. Find the angle of departure at t=0. (d**y(t)**/dt) (4 points)

Question 6.

Determine the steady state errors for the following situations (see figure Q6):

Disturbance **(D)** input signals:

a. step **(D=A/s)** b. ramp **(D=A/s²)** c. quadratic **(D=A/s³)**

Each applied to systems of types 0, 1 and 2.

So nine (9) answers are required.

Question 7.

Bode diagrams.

A. Give the definitions of:

a. Gain Margin. (3 points)

b. Phase Margin. (3 points)

c. For what purpose are these margins used? (4 points)

B. Derive the Bode diagram of:

$$H(s) = \frac{10(10s+1)}{s(s+1)(0.1s+1)}$$

Question 8.

Given a process H_p , a controller H_c (= K_c) and a sensor with t constant of 0.1 sec and a gain of 1. See figure Q8.

a. Determine the value of K_c where this system becomes unstable (10 points)

b. Determine the approximate value of K_c for a damping ratio z 0.5 (10 points)

END OF EE561 EXAMINATION

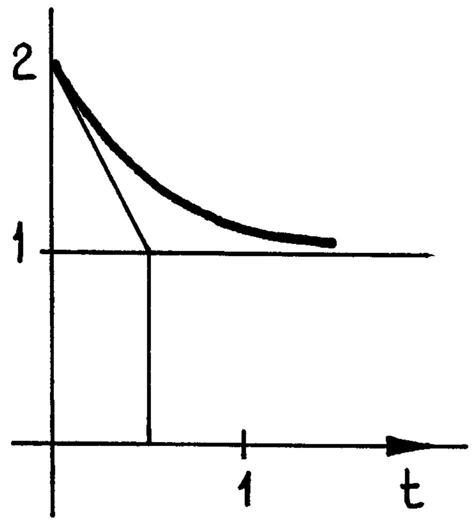


FIGURE Q1A

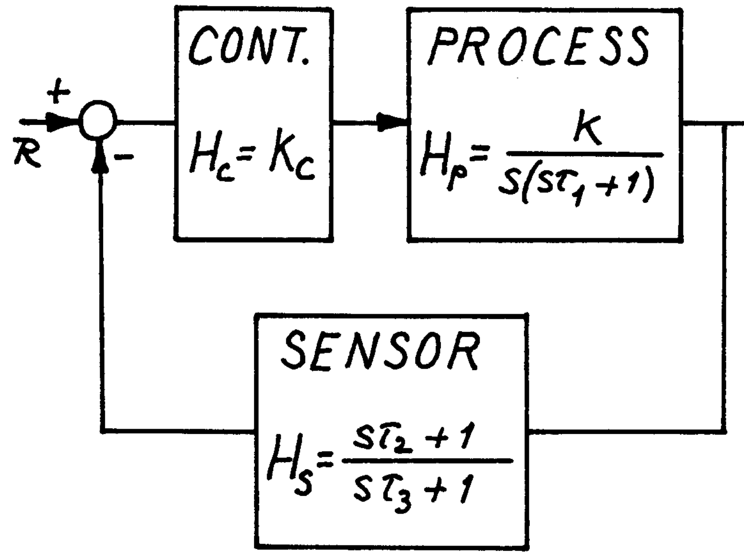


FIGURE Q1B

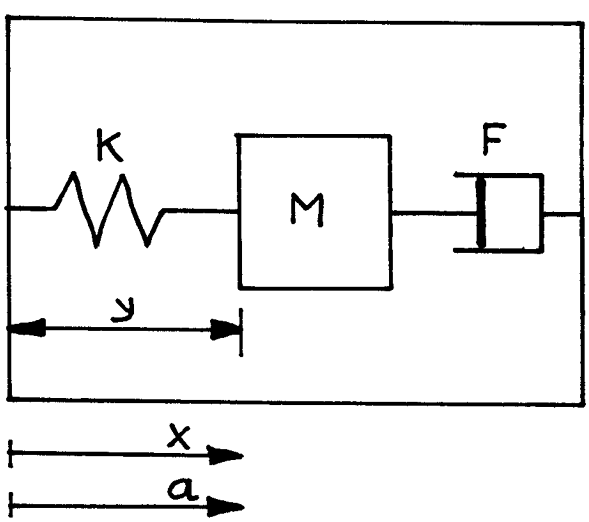


FIGURE Q3

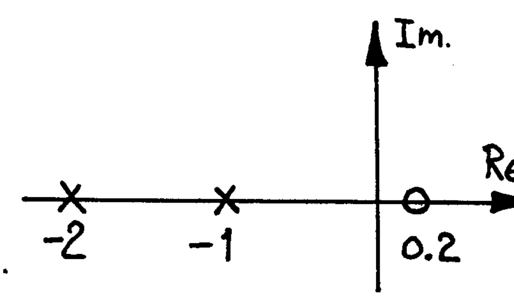


FIGURE Q4

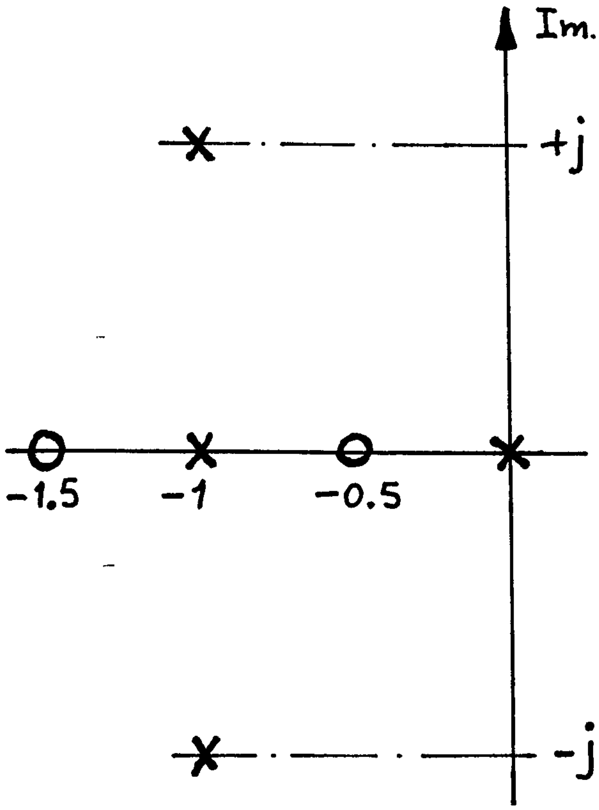


FIGURE Q5

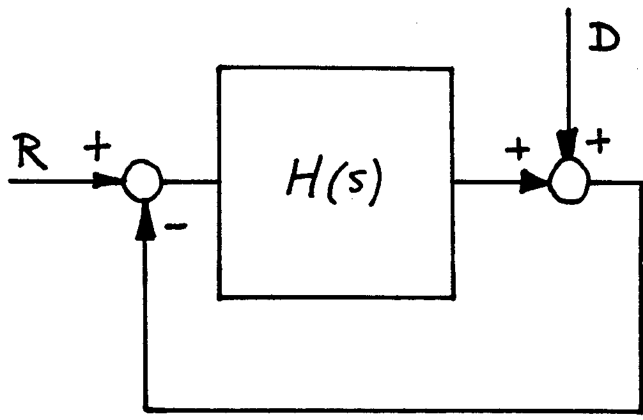


FIGURE Q6

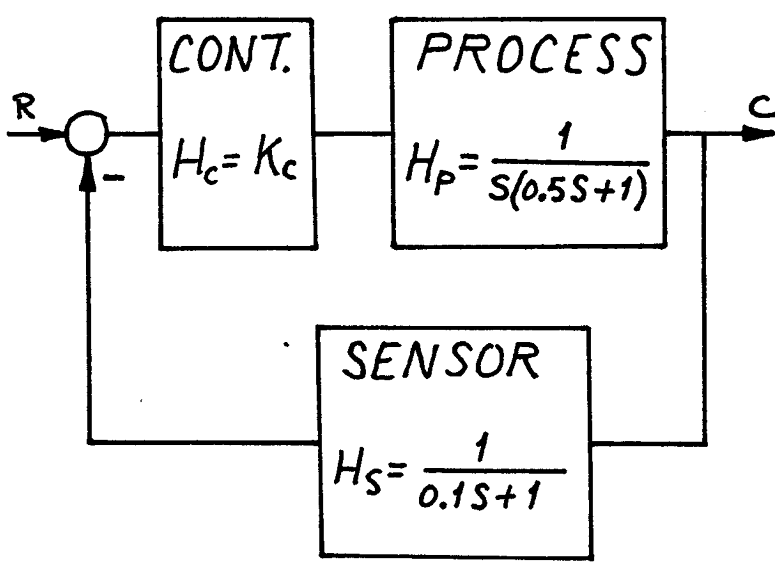


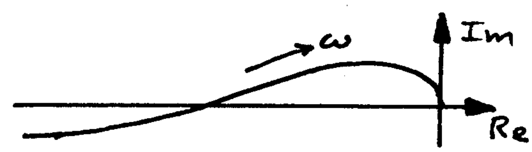
FIGURE Q8

EE 561 EXAM. 1996

THE UNIVERSITY OF ZAMBIA
School of Engineering, Dept of Electrical & Electronic Eng.
UNIVERSITY EXAMINATION 2ND SEMESTER 1996.
CONTROL SYSTEMS EE562 time: 3 HOURS
ANSWER 5 QUESTIONS OUT OF 8. ALL QUESTIONS CARRY 20 POINTS.

Question 1.

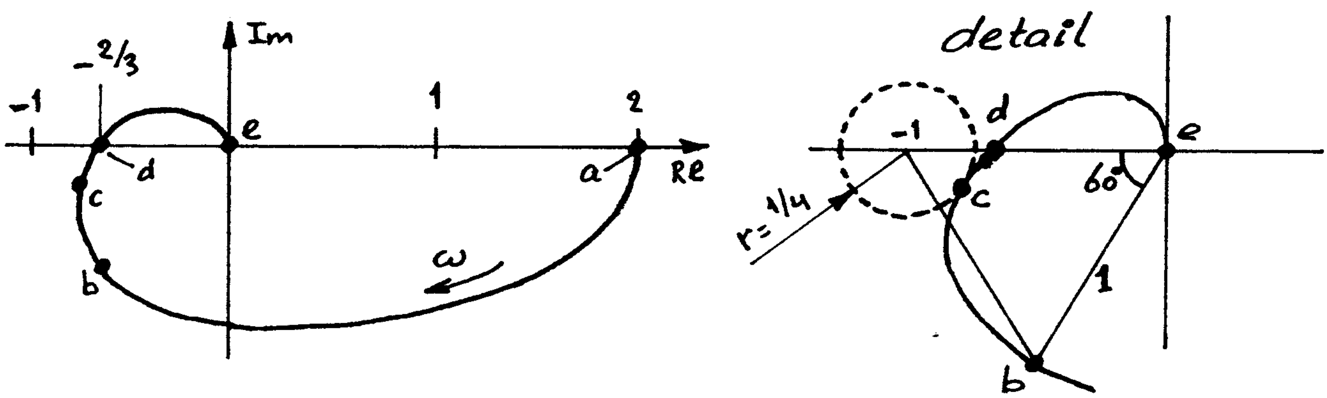
Given is the Nyquist diagram:



a. How many poles are located in the origin. (2 points)
b. How many zeros are there at least? (4 points)
c. Determine $\mathbf{n_p} - \mathbf{n_z}$, the number of poles minus zeros. (4 points)
d. Give the simplest transfer function and define the mutual relations between the various time constants. (10 points)

Question 2.

Given is the polar plot of an open control system:



This system gets a unity feedback.
a. Derive the polar plot of the closed system. (10 points)
b. Is this closed system stable? Why/why not. (5 points)
c. Give its Deviation Ratio. (5 points)

Question 3.

The characteristic equation of a given system is:

$$\mathbf{s^4 + 6s^3 + 11s^2 + 6s + K = 0}$$

a. Give the Routh Hurwitz table. (5 points)
b. What restrictions must be placed upon K in order to ensure that this system is stable? (5 points)
c. Find K for a marginally stable system. (2 points)
d. Derive the associated frequency of oscillation. (8 points)

Question 4.

Given is a first order, type zero, system: $\mathbf{H = \dfrac{1}{s+1}}$

This system's input is a step (1/s), sampled with T = ln2 sec.
a. Derive H(z). (1 point)
b. Derive the output response Y(z). (1 poins)
c. Find the output equivalent in the time domain, using the tables for the inverse z-transform. (2 points)
d. Find Y(kT) for k = 0, 1, 2 and 3 by long division. (3 points)
e. Find the initial value in the z-domain. (4 points)
f. Apply the final value theorem in the z-domain. (4 points)
g. Are the values found in e and f consistent with the values found in c and d? Explain. (5 points)

TABLE: $1/s \Leftrightarrow \dfrac{z}{z-1}$ $\quad 1/(s+a) \Leftrightarrow \dfrac{z}{z-e^{-aT}} \Leftrightarrow e^{-at}$

Question 5.

The position of a robot arm as a function of the steering input is defined by the transfer function:

$$H = \frac{1}{s(s+4)}$$

A first order PD controller has to be designed in order to meet the following specifications:

1. **tpeak** $= \pi / 6\sqrt{3}$ (=0.3 sec.)
2. relative damping $z = 0.5$

Controller and robot are part of a unity feedback system.

a. Translate these specs into pole positions. (2 points)
b. What is the location of the controller's pole, given that its zero is at -4? (4 points)
c. Find K'(root locus gain).(4 points)
d. Find K (system gain) of the PD controller. (4 points)
e. Sketch roughly the response to a unit step input. (6 points)

Question 6.

Given is an industrial process with the transfer function:

$$H = \frac{K'}{s(s+5)(s+20)}$$

K' (root locus gain) = 100
K (system gain) = 1

This process should be controlled in order to meet the following design specifications:

1. relative damping $z = 0.7$
2. $t_{peak} = 0.1\,\pi$

a. Translate these specs into pole positions. (2 points)
b. Show that these specs cannot be met with a proportional con troller only. (3 points)
c. A phase lead compensation network (differential network) with a zero at -10 will be applied.
Show that it is even not possible to meet the specs by using this network. (5 points)
d. Now a second (identical) phase lead network in series is used. Where must the pole of such a network be located? (10 points)

Question 7.

a. Give a definition of state-space feedback. (5 points)
b. Given is the transfer function:

$$H = \frac{ab}{s^2+(a+b)s+ab}$$

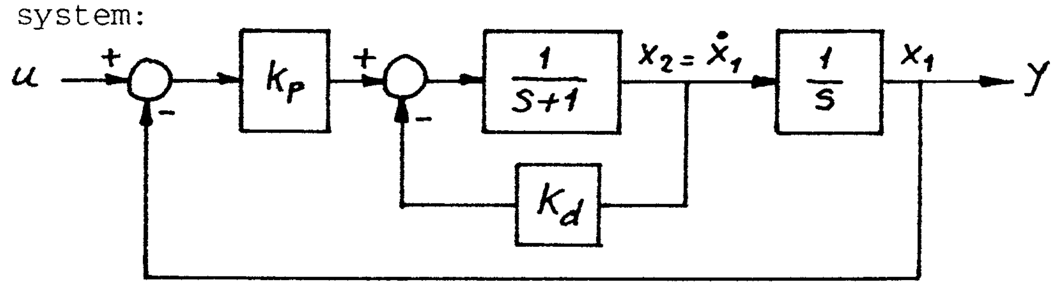
The corresponding state-space notation is in the form of:

$$\dot{x} = Ax + bu \qquad y = cx$$

Find A, b and c. (15 points)

Question 8.

Given is the system:



Find K_p and K_d if the A matrix of this system is $\begin{pmatrix} 0 & 1 \\ -2 & -2 \end{pmatrix}$

END OF EE562 EXAMINATION

University of Zambia

School of Engineering
Dept of Electrical and Electronic Engineering

Examination EE572
June 1996

All questions 20 points.
Answer any 5 questions .

Question # 1

A satellite travelling in an orbit around the earth transmits a radio-signal at aconstant frequency of 100 MHz.
Due to the speed of the satellite compared to the grounstation there is a Doppler shift in the frequency causing the bandwidth of the receiver to be minimal 10Khz.
At arrival at the receiver the signal to noise ratio S/N =1.The signal is processed by a phase locked loop circuit.
Show that the maximum modulation frequency f_M of the satellite will be f_M= 100Hz if the phase locked loop circuit is to improve the S/N to be better than S/N =100.

Question # 2

Give the various components of a complete phase locked circuit and discuss the various parts and their function.
Give a diagram showing how the parts are to be connected.

Question # 3

A lowpass filter will be designed to be of the Butterworth-type.
The -3 dB point is set at a frequency of f_o = 100 Hz and at a frequency of $f = 1.25 \times f_o$ a minimum damping of -10 dB will be required.
Determine the order n of the filter.

Question #4

Use the polynomials in the table given on the last page of this exam to make a design of a 5th order lowpass filter .
Use the Sallen and Key circuit to make the active components of the circuit.
Calculate the value of the value of all passive components if the resistors are set to be R= 10K Ohm and f_o= 10 K Hz.

Question #5

Use the bi-quad filter theory to design a lowpass filter of the 5th order .(Use table on the last page of this exam) .If R= 10 KOhm and f_o=10 KHz.
Give the circuit diagram and calculate the passive components present in the circuit. What are the properties of this circuit compared with a circuit using Sallen and Key.

Question #6

In digital signal processing the XOR circuit can be used to perform as a phase-detector. Give a circuit diagram showing the output of the circuit as a function of both input signals.
Why can you say that this circuit can have superior properties above an analog phase detector.

Question # 7

Show that the following circuit can work as a voltage controlled oscillator. Please add if necessary components and terminals and calculate the components so that the circuit will function at a frequency f_o= 10 KHz keeping R1= 10 KOhm.
Give the terminal on which the regulating voltage is to be supplied.

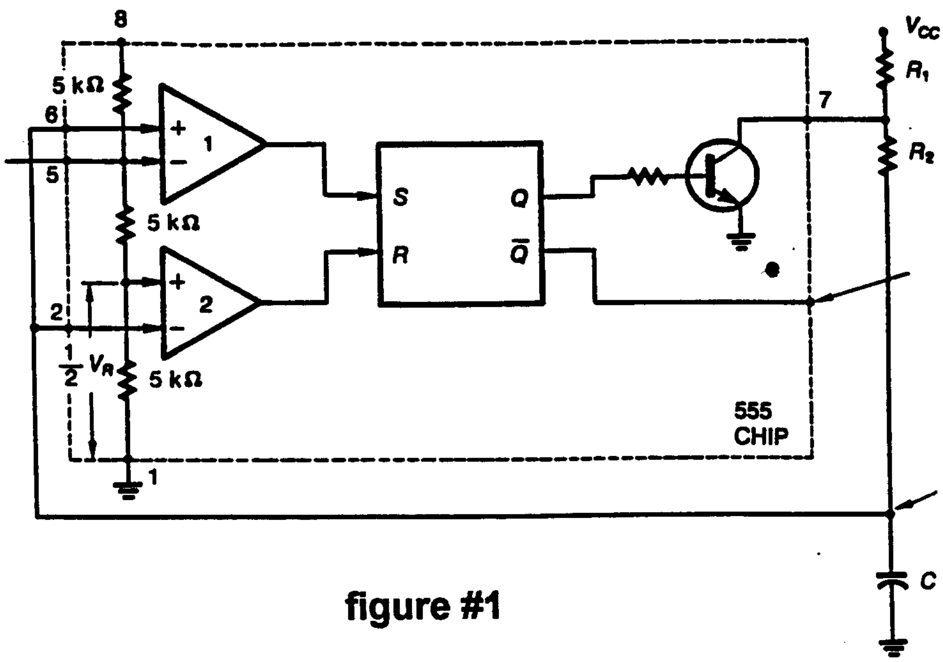


figure #1

Question #8

Show that the duty-cycle of the output-signal of the circuit (in figure1) will always be greater than 50 percent.
Calculate the value of R2 if the duty-cycle is

End of examination.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS - NOVEMBER, 1996

EG 212 - ENGINEERING WORKSHOP TECHNOLOGY

TIME: **THREE (3) HOURS**

ANWER: **ALL 4 SECTIONS** **CLOSED BOOK**

ANSWER EACH SECTION IN A SEPARATE ANSWER BOOKLET

SECTION A: SURVEYING (25 MARKS)
ANSWER ALL FOUR QUESTIONS

1. Give definitions of the following terms:

   a. GIS
   b. Passive microwave systems
   c. Quality control
   d. Vertical (2+2+2+2 marks)

2. Solve the following problem

   Given: The coordinates of point A (643000, 8298000) and point B (643440, 8297720) in the UTM coordinate system (units in meters).

   The measurements to a third point C

   $\alpha_{ABC} = 51° 20' 36''$
   $D_{BC} = 758.26$ m

   Calculate the coordinates of C.
   Give all intermediate results in positive decimal degrees.
   Make a sketch of the situation including the coordinate system. (5 marks)

3. a. What are the basic measurements we can obtain from a

   (i) Theodolite
   (ii) Level
   (iii) GPS receiver

(iv) Stereoplotter.

b. Describe an application where measurements of two or more different instruments as mentioned above are combined (4+2 Marks)

4. a. Use the following terms in a description about map projections:

`map coordinates', `projection method', `projection formulae', `latitude/longitude', `parallels and meridians.'

b. Mention three different map projection methods (3+3 Marks)

END OF SECTION A

SECTION B: ELECTRICAL ENGINEERING WORKSHOP (25 marks)
ANSWER ALL THREE QUESTIONS

1. Describe the major differences between TN-S, TN-C and TT forms of earthing of an electrical distribution system in terms of the neutral and protective functions. Clearly show the differences using sketches. (10 marks)

2. Why are circuit breakers and fuses used in the supplies for electric power and electronic circuits. How can we ensure that the step and touch potentials are within safe limits for all equipment in a workshop or laboratory. (5 marks)

3. Give five practical applications of electronic circuits and five applications for electric motors in domestic, commercial and industrial environments(10 marks)

END OF SECTION B

SECTION C: CIVIL ENGINEERING WORKSHOP **(25 marks)**
CHOOSE ONE QUESTION ONLY.

Q1. (a) Define the term 'design' and state the objectives of design as used in civil engineering. (8 marks)

(b) Describe the process of design, indicating the different stages and parties involved. (10 marks)

(c) List the common materials used in civil engineering construction and comment on their properties in relation to their suitability in construction. (7 marks)

Q2. (a) List the various types of roofing materials used in Zambia. Which two are the most common in urban areas? (7 marks)

(b) List the eight steps in tendering out a Civil Engineering project (9 marks)

(c) Write short notes on the following types of contract:

(i) Lump Sum
(ii) Cost-Reimbursable
(iii) Direct Labour (9 marks)

END OF SECTION C

SECTION D: MECHANICAL ENGINEERING WORKSHOP **(25 marks)**
ANSWER BOTH QUESTIONS.

Q1. (a) List the 5 areas safety deals with, according to the Factories' act and safety provision. (5 marks)

(b) State the 4 most common hazard prevention tenets, when operating a milling machine. (4 marks)

(c) List any 6 of the 12 most common methods of accident reduction. (6 marks)

Q2. (a) Briefly describe (with diagrams) the 3 forms of extrusion (6 marks)

(b) List the most common fluxes used in soldering and briefly outline the role they play in the soldering process. (4 marks)

END OF SECTION D

END OF EG 212 EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

UNIVERSITY EXAMINATIONS - NOVEMBER 1996

INTRODUCTION TO COMPUTING (EG 279)

TIME: THREE HOURS

INSTRUCTIONS: QUESTION ONE IS COMPULSORY; ANSWER IT AND ANY OTHER FOUR QUESTIONS.

QUESTION ONE:

When invoicing customers, the invoice clerk has to work out the discount allowable on each order. Any order over K 500,000 attract a "bulk" discount of 7.5%. In addition, a customer within the trade (A Trade Customer) is allowed a 15% discount. There is also a special 5% discount allowed for any customer who has been ordering regularly for over 2 years.

A) Construct
- i) a flowchart
- ii) a decision table
- iii) a pseudocode

to illustrate the management's policy.

B) State the possible advantages and disadvantages of using each of the following:
- i) a flowchart
- ii) a decision table
- iii) a pseudocode

QUESTION TWO:

A)

DATA		DATA		INFORMATION
	======>		======>	
INPUT		PROCESSING		OUTPUT

The above illustrates, in a simplified way, the three phases of Data Processing irrespective of whether the system is a manual or computerised. You are required to define the following terms:

- i) DATA
- ii) DATA PROCESSING
- iii) INFORMATION

B) i) In regard to a computerised system, define and describe the main features of the term "Multi-Programming".

ii) One of the many services provided by a bureau is "Timesharing". Explain what is meant by this term and how the users gain access to the computing facilities.

QUESTION THREE:

A) The term "COMPILER" and " INTERPRETER" are often used in the area of computer software. Compare and contrast the operations of a computer program using these two methods.

B) Explain the difference between a low level language and a high level language, illustrating your answer by stating the advantages and disadvantages of each type.

C) i) What is a sub-routine (or sub-program)?
ii) State the advantages of using sub-programs.

QUESTION FOUR:

A) The Central Processing Unit (CPU) is the "brain" of the computer. It is a collection of electric circuitry and registers that carry out the processing. The CPU is divided into three areas:

i) The Control Unit
ii) The Arithmetic and Logic Unit
iii) The Memory

Briefly describe each of the three areas of the CPU above, explaining what their specific functions are.

B) Distinguish between a DATABASE and a DATABASE MANAGEMENT SYSTEM (DBMS).

C) i) What is an Expert System?
ii) Briefly describe the features of an Expert System.

QUESTION FIVE:

All the questions under question five below relate to the Operating System, UNIX.

a) You are in a directory called /usr/mail/spool/peter. You want to go to your home directory. What is the shortest command that will achieve this?

b) To find out which directory you are in now, which command can you use?

c) To rename a file, which command will you use?

d) To find out the user names of the persons currently logged in, which command will you use?

e) What are the three possible file permissions you have seen?

f) Which three sets of persons do file permissions in unix apply to?

g) What are the two main modes of the Screen Editor "vi"?

h) Which command would you use to list all files in a directory whose file names are three characters long?

i) In a directory /dev, there are a list of files that are actually devices. You are interested in finding out the names assigned to disk devices. You know that they have the first two characters as "fd". How will you give the command to list only disk drive files?

j) You type in a command to display the contents of a file named "f1" on the terminal screen. You find that the output is scrolling up very fast. How will you modify the command such that you can see the output with pauses?

QUESTION SIX:

A) i) Trace the following part of a program and find the resulting value of x.

```
x := 1;
n := 3;
y := 1;
repeat
   x := x * y;
   y := y + 1;
until y > n;
```

ii) Re-Write the above code by means of a FOR loop.

iii) Re-Write the above code by means of a WHILE loop.

B) i) Trace the following part of a program and specify the final value of x.

```
x := 2;
for i := 1 to 2 do
   for j := 1 to 3 do
      x := x * x;
```

ii) Deduce the formular for the result as function of the initial value.

QUESTION SEVEN:

A) The program below is to display results across your computer screen. Using a dry run, simulate and write down the results exactly as they would appear after execution of the same program.

```
program displayresults (output);
var line, position, number : integer;
begin
  writeln;
  writeln ('The square of ');
  for line := 0 to 2 do
  begin
    for position := 1 to 2 do
    begin
       number := line * 2 + position;
       write (number:2, ' = ', (number * number):4, '      ')
    end;
    writeln
  end;
end.
```

B) Suppose we have the following declarations:

```
program p;
var p1, p2 : real;
    procedure a;
    var a1, a2 : real;
        function b;
        var b1, b2 : real;
        begin
          !
          !
          !
          !
        end;
    begin
      !
      !
      !
      !
    end;
begin
  :
  :
  !
  !
end.
```

Specify exactly parts of the program where the following could be used:
p, p1, p2, a, a1, a2, b, b1, b2.

C) i) The following program contains syntax errors and semantic errors (errors of logic). Identify these errors and say which of them would be detected by the pascal compiler.

```
program average (input, output);
* finds average of whole numbers on a line
var int total; count;
        real average:
begin
    while not eoln
        read n
        total = total + n;
        count = count + 1;
        writeln ('Average is ', count/total)
end
```

ii) Re-Write the program so that it is correct in syntax and semantics.

QUESTION EIGHT:

A) Write a pascal program to read a list of numbers and print the smallest number in the list. The program should read numbers from the screen and the output should be similar to the following format:

The smallest number is "a".

Where "a" is the smallest number in the list.

B) Write a pascal program to read three numbers from the screen and arrange them in increasing order. The output should be in the following format:

A <= B <= C

Where A, B & C are the numbers read.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JUNE 1996

EG 279

INTRODUCTION TO COMPUTING

TIME: 3 HOURS

ANSWER: ALL QUESTIONS IN SECTIOIN A:

ANSWER THREE QUESTIONS IN SECTION B:

CLOSED BOOK (TEXT BOOKS & NOTES) EXAMINATON.

SECTION A (25 MARKS)

1. The following statements appeared in a FORTRAN 77 program. What direct effect would these statements have on the output when such a program is run?

```
.
.
OPEN(UNIT = 1,FILE = 'TELEPH.DIR')
.
.
WRITE(UNIT=1,*) NAME,PHONE
.
.
CLOSE(UNIT=1)
END
```

2. Name three categories of Applications software.

3. Which programming tool is used to create, administer and secure access to a database?

4. What is meant by 'Resident Software'?

5. Programming languages for the preparation of 'source programs' are usually classified into two groups: what names are given to these groups?

6. Distinguish between a translator and a linker program with respect to the process leading to the creation of an executable FORTRAN 77 program.

7. Name the data types most commonly used in FORTRAN 77.

8. Name the three broad forms in which information can be out-put from a computer.

9. Under which category of software would you classify 'bootstrap program'?

10. Distinguish between a subroutine subprogram and a function subprogram.

SECTION B (75 MARKS)

1. The following FORTRAN 77 program has been written by a second year student in the School of Engineering at the University of Zambia.

```
      PROGRAM SORT10
*-----------------------------------------------------------------
*     READ 10 NUMBERS INTO AN ARRAY SORT INTO ASCENDING ORDER
*     AND DISPLAY THE SORTED LIST
*-----------------------------------------------------------------
      INTEGER NUMS(10:1)
      REAL I,K,TEMPORARY
*     --READ IN DATA
      DO 40 I=1,20
         WRITE(*,*)'TYPE VALUE ',I
         READ(*,*)NUMS(I)
40    CONTINUE
*     --SORT THE NUMBERS INTO ASCENDING ORDER OF MAGNITUDE
      DO 60 I=1,9
       DO 50 K=I+1,10
        IF(NUMS(I).GT.NUMS(K) THEN
*         --SWAP CONTENTS OVER
          TEMPORARY = NUMS (K)
          NUMS(K) = NUMS(I)
          NUMS(I) = TEMPORARY
       ELSE
       ENDIF
60   CONTINUE
50   CONTINUE
     --WRITE OUT THE SORTED LIST
     DO 70 I=1,10
       WRITE(*,*) 'RANK ',I,' VALUE IS ',NUMS
100   CONTINUE
      END
```

The student comes to you for advice on the errors resulting from the compilation of the program. Advise accordingly, pointing out the likely causes of errors.

2. Write brief notes on any three of the following:

   (i) Spreadsheet

   (ii) Databases

   (iii) Wordprocessing

   (iv) Computer graphics

3. Show the necessary steps you would take in preparing a FORTRAN 77 program that solves a set of two simultaneous equations.

4. Describe the use of the following control statements in FORTRAN 77; use examples to aid your explanation.

   (i) The IF()THEN-ELSE-ENDIF construct

   (ii) The DO-Loop

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - NOVEMBER 1996
EG 475
ENGINEERING, MANAGEMENT AND SOCIETY I

ANSWER: **FIVE QUESTIONS, CHOOSING TWO QUESTIONS FROM SECTION A AND ONE QUESTION FROM EACH OF SECTIONS C AND D. SECTION B IS COMPULSORY.**

TIME: **THREE HOURS**

SECTION A - COST ACCOUNTANCY

Q1. (a) The following relates to two possible capital projects of which you have to select one to Invest in. Both projects have an initial capital cost of K200 000 and only one can be undertaken.

		Project	
	Expected profits	X	Y
		K	K
Year	1	80 000	30 000
	2	80 000	50 000
	3	40 000	90 000
	4	20 000	120 000

Estimated resale
Value at the end of

	X	Y
Year 4	40 000	40 000

(i) Profit is calculated after deducting straight line depreciation

(ii) The cost of capital is 16%

(iii) Relevant discount factors are:

Years	1	2	3	4	5
	0.862	0.743	0.641	0.552	0.476

For both projects calculate the following:

(i) Pay back period to one decimal place (5 marks)

(ii) Accounting rate of return using average investment (5marks)

(iii) The net present value. (6 marks)

(b) Rank the Investment projects of preference and advise the Board which project in your opinion should be undertaken. (4 marks)

(Total 20 marks)

Q2. (a) Your organisation has no system for authorising and controlling capital expenditure. The Managing Director has asked you, as Cost Accountant to review this situation.

Draft a memorandum to your board of directors detailing a scheme for capital expenditure authorisation, briefly explaining each stage in your system. (10 marks)

(b) (i) What is meant by cost of capital and why is it important in coming to an investment decision. (3 marks)

(ii) State two ways in which risk can be taken into account when making capital investment decision. (3 marks)

(iii) State the 4 relative merits and 4 demerits of:

(1) Accounting Rate of Return (2 marks)
(2) Pay back period (2 marks)

(Total 20 marks)

Q3. (a) Explain the following terms:

(i) Continuous or rolling budget (2 marks)
(ii) Fixed budget and flexible budget (difference) (6 marks)

(iii) Budget Manual (2 marks)
(iv) Budget Period (2 marks)

(b) Distuit Limited Manufactures two major products, A and B. Data necessary for the preparation of the June budget are as follows:

Produce	A	B
Sales Units	1200	1300
Selling price per unit	K200	K 210

Raw materials required in Manufacturing Units

X (Unit costs K50)	4	3
Y (Unit costs K60)	6	8
Z (Unit costs K40)	2	-

Projected finished Goods

	A	B
Stocks		
1st June	1000	500
30 June	1500	1000

Projected Raw Materials

	X	Y	Z
Stocks: 1st June	16000	18000	12000
30 June	17000	19000	11000

Prepare the following budgets:

(1) Sales Budget
(2) Production Budget
(3) Raw Materials Usage Budget
(4) Purchase of Raw Material Budget (8 marks)

(Total 20 marks)

SECTION B - COMMUNICATION

Q4. (a) List five major sources of unclarity in technical writing

(b) From the following sentences, remove the redundancies. (2.5 marks)

(i) With proper planning, we can prepare high quality proposal in a space of a four weeks.
(ii) He will still have sufficient quantity of attitude control gas.
(iii) Switch the range of the meter to the 0 to 50 volt dc range.
(iv) The temperature ranged from a minimum of 1000 to 1800°C.
(v) The power generation is not physically in the building. (2.5 marks)

(c) Rewrite the following sentences in Active voice.

(i) The extraction is sumplified by the new components.
(ii) The pressure is measured by a transducer.
(iii) A variable-gain control is included in this circuit.
(iv) The three photographs are shown in Fig. 4.
(v) However, for the final test four cycles were used. (2.5 marks)

(d) What are the main differences between References and a Bibliography? (2.5 marks)

(Total 10 marks)

SECTION C - ECONOMICS I

ANSWER ANY ONE QUESTION FROM THIS SECTION

Q5. (a) Suppose a consumer's utility is derived from two goods, x and y according to the utility function:

$$U(x,y) = \ln x + \ln y.$$

The consumer has income I to spend; the prices of the two goods are p_x and p_y. Derive the first-order conditions for the equilibrium of the consumer and give their economic interpretation.

(12 marks)

(b) Suppose the demand function for a good is:
$Q = (a - p)/b$.

Find the expression for the elasticity of demand.

(5 marks)

(c) The demand curve for a firm's product is given by:
$Q = 40 - 4P$

The average cost function is given by:
$AC = 5 + Q + 100Q^{-1}$

Find the output which will maximize the firm's profit.

(8 marks)

(Total 25 marks)

Q6. (a) Using a linear market-clearing model, derive and interpret in economic terms the conditions that will ensure:

(i) the existence of the equilibrium price;
(ii) the dynamic stability of the equilibrium price.

(18 marks)

(b) Describe a circular flow model of the economy involving firms, households, financial institutions and the government.

(7 marks)
(Total 25 marks)

SECTION D - ECONOMICS II

ANSWER ANY ONE QUESTION FROM THIS SECTION

Q7. Consider a project with the following data:

Activity (i,j)	Duration (Dij)
(0,1)	2
(0,2)	3
(1,3)	2
(2,3)	3
(2,4)	2
(3,4)	0
(3,5)	3
(3,6)	2
(4,5)	7
(4,6)	5
(5,6)	6

(a) Draw the network corresponding to the above project. (10 marks)

(b) By identifying the activities with zero slack, trace the critical path through the network. What is the duration of the critical path? (15 marks)

(Total 25 marks)

Q8. The following tableau respresents a specific simplex iteration (in a Linear Programming problem):

-Z	X1	X2	X3	X4	X5	X6	X7	X8
620	0	-5	0	4	-1	-10	0	0
12	0	3	0	-2	-3	-1	5	1
6	0	2	1	3	1	0	3	0
10	1	-1	0	0	6	-4	0	0

(a) Identify the basic sequence in the above tableau and the solution to the basic variables. (2 marks)

(b) If the rules of the simplex method are followed, which would be the next entering basic variable and the corresponding leaving variable? (3 marks)

(c) Obtain the revised tableau if the next entering basic is X2. (20 marks)

(Total 25 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1997

EG 475

ENGINEERING. MANAGEMENT AND SOCIETY I

ANSWER: FIVE QUESTIONS, CHOOSING TWO QUESTIONS FROM SECTION A AND ONE QUESTION FROM EACH OF SECTIONS C AND D. SECTION B IS COMPULSORY.

TIME: THREE HOURS

SECTION A - COST ACCOUNTANCY

1. A manufacturing company produces one product only. The following standard data is available:

Selling price per unit	K50
Variable cost per unit	K10
Total fixed cost	K100,000
Budgeted output	3000 units

Required:

(a) Calculate the breakeven point in units and monetary terms. 8 marks

(b) Draw the breakeven chart. 8 marks

(c) Describe in your own words the meaning of breakeven point. 4 marks

2. The following standard costs apply in a business that manufactures a single product.

Standard weight to produce one unit 12 Kg
Standard price per Kg K9
Standard hours to produce one unit 10
Standard rate per hour K4.

Actual production and costs for one accounting period:

Material used	3770 Kg
Material cost	K35815
Hours worked	2755
Wages paid	K11571

The actual output was 290 units.

Required:

(a) Calculate

(i)	Total material cost variance	2 marks
(ii)	Material price variance	2 marks
(iii)	Material usage variance	2 marks
(iv)	Total Labour cost variance	2 marks
(v)	Labour Rate variance	2 marks
(vi)	Labour Efficiency variance	2 marks

(b) Define Standard cost and Standard costing. 4 marks

(c) List down 4 methods of capital investment appraisal. 4 marks

3. (a) State 3 purposes of the cash budget. 3 marks

(b) The following information relates to SHULA Products Limited:

Month	Material Purchases K000	Sales K000	Overhead K000	Wages Incurred K000
February	20	30	8	3
March	30	40	10	4
April	25	60	11	9
May	30	60	13	6
June	30	70	15	7
July	25	80	5	10
August	25	50	2	1
September	30	50	4	3

(i) It is expected that the cash balance on 31 May will be K38000.

(ii) The sales are on credit, the customers are allowed <u>three</u> months credit period.

(iii) All purchases are on credit, the suppliers allow <u>three</u> months credit on purchases.

(iv) There is <u>one month</u> delay in paying the overhead expenses.

(v) The wages may be assumed to be paid within the month they are incurred.

You are required to:

1. Prepare a cash budget for each of the three months of June, July and August. 13 marks

2. State 3 items which are not shown in the cash budget. 1.5 marks

3. List down in order the sequence of functional budgets. 2.5 marks.

SECTION B - COMMUNICATION

4. (a) List the main components of a paper for publication in a technical journal. 3.5 marks

(b) From the following sentences, remove the redundancies

(i) What does the future hold in store?
(ii) A few additional spare tracks should be added.
(iii) Printed wires link together the test points.
(iv) The acoustical noise should be reduced.
(v) The powder is fed to the heater by means of vibrators. 2.5 marks

(c) Rewrite the following sentences in Active Voice.

(i) The threshold level was lowered by chlorine.
(ii) The faculty is accommodated in the new building.
(iii) The current is converted by the diode.
(iv) The noise to signal ratio is reduced by special filters. 2 marks

(d) List four ways in which a long passage in a chapter may be made clear, if it contains several distinct issues. 2 marks

SECTION C - ECONOMICS I

ANSWER ANY ONE QUESTION FROM THIS SECTION.

5. (a) Consider the consumer's utility maximization problem:

$$\text{Max } u(X,Y) = 2XY$$

$$\text{S.t. } P_xX + P_yY \leq M$$

Where $u(X,Y)$ is the utility function of the consumer, X and Y are commodities, P_x and P_y are prices of X and Y respectively, M is income.

For this problem, set up the consumer's utility maximization problem and derive the first-order conditions for a maximum. 12 marks

(b) Explain and illustrate graphically how a consumer maximizes utility. 8 marks

(c) Define the term elasticity of demand. Compare and contrast price and income elasticity of demand. 5 marks

6. (a) What is the economic problem? Explain how firms, households and other sectors interact in the market. 8 marks

(b) Explain and illustrate how monetary and fiscal policy work. What are the strong points and weak points of both policies? Explain. 17 marks

SECTION D - ECONOMICS II

ANSWER ANY ONE QUESTION FROM THIS SECTION.

7. Suppose we have the following total revenue, TR, and total cost TC, functions:

$$TR = 300Q - 6Q^2$$

$$TC = 400 + 3Q^2 + 30Q$$

(a) Obtain the total profit, given the information above. 10 marks

(b) Obtain the profit-maximizing level of output, Q^* given the information above. 15 marks

8. (a) What is linear-programming? Compare and contrast the concepts linear- and non-linear programming. 8 marks

(b) Explain and illustrate numerically how the simplex method is employed to solve linear-programming problems. What other methods would you employ to solve a linear-programming problem? Explain. 17 marks

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
UNIVERSITY EXAMINATIONS JUNE 1996

EG575: ENGINEERING, MANAGEMENT & SOCIETY II

Time: Three hours
Answer five (5) questions, with at least one from each section; use a separate answer booklet for each question.

Section I: Legal Aspects of Engineering

1.

PAT MAT Engineering Company Limited was a subject matter of an order for compulsory liquidation. The liquidator decided to offer the premises belonging to PAT MAT Engineering Company Ltd to MM Laundry Services on 16th June 1995. The purchase price for the premises was K 60 000 000. On 18th June 1995, MM Laundry Services replied and indicated that they were ready and willing to purchase the property at K 55 000 000. On 21st June 1995, the liquidator offered and sold the same premises to WHY NOT Building Contractors at K 60 000 000. On 23rd June, 1995, MM Laundry Services informed the liquidator that they were retracting their proposal of 18th June, 1995 to purchase the property at K 55 000 000. They were now ready and willing to pay the K 60 000 000 earlier on demanded by the liquidator. The liquidator informed MM Laundry Services that the premises had since been sold to WHY NOT Building Contractors.

MM Laundry Services, infuriated by the turn of events decides to sue the liquidator. Advise MM Laundry Services regarding their position at law.

2.

(a) Describe the character and hierarchy of the Zambian Court System.
(b) Define and describe the doctrine of stare decis.

3.

Write short notes on the following.

(a) Consideration must be real.
(b) Revocation of an offer.
(c) Intention to create legal relations.
(d) Communication of acceptance.

Section II: Industrial Management

4.

Discuss the functions of management in one of the following institution:

ZESCO
Minestone
ZAMTEL
Chilanga Cement Plc
GRZ Department of Surveying
ZCCM.

5.

"If you can successfully run an engineering business in Zambia, you would run it even more successfully anywhere else in the world". Discuss this sentiment with reference to Zambia's current business operating environment.

Section III: Technology, Development and the Engineer.

6.

(a)
Discuss various activities in which engineers are involved in their day to day work.

(b)
What are the distinctions between science, technology and technology management?

7.

Compare and contrast technology transfer by foreign direct investment and contractual arrangements. Which of the two modes possesses better prospects for developing indigenous technological capacity?

8.

Describe and discuss the impact of technical assistance on the third world.

END OF EG575 EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
UNIVERSITY DEFERRED/SUPPLEMENTARY EXAMINATIONS JULY 1996

EG575: ENGINEERING, MANAGEMENT & SOCIETY II

Time: Three hours
*Answer **five** (5) questions, with at least one from each section; use a separate answer booklet for each question.*

Section I: Legal Aspects of Engineering

1.

On 5th July 1996, Muyongwe wrote to Mulando offering to sell him his Toyota Hilux van at K5 000 000 and requested Mulando to respond to the offer by return of post not later than 12th July 1996. However the letter of offer was wrongly addressed and as a result reached Mulando on 10th July 1996. On the same day, 10th July 1996, Mulando posted the letter of acceptance of the offer. The letter of acceptance reached Muyongwe on 15th July 1996. In the meantime, on 13th July 1996, Muyongwe had offered the same Toyota Hilux to Mutangama.

Obviously Mulando is infuriated by the turn of events and decides to sue Muyongwe. Advise Mulando.

2.

Write short notes on the following.

(a) The relationship between Common Law and Equity.
(b) Distinguish an offer from an invitation to treat.
(c) Termination of an offer.
(d) Consideration.

3.

Describe in detail the essential elements of a valid contract.

Section II: Industrial Management

4.

Discuss the role of Industrial Relations in industry.

5.

Discuss the functions of management in engineering industry.

Section III: Technology, Development and the Engineer.

6.

(a) Discuss the main bodies of the Engineering Institution of Zambia.

(b) Discuss the possible violations an engineer is likely to meet in his day to day practice. How would these be minimised?

7.

Discuss the pros and cons of Bilateral and Multilateral technical assistance. Zambia's recent experience could be cited as a basis for your argument.

8.

Compare and contrast technology transfer by foreign direct investment (FDI) and contractual arrangements. Highlight the advantages and disadvantages of each of the two modes.

END OF EG575 EXAMINATION

THE UNIVERSITY OF ZAMBIA

SEMESTER (1) ONE DEFERRED/SUPPLEMENTARY EXAMINATIONS - 1996

EM211 - ENGINEERING MATHEMATICS I

TIME ALLOWED: Three(3) Hours.

INSTRUCTIONS: Answer Any five(5) questions.

Q1. An acute counter-clockwise rotation of axes is applied to remove the xy-term from the equation

$$x^2 + 2xy + y^2 - \sqrt{2}x + \sqrt{2}y = 0$$

and obtain the corresponding equation in XY-coordinate system.

a) Find the corresponding equation in the XY-coordinate syst
b) Idintify and sketch the graph.
c) Find the equation(s) of the Latus Rectum/Recta in the xy-coordinate system and show it/these on your diagram.
d) Find the coordinates of the Focus/Foci in the xy-coordina system and show it/these on your diagram.

Q2. a) State, without proof, for a function f on the closed interval $[a,b]$,

i) the Mean Value Theorem, and
ii) Rolle's Theorem.

b) i) Show that if a function f satisfies the hypothesis Mean Value Theorem on $[a,b]$ and $m \le f'(x) \le M$ for $x \in [a,b]$, then

$$m(b-a) \le f(b) - f(a) \le M(b-a)$$

ii) Hence, show that

$$\frac{1}{3} \le \ln\left(\frac{3}{2}\right) \le \frac{1}{2}$$

c) Verify that the function $f(x) = 1 + \cos(2x)$ satisfies Rol Theorem on the interval $[0,\pi]$. Find all the numbers $c \in (0,\pi)$ for which $f'(c) = 0$.

Q3. Evaluate the following indefinite integrals:

i) $\displaystyle\int \frac{dx}{x^2\sqrt{x^2-5}}$ ii) $\displaystyle\int \sin^{-1}(x)dx$

iii) $\displaystyle\int \frac{dx}{2 + \cos x}$

Q4. a) Find the area of the region bounded by the graphs of $f(x) = 4 - x^2$, $g(x) = -x - 2$ and $h(x) = 3x - 6$.

b) Calculate the volume of the cone obtained by rotating the region bounded by the graph of $f(x) = x$ and the x-axis for $0 \le x \le 3$, about the x-axis.

Q5. a) Find the point of intersection P, for the lines:

$$L1: \quad x - 1 = \frac{2 - y}{2} = z - 5$$

$$L2: \quad \frac{x - 2}{2} = \frac{5 - y}{9} = \frac{z - 2}{6}$$

b) Show that the point A(0,4,4) lies on L1.

c) Find the distance of the point A from the point P.

d) Calculate the cosine of the angle between the two lines in (a).

e) Hence, determine the component of the vector $\overline{PA}$ in the direction of the line L2.

Q6. A point P starts from the point (0,1,0) and moves in space with velocity given by

$$\overline{V}(t) = \frac{1}{1+t}\,\hat{i} - \sqrt{1 + t}\,\hat{k}$$

a) Find the acceleration at $t = 0$.

b) Find the speed at $t = 0$.

c) i) Determine the position vector $\overline{R}(t)$ at time t and

ii) hence, determine the distance travelled during the first second.

d) Determine the distance of the particle from the origin after 4 seconds.

END

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1997

EM 212

ENGINEERING MATHEMATICS

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS

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1. (a) Determine whether the following infinite series converge or diverge:

(i) $$\sum_{n=1}^{\infty} \frac{\cos^2 (n\pi)}{1 + n^2}$$

(ii) $$\sum_{n=1}^{\infty} \frac{e^n}{n^2}$$

(b) For what values of x does the infinite series

$$\sum_{n=1}^{\infty} \frac{x^{n-1}}{n3^n}$$

converge

(i) absolutely

(ii) conditionally

2. (a) Give a general expression for the Taylor series expansion of a function $f(x)$ about a point $x = a$.

(b) If $f(x) = \ln(1+x)$, obtain a Taylor series expansion of $f(x)$ about the point $x = 0$ and determine the range of x for which the series converges.

(c) What is the maximum value of x that would make the approximation $\ln(1+x) \approx x$. Such that the error is less than one percent of the absolute value of x?

3. (a) The power consumed in an electrical resistor is given by $P = \frac{E^2}{R}$ watts. If E and R are measured with an error of at most one percent:

   (i) Find the approximate value of the maximum error in the computed value of P.

   (ii) If E = 240 volts, and R = 8 ohms, by how much does the power change if E and R are decreased by 10 volts and 2 ohm respectively?

   (b) Determine the relative maximum, minimum and saddle points of the function

$$f(x,y) = 4y^3 + x^2 - 12y^2 - 36y.$$

4. Solve the following differential equations with the given conditions

   (a) $(x^3 + y^3)\,dx - xy^2\,dy = 0$ given $y = 0$ when $x = 1$

   (b) $\frac{dy}{dx} = \frac{2x - \sin y}{x \cos y}$ given $y = 0$ when $x = 2$

   (c) $\frac{d^2y}{dx^2} + 2\frac{dy}{dx} = yx + 3e^x$

5. (a) If $x = r \cos \theta$ and $y = r \sin \theta$ show that

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = \frac{\partial^2 f}{\partial r^2} + \frac{1}{r}\frac{\partial f}{\partial r} + \frac{1}{r^2}\frac{\partial^2 f}{\partial \theta^2}$$

If f is a function of x and y.

(b) If f is a continuous function of x and y, and if x and y are continuous functions of r and θ i.e. $x = g(r, \theta)$ and $y = h(r, \theta)$, state the chain rules for the partial derivatives

(i) $\dfrac{\partial f}{\partial r}$

(ii) $\dfrac{\partial f}{\partial \theta}$

(c) Find the general solution of

$$\frac{d^2y}{dx^2} - \frac{dy}{dx} = e^x \sin x.$$

Using the method of variation of parameters.

6. (a) Reduce the matrix A given below to echelon form, and then to its row canonical form.

$$A = \begin{pmatrix} 2 & 1 & 4 \\ -1 & 1 & 4 \\ 7 & 1 & 3 \end{pmatrix}$$

(b) By a series of elementary row operations, find the inverse of a matrix B given below indicating at each step the row operation being used.

$$B = \begin{pmatrix} 2 & 0 & 5 \\ 1 & 2 & 2 \\ -1 & 1 & -3 \end{pmatrix}$$

(c) Deduce the inverse of B^t (without row reduction). Hence or otherwise solve the system

$$\begin{aligned} 2x + y - z &= 1 \\ 2y + z &= 2 \\ 5x + 2y - 3z &= 1 \end{aligned}$$

7. Let V be an n-dimensional vector space over a field K.

(a) Define a basis of V

(b) Determine whether **u**, **v**, **w** in V are linearly independent where

$$u = \begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix} \qquad v = \begin{pmatrix} 1 & 0 \\ 0 & 2 \end{pmatrix} \qquad \text{and} \qquad w = \begin{pmatrix} 0 & 3 \\ 2 & 1 \end{pmatrix}$$

(c) Find all the eigen values of matrix A, and a basis of each eigen space where

$$A = \begin{pmatrix} 1 & 2 & 2 \\ 1 & 2 & -1 \\ -1 & 1 & 4 \end{pmatrix}$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS
EM311 MATHEMATICS
1996 JUNE EXAMINATIONS

ME ALLOWED: 3 HOURS

STRUCTION: ANSWER ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

---

a) Show that the substitution $|Ax + B| = e^z$ or $z = \ln|Ax + B|$ will reduce the differntial equation

$$a(Ax + B)^2 \frac{d^2y}{dx^2} + b(Ax + B)\frac{dy}{dx} + cy = 0$$ to a linear differential equation with constant coefficients.

b) Find a complete solution of the differential equation $x^2y'' + 2xy' - 12y = \sqrt{x}$.

a) Define regular singular point of a second order linear differential equation.

b) Determine if the differential equation $xy'' + (\lambda - x)y' + 3y = 0$ has a regular singular point. Hence show that one solution of the given differential equation is

$$1 - \frac{3}{\lambda}x + \frac{3}{\lambda(\lambda+1)}x^2 - \frac{1}{\lambda(\lambda+1)(\lambda+2)}x^3 .$$

thout solving, discuss how the other solution will be found when $\lambda = 2$.

a) By completing the square or otherwise show that the roots of the equation $x^4 + 4 = 0$ are $1-i$, $1+i$, $-1+i$, $-1-i$.

b) A particle moves in a plane so that its coordinates at time t satisfy the simultaneous differential equations

$$\frac{d^2x}{dt^2} - 2y = 0, \qquad \frac{d^2y}{dt^2} + 2x = 0$$

Find the position of the particle at any time t. By evaluating
e determinant of the Operatinal coefficients. determine the number of
dependent arbitrary constants that must be there in any complete solutio
the given system and confirm that the complete solution you have
und has that many arbitrary constants.

Let the operator 'L' represent Laplace transform.

a) Find L(t cost) and hence show that $L(\sin t - t\cos t) = \dfrac{2}{(s^2+1)^2}$

b) Let the function f(t) be defined by

$$f(t) = \begin{cases} \sin t & 0 \le t \le \pi \\ 0 & t > \pi \end{cases}$$

Express f(t) in terms of the unit step function. Hence find Laplace transform of the function f(t).

c) Solve the differential equation $\dfrac{d^2y}{dt^2} + y = f(t).\ t \ge 0.$

$y(0) = y(3\pi/2) = 1$ where f(t) is the function defined in part b.

Verify that $e^{-n^2t}\sin\left(\dfrac{nx}{c}\right)$ is a solution of the heat equation

$$\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}. \text{ Hence show that } \sum_{n=1}^{m} a_n e^{-n^2 t} \sin\left(\frac{nx}{c}\right).$$

Where $a_1, a_2, \ldots a_m$ are arbitrary constants, is also a solution of the heat equation satisfying the boundary conditions $u(0.t) = 0$ and $u(\pi c,\ t) = 0$

b) Apply Picard's method to the following initial value problem. Determine also the exact solution and compare.

$Y' = xy + 2x - x^3,\ y(0) = 0$

6. a) If m and n are integers prove that

$$\int_{-\pi}^{\pi} \sin mx \sin nx \, dx = \begin{cases} 0 & \text{when } m \neq n \\ \pi & \text{when } m = n \end{cases}$$

b) Find the even periodic half range expansion of the function

$$f(x) = \frac{2k}{L}x \qquad \text{if } 0 < x < \frac{L}{2}$$

$$= \frac{2k}{L}(L - x) \qquad \text{if } \frac{L}{2} < x < L$$

and represent it graphically.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS AND STATISTICS

SECOND SEMESTER EXAMINATIONS, NOVE/DECEMBER 1996.

EM312

TIME ALLOWD: Three (3) Hours.

INSTRUCTIONS: Answer any five (5) questions. All working must be sho
for full credit.

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1. a) Explain what type of quadric surface in R^3 space is represented by the following equations.

   i) $xz - 1 = 0$ ii) $36x - 9y^2 - 16z^2 = 0$

   b) Find parametric equations of the line in space through $(-1,2,3)$ that is perpendicular to each of the two lines having parametric equations

$$x = -1 + 3t \qquad\qquad x = -1 - t$$
$$y = 2 \qquad \text{and} \qquad y = 2 + 3t$$
$$z = 3 - t \qquad\qquad z = 3 + t$$

2. Find the parametric equations of the normal line to the surface $xyz = 4$ at point $(1,2,2)$.

   b) The height of a mountain is givey by $h(x,y) = 3000 - 2x^2 -y$ where the x-axis points north, the y-axis points east and all distances are measured in meters. Suppose that a mounta climber is at the point $(30, -20, 800)$.

   i) If the climber moves in the southwest direction, will he or she ascend or descend?

   ii) In what direction should the climber move so as to asce most rapidly.

3. a) Consider a solid bounded by the cylinder $x^2 + y^2 = a^2$ and the planes $z = 0$ and $z = b$. If the mass density of the so at the point (x,y,z) is kz, find the total mass of the sol

b) Let the flux vector of a plane flow be

$F(x,y) = (x^2 + y^2)i + 2xyj$

i) Find the divergence of F.

ii) Use the normal form of the Green's theorem to find the flux of the square with vertices (0,0), (1,0), (1,1) and (0,1).

4. a) Show that the vector field

$F(x,y,z) = y^2z^4i + 2xy\ z^4j + 4xy^2z^3k$ is exact. Hence evalua

the line integral $\int_C F(x).dx$ where C is any piecewise

smooth curve joining the point (0,0,0) to (,3,2,1).

b) Use Stokes's theorem to evaluate the line integral

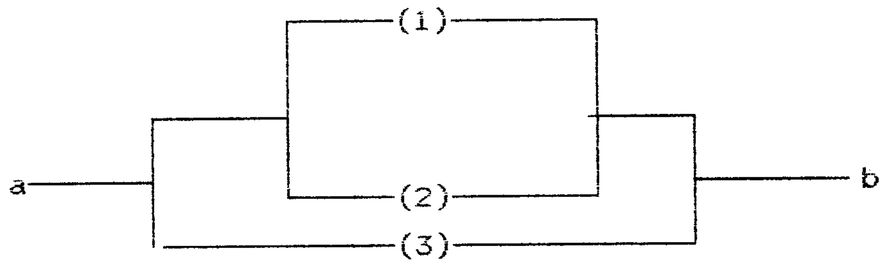
$\oint_C e^x dx + x\ \text{siny}\ dy + (y^2 - x^2)\ dz$

Where C is the equilateral triangle formed by intersection of the plane $x + y + z = 3$ with the three coordinate planes.

5. a) i) Electronic motors coming off two assembly lines are pooled for storage in a common stockroom and the room contains an equal number of motors from each line. Motors are periodically sampled from that room and te It is known that 10% of the motors from Line I are defective and 15% of the motors from line II defective. If a motor is randomly selected from the stockroom and found to be defective, find probability that it came from line I.

ii) Consider the following segment of an electric circuit with three relays. Current will flow from a to b if there is atleast one closed path when the relays are switched "closed". However, the relays may malfunction. Suppose the close properly only with probability 0.9 when the switch i thrown and suppose they operate independently of one anoth Let A denote the event that current will flow from a to b when relays are switched to "close"

Find P(A) and also the probability that relay I is closed properly given that current is known to be flowing from a to b



b) Among 10 applicants for the position of system analyst in the computer centre of the University of Zambia, 6 are female and 4 are males. Suppose 3 applicants are randomly selected from the applicantspool for final interviews. Find the probability distribution for X the number of female applicants among the final three.

6. The following data were obtained on the average life of batteries under continuous use.

Brand and Model	AVerage Life (Hours)
<u>Alkaline AA</u>	
Duracell MM1500	4.1
Eveready Energizer	4.5
K.Mart Super cell	4.3
Panasonic AM3	3.8
Radio Shack 25552	4.8
Ray - O - vac 815	4.4
Sears 3090	4.7
<u>Heavy Duty AA</u>	
Eveready 2115	1.8
Radio shack 25582	2.0
Ray - o vac 5AA	0.6
Sears 344633	0.7
<u>Regular AA</u>	
Eveready 1015	0.8
K.Mart K155	0.7
Radio shack 2368	1.0

a). Construct back to back stem and leaf plot of the alkaline versu non alkaline (Heavy duty and regular) batteries.

b) Construct parallel box plots for the alkaline and non-alkaline batteries and discuss variability from your display. What patte do you detect? Mark outliers if exist in the given data.

c) Draw the cumulative frequency plots for the alkaline and alkaline batteries and write your observations from the plots.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SUPPLEMENTARY EXAMINATION, JULY 1996

ME 209 - ENGINEERING DRAWING 1

TIME ALLOWED : FOUR (4) HOURS

OPEN NOTEBOOK: TEXTBOOKS AND MARKED TUTORIAL SHEETS ARE NOT ALLOWED.

INSTRUCTIONS

1. ANSWER ALL QUESTIONS FROM SECTION A
   TWO QUESTIONS FROM SECTION B

2. ALL DRAWINGS SHOULD BE DRAWN FULL SIZE, i.e. 1:1 UNLESS STATED OTHERWISE.

3. MARKS WILL BE AWARDED FOR CORRECT SOLUTION, ACCURACY, NEATNESS AND GOOD LINEWORK.

4. ALL CONSTRUCTION LINES SHOULD NOT BE ERASED.

5. JUST ABOVE THE TITLE BLOCK, INDICATE YOUR COMPUTER NUMBER AND YOUR GROUP (A, B, C OR D).

6. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS STATED OTHERWISE.

SECTION A. MACHINE DRAWING.

Answer all questions.

You are advised to spend up to two (2) hours on this section.

Q 1. Draw the title block. Title:"SUPPLEMENTARY EXAMINATION" (5 marks)

Q 2. Figure 1 shows two views of a gear box in first angle projections. Draw full scale in third angle projection:

(a) a sectional elevation on section line AA, (10 marks)

(b) an end elevation projected from view (a) looking in the direction of the arrow C. (10 marks)

(c) a complete plan view. (10 marks)

Show all hidden details in (b) and (c) only.

All fillet radii are 3 mm and may be drawn freehand.

Insert six important dimensions in view (c), these should be of varied character and include the following:
a horizontal length, a vertical length, a diameter, and a radius and a tapped hole. (6 marks)

Neatness, spacing and line work. (3, 3, 3 marks)

Suitable dimensions should be estimated where data is not provided.

SECTION B: GRAPHIC

ANSWER ANY TWO QUESTIONS

Q 3. (a) Figure 2 shows a crank and offset linked plunger designed to produce a quick return motion of the plunger P. Draw full-size the locus of the mid-point H in the link BC as QB makes one revolution and state the length of the stroke P makes. (15 marks)

(b) Construct a triangle of perimeter 120 mm whose sides are in the ratio 3:4:5. Circumscribe a circle about this triangle and state its radius. (10 marks)

Q 4. (a) Draw figure 3 to a scale full-size and construct a similar figure in the ratio 3:4. (10marks)

(b) Figure 4 shows a logo for a society. Draw the logo full size, clearly showing the construction used to determine the archimedean spiral AP. The tangents to the curve may be drawn without construction. (15 marks)

Q 5. (a) Incomplete elevation and plan of cylinder penetrating a cone is shown in figure 5. Draw the plan and elevation of the solids showing the curves of interpenetration. (15 marks)

(b) Figure 6 shows a right circular cone which has been cut along X-X parallel to a generator in the position shown. The uncut sloping surface of the cone is to be covered with a single piece of thin metal foil. Determine the necessary shape of the foil. (10 marks)

S.K.VERMA/ME 209.

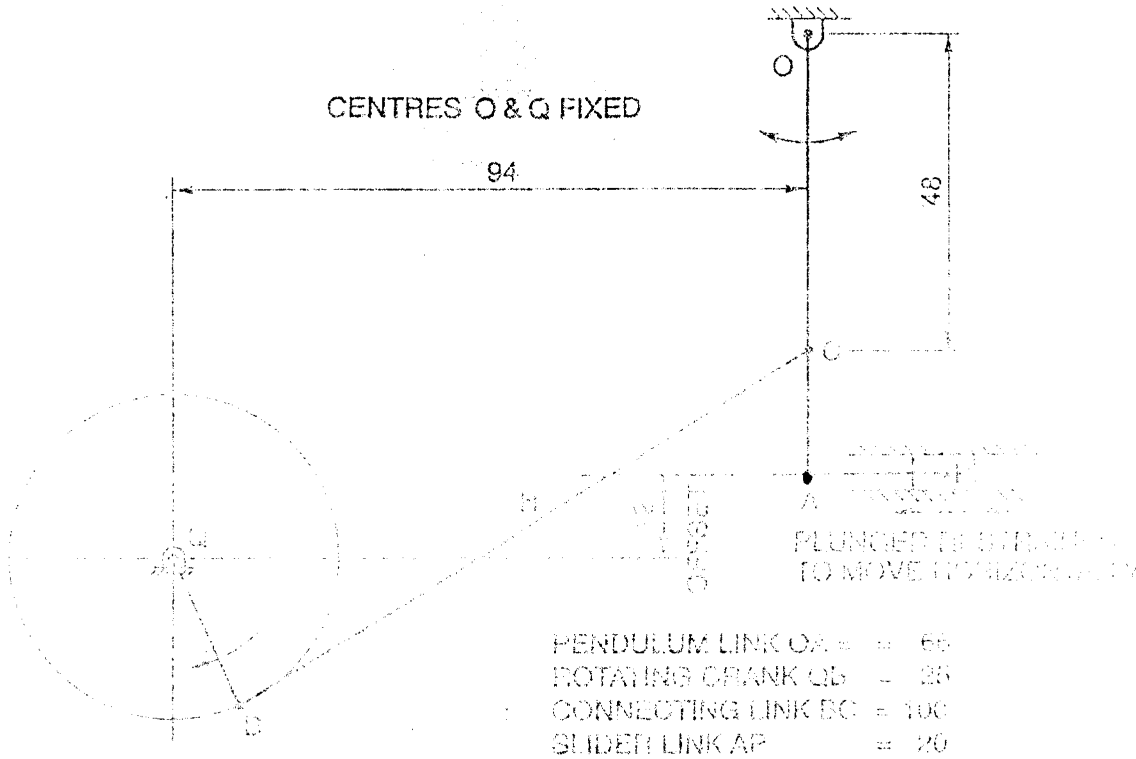

CENTRES O & Q FIXED
O
94
48
C
A
OFFSET
PLUNGER IS STRAINED
TO MOVE HORIZONTALLY
PENDULUM LINK OA = 66
ROTATING CRANK QB = 25
CONNECTING LINK BC = 100
SLIDER LINK AP = 20
B

Fig. 2

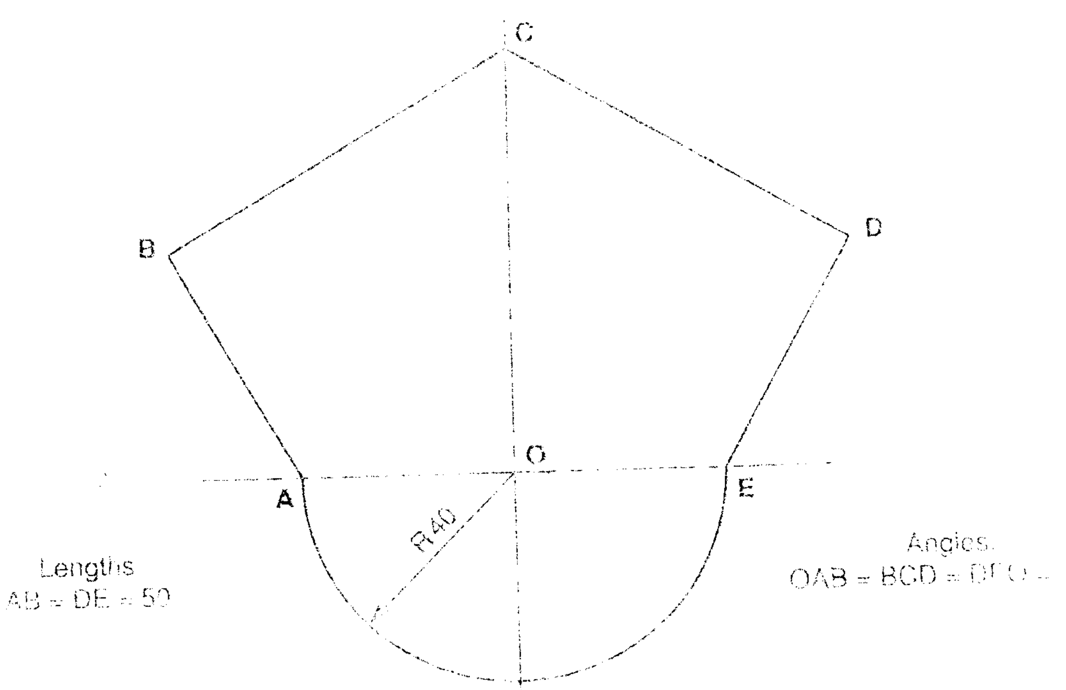

C
B
D
O
A
E
R40
Lengths
AB = DE = 50
Angles.
OAB = BCD = DEO =

Fig. 3

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATION, NOVEMBER, 1996

ME 209 - ENGINEERING DRAWING 1

TIME ALLOWED : FOUR (4) HOURS

OPEN NOTEBOOK: TEXTBOOKS AND MARKED TUTORIAL SHEETS ARE NOT ALLOWED.

INSTRUCTIONS

1. ANSWER: ALL QUESTIONS FROM SECTION A
   TWO QUESTIONS FROM SECTION B

2. ALL DRAWINGS SHOULD BE DRAWN FULL SIZE, i.e. 1:1 UNLESS STATED OTHERWISE.

3. MARKS WILL BE AWARDED FOR CORRECT SOLUTION, ACCURACY, NEATNESS AND GOOD LINE WORK.

4. ALL CONSTRUCTION LINES SHOULD NOT BE ERASED.

5. JUST ABOVE THE TITLE BLOCK, INDICATE YOUR COMPUTER NUMBER .

6. WRITE YOUR GROUP (E OR F) IN PLACE OF DRG NO. IN THE TITLE BLOCK.

7. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.

SECTION A. MACHINE DRAWING.

Answer all questions. You are advised to spend up to two (2) hours on this section.

Q 1. Draw the title block. Title: "SEMESTER 2 EXAMINATION" (5 marks)

Q 2. Figure 1 shows two views of a gear box in first angle projection. Draw full size in third angle projection , the following views:

(a) a sectional elevation, the plane of the section and the direction of the required view being indicated at A-A. (11 marks)

(b)a complete plan as shown, (8 marks)

(c) an end elevation projected from view (a) looking in the direction of arrow C. (11 marks)

Show all hidden details in (b) and (c) only.

All fillet radii are 3 mm and may be drawn freehand.

Insert six important dimensions in view (b), these should be of varied character and include the following:a horizontal length, a vertical length, a diameter, and a radius. (6 marks)

Neatness, spacing and line work. (3, 3, 3 marks)

Suitable dimensions should be estimated where data is not provided.

SECTION B: GRAPHICS

ANSWER ANY **TWO** QUESTIONS

Q 3. (a) An incomplete front view of a cone penetrated by a cylinder, tangential to the outer generators of the cone, is shown in fig. 2. Draw in first angle projections the front view and the top view showing the curve of intersection. Also draw the development of the cone. (9, 6 marks)

(b) Construct a regular heptagon in a circle of diameter 100 mm. Reduce this heptagon to another similar heptagon such that the ratio of the sides is 3:5. (10 marks)

Q 4. (a) Fig 3. represents a link in which the crank OA and SB rotate at the same speed about O and S respectively, and block D moves in horizontal guides.

(i) Draw the locus of C and (12 marks)

(ii) find the length of the stroke of the block. (3 marks)

(b) A chimney, 18 m high and 0.9 m diameter is supported by two sets of three guy wires each, as shown in fig 4. One set is attached at 3 m from the top and anchored 6m above the ground level. The other set is fixed to the chimney at its mid-height and anchored on the ground. Determine the length and slope with the ground, of one of the wires from each set. (Use scale 1:200). (10 marks)

Q 5. (a) Trace the locus of point P on the circle along the lines AB and BC as shown in fig 5. for one revolution of the circle. (15 marks)

(b) Draw the cam shown in fig. 6, showing all the construction lines clearly. (10 marks)

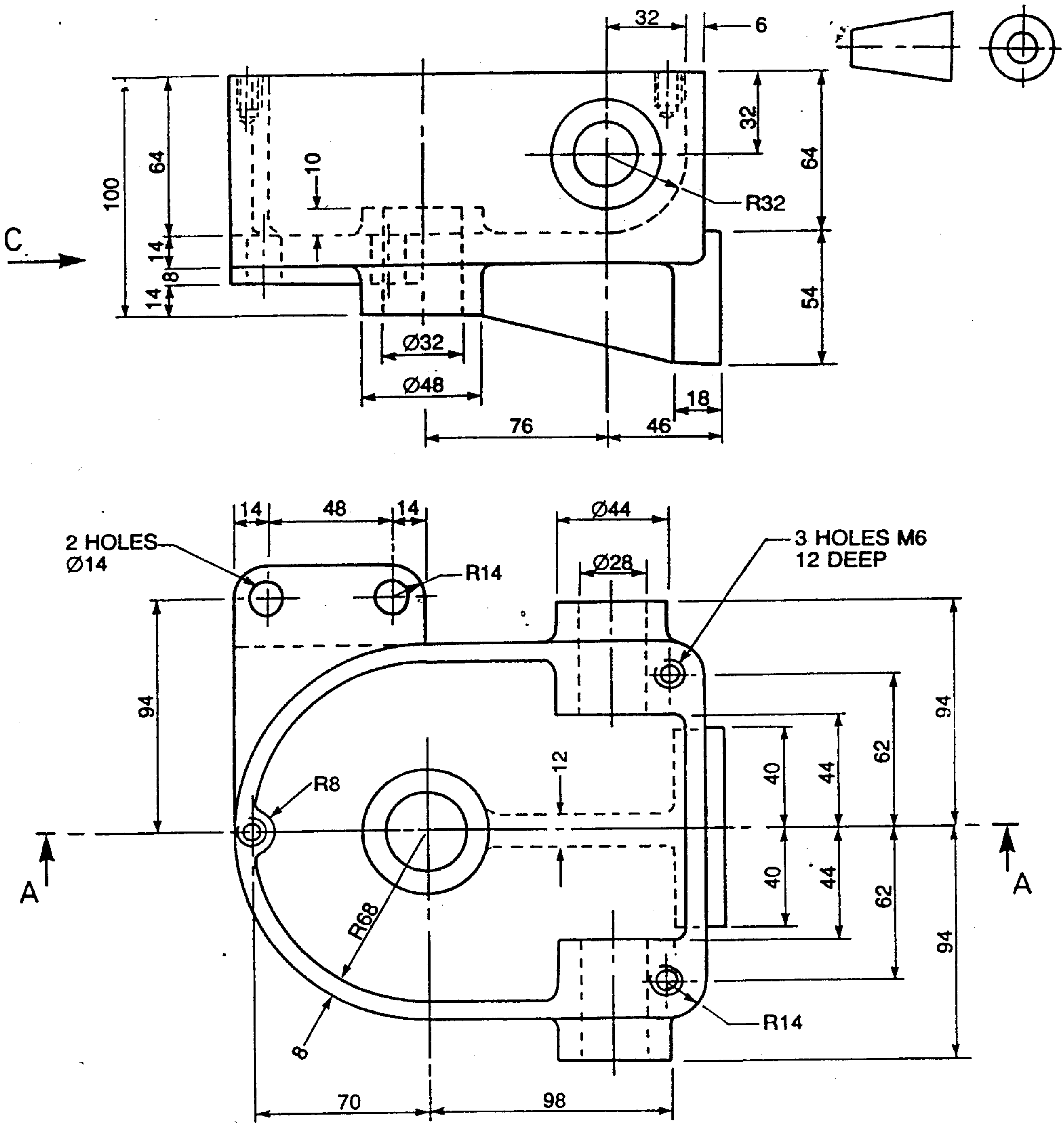


FIG:1

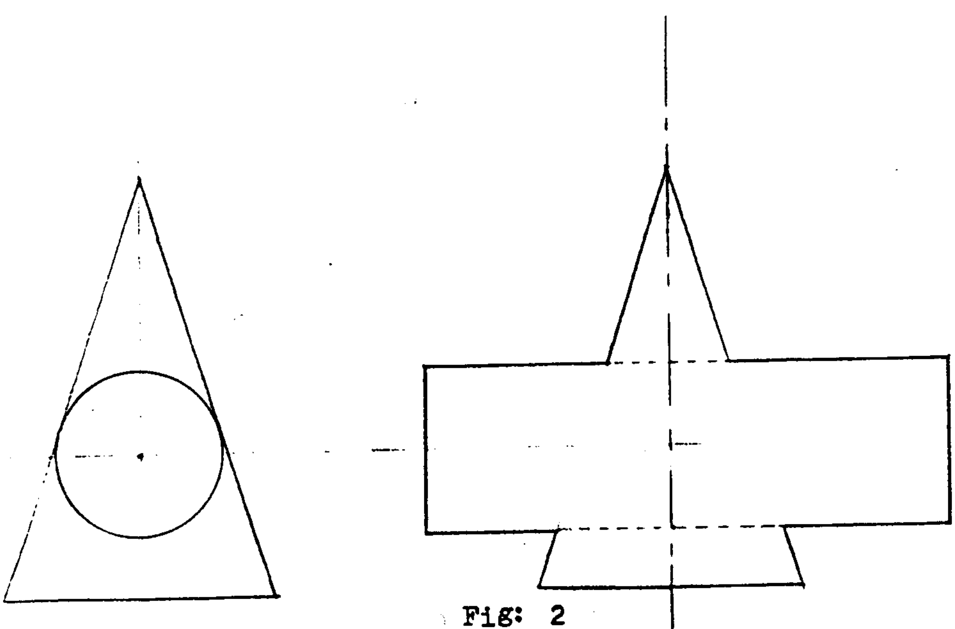


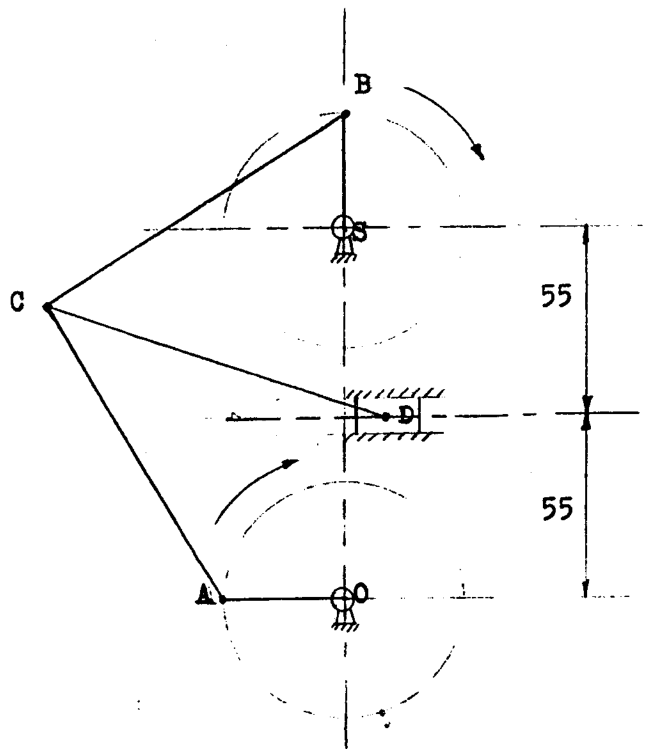
Fig: 2

Cone

Base 70 mm Diameter
Axis 110 mm

Cylinder

diameter= 44 mm



AC=100 mm
BC=100 mm
CD=100 mm
OA=SB=35 mm

Fig: 3

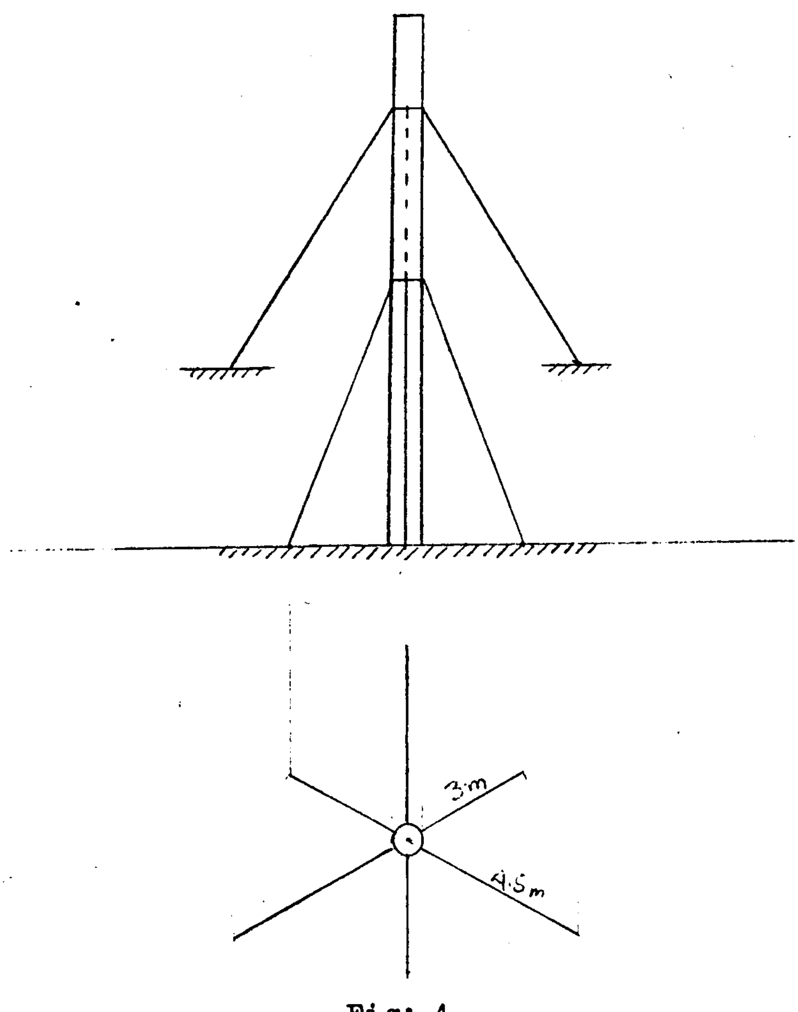


Fig: 4

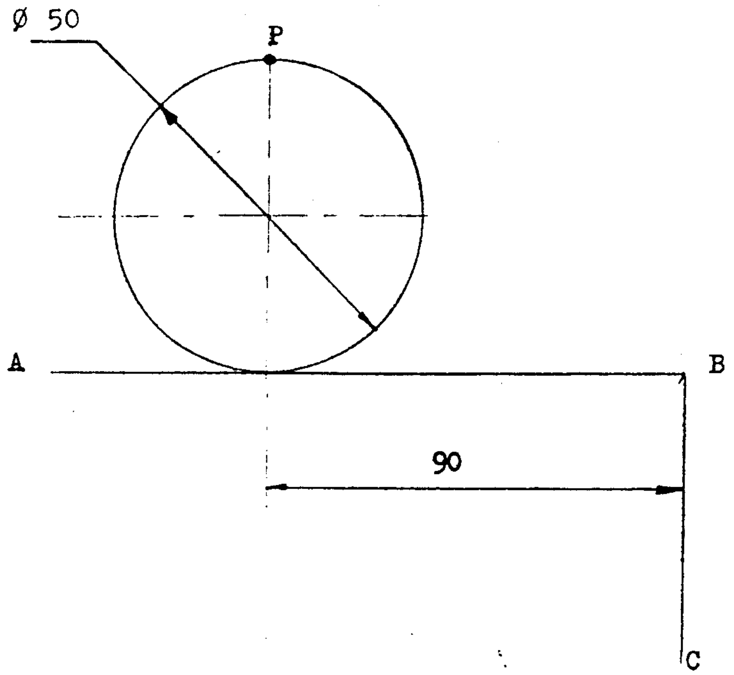


Fig: 5

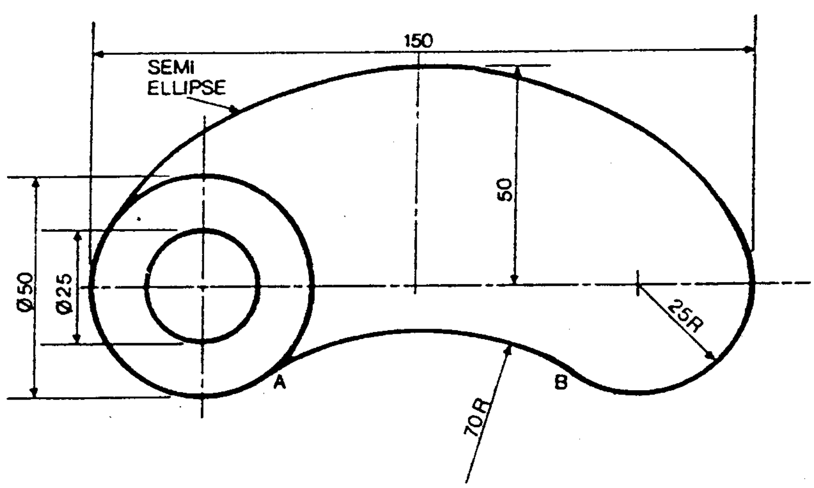


Fig:6

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS - NOVEMBER, 1996

ME 252 - ENGINEERING MATERIALS I

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS

EACH QUESTION CARRIES 20 MARKS

Q1. (a) With the help of sketches, define the following:

(i) Hypo-eutectoid

(ii) Eutectoid

(iii) Hyper-eutectoid.

(b) Describe briefly the term "Solid Solubility."

Q2. Sketch a detailed Fe-C phase diagram indicating and describing all the relevant structural phase constituents and temperatures.

Q3. (a) Describe in detail, the Brinell hardness test.

(b) With the help of sketches, define the following:

(i) Resilience

(ii) Toughness

(iii) 0.2% off-set yield strength.

Q4. (a) Sketch a blast furnace and explain in detail the production process of iron.

(b) Discuss briefly the difference between white and grey cast iron.

Q5. (a) With the help of a sketch, describe the Bessemer process of producing steel.

(b) State the differences between the following types of steel:

(i) Rimmed steel

(ii) Killed steel

(iii) Semi-killed steel.

Q6. (a) Discuss briefly what plain carbon steels are.

(b) Describe the following heat treatment processes:

(i) Full annealing

(ii) Tempering.

END OF EXAMINATION

Dr. C.K. Wamukwamba.

SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS - NOVEMBER, 1996
ME 302: ENGINEERING DRAWING II

Open book: prescribed textbooks, handbook for engineering drawing and handout on ISO standards - fasteners and screw threads allowed.

Answer : All Questions

Time: 4 hours

Next page drawing 1 shows a swivel pulley in an isometric view. The V-pulley (8) rotates freely about its axis. The shaft (5) is retained in fork (4) by two discs (7) and two taper pins (6). The taper pins have a length of 36 mm with a taper ratio of 1:50 and smallest diameter $\phi 2$ h10. The pins are rounded of at the ends with a radius of 1mm.

The fork (4) is threaded at one end to tighten a circular retaining ring (1), which can be put in position by using a special peg spanner fitting in the two holes shown. Between housing (2) and retaining ring (1) a spherical roller thrust bearing (3) is fitted with ID $\phi 30$ mm, OD$\phi 65$ mm and other dimensions as shown in attached SKF table 1. This bearing takes the downwards pressure working on the pully (8). The housing (2) is connected with six bolts to the rest of the assembly (not drawn).

Questions

Drawn in third angle projection scale 1:1

(a) an assembly drawing of a cross section AA. (50 marks)

(b) Draw detail drawings of the fork (4), the shaft (5) and the V-pulley (8), Note: the shaft has a diameter of ϕ 20 mm and its length has to be determined. (30 marks)

(c) Introduce dimensions on the above detail drawings with all dimensional tolerances and surfaces roughness and if necessary geometrical tolerances. (15 marks)

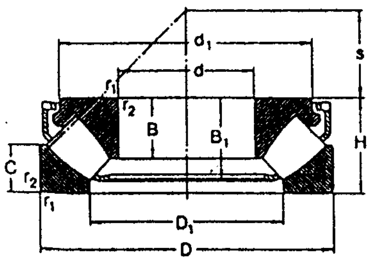
(d) Include a title block and parts list. (5 marks)

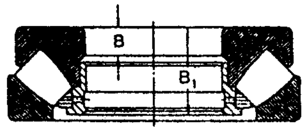
In case dimensions are not given, use your engineering judgement.

END OF ME 302 EXAMINATION - S.J.M. SERRARENS

TABLE OF SOLUTE POTENTIALS OF SUCROSE SOLUTION AT 20°C

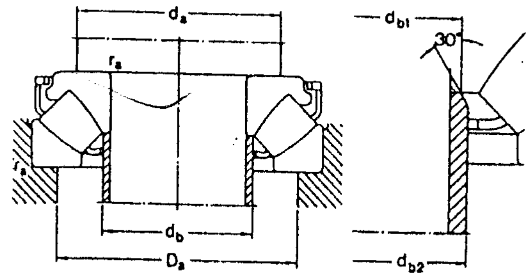
SUCROSE MOLARITY	SOLUTE POTENTIAL KPa
0.10	-260
0.12	-320
0.14	-370
0.16	-430
0.18	-480
0.20	-540
0.22	-600
0.24	-650
0.26	-710
0.28	-760
0.30	-820
0.32	-880
0.34	-940
0.36	-1000
0.38	-1060
0.40	-1120
0.42	-1190
0.44	-1260
0.46	-1320
0.48	-1390
0.50	-1450

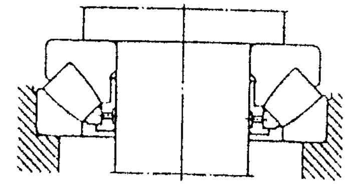




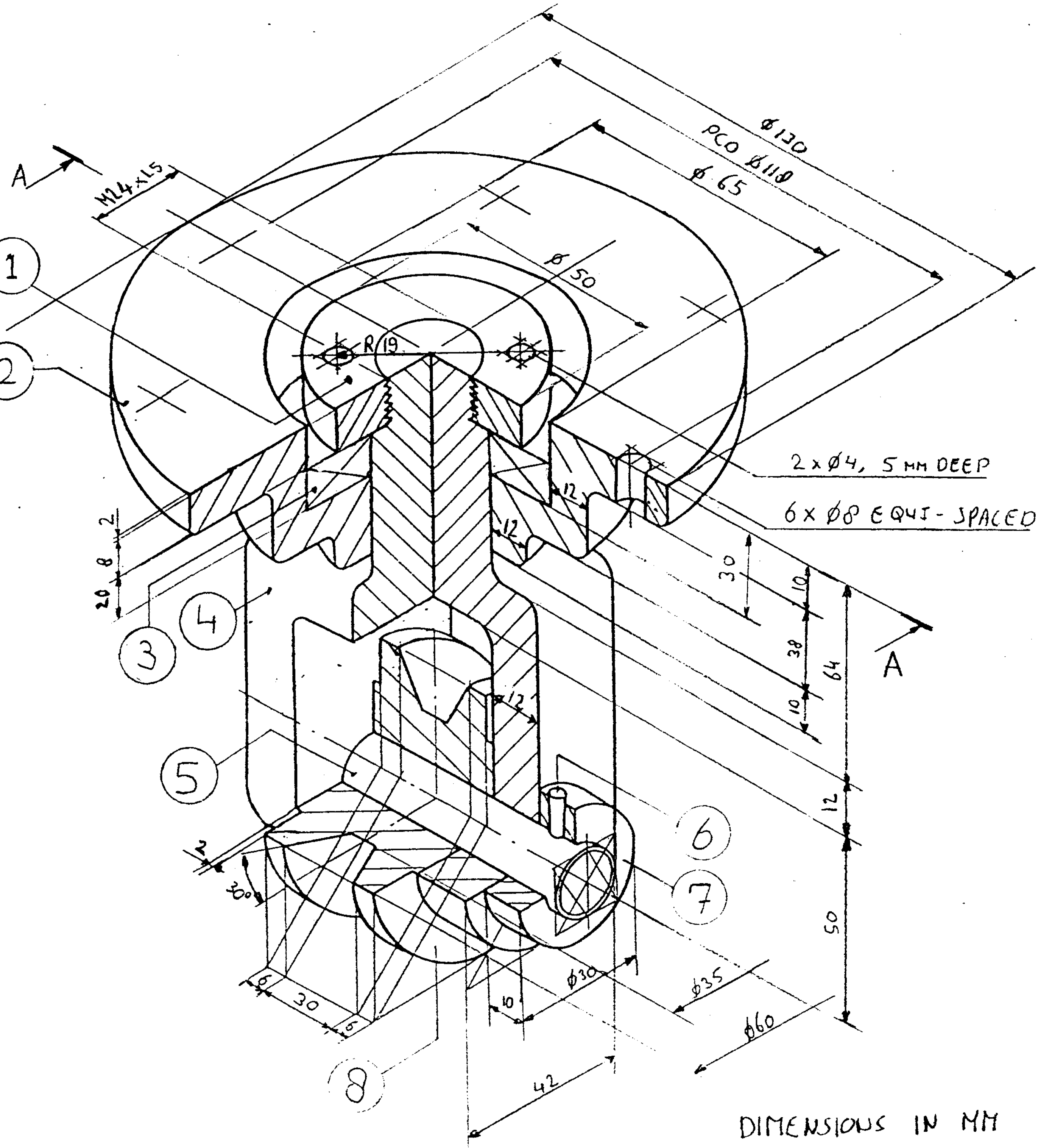
E design

Principal dimensions d	D	H	Basic load ratings dynamic C	static C_0	Fatigue load limit P_u	Minimum load factor A	Speed ratings Lubrication grease	oil	Mass	Designation
mm			N		N	-	r/min		kg	-
30	65	40	166000	450000	56000	21	3200	4100	1.40	29406E





Dimensions d	d_1	D_1	B	B_1	C	$r_{1,2}$ min	s	Abutment and fillet dimensions d_a min	d_{b1} max	d_{b2} max	D_a max	r_a max
mm								mm				
30	58	44	14	37	10	1.0	18	45	36	36	55	1.0



DIMENSIONS IN MM

ALL FILLET RADII 3 MM
UNLESS AS STATED

NOVEMBER / DECEMBER 96	DRG. NO. 1
UNIVERSITY EXAMINATION	
UNIVERSITY OF ZAMBIA	ME 302

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1996

ME 332: STRENGTH OF MATERIALS I

TIME: 3 HRS **CLOSED BOOK**

ANSWER: FIVE (5) QUESTIONS **ALL QUESTIONS CARRY EQUAL MARKS**

Q1. A vertical cantilever plate of uniform thickness b is shaped as shown in figure Q1. The height of the plate decreases uniformly from height h to 0. The plate is loaded vertically by a concentrated force F. Assume the second moment of area at the wall is I.

(a) Working from <u>first</u> principles determine an expression for the deflection at the end of the plate in terms of the flexural stiffness EI, length L and the longitudinal coordinate z.

(b) Determine the deflection at the end of the plate.

Q2. The M20 steel bolt shown in figure Q2 is tightened on a copper bushing, introducing a force of 10 kN in the system. The circular copper bush has an inner diameter (ID) of 25 mm and an outer diameter (OD) of 35 mm. Calculate the unit stress produced in the two components:

(a) at room temperature

(b) when the system is heated from room temperature by 70°C.

Coefficients of thermal expansion for steel and copper are: $\alpha_1 = 10 \times 10^{-6}$ and $\alpha_2 = 18 \times 10^{-6}$ respectively.

Q3. A steel shaft of 700 mm length and a diameter of 25 mm is subjected to a combined axial pull and torsion. The axial pull has a magnitude of 7 kN and the torque applied equals 20 Nm. On one side of the shaft a longitudinal hole is drilled in the shaft over a length of 350 mm, with a diameter of 10 mm. The other half of the shaft is solid.

(a) Determine the magnitude and direction of the principal stresses at the hollow end.

(b) Determine the angle of twist. The modulus of rigidity equals 80 GPa.

Q4. Two rectangular bars made of two different materials having dimensions as shown in figure Q4 (cross-sectional view) are placed together loosely on two supports and form a built-up beam. The built-up beam is subjected to a bending moment about the horizontal axis of 3 kNm.

Find the maximum and minimum stresses in both materials of the beam assuming that the Young's modilii are E_1 = 10 MPa and E_2 = 200 MPa.

Q5. (a) Explain why the yield strength of the material is not relevant in determining the buckling failure load of a steel column according to Euler.

(b) A steel beam with rectangular cross-section, flexural stiffness EI and a length of 1m is tested on buckling between two pinned ends. The buckling load was found to be 85 N. When the same beam of 1m is treated as a beam loaded centrally between two simple supports, the deflection was found to be 0.4 mm per Newton load.

Calculate the theoretical Euler load and explain why this is different from the experimental value.

Note: the maximum deflection of a beam loaded by a concentrated load P centrally on simple supports is: $Pl^3/48EI$.

Q6. Electrical strain gauges are a popular and easy device to determine strains of structures.

(a) Explain the working principle of electrical strain gauges and draw the electrical circuits required to determine the strain.

(b) Explain the difference between an electrical strain gauge and strain rosette. Mention the formulae required to find the stresses from the information obtained from the measurements.

(c) What are the restrictions of strain gauges? And of strain rosettes?

END OF ME 332 SUPPLEMENTARY/DEFERRED EXAMINATIONS-JANUARY 1996

Mr. S.J.M. Serrarens

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1996

ME 332: STRENGTH OF MATERIALS I

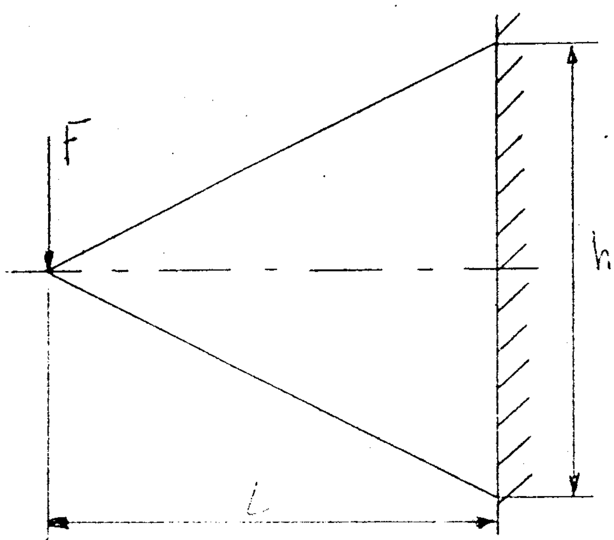


FIG. Q1

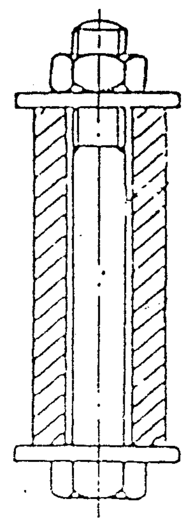


FIG. Q2

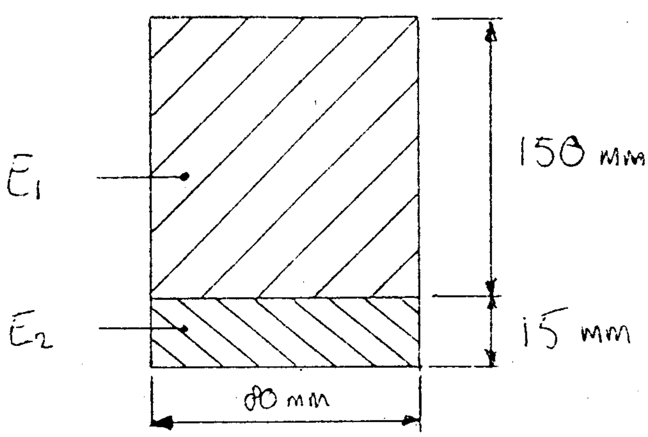


FIG. Q4

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY SEMESTER 2 FINAL EXAMINATIONS

ME 365 - FLUID MECHANICS AND THERMODYNAMICS

TIME: **THREE (3) HOURS** **CLOSED BOOK**

INSTRUCTIONS:
- **-Answer Five (5) Questions only**
- **-Answer at least two (2) questions from each section**
- **-Use separate answer books for each section**
- **-All questions carry equal marks**
- **-Steam Tables, Mollier charts, Freon Tables and Charts may be used.**
- **-Universal gas constant R = 8314.41 J/kgmol.K**

SECTION A

ANSWER QUESTION ONE (1) AND AT LEAST ONE OTHER QUESTION FROM THIS SECTION.

Q1. The following statements are either true or false. Indicate which by writing down the appropriate letter in your answer book.

Marking:

$$\left[\text{Number Correct} - \frac{\text{Number Incorrect}}{2}\right] \times 1.25$$

(i) A wet vapour is a perfect gas T F

(ii) The entropy change between two states is dependent only on the states and not on the process which produces the change. T F

(iii) In an isobaric process, the work done is proportional to the heat added. T F

(iv) For water, a rise in pressure drops the melting point but raises the boiling point. T F

(v) A heat engine with an efficiency of 100% obeys the 1st Law of Thermodynamics. T F

(vi) The 2nd Law of Thermodynamics implies that work cannot be continuously and completely converted into heat. T F

(vii) Entropy is a criterion for reversibility T F

(viii) In an adiabatic expansion process (closed) system, the temperature of the working fluid rises. T F

(ix) There is no change of internal energy in an isothermal process involving an ideal gas. T F

(x) In the saturation envelope, temperature and pressure are not independent of each other. T F

(xi) Two reversible engines operating between the same two reservoirs must have the same efficiency irrespective of their working fluids. T F

(xii) A device converting heat transfer into work transfer is a heat pump. T F

(xiii) If a system is taken through a cycle while exchanging heat with only one reservoir, the work done must either be zero or negative.T F

(xiv) It is impossible to devise a machine to deliver a limited quantity of work without requiring a source of energy in the surroundings. T F

(xv) By definition, a thermodynamic process is defined when the state changes from one equilibrium condition to another. T F

(xvi) An isentropic process with a wet vapour can be expressed in terms of PV^{γ} = Const. T F

(20 marks)

Q2. (a) Steam at 0.15 MPa and 0.80 dryness fraction is to be used to heat air for crop processing using a heat exchanger. If 2 kg of air per second is to be heated from 20^0C to 60^0C at constant pressure, and the steam leaves the exchanger at 0.14 MPa and 0.5 dryness fraction, calculate the required steam flow rate in kg/h. The specific heat at constant pressure for air can be taken as 1.005 kJ/kg.K.

(10 marks)

(b) A 300 W electric powered fan is mounted inside a 4 m^3 box filled with air initially at 0.1 MPa and 25^0C. If the box is perfectly insulated, and ignoring the thermal capacity of the fan, calculate the rise in temperature of the air if the fan is run for 15 minutes. The molecular weight of air can be assumed to be 28.96 kg/kgmol and its ratio of specific heats γ = 1.4. (10 marks)

Q3. (a) Using clearly labelled diagrams describe the process that make the otto (Constant Volume) cycle.

(5 marks)

(b) Derive the expression for the thermal efficiency of the otto cycle in terms of the compression ratio.

(9 marks)

(c) A petrol engine has a bore of 80 mm and a stroke of 85 mm. The clearance volume of the engine is 0.06 litre. The actual thermal efficiency of the engine is 22%. Determine the ratio of the actual to the ideal thermal efficiency of the engine. Take $\gamma = 1.4$.

(6 marks)

SECTION B

SECTION B

Q1. (a) Show that the intensity of pressure at a point in a fluid is the same in all directions.

(b) A circular lamina 125 cm in diameter is immersed in water so that the distance of its perimeter measured below the water surface varies between 60cm and 150cm. Find the total force due to the water acting on one side of the lamina, and the vertical distance of the centre of pressure below the surface. (10+10)

Q2. (a) Show that for fluids at rest, there can be no shear stresses.

(b) What is meant by continuity of flow and under what conditions does it occur?

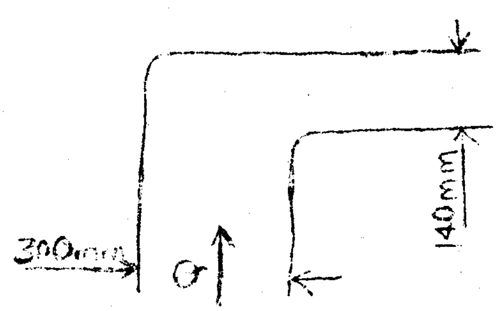
(c) Water flows through a pipeline 60m long at a velocity of 1.8m/s when the pressure difference between the inlet and outlet is $25kN/m^2$. What increase of pressure difference is required to accelerate the water in the pipe at the rate of $0.02m/s^2$. Neglect elasticity effects. (5+5+10)

Q3. (a) Explain in words the meaning of the Momentum Equation

(b) Explain with the aid of diagrams and formulas why and how much head is lost when a submerged pipe discharges into a large reservoir.

(c) Find the hydraulic forces acting on a 90^0 reducing bend joining two horizontal pipelines, one 300 mm and the other 140 mm diameter when the pressure in the large one is $120\ KN/m^2$ and the discharge is $0.25m^3/s$. Give your answer as two forces, acting in the directions mutually at right angles. Neglect the weight of the water filling the bend and take the density of the water as $1000\ Kg/m^3$.

(4+8+8)



END OF ME 365 EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER 2 SUPPLEMENTARY/DEFERRED EXAMINATIONS

ME 365 - FLUID MECHANICS AND THERMODYNAMICS

TIME: **THREE (3) HOURS** **CLOSED BOOK**

INSTRUCTIONS:
- **-ANSWER FIVE (5) QUESTIONS ONLY**
- **-ANSWER AT LEAST (2) QUESTIONS FROM EACH SECTION**
- **-USE SEPARATE ANSWER BOOKS FOR EACH SECTION**
- **-ALL QUESTIONS CARRY EQUAL MARKS**
- **-STEAM TABLES, MOLLIER CHARTS, FREON TABLES AND CHARTS MAY BE USED.**

SECTION A

Q1. Air at 105 kPa, 27^0 C is compressed to 1800 kPa at a rate of 4 kg/s. Find the power of the compressor and the rate of heat removal for:

(a) Reversible Isothermal compression (10)

(b) Reversible Polytropic compression if n = 1.22. (10)

Take C_v = ~~0.287~~ 0.717 kJ/kgK; R = 0.29kJ/kgK

Q2. In a Rankine cycle steam enters the turbine at 20 bars and 400^0 C. The pressure in the condenser is 0.2 bars and the liquid coming out of the condenser is saturated. Calculate the efficiency of the cycle and compare with the Carnot efficiency.

(15+5)

Q3. (a) Write down the energy equation for an open system defining clearly each parameter used. (5)

(b) Air enters a gas turbine system with a velocity of 105 m/s and has a specific volume of 0.8m^3/kg. The inlet area of the gas turbine system is 0.05m^2. At exit the air has a velocity of 135m/s and has a specific volume of 1.5m^3/kg. In its passage through the turbine system, the specific enthalpy of the air i s reduced by 145 kJ/kg. Determine,

(i) the mass flow rate of the air through the turbine system. (5)

(ii) the exit area of the turbine system. (5)

(iii) the power developed by the turbine system. (5)

SECTION B

Q4. (a) A diver descends from the surface of the sea to a depth of 30 m. What will be the pressure under which the diver would be working above that of the surface assuming that the density of sea water is $1025 kg/m^3$ and remains constant.

(b) A cylinder contains a fluid at a guage pressure of $350 KN/m^2$. Express this pressure in terms of a head of

(i) water (density = $1000 kg/m^3$)

(ii) mercury (relative density 13.6)

What would be the absolute pressure if the atmospheric pressure is $101.3 kN/m^2$.

(10+10)

Q5. (a) Distinguish between steady and unsteady flow; and between uniform and non-uniform flow.

(b) With the aid of diagrams, distinguish between rotational and irrotational flow

(c) Describe/define the following terms: velocity potential, stream function, equipotential lines and flow net.

(6+6+8)

Q6. Water is flowing upwards through a vertical pipeline which tapers from 45 mm to 30 mm in a distance of 1.5 m (Fig. Q6). If the static pressure at the 45 mm section is $200 KN/m^2$ and that at the 30 mm section is $135 KN/m^2$, calculate the rate of flow. If the two limbs of a vertical mercury manometer are connected to each end of the 1.5 m section, what would be the differential height indicated on the manometer? (relative density of mercury = 13.6).

(10+10)

END OF ME 365 SUPPLEMENTARY/DEFERRED EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY SEMESTER 2 EXAMINATIONS - NOVEMBER, 1996

ME 375 - DYNAMICS

TIME: **THREE (3) HOURS** **CLOSED BOOK**

INSTRUCTIONS: **ANSWER FIVE (5) QUESTIONS IN TOTAL: QUESTION 1 AND 2 ARE COMPULSORY; CHOOSE ANY 3 QUESTIONS FROM THE REMAINING ONES. ALL QUESTIONS CARRY EQUAL MARKS.**

Q1. A slender, uniform rod of weight W is pivoted at the bottom end and is held in equilibium by two springs, see figure 1.

(i) Show that for small vibrations the natural frequency is given by

$$f_n = \frac{1}{2\pi}\sqrt{\frac{6\,k\,g}{W} - \frac{3\,g}{l}}$$

(ii) Given are the following details:

k = 2 kN/m

l = 1500 mm

W = 49.05 N

Also is given, that at the time t = 0 s, the angle θ (between the rod and the vertical) is 0.035 rad to the right of the vertical (i.e. CW), while at the same time the angular velocity is 2 rad/s in a counter clockwise direction.

Determine the angular displacement of the rod as a function of the time; also determine the amplitude of the motion.

Q2. The disk with the circular slot of 200-mm radius rotates about O with a constant angular velocity $\omega = 15$ rad/s. Determine the acceleration of the slide A at the instant when it passes the centre of the disk if, at that moment,

$$\frac{d\theta}{dt} = 12 \text{ rad/s} \quad \text{and}$$

$$\frac{d^2\theta}{dt^2} = 0, \quad \text{see figure 2}$$

Q3. Given is the mechanism shown in figure 3. Link OA revolves counter-clockwise with an angular velocity of 3 rad/s. Link AB slides through the pivoted collar at C. Determine the angular velocity ω of AB when $\theta = 40^0$, by using the method of the instantaneous centre of zero velocity.

NB. Note that the direction of the velocity of a point on the rod AB, coincident with C, is in the direction of the rod as it slides through the collar.

Q4. Calculate the firing angle θ of the anti-aircraft gun with a muzzle velocity of 600 m/s to score a direct hit on an aircraft flying horizontally at 1000 km/h. The gun is fired at the instant when the aircraft is directly overhead. If a near miss occurs when the shell is on its way up but a direct hit is scored when the shell is on its way down, calculate the time t after firing for the hit to be scored if the altitude of the aircraft is 6000 m. Refer to figure 4.

Q5. See figure 5:
The collar has a mass of 2 kg and is attached to the light spring which has a stiffness of 30 N/m and an unstretched length of 1.5 m. The collar is released from rest at A and slides up the smooth rod under the action of the constant 50-N force. Calculate the velocity v of the collar as it passes position B.

Q6. See figure 6:
The two mine cars of equal mass are connected by a rope which is initially slack. Car A is given a shove which imparts to it a velocity of 1.2 m/s with car B initially at rest. When the slack is taken up the rope suffers a tension impact which imparts a velocity to car B and reduces the velocity of car A.

(a) If 40 percent of the kinetic energy of car A is lost during the rope impact, calculate the velocity v_B imparted to car B.

(b) Following the initial impact car B overtakes car A and the two are coupled together. Calculate their final common velocity v_c.

Q7. The elements of the mechanism for deployment of a spacecraft magnetometer boom are shown. Determine the angular velocity of the boom when the driving link OB crosses the y-axis with an angular velocity $\omega_{OB} = 0.5$ rad/s if at this instant $\tan\theta = 4/3$. Refer to figure 7.

END OF EXAMINATION - ME 375

Ir. H.A. de Keyzer

ME 375 - DYNAMICS

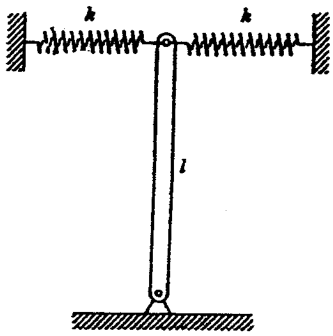


FIGURE 1

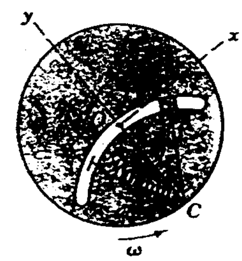


FIGURE 2

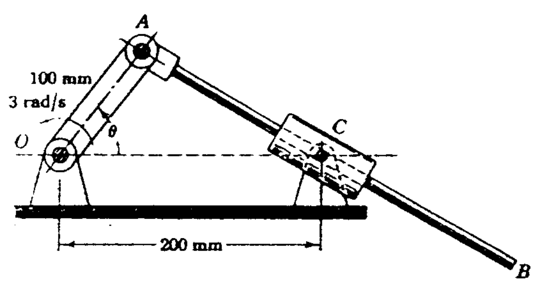


FIGURE 3

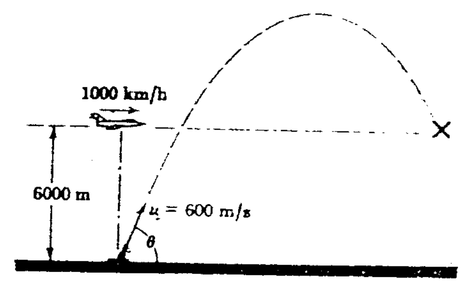


FIGURE 4

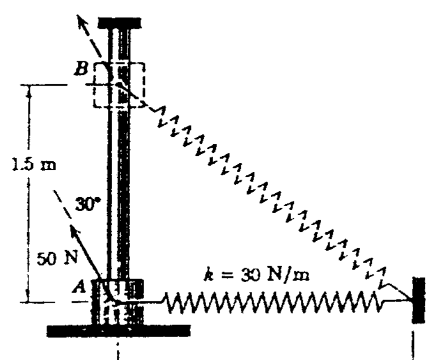


FIGURE 5

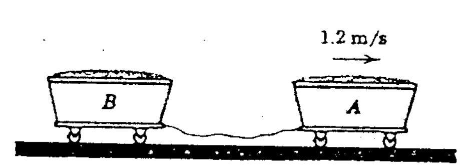
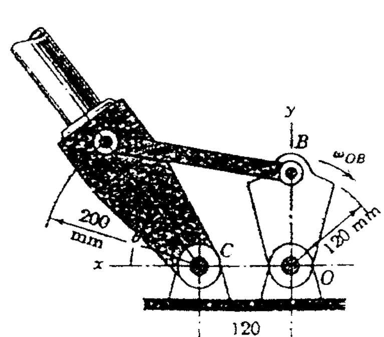


FIGURE 6



THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS - NOVEMBER /1996

ME 405 - MACHINE DESIGN I

PAPER I

TIME:THREE HOURS OPEN BOOK

ANSWER: QUESTION 1 AND TWO OTHER QUESTIONS

Q1.(a) A quarry owner has just bought a diesel engine powered stone crushing machine. The crusher and engine are connected by three V-belts. He however wants to use the engine for powering an electric generator consuming about the same amount of power.

The engine is capable of producing 25 kW at 1800 rpm. At the free end of the engine there is a flywheel where the clutch for the generator is to be connected. The section for clutch contact is 150 mm ID and 350 mm OD.

Design a flat clutch with an actuating system to transmit the power from the engine when the crusher is disconnected. Assume uniform pressure method. [20]

(b) If the farmer referred in Q1 (a) decides to purchase and install a used gearbox instead with an output shaft of ø60 mm then he would need a flanged coupling to connect the generator. The presence of the gear box reduces the power by 10% and the speed increases to 2000 rpm.

You are required to design the appropriate steel coupling specifying the limiting values of stress and dimensions of the coupling assembly. The crusher will be disconnected when the generator is engaged. Assume power transmission in the coupling is through shear of bolts. [20]

Q2. A 260mm long shaft is to be installed in a conveyor system. At mid span there is a 20 degree involute spur gear. The gear is connected to the shaft with 10mm deep key. The shaft is made up of AISI 1015 steel. The gear transmits 20KW at a speed of 800rpm.

Determine the shaft diameter given the following specification:
Ultimate strength, Su =527 MPa
Yield stress Sy = 430 M Pa
Corrected endurance limit , Se = 74 MPa
Safety factor N = 2 [30]

Q3. A simple material hoist is to be designed. Your task is to design a band brake system to be hand operated to stop the hoist. The brake is to be on 500mm diameter drum and the Power is 15KW at 500rpm. Assume a coefficient of friction of 0.15

(a) Produce a sketch of the brake [10]

(b) Determine the actuating force and give the relevant dimensions and the wrap angle [20]

Q4. You are in a team that is delegated to design a Pressure Vessel. The steel vessel is in a cylinder form. The gasket should have a static pressure of about 15 MPa after tightening the bolts to avoid leakages.

•Other details are as follows:

- The cylinder is 1500 m long with inside diameter of 120 mm and 24 mm thick with a provision for cover seat.
- Cover is 250mm in diameter and 24mm thick
- The gasket is 4 mm thick and has inside diameter of 120mm and outside diameter of 250mm
- Proof strength of bolt material is 586 MPa.
- The preload should be about 75% of proof load
- Bolt spacing should not be less than 6d (d = bolt diameter)

(a) Make a sketch of the covered section with a gasket to avoid leakage. [10]

(b) Specify the cover bolts from a selection of 16 and 20mm sizes. [20]

END OF EXAMINATION ME 405 PAPER I

Dr S B KANYANGA

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY EXAMINATIONS - NOVEMBER 1996
ME 405 MACHINE DESIGN I

PAPER II

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

OPEN BOOK

The Government has embarked on a much needed road rehabilitation and improvement programme throughout the country. However, one area of concern is the availability of machinery for road construction work. Your Company has been approached by the Ministry of Works and Supply to design and manufacture a machine that can be used to paint road markings. These are markings on roads used to separate lanes and used also at road junctions. They are either solid lines or dashed lines. In the case of dashed lines the dash varies from 200 mm to 1000mm and about 100mm thick. The spacing between dashes is variable from 200mm to 2000mm. Solid lines are continuous lines which are not broken and about 100mm thick.

In addition the machine, when painting, can be towed by a vehicle or pushed by one person as required

(a) Provide design requirements and factors that are relevant to the machine. [15]

(b) Produce two functional designs for a machine that could be used to paint the markings [60]

(c) Select the better of the two designs in (b) and specify the materials for its components [25]

END OF ME405 EXAMINATION PAPER II

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS 1ST SEMESTER JUNE 1996

ME 415 PRODUCTION TECHNOLOGY I

CLOSED BOOK

TIME: THREE HOURS

ANSWER QUESTION ONE AND ANY OTHER FOUR QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS.

Q1. (a) (i) State briefly the assumptions undertaken for the Merchant's theory of cutting. Briefly state where the theory has good and poor correlation with reference to materials. Finally outline the semi-empirical modifications undertaken to improve the theory.

(ii) From single point cutting theory derive the following equation:

$$Tan\ \phi = \frac{\cos\gamma}{\lambda - \sin\gamma}$$

where $\lambda = h_c/h$, chip compression ratio, γ is the rake angle and Φ is the shear angle.

(b) The following results were obtained from a single point orthogonal cutting test.

Cutting force in direction of cutting velocity
$F_v = 1500N$

Cutting force in cut thickness (feed) direction
$F_f = 650$ N

Cutting velocity = 200 m min^{-1}
Width of cut = 2.5 mm
Cut thickness h = 0.3 mm
Chip thickness h_c = 0.75 mm
Tool rake angle $\gamma = +5^0$
Tool clearance angle $\alpha = +7^0$

Calculate, stating any assumptions made:
- (i) Normal stress on the shear plane
- (ii) Shear velocity.

Q2. (a) (i) Discuss the Manual Metal Arc (MMA) welding process and its mechanism. Use clearly labelled sketches to illustrate your answer.

(ii) Give an outline of the application limitations **MMA** welding has on aluminium and stainless steel.

(b) Explain the metallurgical conditions of a simple butt weld of a medium carbon steel and relate such conditions to the material temperature, phase diagram and hardness. Use clearly labelled sketches to illustrate your answer.

Q3. (a) What do you understand by the following casting processes?
In what ways do the two casting technologies differ?
- (i) Pressure die casting
- (ii) Horizontal centrifugal casting.

(b) Give an outline of quality problems associated with green sand casting. What are the remedies?

Q4. (a) Give an outline of errors associated with mechanical measurements.

(b) (i) In the methology using optical flats as a means for measuring surface undulations, derive the expression that gives the magnitude of the distance between bright and dark bands of monochromatic light.

(ii) How can an optical flat be made to measure flatness of a flat polished surface.

Q5. (a) Develop from first principles an expression for estimating power expended in face milling. In your development, use suitable chip thickness formula. Comment on the accuracy of the formula to predict power.

(b) For the face milling tooling arrangement shown in Figure Q5, the following are given:

Number of face cutting teeth = 8
cutting edge tangential velocity = 0.6m sec^{-1}.
Workpiece feed rate = 3.4 mm sec^{-1}

Determine the chip thickness at the start point of cutting.

3/.....

Q6. (a) For the involute gear milling process, derive the expression given below associated with cutter selection used for cutting a helical gear.

$$T_e = T_h \sec^3 \alpha$$

where T_e is the number of teeth for an equivalent spur gear.

T_h the number of teeth of the helical gear and
α is the helical angle

(b) Sketch and lebel the tooling set-up for involute gear milling.

Given the following
$T_h = 25$
$m_h = 2.125$. helical gear module
$\alpha = 20$ deg. helical angle,
determine a suitable cutter to be used to produce the helical gear.

Q7. In a single point boring operation using a regrindable tool, the following data is given:

<u>Machine tool:</u>

Tool set up time	=	30 min
Tool replacement cost	=	K15,000
Machine usage rate	=	K10,000 hr^{-1}
Tool regrind time	=	20 min
Taylor equation for tool in meter minutes: $VT^{0.3}$	=	109
Total number of regrinds possible	=	100
Regrinding cost rate	=	K6000 hr^{-1}

<u>Workpiece</u>

Length to the machined	=	65mm
Workpiece diameter	=	100mm
Tool feed rate on workpeice	=	0.2mm rev^{-1}
Tool depth of cut	=	0.15mm

Using the above stated data. determine:

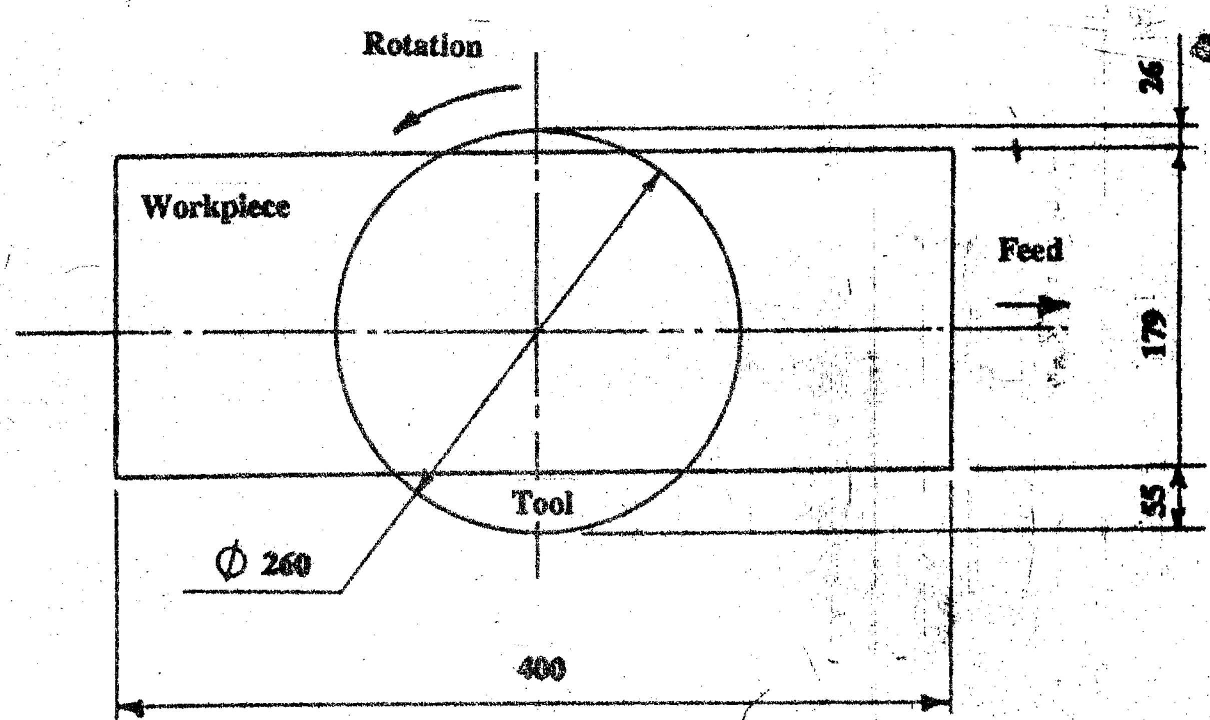
(i) Cutting speed and tool life for minimum cost criteria (No derivations are required).
(ii) Cutting speed and tool life for maximum production criteria
(iii) Total cost of boring 500 pieces if maximum production is required.

END OF EXAMINATION

Dr. H. M. Mwenda
Mr. M.O. Goma

Figure Q5.

Dimensions in mm



THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

END OF SEMESTER I FINAL EXAMINATIONS - JULY 1996

ME 431: STRENGTH OF MATERIALS II

ATTEMPT FIVE QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

Q1. A cylinder which can be considered thin has an internal diameter of 150 mm and a wall thickness of 2.5 mm. It's ends are closed by rigid plates and is filled with water.
When an external axial pull of 37 kN is applied to the ends the water pressure is observed to fall by 0.1 N/mm^2.
Determine the value of poisson's ratio, given that E = 140,000 N/mm^2 and k = 2200 N/mm^2.

Q2. A cylinder is subjected to an internal pressure of 150 MNm^{-2} and has an inside radius r_i = 12.5 mm and outside radius r_o = 25 mm.
The cylinder is made of steel with a critical stress intensity factor K_{IC} = 60 MNm$^{-3/2}$.

(a) Find the minimum crack length to cause fracture assuming thick cylinder (vessel) theory.

(b) If a thick cylinder approach is used, what is the minimum crack size to cause fracture.

Q3. A motor vehicle mounted crane has a hook whose horizontal cross is trapezoidal in shape.
The trapezoid is 50mm wide at the inside and 25mm wide on the outside and is of thickness 50mm.
The hook carries a vertical load of 1000 kg whose line of action is 38 mm from the inside edge of the section. If the centre of curvature is 50 mm from the inside edge, calculate

(a) the maximum tensile stress

(b) the maximum compressive stress.

Q4. A plane state of stress is given in the figure below, in which σ_x = 10kPa., σ_y= -4 kPa and τ_{xy} = 8kPa.

Calculate the values of the stresses σ_{x1} and τ_{x1y1} when the x_1-axis is at a positive angle $\theta = 30°$ (counter - clockwise) with the positive end of the x - axis.

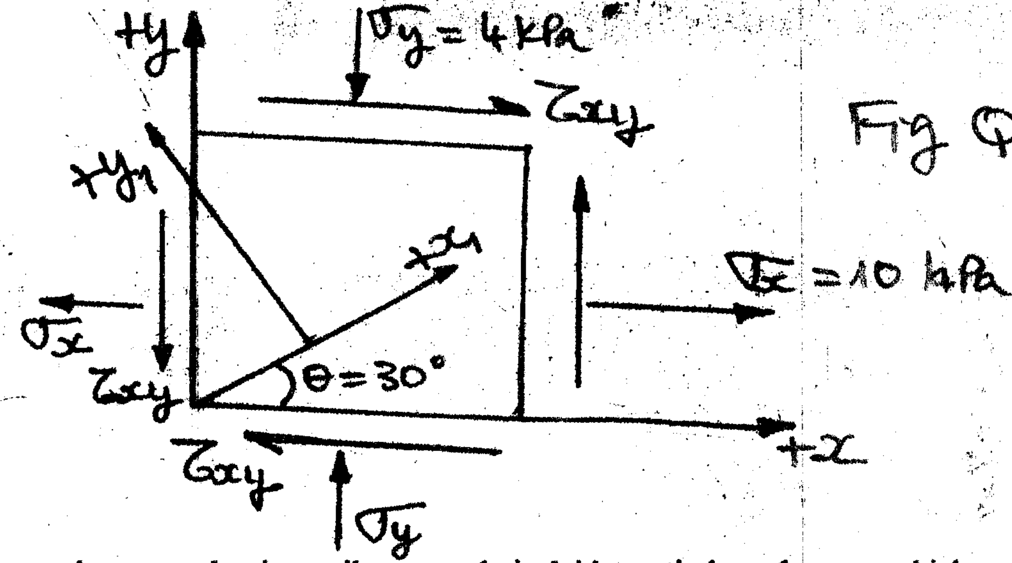


Fig Q4.

Q5. An under ground mine railway track is laid on timber sleepers which exert an equivalent load of 2800 N/m length of rail per millimetre deflection from the position of zero load. For each rail the following parameters hold $I = 12 \times 10^6$ mm^4, $Z = 16 \times 10^4$ mm^3 and E = 205, 000 N.mm^2.

If a point load of 100kN acts on each rail, calculate:

(a) the length of rail over which the sleepers are depressed

(b) the maximum bending stress in the rail.

Q6. A circular bar AB, fixed at one end and free at the other, is loaded by a distributed torque of constant intensity q per unit distance along the axis of the bar.

(a) Derive a formula for the amount of strain energy stored in the bar when the load is applied.

(b) Evaluate the strain energy for the following numerical values : L = 8m Ip = 120×10^{-6} m^4, q = 5 kN.m/m and G = 78GPa.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY EXAMINATIONS - NOVEMBER, 1996

ME 452: ENGINEERING MATERIALS SCIENCE

CLOSED BOOK

TIME: **THREE (3) HOURS**

ANSWER: **FOUR QUESTIONS**
ALL QUESTIONS CARRY EQUAL MARKS

SECTION A: **ATTEMPT TWO QUESTIONS.**

Q1. (a) Describe the following plastic deformation processes

(i) Slip ✓

(ii) Twinning ✓

(b) What is dislocation climb? ✓

Q2. (a) Derive a relationship illustrating the magnitude of stress that may be required in order to induce deformation in a perfect lattice by the translation of one plane of atoms over another.

(b) Discuss briefly the types of internal stresses that may be found in a metal being subjected to deformation.

Q3. (a) Describe briefly with the help of diagrams

(i) Edge dislocations ✓

(ii) Screw dislocations. ✓

(b) Discuss in detail the Griffith criterion.

Q4. (a) With the help of cooling curves, explain the possible classification of materials based on structure.

(b) What are the typical properties of metals?

Discuss what distinguishes metals and metallic alloys from other crystals.

SECTION B: ATTEMPT ALL QUESTIONS

Q5. (a) With the help of sketches discuss in detail the mechanical behaviour of polymers called anelasticity.

(b) Describe the differences between addition and condensation polymerization.

Q6. (a) Give four examples of crystalline ceramic phase structures, stating briefly the formation of each structure.

(b) Discuss briefly the composition of the group of materials generally known as "traditional ceramics."

END OF EXAMINATION - Dr. C.K. Wamukwamba
09.09/96

UNIVERSITY OF ZAMBIA
DEPARTMENT OF MECHANICAL ENGINEERING
FIRST SEMESTER UNIVERSITY EXAMINATIONS- JUNE 1996

ME 461 - FLUID MECHANICS II

(CLOSED BOOK)

Answer: ANY FIVE (5) QUESTIONS

Time: THREE (3) HOURS

ALL QUESTIONS CARRY EQUAL MARKS

Briefly and clearly State any assumptions taken.
Unless otherwise stated, density of water and acceleration due to gravity are 1000 kg/m^3 and 9.81 m/s^2 respectively while atmospheric Pressure is 101.4 KN/m^2.

Q1. (a) Briefly state three reasons why dimensional and model analysis is important in Engineering fluid Mechanics.

(b) Dimensional analysis can be used to show that the Law governing the flow of fluids is;

$$\frac{F}{\rho . V^2} = \phi \left(\frac{\rho . V . d}{\mu}\right)$$

where F = frictional force per unit wetted area,
ρ = fluid mass density, V = velocity of fluid,
d = pipe diameter, μ = absolute viscosity of fluid
ϕ = some mathematical functional relation

The flow of a gas in a uniform duct is to be simulated by means of water flow in a one quarter -scale transparent model. In the full- scale duct, gas velocity is expected to be 24 m/s. Find

(i) the corresponding water velocity in the model
(ii) the pressure drop to be expected per unit length of the full scale duct.

One kilogram of gas under conditions in the full-scale duct occupies 0.686 m^3 and the absolute viscosity for water is 62 times that for gas.

2/.................

Q2. (a) Define (i) skin friction drag
(ii) Pressure drag
(iii) Distinguish between stream lined and bluff bodies in terms of the skin drag and Pressure drag that act on these bodies.

(b) A 1 m by 1.2 m plate moves at 13.5 m/s in still air at an angle of 12° with the horizontal. If the drag coefficient $C_D = 0.17$, lift coefficient, $C_L = 0.72$, and density of air is 1.2 kg/m³, determine

(i) the resultant force exerted by the air on the plate
(ii) the frictional force
(iii) the power required to keep the plate moving.

Q3. (a) (i) Define a prime mover.
(ii) Give two examples of prime movers that work on principles of fluid mechanics

(b) A Pelton wheel is supplied with water under a head of 30 m at a rate of 41 m³/s. The buckets deflect the jet through an angle of 160° and the mean bucket speed is 12 m/s.

Determine the power and the hydraulic efficiency of the machine.

Q4 (a) State two main differences between a centrifugal pump and an axial-flow pump in terms of the head and discharge these pumps can handle.

(b) (i) If the static lift for a centrifugal pump is h meters, the speed of rotation is N rev/min and the external diameter of the impeller is D metres, deduce the expression;

$$N = 83.5\frac{h^{0.5}}{D}$$

for the speed at which pumping commences, assuming only rotation of water in the impeller at the " no-flow" condition.

(ii) Such a centrifugal pump described above delivers 1.27 m³ of water per minute at 1200 RPM. The impeller diameter is 350 mm and the breadth at outlet is 12.7 mm. The pressure difference between inlet and outlet flanges is 272 kN/m². Taking the manometric efficiency at 63%, determine the impeller exit blade angle.

Q5. (a) Briefly state what the following terms or Laws represent in fluid mechanics
(i) Continuity equation
(ii) Bernoulli's equation.
(iii) Newton's Law of motion

(b) A 45° reducing bend with 0.6 m diameter upstream and 0.3 m diameter down stream has water flowing through it at the rate of 0.45 m^3/s under a pressure of 1.45 bar at its bigger upstream end where the water enters the bend. Neglecting any loss in the bend, calculate the force exerted by the water on the reducing bend if the centre line axis of the bend is horizontal and the pressure at the smaller end of the bend is well above atmospheric pressure.

Q6. (a) (i) Give the approximate value of the Mach number above which fluid flow becomes compressible.

(ii) Give the approximate value of the Mach number above which Navier-Stokes equations for fluid flow do not hold.

(b) Carbon-dioxide gas discharges through a 12.7 mm diameter hole in the wall of a tank in which the absolute pressure is 8.6 bar and the temperature is 20°C. Determine the velocity of the issuing jet.
The characteristic gas constant and isentropic exponent for carbon-dioxide are 187.8 J/kg°K and 1.3 respectively.

End of Examination

Dr. F.C. Nsunge

MHSRP
died in [illegible]

So what? Everybody dies!
F.U!

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY SEMESTER 1 SUPPLEMENTARY/DEFERRED EXAMINATIONS - JULY 1996.
ME 501 - MACHINE DESIGN AND PRODUCTION MANAGEMENT

TIME: SIX (6) HOURS OPEN BOOK

You are working in the Design department of a saloon vehicle manufacturing unit and requested to design the rear axle of a rear wheel driven saloon vehicle. The rear wheels are driven by a differential gear system. An example of such a gear system is shown in figure 1, together with an explanation of such a gear system. The main driving mechanism is a straight bevel gearing consisting of pinion G and gear F. The assumption for the analysis is that the bevel gearing is driving only one wheel.

The mass of the vehicle is 1000kg while the torque transmitted through gear G is 30Nm. Both gears G and F have a pressure angle of 20°, are shaped with a module of 4mm and have accurate and stiff montings - the power sources is uniform. The face width equals 30 mm. The pinion has 18 teeth and the gear has 40 teeth. Both pinion and gear are made of machine steel with a tensile strength of 600 MPa and a Brinell hardness of HB320.

The efficiency of the bevel gearing is 0.99, while the efficiency of the bearings is 0.97. Each rear wheel tensile is suspended by two ball bearings at the position shown.

The pinion G rotates at 1500 rpm.

QUESTIONS

Q1. Determine the torque at the driven wheel.

Q2. Determine the pitch line velocities of the bevel gearing.

Q3. Calculate the transverse, radial and axial load on the pinion.

Q4. Determine the common factor of safety against fatigue bending for a 10^6 cycle life and a reliability of 99%.,

Q5. Determine the common factor of safety against contact fatigue stress under the same conditions.

Q6. Make a design sketch of the wheel shaft including the bevel gear and the ball bearings. Indicate dimensions which are important for determining the shaft diameter and make an estimation of the position of the bearings.

Q7. Assess the forces on the rear wheel shaft and draw the diagrams for torque and bending moment. Assume the forces are acting in the middle of the gears and bearings.

Q8. Find the appropriate shaft diameter, using the combined Von Mises- Hencky and Goodman theory, with a 98% reliability and a factor of safety of 2.

Q9. Select appropriate ball bearings for the rear wheel shafts for a life span of at least 3000 hrs. Use a factor of safety of 98%.

Q10. Dimension parallel key(s) for the bevel gear F.

Q11. Make a detail drawing for the rear wheel shaft. Use an appropriate scale including dimensions and tolerances.

Marking Key:

Questions:	Q1 - Q5:	30
"	Q6 - Q8:	30
"	Q9 - Q11:	40

END OF EXAMINATION - ME 501

S.J.M. Serrarens

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY SEMESTER 1 SUPPLEMENTARY/DEFERRED EXAMINATIONS - JULY 1996.

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END OF EXAMINATION - ME 501

S.J.M. Serrarens

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF ENGINEERING

ME 515 PRODUCTION TECHNOLOGY II

PAPER I

UNIVERSITY EXAMINATIONS - NOVEMBER,1996

TIME: THREE HOURS **CLOSED BOOK**

ANSWER: QUESTION ONE AND ANY OTHER FOUR QUESTIONS.

Q1. (a) Derive the expression for flat rolling mean pressure given by:

$$P_{ave} = \frac{2kh}{\mu L} \left[e^{\mu L/h} - 1 \right]$$

State all assumptions.

(b) The plane-strain flow stress of a metal is 190 MNm^{-2}. A sheet of the metal is to be rolled from a thickness of 12 mm to 8 mm in a single pass using rolls with a radius of 0.15 m. The rolling process incorporates front and back tension of 50 MNm^{-2} on the sheet. The coefficient of friction between the rolls and the material is given as 0.095. The sheet width is 0.8m.

Determine the mean pressure and the force transmitted to bearings of the rollers.

(24 Marks)

Q2. (a) Derive the expression for maximum drawing force in the deep drawing process for pot production. State assumptions.

(b) Use the derived expression for force to estimate the maximum load for deep drawing a rectangular mess-tin with the following dimensions: length 170 mm, width 110 mm and depth 80 mm. The material flow stress is given as 140 MNm^{-2} and the sheet thickness is 1.8 mm.

(19 Marks)

Q3. (a) Discuss and compare thermoplastics and thermoset plastics. Give at least one example of each type of plastic.

(b) Discuss and compare injection and transfer moulding.

(19 Marks)

Q4. (a) Mild steel components used as structural members in the installation of an electricity distribution line require zinc plating to achieve a long outdoor service life.

Suggest a cleaning process sequence for the mild steel parts prior to zinc plating.

(b) Determine the plating bath capacity for a throughput of 100 parts per hour given the following data:
Time for electrolytic cleaning: 5 minutes;
Time for electroplating: 9.5 minutes;
Single component surface area: 45,000 mm^2;
Current density for electrolytic cleaning: 3.5 A dm^{-2};
Zinc density: 7130 kg m^{-3};
Zinc electrochemical equivalency: 1.22 g A^{-1} hr^{-1};
Electroplating bath efficiency: 75 % ;
Thickness of material deposit: 7.5 μm.

(19 Marks)

Q5. (a) Discuss factors that favour investment in CNC metal removal technology.

(b) UNZA's Department of Mechanical Engineering is in the process of installing a production type CNC machining centre with a 16 tool automatic tool changer. Discuss technology related problems that will need to be overcome in order to sustain this kind of technology in the Department.

(19 Marks)

Q6. In a door frame manufacturing process, a break press is used for sheet metal bending. The tooling comprises a bending blade with a radius of 2 mm co-acting with a V-shaped block. The effective length for bending across the V shape is 20 mm. This tooling combination is set to produce a 90 degree bend.

Determine the load required to produce a 90 degree, 1960 mm long, bend of the door frame. The door frames are manufactured from mild steel sheets with a 0.9 mm thickness and with a material flow stress of 210 Nmm^{-2}. Derive the expression used to determine the load. (19 marks)

Q7. Using the Upper Bound Theory, determine the force required to forge, between two flat platens, a 0.75 height-to-diameter ratio cylindrical mild steel billet in the hot state at a temperature of 880 deg. Celsius. At this temperature, the material yield stress in uniaxial tension, Y, is 55 N mm^{-2}.

The starting diameter for the billet is 350 mm. The forging machine tool has one fixed and one moving platen. The speed for the moving platen is 2.3 m sec^{-1}. State any assumptions. 19 marks)

END OF EXAMINATION

Dr. H.M. Mwenda

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER 2 SUPPLEMENTARY/DEFERRED EXAMINATIONS, 1996

ME 515 PRODUCTION TECHNOLOGY II, PAPER 1

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS **CLOSED BOOK**

EACH QUESTION CARRIES 20 MARKS

Q1. What assumptions are made when applying the Upper Bound Theory to metal deformation analysis?

Derive the applied force and material flow stress relationship in plane strain indentation using the Upper Bound Theory. In the derivation, a frictionless interface should be assumed to exist between the tool and the material.

Q2. Give brief outlines for the processes listed below:

(a) Vacuum forming
(b) Blow moulding
(c) Transfer moulding.

Q3. Suggest and fully explain industrial cleaning and finishing treatment for each one of the following products.

(i) Wooden chair leg
(ii) Zinc plated steel component
(iii) Filing cabinet made of mild steel sheet.

Q4. (a) Derive an expression for estimating maximum force in deep drawing of a cylindrical pot. State any assumptions used in the derivation.

(b) An aluminium pot with a diameter of 200 mm is to be deep drawn using a 2 mm thick disc with a diameter of 380 mm. A pressure pad is to be used on the flange. Estimate the maximum drawing force required. The material flow stress is given as 100 MNm^{-2}.

Q5. (a) Give an outline of the functions of a CNC machine tool; highlight the main advantages of such a machine tool.

(b) What considerations must be taken into account when applying CNC machine tools in Zambia?

Q6. (a) Derive an expression for the moment required to cause plastic bending of a sheet metal.

(b) A mild steel sheet 1 mm thick is bent to a radius of curvature of 2 mm. The material flow stress is 215 MNm^{-2}. Determine the bending moment over a 1.35 m length of the sheet.

Q7. Discuss the significance of yield criteria for metal deformation.

In a plane stress system

$\sigma_x = 700\ Nmm^{-2}$, $\sigma_y = 100\ Nmm^{-2}$.

$\sigma_z = 0\ Nmm^{-2}$ and $\tau_{xy} = 130\ Nmm^{-2}$.

Determine the magnitudes of principal stresses.

If the stress system causes yielding, what is the uniaxial yield stress Y on the material according to (a) Tresca criterion, (b) Von Mises criterion?

END OF SUPPLEMENTARY/DEFERRED EXAMINATION

Dr. H.M. Mwenda

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS-NOVEMBER 1996

ME 525 REFRIGERATION AND AIR CONDITIONING

TIME: **THREE HOURS**

ANSWER: **FIVE QUESTIONS**

All Questions Carry Equal Marks.
Steam Tables, Psychrometric Charts and Freon-12 Property charts may be used.

Additional Data:

For dry air: C_p = 1.0005 kJ/kgK; R = 287 J/kgK
M = 28.97, ρ = 1 kg/m3

For moisture: C_p = 1.84 kJ/kgK; R = 466 J/kgK

M = 18.02; hfg = 2500 kJ/kgK

For water/ice: Enthalpy of fusion = 334 kJ/kgK

Barometer: 1.013 bar unless otherwise stated

For solar angles:

$$\sin(\alpha) = \cos(L)\cos(h)\cos(d) + \sin(L)\sin(d)$$

$$\tan(z) = \frac{\sin(h)}{\sin(L)\cos(h) - \cos(L)\tan(d)}$$

Q1. (a) For moist air show from first principles that:

specific humidity (W) = $(0.62\ P_s)/(P_b - P_s)$

Relative humidity (ϕ) = $$\frac{w(P_b - P_s)1.62}{P_g}$$

(b) Calculate the following psychrometric properties of air when dry bulb temp is 21° C and relative humidity is 30% at barometric pressure of 1 bar.

(i) specific humidity (ii) specific enthalpy

(iii) dew point

Q2. (a) Define the Room Ratio Line and the Grand Sensible Heat factor line and discuss their significance in the choice of supply conditions.

(b) An air - conditioning plant comprising filter, fan and distributing duct work uses only fresh air for the purpose of maintaining comfort conditions in summer. Using the information listed below:

Calculate the

(i) Cooler coil load
(ii) Grand Sensible Heat Factor
(iii) Coil contact factor.

Sensible heat gain to conditioned space: 11.75 kW
Latent heat of gain to conditioned space: 2.07 kW
Outside design state: 28^0 C db; 20^0 C wb
Inside design state: 21^0 C db; 50% RH
Supply air temperature to be about 10^0 C below room temperature.
Temperature rise due to fan power and duct heat gains: 1^0 C.

Q3. (a) Define with relevant sketches the volumetric efficiency of a reciprocating compressor and show that η_{vol} may be written as

$$1 + C - C\left(\frac{P_d}{P_s}\right)^{\frac{1}{n}}$$

Where C is clearance ratio; P_d is discharge pressure, P_s is suction pressure and n is compression index.

(b) A two cylinder freon-12 compressor has a bore 5.65 cm and stroke 5 cm. Its speed is 450 rpm and clearance ratio is 4%. The refrigerant reaches the compressor suction saturated at -10^0 C and enters the throttle valve at 40^0 C. Determine

(i) the refrigerant mass circulation rate
(ii) the refrigerating capacity the compressor can handle.

Q4. (a) For a space of volume $V_m{}^3$ inside which a pollutant gas is produced at the rate of A m^3/s while fresh air is supplied for ventilation at the rate of B m^3/s and an equal amount of polluted air is expelled, show that:

$$X = X_0 e^{-n} + \left(X_f + \frac{A}{B}\right)\left(1 - e^{-n}\right)$$

where X is the volume fraction of pollutant in the room at time t, X_0 is the volume fraction of pollutant in the room at zero time, n is the number of air changes in the time period t and X_f is the volume fraction of pollutant in the incoming fresh air.

(b) A room is designed for 25 m^3 per person and the occupants breathe at a steady rate of 0.5 litre (air)/second per person. Assuming no ventilation, how long will it take to decrease the room oxygen percentage by volume from 21% to 20.5% if 20% of the oxygen inhaled by a person is metabolised.

Q5. (a) Define the Sol air temperature and explain its significance in air conditioning design.

(b) A window facing North West is 2 m high and 1.5 m wide and is recessed back 30 cm from the outer surface of the wall. For the time and location given below; Calculate:

(i) the shaded and unshaded areas of the window

(ii) the recess value that would give complete shading at the given time and location.

Location: Mazabuka 18^0 S Latitude

Time: 14.00 hours on 21st June 1990.

Q6. (a) Show that for a natural draught cooling tower, the mass ratio of dry air to water at entry to the tower is given by the expression

$$\frac{m_2}{m_1} = \frac{h_3 - h_1}{h_2 - h_4 + h_3(w_4 - w_2)}$$

where the thermodynamic states 1 to 4 refer respectively to the water entry, air entry, water exit, and air exit.

(b) If for the tower described above air enters at a temperature of 25° C and 50% RH, and leaves at 30° C, determine with the aid of a psychrometric chart:

(i) the mass ratio of dry air to water both at entry to tower

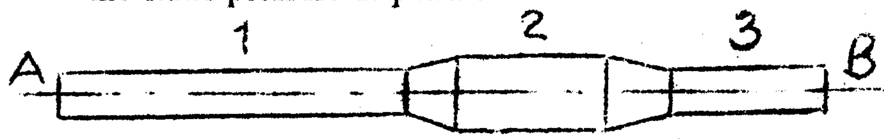
(ii) percentage evaporation loss

(iii) volume of air at entry per unit mass of incoming water

(iv) sensible heat ratio of air through the cooling tower.

Q7. (a) Discuss briefly the criteria for air conditioning duct design.

(b) The duct shown is supplied with air at point A and the same air is discharged freely at point B. Given the specifications below, calculate the static pressure at point A.



$L_1 = 50$ m $L_2 = 20$ m $L_3 = 20$ m

$d_1 = 0.6$ m $d_2 = 1.2$ m $d_3 = 0.45$ m

$V_1 = 12$ m/s

The loss in the expansion piece connecting section 1 and 2 is 0.5 p_{v1} and the loss
in the reducing piece connecting sections 2 and 3 is 0.2 P_{v3}.

Friction loss in mm of water per 100 m of duct may be calculated from the equation

$$h = 90.7\frac{V^{1.852}}{D^{1.269}}$$

where V is velocity in m/s and D is diameter in cm.

END OF EXAMINATION - Dr. E. Ohaom

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER 2 SUPPLEMENTARY/DEFERRED EXAMINATIONS

ME 525 - REFRIGERATION AND AIR CONDITIONING

TIME: **THREE HOURS**

ANSWER: **QUESTION ONE (1) AND FOUR (4) OTHERS (FIVE QUESTIONS IN ALL)**

Steam tables, Psychrometric charts and Freon R -12 property charts are supplied.
Atmospheric pressure = 1.01325 bar
For dry air: C_P = 1005 J/kgk; R = 287 J/kg k. ρ = 1 kg/m^3
For moisture: C_P = 1.88 kJ/kgk; R = 466 J/kg k. h_g = 2500 kJ/kg
Use pyschrometric charts for checking only; unless otherwise stated.

Q1. An air conditioned hall is to be maintained at 27^0 C db and 21^0 C wb. It has a sensible heat load of 46.5 kW and a latent heat load of 17.5 kW. Outside air (at 30^0 C db and 27^0 wb) to be conditioned is passed through a cooling coil whose apparatus dew point is 15^0 C. The air recirculated from the hall is 60% and this is mixed with the conditioned air after the cooling coil. Additionally, 25 m^3 per minute of fresh air from outside is supplied directly and through infiltration. Assuming standard barometric conditions:

determine:

(i) the condition of the air after the cooling coil and before the recirculated air mixes with it

(ii) the condition of the air entering the hall

(iii) the mass flow rate of air entering the cooler

(iv) the by-pass factor of the cooling coil

(v) the refrigeration load on the cooling coil [40 marks]

Psychrometric chart may be used.

Q2. (a) Explain briefly the objectives of controlled ventilation air supply

[5 marks]

(b) A room is designed for 15 m^3 per person and the occupants breathe at the rate of 0.5 litres per person, 18% of the oxygen inhaled being consumed. How long will it take to reduce the room O_2% from 21% to 20% with negligible ventilation.

[10 marks]

Q3. 0.6 kg/s of air at 25° C and 50% RH is mixed with 0.2 kg/s of air at 40° C and 30% RH, and the mixture is then passed over a cooling coil so that the final condition of the mixture is 15° C and 0.00968 specific humidity.

Required:

(a) the cooling coil capacity in kW and TOR, and the water extraction rate.

[7 marks]

(b) using the psychrometric chart, determine the coil by-pass factor and the apparatus dew point.

[8 marks]

Q4. Estimate the fabric heat gain through 100 m^2 of roof of light construction, neglecting thermal capacity and time-lag, at 15.00 hours solar time on 15th October at a location 15° South latitude, given:-

sun declination	=	-12°
outside air temperature	=	38° C
inside air temperature	=	23° C
air film heat transfer coefficients on both sides	=	15 W/m^2 °C
roof material, k = 1.28 W/m °C: 12 cm thick; α	=	0.80
normal solar radiation intensity	=	800 W/m^2

Use for sun altitude:-

sin a = cos(L). cos(h). Cos(d) + sin(L). Sin(d).

[15 marks]

Q5. An air duct, carrying 400 m^3/min of air at 30° C and 70% RH, is 15 m long. At the end of the duct the air is equally distributed to two branch ducts one of 10 m length and the other of 5 m length.

Determine the duct diameters at the various sections and the required fan power, assuming:-

friction loss for the longest route	=	8 mm water per 100 m
friction coefficient,	f =	0.006
fan efficiency	=	0.65
pressure drop in the air treatment section	=	15 mm water.

[15 marks]

Q6. An evaporative condenser (in a cooling tower) for a Refrigerating plant has the following particulars:

Working fluid	= Freon 12
Condensing temperature	= 45^0 C
Air intake to tower	= 30^0 C db; 50% RH
Air exit from tower	= 30^0 C db; 90% RH
Evaporator cooling load	= 500 kW
Compressor power	= 130 kW
Air velocity at fan outlet	= 40 m/s
Overall heat transfer coefficient	= 280 $W/m^2 {}^0C$

Determine (using psychrometric chart where necessary)

(a) the amount of cooling air required

(b) the air fan diameter

(c) the amount of make up water

(d) the outer surface area for the condenser [15 marks]

Q7. (a) Outline the difficulties which arise when attempting to attain low temperatures with a single-stage vapour compression plant. How can these difficulties be overcome. [5 marks]

(b) A two stage Freon 12 refrigeration system uses flash intercooling at an intermediate pressure of 3.5 bar. Evaporator temperature is - 20^0 C and condenser temperature is 35^0 C. Assume all stage compression is isentropic and the vapour leaving the LP compressor is passed through the flash intercooler and only the flash vapour goes through the HP compressor. For a refrigeration capacity of 352 kW estimate the power requirement and coefficient of performance for the system. Assume saturated vapour at entry to LP compressor and no subcooling in the condenser.

[10 marks]

END OF SUPPLEMENTARY/DEFERRED EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS - JULY 1996

ME 571 - VIBRATIONS AND CONTROL ENGINEERING

TIME: THREE (3) HOURS | CLOSED BOOK

INSTRUCTIONS: - ANSWER FOUR (4) QUESTIONS ONLY. TWO (2) QUESTIONS MUST BE ANSWERED FROM EACH SECTION
- ALL QUESTIONS CARRY EQUAL MARKS

SECTION A - CONTROL ENGINEERING

USE A SEPARATE ANSWER BOOKLET FOR THIS SECTION

ANSWER ANY TWO (2) QUESTIONS

QA-1. Given is the system shown in Figure A-1

(i) Determine the differential equation of operation for this system.

[6 marks]

The system is in a state of equilibrium at t = 0 s, with $r(0) = 1$, $d(0) = 0$ and

$$\frac{dc}{dt}(0) = -1$$

(ii) show that $c(0) = 2$ [5 marks]

A step function disturbance $d(t) = 2$ is then initiated at time $t = 0$ s

(iii) Determine the system response for $t \geq 0$ s. [8 marks]

(iv) Verify the solution of (iii) by applying the initial and final value theorem.

[3 marks]

(v) Draw the response for $0 \leq t \leq 10$ s [3 marks]

QA-2. A second order process is determined by the transfer ratio

$$H(D) = \frac{2}{(D+1)(D+7)}$$

The process is proportionally controlled (static gain factor of the controller K_r) in a unity negative feedback loop, as shown in Figure A-2

(i) Draw the root locus. [6 marks]

(iii) Determine the value of K_r, for which the damping ratio ζ equals 0.5. [5 marks]

(iii) Determine the values of K_r, for which the system is stable. [3 marks]

(iv) Compare the result of (iii) with the result obtained when applying Routh's stability criterion. [3 marks]

(v) With $r(t) = 0$, $c(0) = 1$ and $\dfrac{dc}{dt}(0) = 1$

determine the output $c(t)$ of the system in Fig A-2, when $K_r = 4$

[8 marks]

QA-3. Given are three transfer functions

$$H_1(D) = 16D + 1$$

$$H_2(D) = \frac{1}{12D}$$

$$H_3(D) = \frac{1}{4D+1}$$

For the system with transfer ratio

$$H(D) = H_1(D) \cdot H_2(D) \cdot H_3(D),$$

(i) sketch the bode diagrams for the amplitude ratio (asymptotes only) and the phase angle; [14 marks]

(ii) determine the maximum angle by which the output is lagging or leading, and the corresponding circular frequency; [7 marks]

(iii) indicate the values calculated under (ii) in the diagrams for the amplitude ratio and the phase angle. [4 marks]

SECTION B – VIBRATIONS

USE A SEPARATE ANSWER BOOKLET FOR THIS SECTION
ANSWER ANY TWO (2) QUESTIONS

QB-1. (a) Given that the displacement transmissibility for a damped spring-mass system under the harmonic motion of the base is given by

$$\frac{X}{Y} = \left[\frac{1+(2\zeta r)^2}{(1-r^2)^2+(2\zeta r)^2}\right]^{1/2}$$

Show that the displacement transmissibility attains a maximum for
$0 < \zeta < 1$ at the frequency ratio $r = r_m < 1$ such that

$$r_m = \frac{1}{2\zeta}\left[\sqrt{1+8\zeta^2}-1\right]^{1/2}$$

[10 marks]

(b) A heavy machine, weighing 3000N, is supported on a resilient foundation. The static deflection of the foundation due to the weight of the machine is found to be 7.5cm. It is observed that the machine vibrates with an amplitude of 1cm when the base of the foundation is subjected to harmonic oscillation at the undamped natural frequency of the system with an amplitude of 0.25cm. Find
(i) the damping constant of the foundation
(ii) the dynamic force amplitude on the base and
(iii) the amplitude of the displacement of the machine relative to the base. Comment on your answer.

[15 marks]

QB-2. Figure QB-2 shows the anvil and foundation block of a forging hammer. Find the natural frequencies and mode shapes of the system for the following data:

mass of the anvil and frame	=	200kg
mass of the foundation block	=	250kg
stiffness of the elastic pad	=	150MN/m
stiffness of the soil	=	75MN/m

[25 marks]

QB-3. (a) Discuss the significance of the following expression for a vibration measuring instrument:

$$= \frac{(\omega/\omega_n)^2}{\sqrt{\left[\left(1-\frac{\omega^2}{\omega_n^2}\right)^2+\left(2\zeta\frac{\omega}{\omega_n}\right)^2\right]}}\, Y\sin(\omega t-\phi)$$

[10 marks]

(b) A spring-mass-damper system, having an undamped natural frequency of 100Hz and a damping constant of 20N-s/m is used as an accelerometer to measure the vibration of a machine operating at a speed of 3000rpm. If the actual acceleration is $10 m/s^2$ and the recorded acceleration is $9 m/s^2$, find the mass and the spring constant of the accelerometer.

[15 marks]

END OF EXAMINATION - ME571

Mr H A de Keyzer and Dr A N Ng'andu

ME 571 - VIBRATIONS and CONTROL ENGINEERING

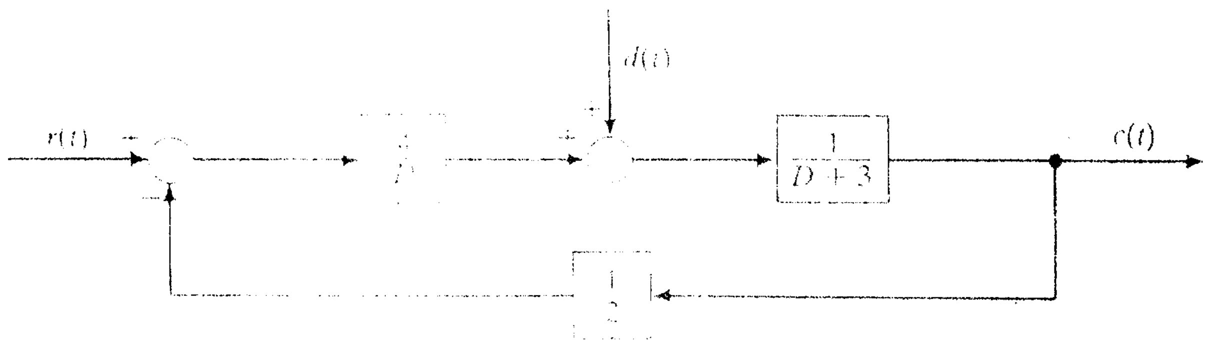


FIGURE A - 1

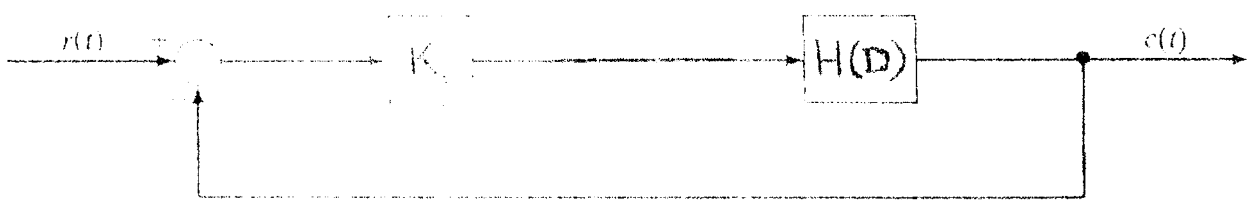


FIGURE A - 2

Laplace transform pairs

$f(t)$	$F(s)$	$f(t)$	$F(s)$
$u_1(t)$	1	$t^n e^{at}$	$\dfrac{n!}{(s-a)^{n+1}}$
$u(t)$	$\dfrac{1}{s}$	$\sin \omega t$	$\dfrac{\omega}{s^2+\omega^2}$
t	$\dfrac{1}{s^2}$	$\cos \omega t$	$\dfrac{s}{s^2+\omega^2}$
e^{at}	$\dfrac{1}{s-a}$	$e^{at}\sin \omega t$	$\dfrac{\omega}{(s-a)^2+\omega^2}$
t^n	$\dfrac{n!}{s^{n+1}}$	$e^{at}\cos \omega t$	$\dfrac{s-a}{(s-a)^2+\omega^2}$

Laplace transform properties

Time function	Laplace transform
$kf(t)$	$kF(s)$
$f_1(t) \pm f_2(t)$	$F_1(s) \pm F_2(s)$
$f'(t)$	$sF(s) - f(0)$
$f''(t)$	$s^2F(s) - sf(0) - f'(0)$
$f^n(t)$	$s^nF(s) - s^{n-1}f(0) - \cdots - f^{n-1}(0)$
$f^{(-1)}(t)$	$\dfrac{F(s)}{s} + \dfrac{f^{(-1)}(0)}{s}$
$f^{(-n)}(t)$	$\dfrac{F(s)}{s^n} + \dfrac{f^{(-1)}(0)}{s^n} + \cdots + \dfrac{f^{(-n)}(0)}{s}$
$f(at)$	$\dfrac{1}{a}F\left(\dfrac{s}{a}\right)$
$e^{at}f(t)$	$F(s-a)$
$t^nf(t)$	$(-1)^n \dfrac{d^n}{ds^n}F(s)$
$f(\tau) = f(t - t_0)$	$e^{-t_0 s}F(s)$
$\int_0^t f(\lambda)g(t-\lambda)\,d\lambda$	$F(s)G(s)$

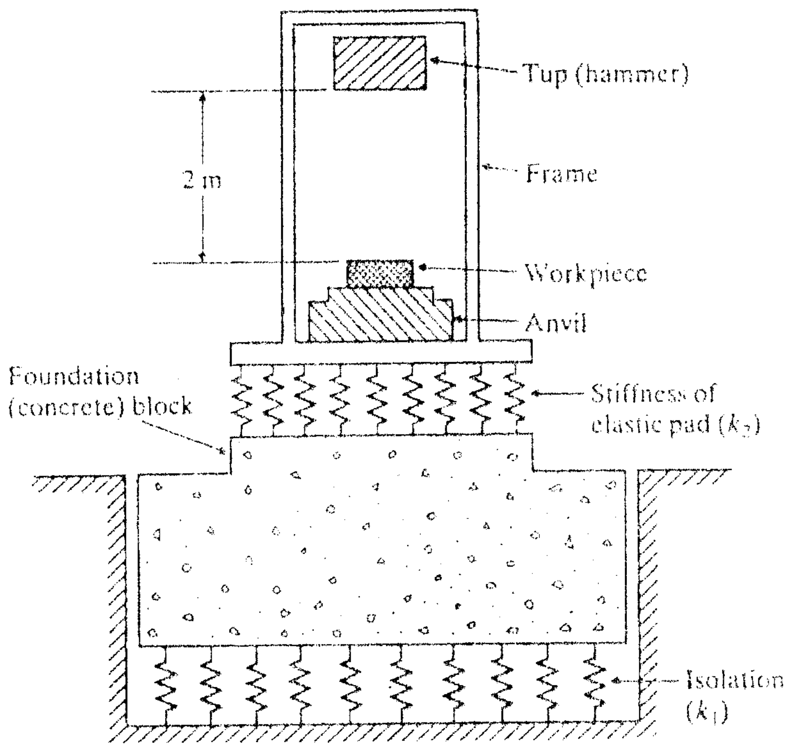

Tup (hammer)
2 m
Frame
Workpiece
Anvil
Foundation (concrete) block
Stiffness of elastic pad (k_2)
Isolation (k_1)

FIGURE QB - 2

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY SEMESTER I SUPPLEMENTARY/DEFERRED EXAMINATIONS - JULY 1996

ME 571 - VIBRATIONS AND CONTROL ENGINEERING

TIME: THREE (3) HOURS CLOSED BOOK

INSTRUCTIONS:
- ANSWER FOUR (4) QUESTIONS ONLY, TWO (2) QUESTIONS MUST BE ANSWERED FROM EACH SECTION
- ALL QUESTIONS CARRY EQUAL MARKS

SECTION A - CONTROL ENGINEERING

USE A SEPARATE ANSWER BOOKLET FOR THIS SECTION

ANSWER TWO (2) QUESTIONS

QA-1. Given is the system shown in Figure A-1.

(i) Determine the differential equation of operation for this system.

For the following, let A = 1, K_1 = 1, K_2 = 2, K_H = 0.5, B = -5, τ_1 = 1/6, τ_2 = 1.

The system is in a state of equilibrium at t = 0s, with u (0) = 0, v (0) = 2 and

$$\frac{dc}{dt}(0) = 0$$

[6 marks]

(ii) Show that c (0) = 2.

A step function disturbance u(t) = 3 is then initiated at time t = 0 s

[5 marks]

(iii) Determine the system response for t > 0 s. [8 marks]

(iv) Verify the solution of (iii) by applying the initial and final value theorem.

[3 marks]

(v) Draw the response for $0 \le t \le 5$ s. [3 marks]

Scale to be used: horizontal: 1 cm = 0.25 s.

vertical: 1 cm = 1 unit

QA-2. A second order process is determined by the transfer ratio

$$H(D) = \frac{4}{(D+2)(D+10)}$$

The process is proportionally controlled (static gain factor of the controller K_r) in a unity negative feedback loop, as shown in Figure A-2.

(i) Draw the root locus. [6 marks]

(iii) Determine the value of K_r, for which the damping ratio ζ equals 0.4. [5 marks]

(iii) Determine the values of K_r, for which the system is table. [3 marks]

(iv) Compare the result of (iii) with the result obtained when applying Routh's stability criterion. [3 marks]

(v) With r (t) = 2, c (0)= 1 and $\frac{dc}{dt}(0) = 0$

determine the output c(t) of the system in Fig A-2, when K_r = 4. [8 marks]

QA-3. Given are three transfer functions

$$H_1(D) = 6D+1$$

$$H_2(D) = 8D$$

$$H_3(D) = \frac{1}{12D+1}$$

For the system with transfer ratio

$$H(D) = H_1(D).\ H_2(D).\ H_3(D),$$

(i) sketch the bode diagrams for the amplitude ratio (asymptotes only) and the phase angle; [14 marks]

(ii) determine the maximum angle by which the output is lagging or leading, and the corresponding circular frequency; [7 marks]

(iii) indicate the values calculated under (ii) in the diagrams for the amplitude ratio and the phase angle. [4 marks]

SECTION B: VIBRATIONS

USE A SEPARATE ANSWER BOOK AND ANSWER TWO (2) QUESTIONS ONLY

QB-1 (a) Assuming that the phase angle is zero, show that the response x(t) of an under-damped single degree of freedom system reaches a maximum value when

$$\sin \omega_d t = \sqrt{1-\zeta^2}$$

[10 marks]

(b) An under-damped shock absorber is to be designed for a motorcycle of mass 200kg (Figure QB-1a). When the shock absorber is subjected to an initial vertical velocity due to a road bump, the resulting displacement time curve is as shown in Figure QB-1b. Find the necessary stiffness and damping constants of the shock absorber if the damped period of vibration is to be 2sec and the amplitude is to be reduced to 1/4 in one half cycle. Also find the maximum initial velocity that leads to a maximum displacement at 250mm.

[15 marks]

QB-2 (a) In the analysis of the response of a damped system under the harmonic motion of the base, it can be shown that the motion of the mass relative to the base is given by

$$z(t) = Z\sin(\omega t - \phi)$$

where

$$Z = \frac{r^2}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}}$$

Show that the maximum value of the amplitude Z occurs when

$$r = \frac{1}{\sqrt{1-2\zeta^2}}$$

[10 marks]

(b) A velometer is to be designed such that the maximum error is to be limited to 1% of the velocity. Determine the spring stiffness and the damping constant given that the natural frequency and the suspended mass of the instrument are 80Hz and 0.05kg respectively.

[15 marks]

QB-3 (a) Derive Rayleigh's quotient for the fundamental frequency.

[10 marks]

(b) Calculate the first approximation to the fundamental frequency (in terms of EI) of lateral vibration for the system shown in Figure QB-3, given that the deflection of the beam at any point x from the left end due to a single load W at a distance b from the right end is

$$y(x) = \frac{Wbx}{6EIl}(l^2-x^2-b^2); \qquad x \leq (l-b)$$

[15 marks]

END OF EXAMINATION - ME571

Mr H A de Keyzer and Dr A N Ng'andu

ME 571 - VIBRATIONS and CONTROL ENGINEERING

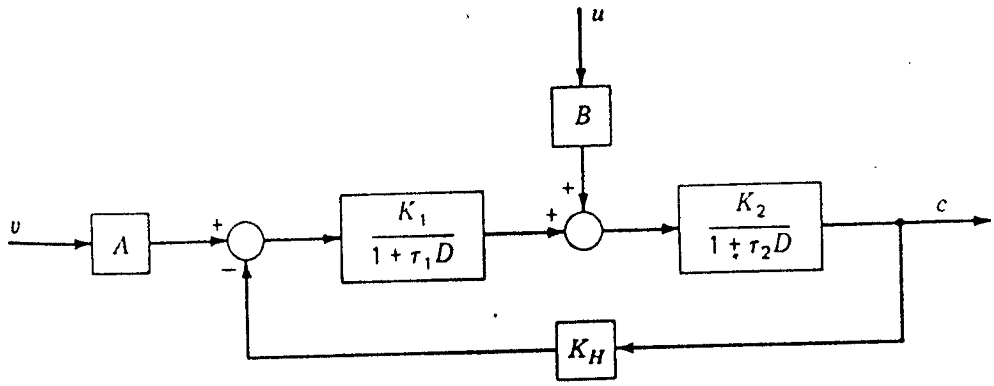


FIGURE A - 1

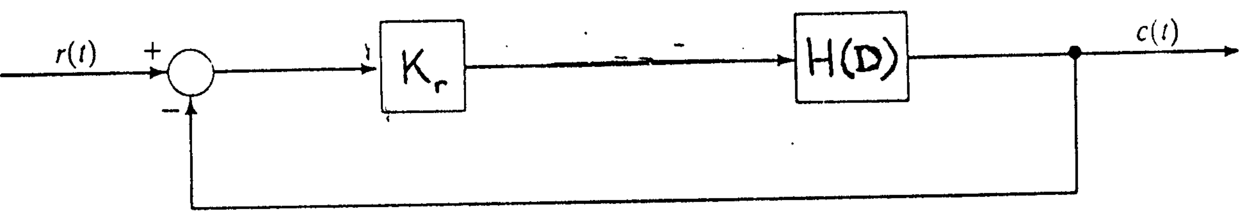


FIGURE A - 2

Laplace transform pairs

$F(s)$	$f(t)$	$F(s)$
1	$t^n e^{at}$	$\dfrac{n!}{(s-a)^{n+1}}$
$\dfrac{1}{s}$	$\sin \omega t$	$\dfrac{\omega}{s^2+\omega^2}$
$\dfrac{1}{s^2}$	$\cos \omega t$	$\dfrac{s}{s^2+\omega^2}$
$\dfrac{1}{s-a}$	$e^{at} \sin \omega t$	$\dfrac{\omega}{(s-a)^2+\omega^2}$
$\dfrac{n!}{s^{n+1}}$	$e^{at} \cos \omega t$	$\dfrac{s-a}{(s-a)^2+\omega^2}$

Laplace transform properties

Time function	Laplace transform
$kf(t)$	$kF(s)$
$f_1(t) \pm f_2(t)$	$F_1(s) \pm F_2(s)$
$f'(t)$	$sF(s) - f(0)$
$f''(t)$	$s^2F(s) - sf(0) - f'(0)$
$f^n(t)$	$s^nF(s) - s^{n-1}f(0) - \cdots - f^{n-1}(0)$
$f^{(-1)}(t)$	$\dfrac{F(s)}{s} + \dfrac{f^{(-1)}(0)}{s}$
$f^{(-n)}(t)$	$\dfrac{F(s)}{s^n} + \dfrac{f^{(-1)}(0)}{s^n} + \cdots + \dfrac{f^{(-n)}(0)}{s}$
$f(at)$	$\dfrac{1}{a} F\left(\dfrac{s}{a}\right)$
$e^{at}f(t)$	$F(s-a)$
$t^n f(t)$	$(-1)^n \dfrac{d^n}{ds^n} F(s)$
$f(\tau) = f(t - t_0)$	$e^{-t_0 s}F(s)$
$\int_0^t f(\lambda)g(t-\lambda)\, d\lambda$	$F(s)G(s)$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS - SEMESTER II, NOVEMBER 1996

ME 585 - AUTOMOBILE ENGINEERING

TIME: **THREE (3) HOURS** **CLOSED BOOK**

INSTRUCTIONS: ANSWER TWO (2) QUESTIONS FROM SECTION A AND THREE (3) FROM SECTION B

ALL QUESTIONS CARRY EQUAL MARKS

SECTION A

ANSWER TWO (2) QUESTIONS ONLY

Q1. (a) Outline the fundamental requirements of an automotive braking system and discuss the various types of systems available. Your answer should also highlight their advantages and disadvantages.

(b) What are the requirements for good handling of a motor vehicle? Give a brief description of each one but discuss stability in greater detail, carefully outlining the lateral stability characteristics and their methods of measurement.

[20 marks]

Q2. Zambia, being a developing country does not have the capability to manufacture motor vehicles. There is therefore a proliferation of imported vehicles. In view of this, discuss in detail the various factors which are likely to prolong service life of motor vehicles in Zambia. In your discussion, indicate any measures which can be applied to existing conditions and infrastructure to achieve the desired goal of prolonged service life of motor vehicles in the country.

[20 marks]

Q3. Discuss the responsibilities of the vehicle maintenance function. In your answer outline the objectives of vehicle maintenance and highlight the critical considerations when developing a vehicle maintenance policy.

[20 marks]

END OF SECTION A.

SECTION B

ANSWER THREE (3) QUESTIONS ONLY

Q4. MINCHIMA TRANSPORT is contemplating buying vehicles for hauling maize on asphalt roads which have an average grip coefficient of 0.8. As the firms automotive expert, you are required to advise the purchasing office on what type of motor vehicle to buy from a short list of two. One of the roads on which the vehicles are to operate has a particularly dangerous corner with an arc radius of 60 m. The following vehicle details are available:

	vehicle 1	vehicle 2
Wheel radius	0.5 m	0.55 m
Distance from C.G. to the front axle	2.3 m	2.5 m
Distance from C.G. to the rear axle	2.1 m	2.2 m
Height of C.G.	0.7 m	0.9 m
Coefficient of Rolling Resistance	0.03	0.03
Track width	1.6 m	1.8 m.

(a) If your choice is solely dependent on the critical speeds for toppling, skidding and steerability and the hill-side critical angle for toppling, and also bearing in mind that the maize-hauling exercise has to be completed within a limited period, which of the two vehicles would you recommend and why?

(b) What is the maximum speed you would recommend for the drivers to use for the chosen vehicle as they go round the dangerous corner and why?

(c) If one of the vehicles you have chosen is involved in an accident during operation, determine the speed at which the vehicle was travelling prior to the accident if it is ascertained that the time during which skidding occurred was 0.2 seconds and that in trying to avoid the accident, the driver sharply turned the steerable wheels (angular velocity = 0.2 rad/sec).

0.2 [20 marks]

Q5. A 4200 kg Land-Cruiser having a track and maximum height of 2.5 m and 3.6 m respectively is moving behind a truck at the same speed up a road with a gradient of 3° 30'. During this period, the engine of the Cruiser develops a torque of 268.7 Nm at a partial speed of 3200 rpm in direct drive. In order to overtake the truck, the Land-Cruiser develops maximum power at an engine speed of 3600 rpm, and attempts to overtake in Direct drive.

The equation for determining the effective power at any partial speed is given as:

$$N_e = N_{e\max}\left[\left(\frac{\omega_e}{\omega_N}\right) + \left(\frac{\omega_e}{\omega_N}\right)^2 - \left(\frac{\omega_e}{\omega_N}\right)^3 \right]$$

where ω_e = angular speed at any partial condition
ω_N = angular speed at maximum power

The following are also given:

Gear ratios:	1st = 3.51;	2nd = 2.26;
	3rd = 1.45;	4th = Direct
	Differential = 4.1	

Coefficient of rolling resistance at speeds less than 14 m/s is 0.02.
Streamlining factor = 0.54 Ns^2/m^2
Wheel radius = 0.35 m
Transmission efficiency = 90%
Grip coefficient = 0.8
Coefficient accounting for rotating masses = 1.16

(a) Determine the acceleration of the Landcruiser during overtaking. If acceleration is not possible under the given conditions, what option is available to the driver in order to be able to overtake? Use calculations to explain your answer.

(b) If there is no on coming vehicle, determine the time and distance needed for safe overtaking in the new regime of motion. Comment on your answer. For simplicity assume that:

$$s_1 = s_2 + s_3 = 0.5\, v_2$$

[20 marks]

Q6. A motor vehicle is travelling on a dry horizontal asphalt road (grip coefficient = 0.8) when the driver suddenly sees a pedestrian crossing the road ahead. The pedestrian is 0.9 m away from the line of motion of the vehicle and 110 m ahead. The following data is also available:

Maximum deceleration	= 5 m/s^2
Reaction time of the driver	= 0.53 sec
Time for the brake system to operate	= 0.35 sec
Mass of the motor vehicle including the driver	= 1800 kg .

If during the increment of deceleration from zero to the maximum value the speed drops from 30 m/s to 27.5 m/s, determine:

(a) the stopping time and distance of the motor vehicle for the given conditions at maximum deceleration; and hence assess whether the driver can avoid hitting the pedestrian.

(b) the speed of the vehicle at the moment proceeding the braking if the skidding trace is ascertained to be 75.5 m and the driver brakes at the maximum deceleration of 5 m/s^2.

(c) whether the reaction of the driver is timely or not if the pedestrian's average walking speed is 0.5 m/s.

(d) the optimum brake force distribution and the reaction change coefficients, given that:

wheel base - 2.93 m
Distance from C.G. to front axle - 1.52 m
Height of C.G. - 0.6 m

[20 marks]

Q7. The table below gives the relationship between road speed, power required to overcome resistance to motion and power developed by the engine on the level for a certain motor vehicle.

Speed in km/hr	40	60	80	100	120
Power required to overcome resistance to motion in kW	1.87	7.46	17.5	29.8	44
Power developed by engine in kW	21	31.8	38.8	38	29

(a) Using a graphical method, determine:
 (i) the maximum speed of the car on the level
 (ii) the maximum power available for acceleration, the speed at which this occurs and the maximum acceleration if the vehicle has a mass of 1750 kg.

(b) Determine the running fuel consumption at the maximum speed if the effective fuel consumption, the transmission efficiency and the fuel density are given as 350g/kW hr, 0.9 and 0.76 kg/m^3 respectively.

(c) If the vehicle has a wheel base of 2.93 m, the centre of gravity being 1.52 m from the front axle, what would happen if an attempt is made to drive the vehicle on a level road characterized by a grip coefficient of 0.1 in two-wheel drive and at maximum power? Would engagement of four-wheel drive redress the situation?

The following parameters are also given:

Transmission efficiency = 0.9
Air Resistance = 300 N
Wheel radius = 0.4 m
Height if C.G. = 0.57 m.

Data not supplied can be deduced from your graph.

[20marks]

END OF EXAMINATION - ME 585
Dr. A.N. Ng'andu

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - JUNE, 1996

SE 321 - CARTOGRAPHY I

Time: Three hours
Answer: All questions in Part A and one in Part B

Part A

1. Explain briefly the following cartographic terms:
   a) Standard Line, b) Folding resistance, c) Micronorm-classification,
   d) Graticule, e) Representative fraction, f) Derived topographic map,
   g) Graphical accuracy, h) PE, i) General plan, j) Phototypesetting.

(20)

2. In the appendix 1 you will find an extract from a Zambian map with the declination diagram and a list related to the mathematical values of the same sheet.
   (a) What is the map and the sheet number of it?
   (b) What is the field bearing now if the grid bearing which is measured on this map is 232°10'.
   (c) In the appendix you will find a list of things related to the mathematical values of the map. Fill the list as it should appear on this map.

(6+6+8)

3. In Zambia two different grid systems are in use, one for national mapping and the other for cadastral surveys.
   (a) What are these systems?
   (b) What is common and what are the differences?
   (c) Why one system is not enough?

(4+10+6)

4. (a) For the lettering of a map there are many variations to choose. Which different ways the lettering can be varied?
   (b) How are the differences of the features expressed on the maps by lettering?
   (c) Which methods of lettering are used in mapmaking?

(7+7+6)

Part B

1. You are using a 1: 1.5 million map, of which projection is Mercator and spherical assumption (R=6371.1km) has been used in its construction. What are:

   a) scale factors

   b) actual scales and

   c) lengths of 1° of longitude (on the map)

   on 8°S and 18°S parallels (Zambia is situated between these parallels)?

(7+6+7)

2. a) What is the constructional grouping of map projections?

   b) What kind of distortions in geometrical relationships you can expect in different map projections and how the projections are 'classified' in this case?

   c) What is the *Tissot's Theorem* and what is the meaning of *Indicatrix* in it?

(4+6+10)

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER 2 SUPPLEMENTARY/DEFERRED EXAMINATIONS

ME 585 - AUTOMOBILE ENGINEERING

TIME: **THREE (3) HOURS** **CLOSED BOOK**

INSTRUCTIONS: ANSWER TWO (2) QUESTIONS FROM SECTION A AND THREE (3) FROM SECTION B

ALL QUESTIONS CARRY EQUAL MARKS

SECTION A

ANSWER TWO (2) QUESTIONS ONLY

Q1. What do you understand by 'Wear' in automobile engineering? In your answer, discuss the various types of wear which are likely to occur during exploitation of motor vehicles. How is this wear qualitatively and quantitatively measured and what measures can be undertaken to reduce it? [20 marks]

Q2. (a) Discuss the requirements for good steerability of a motor vehicle. What do you understand by the terms 'Oversteer' and 'Understeer' and what conditions determine the presence of one or the other?

(b) The fuel consumption equation as given below is inadequate for determining the fuel consumption rate. Explain why this is so and discuss the subsequent adjustments to render it more realistic.

$$q_{run} = \frac{g_e}{36000\rho_f\,\eta_{tr}}(F_{rd} + F_{air} + F_{in})$$

[20 marks]

Q3 (a) Derive the equation of motion of a motor vehicle stating clearly any assumptions made. Explain the significant steps, if any, in the derivation.

(b) What is aerodynamic drag and how is it caused? Discuss the methods which are employed to reduce it. [20 marks]

END OF SECTION A

SECTION B

ANSWER THREE (3) QUESTIONS ONLY

Q4. The management of a car manufacturing company has decided to introduce a new two-seater car based on an existing 4-door saloon. In order to improve the performance of the new two-seater car, its weight and aerodynamic resistance have been reduced. In order to keep the costs as low as possible, the same engine, transmission and differential have been used.

The following data is given:

Engine power at maximum angular velocity of 6000 rpm. = 40 kW

Transmission: top gear ratio - direct drive
Total Efficiency $\eta_{tr} = 0.90$
Rear wheel drive

Rolling Resistance coefficient = 0.020
Air density in testing zone = 1.2 kg/m^3

	4 - door	Two - seater (new)
Tyre Diameter (radial)	0.6 m	0.5 m
Mass	1400 kg	1200 kg
Frontal Area	1.8 m^2	1.6 m^2
Aerodynamic drag coefficient	0.40	0.35

(a) Determine, for both models, a relationship from which the top speed can be immediately derived when the vehicles are moving up a gradient of 3^0 in still air during testing.

(b) Estimate the top speed for each vehicle in still air and with no gradient and hence determine the best overall transmission ratio.

(c) If the first gear ratio is 4, how long does it take the new two-seater car to accelerate from 0 to 20 km/hr in first gear given that there is no wind, no slip, no gradient and that acceleration is constant from the start. Assume that the coefficient accounting for rotating masses is 1.4. [20 marks]

Q5. As a graduate engineer, you have joined a transport organisation which has recently acquired a fleet of new vehicles to be used for transporting Kapenta from Mpulungu to the Copperbelt on asphalt roads with an average grip coefficient of 0.8. The vehicles have the following specifications:

Distance from CG to the front axle	1.80 m
Distance from CG to the rear axle	1.42 m
Height of CG	0.6 m
Track width	1.6 m
Mass	2000 kg
Wheel radius	0.5 m.

Allowable angular velocity of steerable wheels is 0.2 rad/sec.

(a) In your capacity as the firm's automotive expert, what maximum speed would you recommend to your drivers to prevent any of the vehicles from toppling or skidding, particularly on a dangerous corner with an arch radius of 60 m?

(b) Determine the transverse component of the centrifugal force that would act on one of the vehicles over a ~~transmission~~ curve at a speed of 10 m/s. transition

(i) at the initial moment of turn
(ii) Four (4) seconds after the beginning of the turn.

(c) If one of the vehicles is involved in an accident during operations, determine the speed at which the driver was travelling if investigations reveal that the time during which skidding occurred was 0.19 seconds. Comment on your answer. [20 marks]

Q6. (a) The engine of a motor vehicle of mass 1270 kg develops an effective power of 40 kW at 4200 rpm. The transmission efficiency is 92% in the top gear with transmission ratio 4.7 to 1, and 85% in the second gear of transmission ratio 7.5 to 1. The performance characteristics are such that the vehicle will just reach a speed of 108 km/hr at full throttle (top gear) when running on the level in still air and at the maximum power speed in second gear, it will just climb a gradient of 1 in 12.

The combined air and rolling resistance is given by the formula of the form $R = A + BV^2$. Calculate the values of A and B when R is in Newtons and V in km/hr and hence deduce the engine power required for running on the level at 50 km/hr in top gear. The rolling resistance coefficient, streamlining factor and wheel radius are given as 0.024, 0.5 Ns^2/m^2 and 0.33 m respectively.

(b) If the vehicle can develop a tractive power of 40 kW at a speed of 1100 rpm at the wheels in two-wheel drive, examine, using dynamic factors, the possibility of motion of the vehicle on a road characterised by a grip coefficient of 0.4, road resistance coefficient of 0.01 and a gradient of 3^0. The following information is also available.

Distance from CG to rear axle	= 1.49 m	
Distance from CG to front axle	= 1.40 m	
Height of CG	= 0.57 m	[20 marks]

Q7. (a) In an acceleration performance test on a flat asphalt road with a road resistance coefficient of 0.03, a motor vehicle is driven from rest to 100km/hr in 6 sec. During the test, the speed of the vehicle at the initial moment of the gear change from 2nd gear to 3rd gear is 56 km/hr. Given that the clutch inertia and torque are 0.5 kgm^2 and 10 N rad-m respectively, determine the distance covered by the vehicle during the gear change time if the synchronising torque is 15Nrad-m and the initial speed at the input side of the synchroniser is 50.5 rad/sec. The radius of the rolling wheel is 40 cm and the differential gear ratio is 1.0. Ignore information not supplied.

(b) The same vehicle is subjected to an overtaking test from which the following are obtained:

Speed of overtaking vehicle	= 32 m/s
Speed of overtaken vehicle	= 26 m/s

Determine:

(i) the distance and time ~~requested~~ required for overtaking to take place

(ii) the safe intervals between overtaking and overtaken vehicles at the beginning and end of overtaking.

[20 marks]

END OF ME 585 EXAMINATION

Dr. A.N. Ng'andu

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING
DEPARTMENT OF SURVEYING

SE 352-LAND LAW, CADASTRE AND SURVEY REGULATIONS.
FINAL EXAMINATION/NOVEMBER, 1996.

INSTRUCTIONS

TIME: 3 HOURS
ANSWER: ANY THREE QUESTIONS FROM SECTION I. AND ALL QUESTIONS FROM SECTION II. ALL QUESTIONS CARRY EQUAL MARKS

SECTION I.

QUESTION 1. (6 + 14 Marks)

(a) Briefly describe what is meant by;
   (i) Joint Tenancy
   (ii) Tenancy in Common

(b) Mulevu and Chuma entered into an agreement on the 9th September, 1996 for the sale of Mulevu's mansion situated in Kalundu at K90,000,000. Two days later Mulevu applied for consent at the Ministry of Lands. He got no response and on the 29th October, 1996 the two exchanged documents and Chuma paid the first instalment of K50,000,000. The rest to be paid in two instalments. When the second payment was due two Months later, Chuma refused to pay saying the sale was illegal as Mulevu had not obtained the relevant presidential consent. Mulevu has sued Chuma and is seeking a court order to enforce the contract. Chuma comes to you for legal advise. Advise?

QUESTION 2. (10 + 10 Marks)

(a) Distinguish between a lease and a licence?

(b) Briefly state and describe five ways in which a lease may be determined?

QUESTION 3. (5 + 15 Marks)

(a) What is an easement?

(b) John Bull is a businessman as a real estate agent. Due to his enormous arrears in rent payments, he has been evicted from his offices in town. He now has no premises to operate from. His only option is to use one of his houses in Rhodes Park as offices for his real estates agency. He now comes to you for advise as to the legalities involved. Advise him?

QUESTION 4. (8 + 12 Marks)

(a) Briefly distinguish between legal and equitable rights in land?

(b) (i) What is a mortgage?
(ii) What are the rights of the parties in an equitable mortgage?

SECTION II.

QUESTION 5. (20 Marks)

A west African Chief has been quoted as having described customary tenure as a system in which land is considered to belong to a vast family of which many are dead, few are living and countless numbers of people still to be born.

The Lands Act, 1995 provides for statutory recognition of customary tenure. Discuss the advantages and disadvantages of allowing customary land tenure?

QUESTION 6. (6 + 7 + 7 Marks)

There are three distinct procedures of land conveyancing (transfer) that can be effected, namely;

- Private Conveyancing
- Registration of deeds and
- Registration of title

Describe the above procedures and what are their respective advantages and disadvantages?

END OF EXAMINATION

The University of Zambia
School of Engineering
Department of Surveying

Supplementary University Examination July 1996
SE371 Principles and Methods of Surveying I

TIME: 3 HOURS
ANSWER: ALL QUESTIONS

QUESTION 1. (25 p)

The following field results were obtained running a link traverse from TP11 to TP12:

Point No	Measured Angle β	Bearing α	Distance d	COORDINATES X	COORDINATES Y
TP10		**320°45'57"**			
TP11	188°49'52"		1154.11	**-21 650.42**	**+ 2 068.32**
STP5	160°22'53"		1429.65		
STP6	199°10'24"		868.09		
STP7	184°20'13"		1967.68		
STP8	192°17'38"		1227.97		
STP9	180°38'04"		1377.57		
TP12	158°18' 38"			**-14 700.63**	**- 1 560.17**
TP13		**324°43'34"**			

Calculate the final adjusted values for the standard traverse points (STP) on the the traverse form provided.

QUESTION 2. (25 p)

The following observations were taken during a stadia tacheometric survey by a theodolite correctly centred and levelled at height 1.60 m above a station P of relative elevation of 1350.75 m MSL. The staff was held vertically for all readings and the theodolite constant was 100.

Staff at Station	Staff Reading (m)	Zenith Angle
At point A	Upper 2.468	
	Lower 1.288	
	Centre 1.878	83° 14'
At point B	Upper 3.579	
	Lower 1.235	
	Centre 2.407	97° 22'

Calculate:
2.1 The horizontal distances PA and PB
2.2 The elevations H_A and H_B

QUESTION 3. (20 p)

Describe the difference between geometric (ordinary) levelling and trigonometric levellening. Use sketches and formulas to illustrate your answer.

QUESTION 4. (30 p)

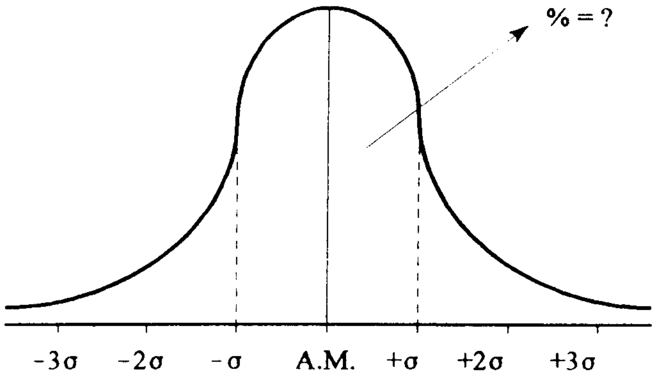
1. Explain the difference between direct and indirect measurements.

2. Describe briefly the main classes of errors and try to illustrate them by giving examples.

3. Do the random errors conform to the law of probability?

4. What is a variance? Show the difference between the theoretical variance (σ^{2}) and an estimate of the variance **(s^2)** of a sample of a limited series of observations.

5. Assuming that the error distribution follows the normal distribution curve (See below), what is the percentage of all observations lieing within $\pm\sigma$ one standard deviation (one standard error) of the most probable value (the arithmetic mean)?



Probability curve

6. Explain the terms ***"accuracy"*** and ***"precision"***. Give examples to illustrate your answer.

7. An angle has been observed ten times with the results recorded below. Calculate:

a/. The most probable value ($\bar{X}$),
b/. The standard deviation (S_X) and
c/. The standard deviation of the mean ($S_{\bar{X}}$).

No	Measured Angle	$X_i - X_o$	$X_i - \bar{X}$	$(X_i - \bar{X})^2$	Results
1	125°00'08"				
2	125°00'03"				$\bar{X}$ = ...
3	124°59'56"				
4	125°00'10"				
5	124°59'12"				S_X= ....
6	124°59'48"				
7	125°00'11"				$S_{\bar{X}}$= ....
8	124°59'58"				
9	125°00'06"				
10	125°00'02"				

END OF EXAMINATION

COMPUTATION OF TRAVERSE

Point No	Measured Angle	Bearing α	$\sin\alpha$ $\cos\alpha$	Distance D	Coordinate differences		Coordinates		Point No	Remarks
					Δx	Δy	X	Y		

A:\LABORAT 373\FORMTRV1

The University of Zambia
School of Engineering
Department of Surveying

University Examination June 1996
SE371 Principles and Methods of Surveying I

TIME: 3 HOURS
ANSWER: QUESTION 6 AND ANY OTHER 4 QUESTIONS

QUESTION 1. (3 + 3 + 3 + 3 + 3 + 5)

Give definitions and describe with necessary sketches the following terms:

- Mean Sea Level
- Sea-level Datum
- Level surface
- Level line
- Horizontal line
- Leveling

QUESTION 2. (8 + 4 + 8)

2.1 Describe the effect of curvature and refraction on the levelling and derive the formula for the combined effect of it.

2.2 Compute the correction for curvature and refraction at the following distances:

- 120 m
- 300 m
- 1000 m
- 10 000 m
- 100 000 m

2.3 A two-peg test has been carried out between two points 80 m apart with a tilting level and the following staff readings were made:

INSTRUMENT	STAFF READING AT A	STAFF READING AT B
Between A and B	a_1 = 1.546 m	b_1 = 1.234 m
On 3 m from B	a_2 = 1.284 m	b_2 = 0.998 m

Calculate the collimation error in the level and describe the error removal procedure.

QUESTION 3. (12 + 8)

3.1 What are the test procedures for locating linear and angular errors in traversing? Is it possible to locate the position of two or more mistakes in a traverse?

3.2 Describe the Bowdich method for distribution of the closing error in a traverse. Compute the corrections for a traverse leg with length d = 379.379 m, if the total length of the traverse is S = 2965.456 m, and the linear misclosure in X and Y coordinates are f_x = 0.033 m and f_y = 0.012 m respectively.

QUESTION 4. (20)

The following observations were taken during a stadia tacheometric survey by a theodolite correctly centred and levelled at height of 1.60 m above a station P of relative elevetion (RL) of 1280.50 m MSL. The staff was held vertically for all readings and the theodolite constant was 100.

Staff at Station	Staff Readings (m)	Zenith Angle
At point A	upper 2.568 m lower 1.646 m centre 2.107 m	87°25'
At point B	upper 3.228 m lower 1.914 m centre 2.571 m	94°44'

Calculate:
- □ the horizontal distance PA and PB
- □ the elevations H_A and H_B .

QUESTION 5. (5 + 15)

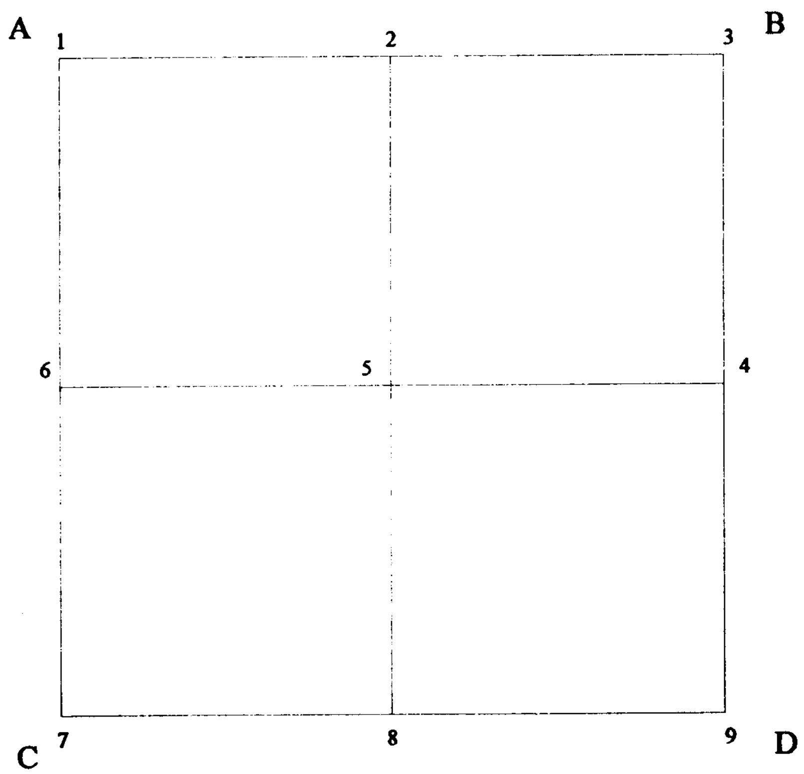
5.1 Which are the operations involved in a temporary adjustment of a theodolite with optical plummet and how often the adjustment is carried out?

5.2 What are the checking procedures for:

- □ Horizontal collimation (Z ⊥ H), and for
- □ Horizontal axis dislevelment (H ⊥ V) in a theodolite. Illustrate your answer by giving numerical examples.
- □ If the above two conditions are not fulfilled how could the errors resulting of it be eliminated?

QUESTION 6.. (20)

Grid-levelling for design purposes had been made on a certain area ABCD as shown below. Draw the contour lines with a contour interval of 0.2 m, if the heights of the points are as follows:



1. 100.96 m	4. 99.86 m	7. 99.70 m
2. 100.35 m	5. 100.27 m	8. 99.66 m
3. 99.97 m	6. 100.36 m	9. 99.50 m

END OF EXAMINATION

The University of Zambia
School of Engineering
Department of Surveying

University Examination June 1996
SE371 Principles and Methods of Surveying I

TIME: 3 HOURS
ANSWER: QUESTION 6 AND ANY OTHER 4 QUESTIONS

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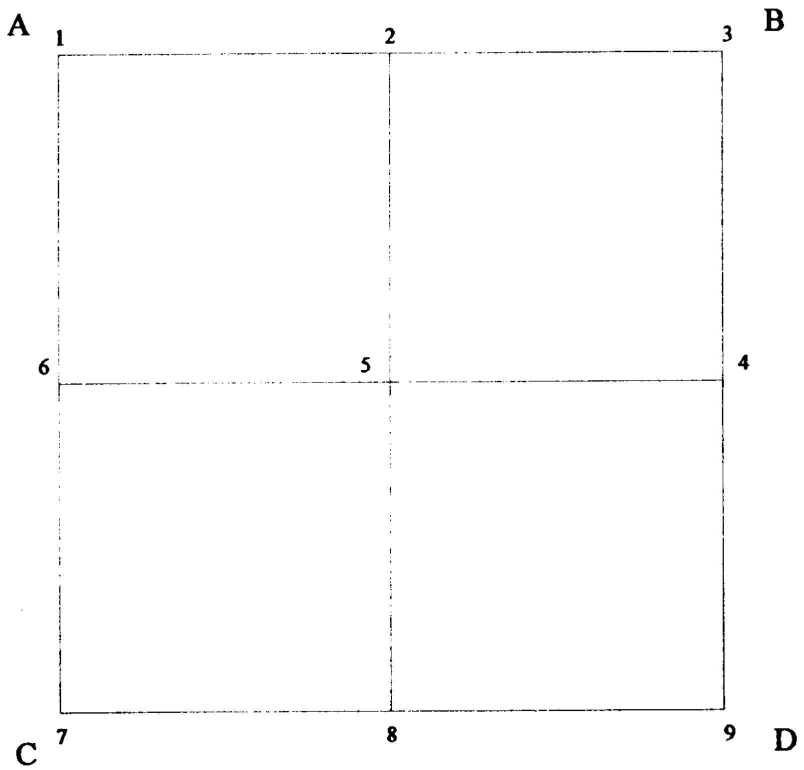


1. 100.96 m	4. 99.86 m	7. 99.70 m
2. 100.35 m	5. 100.27 m	8. 99.66 m
3. 99.97 m	6. 100.36 m	9. 99.50 m

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION 1996
SE411 SURVEYING MATHEMATICS

DURATION: THREE HOURS
ANSWER: PART A- ALL QUESTIONS (70 MARKS)
PART B- ONE QUESTION (30MARKS)
TOTAL: 100 MARKS

PART A

QUESTION 1 (5+5+10 marks)

An observer obtained the following values for a distance between two points A and B: 212.22m, 212.25m, 212.23m, 212.15m, 212.23m, 212.11m, 212.29m, 212.34m, 212.22m, 212.24m, 212.19m, 212.25m, 212.27m, 212.20m and 212.25m.

Calculate:

a) The most probable value
b) The standard deviation
c) The 50% and 90% uncertainties

QUESTION 2(5+5+5+5 marks)

The following matrix is given

$$A=\begin{bmatrix} 1 & 1 & 2 \\ 1 & -2 & 4 \\ 2 & 4 & 4 \end{bmatrix}$$

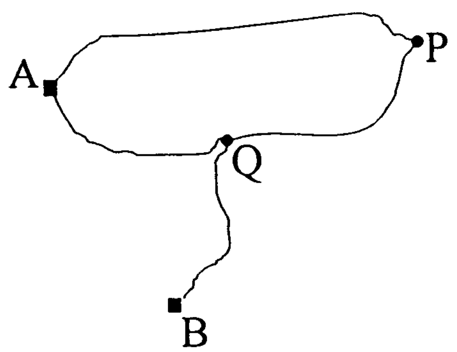
and the column vector

$$y=\begin{bmatrix} 14 \\ 21 \\ 30 \end{bmatrix}$$

a) Calculate the determinant of A
b) Calculate A^{-1} using the adjoint matrix
c) Check the result with $A^{-1}A=I$
d) Hence solve the set of equations $Ax = y$.

QUESTION 3 (30 marks)

Adjust the levelling net given below, by using the method of correlates. The weights are inversely proportional to the distances.
Find the heights of the points P and Q after the adjustment.
Find the standard error of the adjusted heights H_P and H_Q after the adjustment.



Given: H_A= 20.000 m
H_B= 24.000 m

Observations:

	From	To	Measured Value (m)	Distance (km)
1	A	P	+2.006	2.0
2	P	Q	+4.006	1.0
3	Q	A	-5.996	2.0
4	Q	B	-2.008	1.0

PART B

QUESTION 4 (30 marks)

Explain the following terms:

a) precision, accuracy and uncertainty
b) normal distribution
c) variance-covariance matrix
d) error ellipse
e) least square adjustment
f) redundancy
g) systermatic error
h) residual

QUESTION 5 (10+10+10 marks)

A cadastral survey has been carried out. The survey was based on a local coordinate system, which now has to be connected to the National (UTM) Grid.

The following coordinates are known.

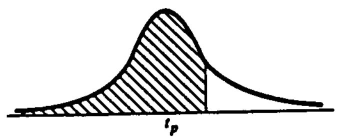
	Local System		National (UTM) System	
Point	x (m)	y(m)	x (m)	y (m)
201	2095.53	3278.12	8300348.313	642949.453
202	2151.33	3501.95	8300404.089	643176.096
1	2163.71	3299.27		
2	2093.14	3387.36		

a) Find the transformation parameters between the two systems.
b) Calculate the coordinates of points 1 and 2 in the National Grid.
c) Normally, we would prefer more common points for the determination of the transformation constants, why?

END OF QUESTIONS

Table I. Values of the Standard Normal Distribution Function

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-u^2/2}\, du = P\,[Z < z]$$



z	0	1	2	3	4	5	6	7	8	9
−3.	.0013	.0010	.0007	.0005	.0003	.0002	.0002	.0001	.0001	.0000
−2.9	.0019	.0018	.0017	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0126	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0238	.0233
−1.8	.0359	.0352	.0344	.0336	.0329	.0322	.0314	.0307	.0300	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0570	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0722	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
− .9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
− .8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
− .7	.2420	.2389	.2358	.2327	.2297	.2266	.2236	.2206	.2177	.2148
− .6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
− .5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
− .4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
− .3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
− .2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
− .1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
− .0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

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z	0	1	2	3	4	5	6	7	8	9
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7703	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9278	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9430	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9648	.9656	.9664	.9671	.9678	.9686	.9693	.9700	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9762	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9874	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.	.9987	.9990	.9993	.9995	.9997	.9998	.9998	.9999	.9999	1.0000

The University of Zambia
School of Engineering
Department of Surveying
SE412: Numerical Methods and Programming for Surveyors
Final Examinations November/December, 1996.

Instructions:
Answer Question 1 and any other three(3) questions.
Total:100 points.
Duration: 3 hours.

Question 1(5+2+18 points)

a) Define the idea behind Newton's method for solving the equation f(x)=0?

b) Explain what the order of convergence is for the Newton's method.

c) The roots of

$$f(x)=3x^3-\frac{1}{5}\tan x$$

can be found by the Newton's method i.e. the iteration formula

$$x_{n+1}=x_n-\frac{f(x_n)}{f'(x_n)}$$

Write a program in Turbo Pascal that asks for

i. the initial approximation x_0

ii. the required precision for the absolute error ε

iii. the maximum number of iterations N, and returns

iv. the root reached if convergence is reached
or
v. reports after N iterations that no convergence is achieved from the initial value x_0.

Question 2 (10+9+3+3 points)

a) Describe the main (for Surveyors) problem of non- least squares and the Gauss-Newton method for solving it.

b) Define the householder transformation (matrix) and state its properties.

i. Where are the householder transformations used?

Let

$$u = \begin{bmatrix} 3 \\ -2 \\ 1 \end{bmatrix}$$

ii. write down $\|u\|_2^2$, $u^T u$ and uu^T

Question 3 (10+5+10)

a) Define an orthogonal matrix and state its main properties.

b) What is meant by partial pivoting?

c) Solve by Gaussian elimination and backward substitution the following system of equations:

$$\begin{aligned} 10x_1 - 7x_2 \qquad &= 7 \\ -3x_1 + 2x_2 + 6x_3 &= 4 \\ 5x_1 - x_2 + 5x_3 &= 6 \end{aligned}$$

Question 4(4+15+3+3 points)

a) What is a purpose for a norm of a vector of a matrix?

b) Determine the inverse and the condition number of the matrix

$$A(x)=\begin{bmatrix} 1 & 1 & 1 \\ 2 & 1 & 1 \\ 0 & 1+x & 1 \end{bmatrix} \qquad ;\ (x>0)$$

c) Find the condition number when x=0.001, 0.1, 1, 2, 10, 1000.

d) What value of x gives the most well conditioned matrix A(x)?

Question 5 (8+5+6+6 points)

a) Define the absolute error, relative error, over-flow and residual.

b) What is meant by error bound?

c) Assume that you have solved the systems of equations Ax=b and have got an approximate solution x*. By substitution it is found that the approximate solution x* does not satisfy the system of equations exactly, but we get a residual r, $r=\|Ax\ -b\|$.
Assume that you have computed r and $\|A\ ^{1}\|$.
Give an overall error bound for the error $\|x-x\ \|$ expressed in terms of $\|A\ ^{1}\|$ and $\|r\|$.

d) What is meant by cancellation of terms, and how can it be avoided?

Question 6 (6+4+15 points)

a) Define the terms positive definite matrix, symmetric matrix, triangular matrix.

b) Define the Cholesky decomposition of a positive definite matrix.

c) In the 18th Century, it was believed that someone had discovered the so called Titius-Bodes Law which gives the distance of a planet from the sun. The n-th planet according to this law lies at a distance:
$R_n = a+b.2^n$
where,
a and b are constants, and
n is a variable.

Determine a and b with the least squares method when the distance to the planet (measured with the earth's orbital radius taken as unit) is known according to the table below.
Therefore, calculate the distance to the planet using the Titius-Bodes Law and compare with the measured values.

	n	R_n
Venus	1	0.72
Earth	2	1.00
Mars	3	1.52
The Asteroid belt	4	2.77
Jupiter	5	5.20

End of Questions

Good Luck!

M. Phiri

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - 1996

SE 422 - CARTOGRAPHY II

Time: Three hours
Answer: All questions in Part A and one in Part B

Part A

1. Explain briefly the following cartographic terms:
a) Threshold of differentiation, b) Value or Lightness, c) Moiré effect, d) Wrong-reading image, e) Subtractive primaries, f) 'Kwick-proof', g) Flatbed scanner, h) Half-tone image, i) Wash-off process, j) Dot screen.
(20)

2. (a) In topographic mapping there are three levels of generalization. Name these levels and explain them briefly.
(b) What are the factors which influence the cartographic generalization?
(12+8)

3. You are supposed to produce a new topographic map at scale of 1: 500 000. The following information will be printed: place names, international boundaries, grid, shore lines and other water features, contours, roads, areas liable to flood, railways, villages and built-up areas, and national parks. The map will be printed in four colours.
(a) Decide what are those four printing colours and how the information will be separated among these colours.
(b) What type of information could be advisable for tint screening. Explain the technique which should be used.
(c) Explain what could be the solution, if the fifth colour is wanted, but you can only print in four colours.
(5+8+7)

4. (a) Explain briefly the two main processes to convert cartographic data (an existing map) from analogue form to digital data base?
(b) What are the advantages and disadvantages of these processes?
(10+10)

cont.

Part B

1. (a) When a contact copying in a vacuum frame can be used and when a process camera must be used in cartographic processes?

(b) Explain briefly the idea of 'Copyproof' copying. In which occasions it is used in cartographic reproduction?

(8+12)

2. Three different printing techniques are used to print maps.

(a) Name these techniques.

(b) Explain the principles of these processes.

(c) Which one of these is nowadays the most common process in printing maps?

(6+10+4)

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JUNE 1996

SE 431 - PHOTOGRAMMETRY II

TIME: THREE HOURS
ANSWER FOUR QUESTIONS: PART A - ALL QUESTIONS
PART B - ONE QUESTION

PART A

1.
(a) Derive a rotation matrix ω,ϕ,κ, which converts a measured image (camera) coordinates system to a camera system - parallel to the X,Y,Z reference system. Assume that ω,ϕ,κ are clockwise rotation angles around X, Y, Z, respectively.

(b) Referring to the question 1(a), explain and show in figures mean of the orientation angles ω,ϕ,κ and the reference coordinates systems in such basic photogrammetric operations as;
- angular relative orientation of a pair of photographs, and
- exterior orientation of a photo.

(15 + 10)

2.
(a) Explain the principles and the functions of projection, viewing measuring systems in mechanical projection stereoplotter.

(b) Describe procedures for both, the angular and the single project method of relative orientation of two photographs with stereoplot and explain what does mean over correction factor 'n'.
Which type of stereoplotter accommodates both methods of relativ orientation.

(12 + 13)

3.
(a) Explain shortly the purpose and the main principles of aerial triangulation.

(b) Explain the differences between aerial triangulation by independ models and independent bundles (photographs) methods in respect
- execution of aerial triangulation,
- mathematical models used for setting of observational equatior
- unknown parameters to be determined in adjustment process, and
- which method is more universal and why.

(8 + 17)

PART B

4.
(a) Derive equations for three dimensional similarity transformation use for absolute orientation of 3D photogrammetric model. Explain meanin of all unknown parameters.

(b) Referring to derived equations for absolute orientation in 4(a), explain how all seven unknown parameters are determined in absolut orientation of a model with graphical stereoplotter.

(12 + 13)

5.
(a) Explain what does mean differential rectification of a photo ?

(b) How differential rectification is executed with an indirect optica orthophoto system, for example Wild PPO8 ?

(c) What are the differences between on line and off line orthophoto systems ? Which of the above systems are more universal and why ?

(8 + 9 + 8)

END OF EXAMINATION

GOOD LUCK

The University of Zambia
School of Engineering
Department of Surveying

University Examination June 1996
SE441 Geodesy I

TIME: 3 HOURS
ANSWER: ANY FOUR QUESTIONS

QUESTION 1. (20 + 5)

The geodetic coordinates of Bulawayo are $\varphi = 20°11'$ S, $\lambda = 28°37'$ E .The orthometric height H is equal to 1275 m and geoidal undulation is equal to 75 m. Calculate:

1.1 the 3D Cartesian (geocentric) coordinates of Bulawayo on the Modified Clark 1880 Ellipsoid with parameters a = 6 378 249.145 m and f = 1/293.465, and
1.2 the reduced β and geocentric ψ latitudes of Bulawayo.

QUESTION 2. (15 + 10)

A small plane is to fly from Lusaka to Cape Town and the pilot wants to know the direction and distance between the two towns. The pilot reads the geodetic coordinates of the towns from a map as follows:

	φ	λ
Lusaka	15°24' S	28°20' E
Cape Town	33°50' S	18°20' E

Assuming the earth is a sphere with a mean radius $R_m = (MN)^{1/2}$ and if the parameters for the Modified Clark 1880 Ellipsoid are used to calculate (R_m) for midlatitude (φ_m) between the two towns, calculate:

2.1 the bearing from Lusaka to Cape Town and vice versa and
2.2 the distance between the two cities in kilometres

QUESTION 3. (7 + 7 + 7 + 2 + 2)

By a definition each normal plane cuts the ellipsoid along a normal section. The curvature along a normal section of an spheroid varies with the latitude and the azimuth of the cut. For each point of the curve obtained as a result of the intersection of the ellipsoid with the normal section the radius of curvature is minimum in the meridian plane and maximum in the east-west direction (in the prime vertical). These two radii of curvature are called principal radii of curvature and are denoted by M and N respectively.

3.1 Write down the formula for curvature in an arbitrary azimuth α . Under what name is the formula known?

3.2 Meusnier's theorem gives very important relationship between radius of curvature of a normal section and that of an arbitrary (inclined) cut to it. Write the Meusnir's theorem for ***a sphere*** and ***an ellipsoid.***

3.3 Derive the formula for the mean radii of curvature R_m used for spherical approximation of a small region of an ellipsoid.

3.4 What is a Gaussian curvature?

3.5 What is the mean curvature on the ellipsoid?

Question 4. (3 + 3 + 10 + 3 + 3 + 3)

Explain the following terms and phenomena and use drawings to illustrate your answer:

4.1 Spherical earth and a spheroid (ellipsoid). Best fitted ellipsoid.

4.2 Geodetic Datum

4.3 Deflection of the vertical (θ), ellipsoidal height(h), geoid height (N) also known as geoidal undulation and orthometric height (H). Laplace's equation.

4.4 Precession of the equinoxes or precession

4.6 Nutation

4.7 Annual aberration and diurnal aberration.

QUESTION 5. (25)

At point Q in Chipata the astronomical and geodetic coordinates are known to be:

- ☐ astronomic coordinates $\phi_Q = 13°40'40''.0$ S $\Lambda_Q = 32°38'30''.0$ E
- ☐ geodetic coordinates $\varphi_Q = 13°40'28''.0$ S $\lambda_Q = 32°38'22''.0$ E

Calculate the deflection of the vertical (θ or ε) of point Q and the geoidal height (N_Q) if at a nearby point P at Chadiza, situated at a distance of 33 km from point Q and at geodetic azimuth of $\alpha_{QP} = 195°$ is given by its geoidal height $N_P = 50.0$ m and the components of the deflection of the vertical at P are known to be $\xi = 10''.0$ in north-south direction and $\eta = 10''.0$ in east-west direction.

QUESTION 6. (4 + 4 + 3 + 6 + 8)

6.1 For point P at Kaoma, with latitude $\varphi = 14°48'$ S on the Geodetic Reference System 80 (GRS 1980 Ellipsoid ($a = 6\ 378\ 137$ m, $e^2 = 0.0066943800229$) compute the following quantities:

- the radius (M) of curvature in the meridian plane through P;
- the radius (N) of curvature in the prime vertical at P;
- the mean radius (R_m) of curvature at P;
- the radius (R_α) of curvature of a normal section at P with azimuth $\alpha = 225°$ (Azimuth from Kaoma to Sibeta).

6.2 The position of a celestial body can be determined on the celestial sphere using coordinate representation in either

- the celestial horizon system, or
- the celestial equatorial system.

Describe them and draw the necessary sketches to enhance your answer.

END OF EXAMINATION

The University of Zambia
B.Eng(Surveying)

Final examination November 1996

SE 462 - REMOTE SENSING

Instructions:

1. Time allowed: 3 hours
2. Answer ***all*** questions from ***SECTION A*** and only TWO(2) questions from SECTION B.
3. Questions in section A carry fifteen(15) marks each while those in section B carry twenty(20) marks each.

Section A:

A1:

What do the following terms mean;

(15)

(a) SLAR
(b) Geometric correction
(c) Thematic image (map)
(d) BIL & BSQ
(e) Pixel
(f) Linear stretching
(g) HRV

A2:

(a) Explain the term geometric correction as used in remote sensing. Why are four or more "ground control points" (GCPs) used in geometric correction when three points are sufficient? Use an equation to support your answer and explain the parameters of that equation.

(10)

(b) Give the main differences between the following types of film and give example areas in which they can be applied;
- Color Infrared film
- Panchromatic Black and White film

(5)

A3:

Name the methods used for resampling and compare and constrast the methods in terms of advantages and disadvantages

(15)

A4:

Fill in the required parameters in the table below

(15)

	Landsat MSS	NOAA-AVHRR	SPOT PAN	SPOT XS
Number of bands				
Spatial resolution				
Radiometric resolution				
temporal resolution				

Section B:

B1:

(a) What are the major differences between a sun-synchronous and a geostationary satellite orbit

(2)

(b) Give the advantages of aerial photography over satellite remote sensing.

(4)

(c) Define the term remote sensing from two perspectives, that is, airborne and spaceborne remote sensing. Also give the typical platforms used in each case.

(4)

(d) Enviromental disasters can be monitored by remote sensing especially over large areas such as in flood monitoring. Explain the characteristics of NOAA-AVHRR that make it idle for monitoring. Also explain the shortcomings of NOAA in such cases. Which bands of AVHRR are more suited for such application?

(10)

B2:

(a) **Give a detailed account of the main groups of classification methods used in image processing;**

(10)

(b) **What are the characteristics of SPOT PAN that make it competitive to medium/small scale aerial photography.**

(4)

(c) **Briefly describe the moving average filter. Using a 3x3 moving average filter B, show how the pixel values of the output image C when filtering is performed on a 5x5 image (matrix) A . Fill the pixels which do not participate in the filtering process in the output image with zeros(0s). The elements of the matrix A are as shown below;**

(6)

0	1	2	3	4
1	2	0	4	5
2	0	4	0	6
3	4	0	6	7
4	5	6	7	8

B3:

(a) **What are the major advantages of SPOT panchromatic imagery over Landsat MSS with regard to;** **(10)**

- **spatial resolution**
- **sensor mechanism**
- **nadir/off nadir imaging capability**

(b) **One of the application areas of remote sensing is in mineral exploration. The analysis may be based on the geology and vegetation coverage of the area . Give a scientific basis on the choice of the sensor and the spectral bands you would use for your analysis. Explain why the geology/vegetation combination can give a good guide to mineral exploration.**

(10)

******_End of Exam, Good luck!!!!_******

The University of Zambia
School of Engineering
Department of Surveying
SE472- Principles and Methods of Surveying II
Second Semester Examinations- 1996

Time: 3 hours
Answer: Any four questions

Question 1

a) An EDM instrument using an infra-red carrier wave with a wavelength of 0.900μm is used to measure a slope distance between A and B of 1340.532 m where E_A= 642936.432m, E_B= 643617.893m . The prevailing atmospheric conditions are
atmospheric pressure = 655 mmHg
temperature = 24° C
Calculate the projected distance (in UTM) of the measured distance given the vertical angle to be 89° 15' 30", the scale factor = $0.9996(1+(0.01237E^2_m\times10^{-6}))$
The standardising refractive index = 1.00028172
Given also

$$n_g = 1 + \left(287.604 + \frac{4.8864}{\lambda^2} + \frac{0.068}{\lambda^4}\right)10^{-6}$$

$$n_a = 1 + \frac{0.359474(n_g - 1)p}{273.2 + t}$$

(16 marks)

b) Mention three systematic errors normally encountered in EDM instruments and explain how these can be determined.

(9 marks)

Question 2

a) Two straight sections of a proposed new road deflect through an angle of 12°. A circular curve of 800 m radius is to be inserted to connect the two straights. The through chainage of the point of the intersection is 1047.23 m

(5+10)

i) Calculate the through chainage of the two tangent points

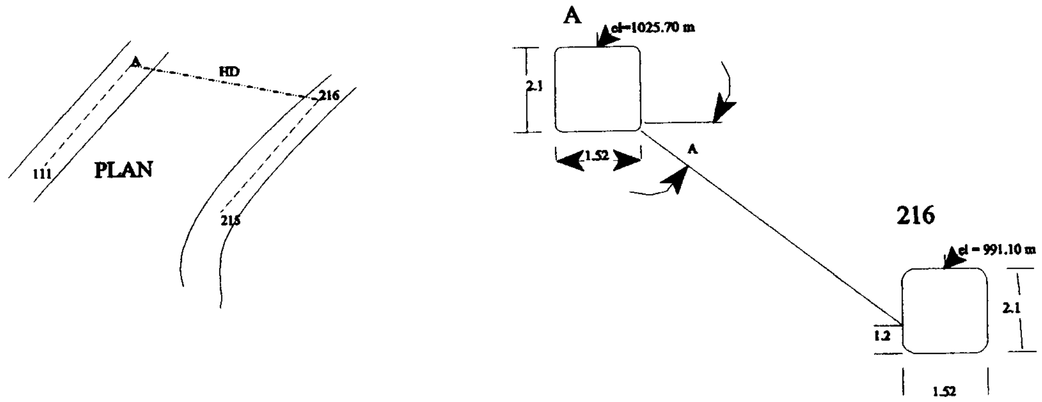
ii) Tabulate the deflection angles required to set out the curves assuming that the points are required at every 20 m of through chainage.

b) A wholly transitional curve is to be inserted to connect two straights which deflect through an angle of 15°. Calculate the total length of the curve if the design speed of the road is 100 km/h and the rate of change of radial acceleration is to be 0.3 m/sec^3.

(10 marks)

Question 3

In order to improve ventilation in a mine a raise was to be drilled to connect two levels.(see Fig below)



a) Calculate the length of the raise drive and the vertical angle from level 216 to A given that it will start at 1.2m above the ground in drive 216 and also that *A* (1313.84mN, 1922.14mE, 1025.70m) *216* (1266.81mN, 1966.40mE, 991.10m) The bearing 111 to A = 50°00' and 215 to 216 = 47°30'.

b) What are the horizontal angles to be used for setting out at A with reference to 111 and at 216 with reference to 215.

c) In order to connect the upper level of a mine with one below using one vertical shaft the method of connection triangles is used to determine the bearing of the initial line in the lower level as well as coordinates of the initial point. Show using a sketch and formulae how this is achieved.

(9+6+10 marks)

Question 4

a) A new bridge at Luangwa is to be built. As a surveyor on the project what kind of work are you expected to do from initial stages to completion?

(9marks)

b) What methods of monitoring deformations on a new dam can one employ?

(6 marks)

c) Findeco House is being checked for vertical movement by use of two pillars A and B which are set up on solid foundations somewhere near misisi. A target C was fixed near the top of the building and a series of angles was measured. During a period of six months the same angles were measured with the same equipment and methods. The following values remained constant throughout the six month period:
horizontal distance between A and B = 247.232m, horizontal angle BAC = 58°17'24", horizontal angle ABC = 63°24' 49". The vertical angle from A to C varied as follows throughout the period
initially= 16°18'22" after three months = 16°18' 11" after three months = 16°18' 06"

Assuming that the angular changes are due solely to the movement og the building, calculate the amounts of the vertical movement over the periods separating the observations.

(10 marks)

Question 5

a) Through a flow diagram show the components of an interactive surveying system and mention the advantages of such a system.

(10 marks)

b) One of the problems of interactive surveying is the communication between the field data equipment and the computers. Mention four transmission parameters that have to be set in both the datalogger and the computer to facilitate communication.

(5 marks)

c) Two methods of analogue-digital conversion are used in electronic theodolites for angular conversion. Briefly describe these methods.

(10 marks)

End of Examination!!!

University Of Zambia
School Of Engineering
Department Of Surveying

SE481- Introduction to Surveying
EXAMINATION- JUNE 1996

TIME: 3 HOURS

ANSWER: THREE OUT FOUR IN SECTION A
SECTION B

B1	CIVIL ENGINEERING STUDENTS
B2	AGRICULULTURAL ENGINEERING STUDENTS
B3	GEOLOGY STUDENTS
B4	SOIL SCIENCE STUDENTS

SECTION A

1. (10+5+10)

A tacheometric survey using a theodolite (multiplying constant 100, additive constant 0) and a levelling staff is carried out in order to produce a contour map of an area where a road is planned. Two points A and B are already known in a locally established coordinate system:

Pnt	Easting(m)	Northing(m)	RL(m above MSL)
A	125.48	247.65	1265.074
B	274.61	235.44	1267.398

The instrument is set up at point A and tacheometric readings are taken to a staff held vertically at detail points 1, 2, 3 etc.
station A. *Instrument height 1.58m*

Pnt	hor.reading	vertical reading	stadia lines(m) U	M	L
B	12°30'				
1	62°00'	85°49'30"	2.312	1.881	1.450
2	152°30'	95°05'00"	2.385	1.881	1.376

Calculate

a) The coordinates of target points 1 and 2 .
b) The horizontal distance between 1 and 2.
c) The Reduced levels of 1 and 2.

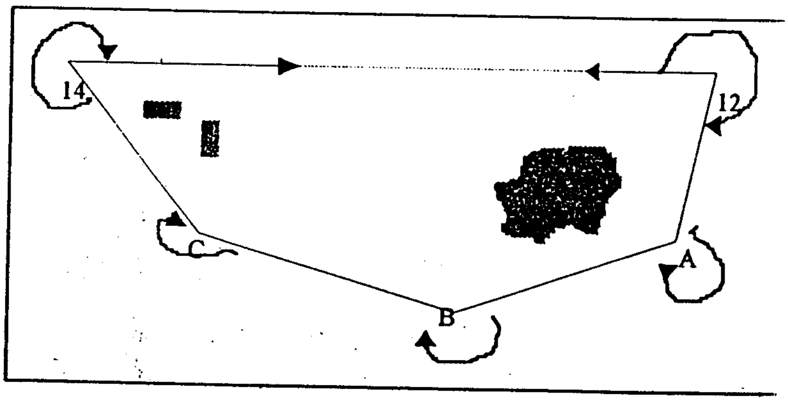
2. (10+5+10)

A line AE has to be brought to a constant gradient of 1/100 falling from A to E, for irrigation purposes. Point A is to keep its original height and is assumed to be at chainage 00 (ch.00). At a constant interval of 20m points have been pegged out along the line, and a level survey is conducted for determination of the vertical situation. The loop starts and closes at BM31(RL 676.063m). The observation made during the survey are as shown in the booking form Q2.

a) Complete the form according to the 'rise and fall' method.
b) Find the misclosure in the loop and derive whether or not it is acceptable, assuming δ = 30mm. (no adjustments are necessary).
c) Find the height of cut and fill at the 5 points along the line A, B, C, D, E.

3 (7+18)

Points 12 and 14 are part of a horizontal control network enclosing an area to be surveyed for the production of a topographical map. For detail surveying the network is densified and a traverse is run between the two points using theodolite and tape. The known co-ordinates are:



Point	E(m)	N(m)
12	1666.832	1588.482
14	1453.844	1580.239

The observations are as follows:

Pnt	hor.dist.	value	LHA	value
12	12 - A	82.40	14 - 12 - A	289°35'
A	A - B	87.19	12 - A - B	234°44'
B	B - C	79.25	A - B - C	229°43'
C	C-14	67.36	B - C - 14	203°48'
14	---------	-------	C - 14 - 12	302°15'

A. Compute the angular misclosure and adjust the measured LHA's.
B. Find the linear misclosures and the Fractional Linear Misclosure. state whether or not the accuracy limit of 1/10000 has been achieved.

4. (10+7+8)

Explain the following

(i) Electronic distance measurement using phase differences. Present also the fundamental equation relating distance to phase delay.

(ii) Magnetic declination. What variations affect this declination?

(iii) Mention with illustrations four methods of determination of areas of irregular figures.

Form Q2

Pnt Nr.	Readings BS	IS	FS	dist BS	FS	height diff. RISE	FALL	RED. LEV	REM
BM31	0.810			64.2					BM
1	1.604		1.462	50.8	67.0				CP
A	1.215		1.543	29.2	48.5				CP Ch.0
B		1.683							Ch.20
C		1.998							Ch.40
D	1.852		2.274	42.6	31.0				CP ch60
E		1.859							ch80
2	2.031		1.288	61.0	40.9				CP
BM31			0.960		60.7				BM

SE481 part B4 (Geographic Information Systems part)

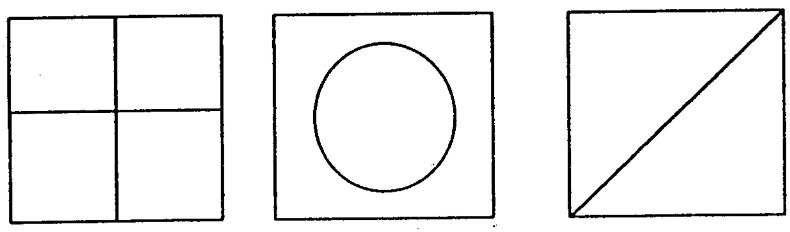
Total points: 25
Answer all 4 questions

Total number of pages: 1

1. Discuss the advantages of GIS over the paper map.
(6 points)

2. Mention the most important data sources for GIS and clarify whether they provide geometric data and/or attribute data.
(6 points)

3. Perform a topological overlay on the following three maps.
Indicate the nodes, arcs and polygons in the original maps and the resulting map, following the topological vector model.



(7 points)

4. Give a decription of the following terms:

   a. Vector to raster conversion
   b. Data quality

(3+3 points)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JUNE 1996

SE 531 PHOTOGRAMMETRY III

TIME: THREE HOURS

ANSWER FOUR QUESTIONS: PART A: ALL QUESTIONS
PART B: ONE QUESTION

PART A

1.
(a). Explain what are the functions of computers in two following types of stereoscopic instruments;
- computer supported stereoplotter,
- conventional analytical plotter.

(b). What are the advantages of computer supported stereoplotters against graphical stereoplotters ?

(15 + 10)

2.
(a). What are the differences in the principles of conventional analytical plotter and photogrammetric digital system ?

(b). Discuss the advantages and disadvantages of photogrammetric digital systems against conventional analytical plotters.

(15 + 10)

3. What principles would you assume for photogrammetric compilation of a basic digital planimetric map of Lusaka, to be subsequently used for various urban applications, if the required accuracy for determination of planimetric positions of various types of features were in range from 0.05 to 0.15 meters. Consider the whole process from design of aerial photography and field network up to compilation of final results.

(25)

PART B

4.

(a). What does mean image correlation ?
How is image correlation executed in the human operated stereo instruments.

(b). What does mean image correlator ?
What are the basic principles and functions for electronic and digital image correlators ?

(c) Give examples of stereo instuments applying the electronic and digital correlators.

(8 + 10 + 7)

5.

(a). Explain what does mean close range photogrammetry and which main areas are involved in it.

(b). Describe shortly the main acquisition systems for recording the objects and the main compilation methods used in medical applications of close range photogrammetry.

(c) What tasks can be solved by close range photogrammetry in medical aeras.

(7 + 11 + 7)

END OF EXAMINATIONS

University of Zambia
University Examinations
Second Semester, 1995/96 Academic Year
Department of Surveying, School of Engineering
Geodesy II, SE 542

Answer all questions in Part A and one question of your choice from Part B.
Total marks is 100
Time: 3Hrs

PART A

Question 1

a) Briefly discuss the principle of arc measurements and mention its relevance in geodesy.

b) Determine the Cartesian coordinates for a point in West Africa on WGS 84 given the following data:

Geodetic latitude, $\phi = 31° 34'$
Geodetic Longitude, $\lambda = -15° 06'$ (or $344° 54'$)
Orthometric height, H = 1478m
Geoidal Height, N = -5m
Semi-major axis, a = 6378137m
Flattening, f = 1/298.257

c) (i) Explain what is meant by a geodesic

(ii) What is Clairaut's equation for the geodesic and of what relevance is this formula

d) Using a relevant figure, explain the terms direct and indirect problems of geodesy

(6 + 7 + 6 +6)

Question 2

a) Briefly describe the following terms with a relevant formula where possible

i) deflection of the vertical at the geoid

ii) reference ellipsoids: regional or local and Mean Earth Ellipsoid
iii) Brun's formula
iv) gravity disturbance
v) gravity flattening

b) Compute the Bouguer and free-air anomalies for the following point:

$\phi = -15° 28'$
$\lambda = 28° 59'$
$H = 1300m$
$\rho = 2.67 g/cm^3$

Measured gravity, g = 978293.6 mGals and the international gravity formula 1980 is proposed to be used:

$$\gamma = \gamma_a(1 + 0.0053024 \sin^2\phi - 0.0000058 \sin^2 2\phi) \qquad \text{mGals}$$

and also $\gamma_a = 978032.7$ mGals.

(20+5)

Question 3

a) Give three orbital parameters. Use a diagram in your answer

b) Briefly comment on the accuracies (orbital and point positioning accuracies) pertaining to broadcast ephemeris and precise ephemeris.

c) What do you understand by phase differencing and of what importance is it in geodetic positioning?

d) Compare conventional terrestrial surveying methods to satellite surveying method.

(5 + 8 + 8 + 4)

PART B

Question 4

a) The geoid is held to be the reference surface for vertical coordinates, i.e. heights. Give three examples of heights. Do all your heights refer to the geoid? Comment. Please use figures in your answer.

b) Relate the astronomical observations to geodetic ones. What quantities are involved in these relations and how does one obtain them?

(15 + 10)

Question 5

a) Discuss the scaling and orientation of geodetic surveys in classical methods.

b) Describe the two atmospheric effects that affect GPS or indeed satellite observations in general

c) Give two examples of absolute gravity determination.

d) Explain the following terms

(i) cycle slips
(ii) Laplace stations

(8+7+5+5)

Good Lucky

The University of Zambia
School of Engineering
Department of Surveying

University Examination 1996
SE561 Geographic Information Systems

Time: Three hours
Total number of pages: 5
Total points: 100
Answer all questions 1,2,3,4 and two out of 5,6,7. (answer 6 questions in total)

1. Give a detailed description of the following terms:

    a. Topological overlay
    b. Thiessen polygon
    c. Map registration
    d. Stream digitizing
    e. Run-length encoding
    f. Spaghetti data model

(4+4+4+4+4+4 points)

2. Study the text and accompanying figures in appendix A carefully and answer the questions below.

    a. Construct the flow diagram which is followed in this program to create the map in figure 2.3, stating the inputs, intermediate products, processes and outputs. Indicate for all products in which form (maps, tables, etc.) they exist.

    b. Give an alternative method where the interpolation process(es) will get another place in the flow diagram. Discuss the possible differences of the resulting end-product (growing periods isoline map) with the map created as in figure 2.3.

    c. What criteria would have played a role in establishing the intervals between the isoline values ?

    d. What factors and processes determine the accuracy of the map in figure 2.3 ?

(8+5+3+5 points)

3. Which datastructures or combinations of datastructures (raster, topological vector, non-topological vector, TIN, 3-D) would you use in the following GIS applications ?
Also mention for each application the type of GIS analysis functions which would be needed.

   a. Monitoring urban growth of the city of Lusaka with help of remote sensing techniques.

   b. Producing a general pupose road map of Zambia.

   c. Management of the water supply of a newly built city area.

   d. Mapping erosion hazards by means of terrain slope data.

   e. Identification of a suitable site for timber logging, given the constraint the site should not be situated within 500 meters of open water.

(3+3+3+3+3 points)

4. A district council in one of Zambia's provinces requires a more efficient rural development planning method and wants to change to a GIS-based rural planning system in their planning unit. You are a GIS consultant and should advise the district council on several matters involving the implementation of GIS in the organization, for which the council has set a certain budget.

   a. Discuss to which components of the implementation process the costs have to be distributed.

   b. Which choices have to be made in general with respect to the geographic coverage, thematic coverage and data quality. What would be your advise for the district council ?

(8+8 points)

5. a. Mention three sampling strategies and explain in which situations they are used.

   b. Consider the figure in appendix B. Mention some possible reasons for the devision into sampling areas like it is being done here.

(6+6 points)

6. a. State the names of the following coordinate transformations and explain their properties (no calculations are needed).

i)
$$u = 100000 + 1.009 * x - 0.8988 * y$$
$$v = 2050000 + 1.009 * y + 0.8988 * x$$

ii)
$$u = 0.9562 * x + 0.5898 * y$$
$$v = 0.6956 * x + 0.9509 * y$$

b. Mention a third type of coordinate transformation and describe its properties.

(8+4 points)

7. Mention six characteristics which determine the functionality of GIS software. For each characteristic give two possible occurrences.

For example:	Characteristic	Possible occurrences
	User interface	*1. Command input* *2. Menu driven*

(12 points)

End of Exam

Agro-climates at the global scale

In Chapter 1, reference was made to the Agro-ecological Zones project of FAO which has as its aim a first approximation of the production potential of the world's land resources. The starting-point in such a land evaluation exercise is the definition of climatic and soil requirements for the different crops. In the Agro-ecological Zones project, inventories of crops were prepared based on their climatic requirements for both photosynthesis and phenology. Then it was necessary to assemble an agro-climatic inventory with particular emphasis on the attributes of land relevant to the defined climatic requirements. Particular emphasis was given to water availability and temperature as initial factors in determining crop suitability for rainfed agriculture. The combination of available water and adequate temperature for crop growth is expressed in *the growing period*. For the Agro-ecological Zones project, the growing period is taken as the continuous period from the time when rainfall is greater than half the potential evapotranspiration until the time when rainfall is less than the full potential evapotranspiration, plus a number of days required to evaporate an assumed 100 mm of soil moisture reserve when available (FAO 1978a). The objective of defining the beginning of the growing season in this way is largely to eliminate the problem caused by 'false start of rains'. The end of the growing period extends beyond the rainy season to varying extents with crops extracting water from soil moisture reserves. The definition assumes a general figure of 100 mm storage water being available to crops. An example of a normal growing period is shown in Figure 2.2. An intermediate growing period exists when the average monthly precipitation is between the full and 0.5 average monthly potential evapotranspiration. For the African study it was concluded that crop growth is severely restricted when the 24 hour (daily) mean temperature falls below 6.5°C. Thus the period during which temperature falls below 6.5°C is subtracted from the growing period as determined from water availability. Data from more than seventy meteorological stations in Africa were obtained and the length of the growing season was computed. Isolines of growing periods of values of 0, 75, 90, 120, 150, 180, 240, 270, 300, 330 and 365 days were interpolated indicating growing period zones of 0–74 days, 75–89 days, 90–119 days, etc (Figure 2.3). Such a map is an excellent example of an agro-climatic inventory designed to be relevant to a particular crops.

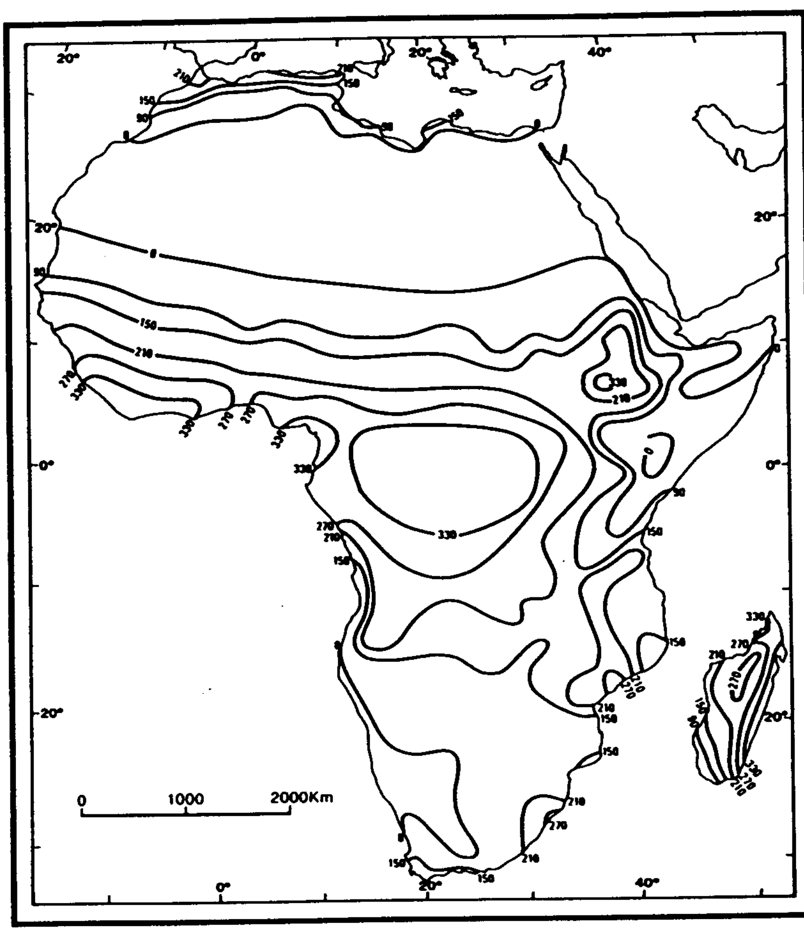


Figure 2.3 Length of growing periods in Africa (source: FAO 1978a: 40)

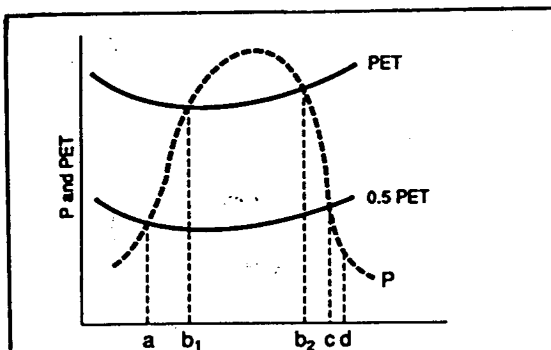
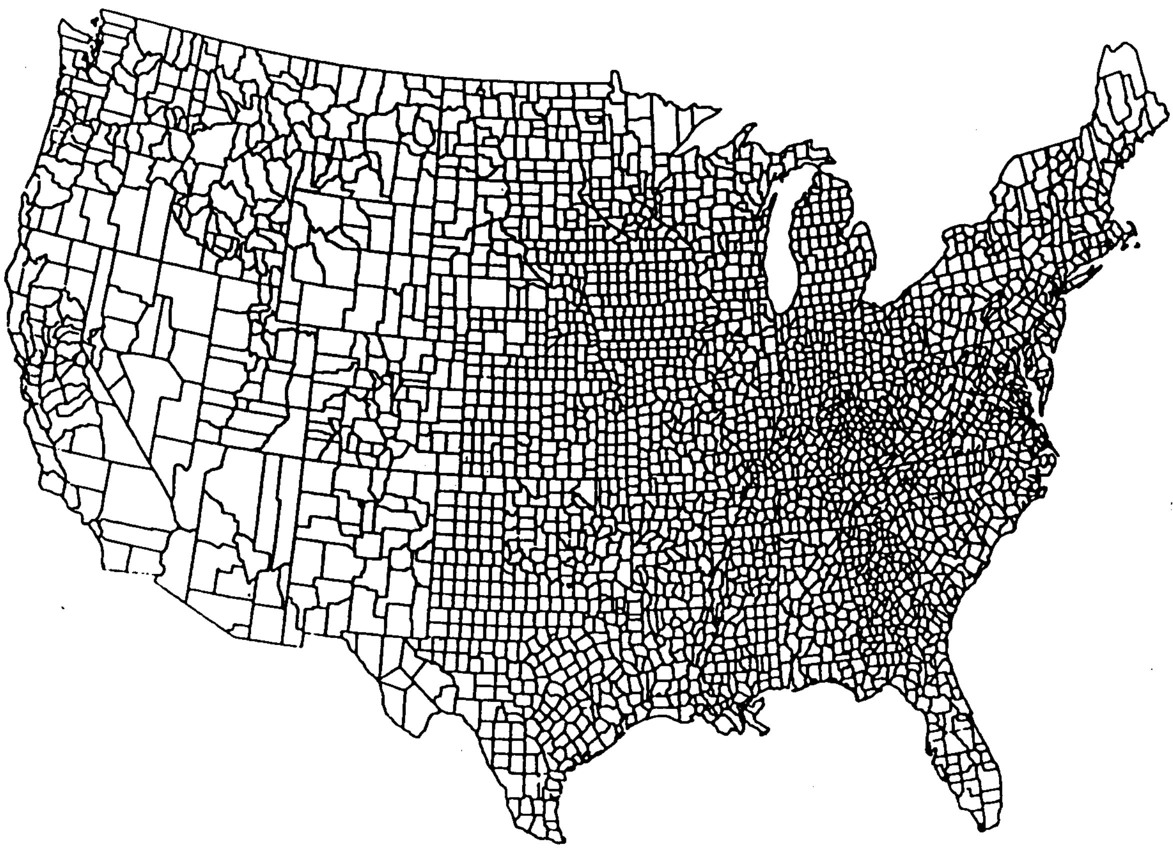


Figure 2.2 An illustration of the growing period as defined FAO (1978a).
PET potential evapotranspiration
P precipitation
a beginning of rains and growing period
b_1 and b_2 start and end of humid period respectively
c end of rains and rainy season
d end of growing period
(source: FAO 1978a: 36)

Appendix B



County map of the United States.

UNIVERSITY OF ZAMBIA
DEPARTMENT OF SURVEYING

SE 562 LAND RESOURCES PLANNING

NOVEMBER/DECEMBER 1996 EXAMINATIONS

TIME: 3 HOURS

SECTION A: ANSWER ALL QUESTIONS

Question 1 (3+10+12)

(a) What is the role of land evaluation in land use planning?

(b) Explain with illustrations the difference between the following terms;
- factor rating vs. degrees of limitation
- current suitability vs. potential suitability
- land characteristic vs. land quality
- land use requirement vs. land quality

(c) Tables II and III show suitability ratings of selected crops at different input levels for four land units.
(i) What type of constraints (permanent or variable) do the four land units present with respect to a) maize and b) rice? Explain your answer.
(ii) Allocate the land use types, at medium input level, to the four land units assuming the financial returns are the only consideration.

Table II Suitability classes for selected crops

Units	tyUps				tyUks				tyUkh/tyUkh-s				aqUps			
Crops	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
maize	III	II	I	I	III	II	I	I	III	II	I	I	VII	VII	VII	VI
f.millet	II	I	IA	IA	III	II	I	I	IV	II	I	I	VII	VII	VII	IV
sorghum	II	I	I	I	IV	I	I	I	IV	I	I	I	IV	IV	IV	IV
rice	III	III	III	III	IV	IV	IV	IV	IV	IV	IV	IV	I	I	IA	IA
g/nuts	II	I	I	I	II	I	I	I	II	I	I	I	IV	IV	IV	IV
bananas	IV	IV	IV	IV	III	II	I	I	III	II	II	I	IV	IV	IV	IV

N.B. (a) A = low; B = medium; C = high; D = very high input level
(b) The classes are defined according to the Zambian suitability classification system.

Table III Yield levels in averages at medium input level (kg/ha) per suitability class

	Price/Kg	IA-I	II	III- IV	V-VII
banana	100	18750	9375	4690	2345
maize	200	3125	1550	782	390
g/nuts	300	1250	620	313	94
f.millet	200	1250	620	313	94
sorghum	200	1890	937	469	234
rice	350	3125	1550	782	390

Question 2 (8+5+12)

During a preliminary study of Chief Saileti's village the following problems were identified as affecting the village people; low incomes, poor nutrition, inadequate subsistence production, and shortage of fuelwood.

These problems have resulted from poor soil conservation practices and inadequate periods of bush fallow. The land profile in the Chief's area consists of a forest reserve (234 ha) on the hills, hill slopes (408 ha) and a valley (600 ha) at the bottom of the slopes. About 70 percent of the food production is from the valley and the rest is from the slopes. The hill slopes also provide fuelwood, but this is decreasing and women have to walk long distances to collect fuelwood, thus spending very little time in their gardens.

The total population in the village is 500. The total agricultural production is 15 tonnes of cereal and 10 tonnes of vegetables per annum. The market price per 90 kg of cereals is K18000 and K4000 for vegetables. The total cultivated area is 720 ha. It is intended to improve the existing situation by intercropping of cereals and vegetables with fruit trees. The trees take 3 years before they start to produce fruits. It is estimated at full production, the yields from the trees will be 15 000 kg per year, and the total cereal and vegetable production will slightly improve by 3 tonnes each. The existing market price for fruits is K4000 per 10 kg. The initial investment in the first year is K800,000 for the entire cultivated area.

(a) Using the cause-effect diagram, structure the problems in Chief Saileti's area.
(b) Calculate the gross income per person per annum before and after full fruit production.
(c) Calculate the difference in per capita Net Present Value between the existing and improved situation over a period of 5 years, assuming a discount rate of 12 percent per annum.

SECTION B: ANSWER ONLY TWO QUESTIONS

Question 3 (10+10+5)

(a) Explain the roles of land registers and cadastres, and mention three advantages to an individual of land registration.
(b) Compare the Zambian system of land registration against the three guarantee principles. What system would you say it is, deeds, improved deeds or titles, and why?
(c) Describe the main problems of customary tenure in Zambia.

Question 4 (10+10+5)

Regional development planning is aimed at reducing inter-regional disparities through integrating rural regions into the national market.

(a) Explain the *means* and *process* of accomplishing this.
(b) Enumerate the main data types needed to undertake regional planning.
(c) What are the advantages of using a region in development planning?

Question 5 (10+10+5)

Appraising of alternative land uses is done by performing impact analyses while the goals achievement matrix can be used in selecting the best alternative on the basis of specified policy guidelines.

(a) Explain the meaning and purpose of following analyses:
- environmental impact analysis
- financial and economic impact analysis
- social impact analysis

(b) Explain with an illustration the use of the goals achievement matrix.

(c) Determine which land use type will be allocated to a land unit X for which the following data is given for land use types A, B, and C, respectively.

Land use type	Net Income(K/ha)	PCC (Calories/day)	EI (%)
A	200,000	340	80
B	230,000	310	20
C	250,000	300	100

NB K/ha = Kwacha per ha, PCC = population carrying capacity, EI = environmental impact.

Question 6 (10+10+5)

The demands for arable land, grazing, forestry, wildlife, tourism and urban development are greater than the land resources available. Even where land is still plentiful, many people may have inadequate access to it or benefits from its use. Land use planning tries to address these problems.

(a) Explain the
(i) process of land use planning indicating the output at each stage, and
(ii) how land use planning tries to resolve the problems stated above.

(b) What is the role of land evaluation in land use planning, and how is this done in Zambia?

(c) Why is it necessary to have government intervention in order to influence the needed changes in land use? Mention three methods that can be used to influence these changes.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
DEPARTMENT OF SURVEYING

SE 562 LAND RESOURCES PLANNING

NOVEMBER/DECEMBER 1996 EXAMINATIONS

TIME: 3 HOURS

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sorghum	II	I	I	I	IV	I	I	I	IV	I	I	I	IV	IV	IV	IV
rice	III	III	III	III	IV	IV	IV	IV	IV	IV	IV	IV	I	I	IA	IA
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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING
DEPARTMENT OF SURVEYING

SE 571 - ENGINEERING SURVEYING
FINAL EXAMINATION, JUNE 1996.

TIME: 3 HOURS
ANSWER: ANY FIVE QUESTIONS, ALL QUESTIONS CARRY EQUAL MARKS.

QUESTION 1. (6 + 14 Marks)

(a) Explain in detail why it is always preferable to use reciprocal observations in extensive heighting exercises?

(b) Calculate the height of point A. If height of point B. Is 151.34m.

Given horizontal distance A-B = 21,160.00m
vertical angle at B to A = +00 22' 30.4"
height of signal at A = 3.61m
height of instrument at B = 1.44m
mean radius of earth = 6370km
coefficient of refraction = 0.074

QUESTION 2. (6 + 14 marks)

(a) Define the following terms
(i) Collimate
(ii) Autocollimate

(b) With the aid of a sketch, describe how you can transfer by autocollimation a bearing from a higher level to a lower level in a multstorey building?

QUESTION 3. (9 + 11 Marks)

(a) Name and explain three instrument features which determine precision in automatic levels?

(b) Stations P. And Q are 780m apart. Observations with a level gave:

P, height of instrument 1.683m, staff reading at Q, 1.908m.
Q, height of instrument 1.656m, staff reading at P, 1.211m

Calculate the height difference and the error of the instrument (collimation), if refraction correction is one seventh that of curvature. Assume R= 6378km, mean earth radius.

QUESTION 4. (8 + 12 Marks)

(a) Describe how the tilting level's collimation error can be adjusted by reciprocal levelling.

(b) Reciprocal vertical angles were observed between stations R. And T. As follows:

mean observed angle R. To T. = +01 48' 15"
" T. To R. = -01 48' 02"

Height of instrument at R = 1.35m
" T = 1.36m

height of signal at R = 3.10m
" T = 4.50m

Reduced level of station R = 185.40m

Geodetic distance (Horizontal) R-T = 5800m
mean radius of earth = 6370km

Calculate (i) the reduced level of T
(ii) the refraction correction in seconds of arc

QUESTION 5. (8 + 12 Marks)

(a) Using the quadrilateral method, describe how you would transfer a surface bearing down a shaft and set out a base line underground in the same direction.

(b) In order to check the azimuth of the above correlation the gyrotheodolite was used in a reversal point method and the following observations were taken:

left reversal	330° 20' 40"
right reversal	338° 42' 50"
left reversal	330° 27' 18"
right reversal	338° 22' 20"

* mean horizontal circle reading of the baseline = 28° 32' 46"
* convergence of meridians = 00° 20' 18"
* (t-T) correction = 00° 00' 04"
* grid eastings of baseline = 500, 000m E.
* central meridian = 400, 000m E.

Prior to the above observations, the gyrotheodolite was checked on a surface baseline of known azimuth. The following data were obtained:

Known azimuth of surface baseline = 140° 25' 54"
Gyro azimuth of surface baseline = 141° 30' 58"

Determine the grid bearing of the underground baseline assuming it was located in northen hemisphere.

QUESTION 6. (8 + 12 Marks)

(a) Describe and contrast the reversal point method and the transit method of gyro observations.

(b) The following "transit" observations were recorded with a gyrotheodolite on a laboratory baseline of azimuth 128° 17.52'

Observations east of true north
Horizontal circle reading during transit oscillations = 15° 30.00'
Horizontal circle reading to reference object = 143° 32.45'
Times of transit: 00min 00sec, 03min 57.7sec, 07min 20.5sec, 11min 18.5sec, 14min 41.1sec

Amplitudes: -10.8, +8.3, -10.7, +8.2

Observations west of true north
Horizontal circle reading during transit oscillations = 15° 00.00'
Horizontal circle reading to reference object = 143° 32.45'
Times of transit: 00min 00sec, 04min 05.7sec, 07min 20.4sec, 11min 26.0sec, 14min 41.2sec

Amplitude: +7.9, -5.6, +7.9, -5.5

Determine (I) the additive constant and
(ii) the proportionality factor for this particular gyrotheodolite.

END OF EXAMINATION