SCHOOL OF ENGINEERING
2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

CE 219	:	STATISTICS AND INTRODUCTION TO STRENGTH OF MATERIALS
CE 305	:	CIVIL ENGINEERING DRAWING
CE 365	:	SOIL SCIENCE- ROADS AND HYDROLOGY
CE 425	:	SOIL MECHANICS AND FOUNDATION ENGINEERING
CE 425	:	DEFERRED
CE 431	:	STRUCTURAL MASONRY AND TIMBER STRUCTURES
CE 531	:	REINFORCED AND PRESTRESSED CONCRETE DESIGN
CE 565	:	WATER MANAGEMENT AND HYDRAULIC STRUCTURES
EA 311	:	FARM POWER AND MACHINERY
EA 311	:	(DEFERRED)
EA 401	:	FARM POWER
EA 421	:	FUNDAMENTALS OF FARM STRUCTURES (DEFERRED)
EA 521	:	FARM STRUCTURES I
EE 209	:	PRINCIPLES OF ELECTRICITY
EE 209	:	PRINCIPLES OF ELECTRICITY (DEFERRED)
EE 311	:	NETWORK ANALYSIS
EE 321	:	ELECTROMECHANICS AND ELECTRICAL MACHINES
EE 342	:	ELECTRONIC ENGINEERING I
EE 411	:	ELECTROMAGNETIC FIELDS
EE 431	:	ELECTRONICS AND ELECTRONIC ENGINEERING I(EE 441)
EE 521	:	ELECTRICAL MACHINES II
EE 561	:	SYSTEMS AND CONTROL ENGINEERING
21. GE 211	:	WORKSHOP TECHNOLOGY
22. GE 321	:	CARTOGRAPHY I
23. GE 371	:	SURVEYING I
24. GE 411	:	ERROR ANALYSIS AND NETWORK ADJUSTMENT
25. GE 422	:	CARTOGRAPHY II
26. GE 441	:	GEODESY I
27. GE 461	:	REMOTE SENSING
28. GE 561	:	PRINCIPLES OF GIS/LIS
29. GE 571	:	ENGINEERING SURVERYING
30. ME 209	:	ENGINEERING DRAWING I
31. ME 331	:	PROPERTIES OF ENGINEERING MATERIALS
32. ME 341	:	ENGINEERING THERMODYNAMICS
33. ME 375	:	DYNAMICS
34. ME 415	:	WORKSHOP TECHNOLOGY
35. ME 431	:	STRENGTH OF MATERIALS II
36. ME 461	:	FLUID MECHANICS II
37. ME 515	:	PRODUCTION TECHNOLOGY II PAPER I
38. ME 541	:	HEAT TRANSFER
39. ME 545	:	ALTERNATIVE ENERGY SOURCES

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

CE 219: STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS.

TIME: Three Hours.
INSTRUCTIONS: ANSWER Any **THREE** Questions from Section A, **AND** Any **TWO** from Section B. All questions carry equal marks (20%).

Section – A.

1. Find the moment of the 2000N force about the diagonal line AB. Express the answer as a vector (*Fig 1*).

2. The bracket BCD (*Fig 2*) is hinged at C and attached to a control cable at B. For the loading shown, determine

   (a) The tension in the cable
   (b) The reaction at C

3. Determine the forces in BD and DE of the truss shown (*Fig 3*).

4. The figure (*Fig 4*) displays a plate of constant thickness and uniform material. The plate is bounded by the straight line from above and a 4th order parabola from below. Consider the constants "a" and "b", the thickness of the plate and the density of the material as given. Derive the expression for the x-coordinate, $\bar{x}$, of the centre of mass for this body as function of the constants "a" and "b".

Section – B.

5. Determine the two principal (i.e. maximum and minimum normal) stresses at the two points where the stresses are as shown in the figures (*Fig 5a and Fig 5b*). For each case, calculate the orientation of the principle stresses with respect to the X and Y axes, and show the results in a sketch.

6. In the structure shown (*Fig 6*) the L-shaped rigid member BCD is supported by Steel rod AB and Aluminum member DE, and pinned at point C. Member DE has a cross sectional area of 10 cm^2 and member AB has a cross sectional area of 5 cm^2. The structure is initially unstressed and then experiences a temperature decrease of 60 degrees Fahrenheit.

For this structure:

A. Draw a Free Body Diagram showing all support forces and loads
B. Determine the axial stress that develops in steel rod AB.
C. Determine the resulting movement of point D.

($\alpha_{Steel} = 6.5 \times 10^{-6}/^{\circ}F$; $\alpha_{Aluminum} = 13 \times 10^{-6}/^{\circ}F$; $E_{Steel} = 200\ N/mm^2$; $E_{Aluminum} = 75\ N/mm^2$)

7. Draw the Shear Force and the Bending Moment Diagrams for the beam and loading shown (*Fig 7*). Show all your free body diagrams and equations.

END OF EXAMINATION

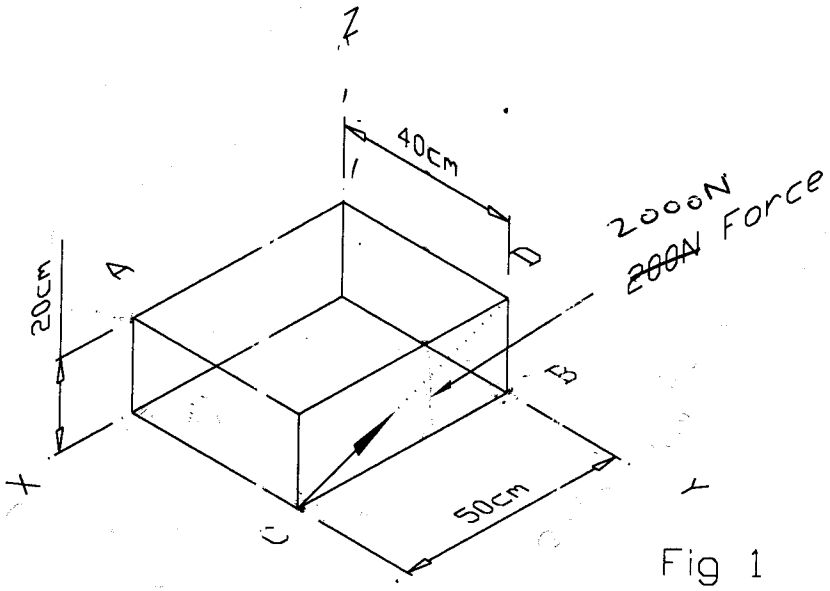

Fig 1

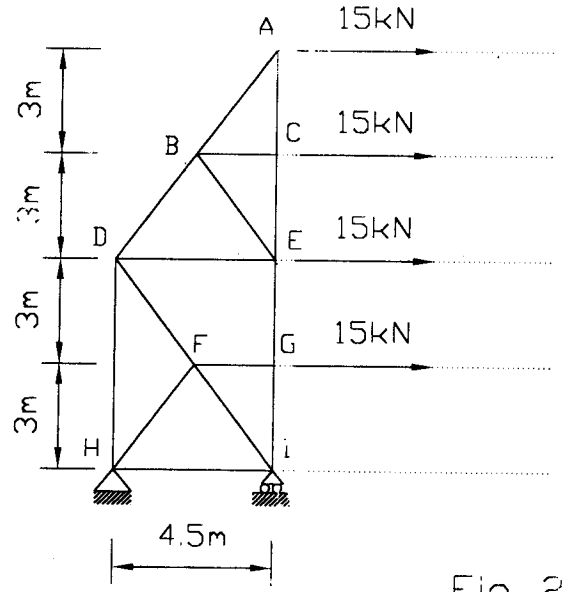

Fig 2

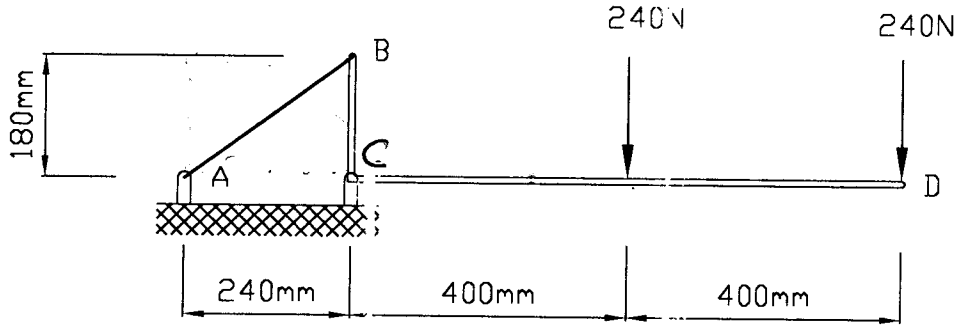

Fig 3

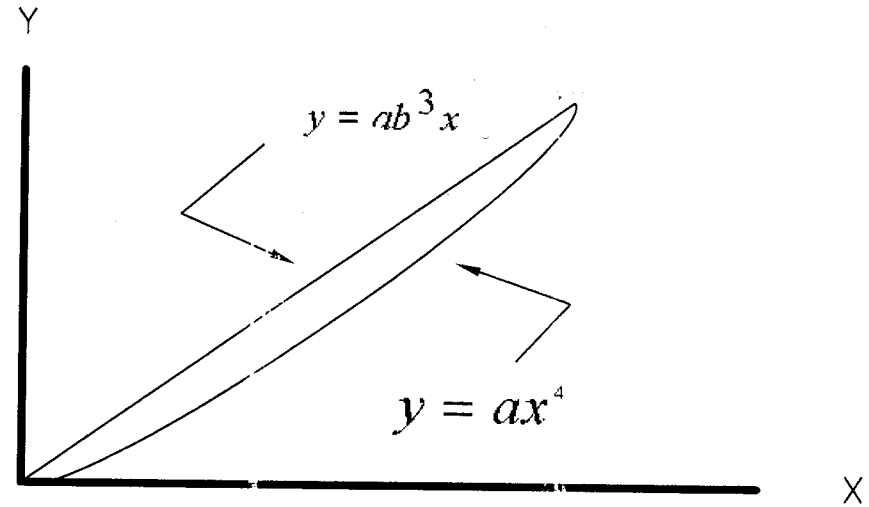

Fig 4

THE UNIVERSITY OF ZAMBIA, SCHOOL OF ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER, FINAL EXAMINATIONS

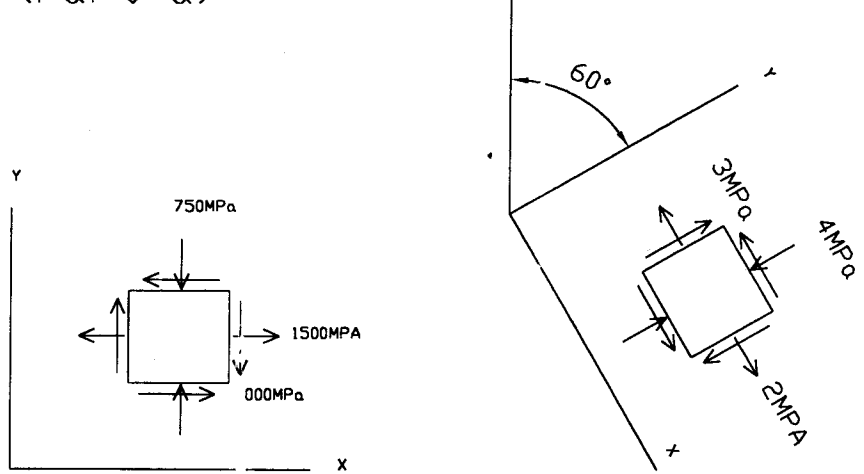

Fig 5

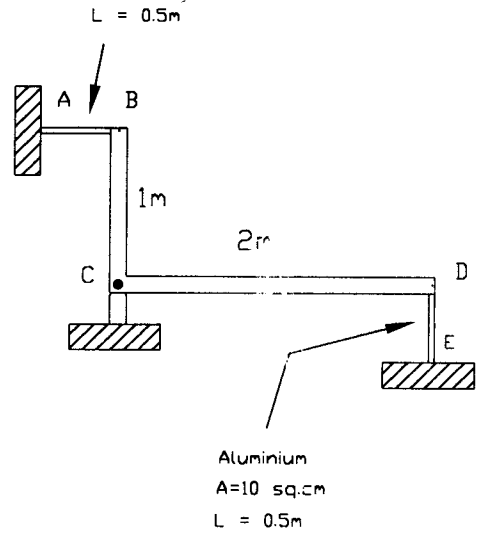

Fig 6

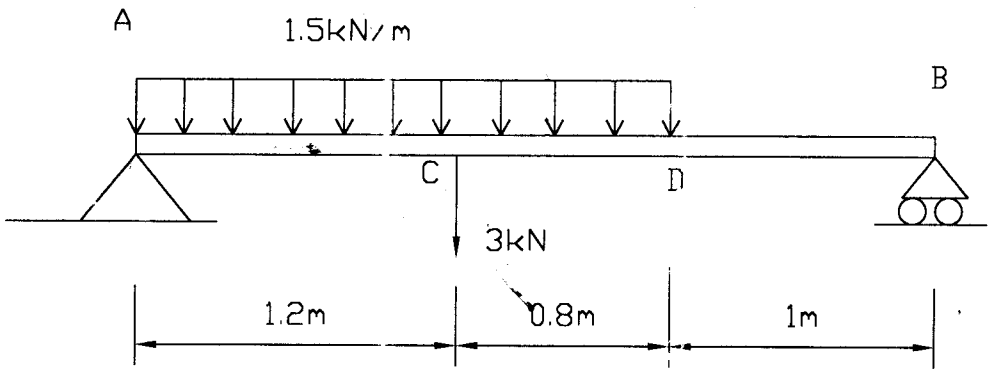

Fig 7

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS
2004 ACADEMIC YEAR
JUNE 2004
CE 305 - CIVIL ENGINEERING DRAWING

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

1. **Provide a simple title block containing only the computer number and the course code.**

2. **Make sure this question paper has all of the following attached:**
   a) Section standards for universal beams and angles
   b) a bar schedule
   c) extract on measurement of bending dimensions of bars for reinforced concrete

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QUESTION ONE

Detail a beam simply supported on two 400*400 mm columns as shown in figure 1. The following are its properties:

(I) Depth = 600 mm
(II) Width = 400 mm
(III) Span (the distance between the faces of the supports) = 6000 mm
(IV) Reinforcement:
   (i) Two 20 mm high yield steel bars are provided for the main reinforcement. The bars are hooked at the ends.
   (ii) Two 16 mm straight medium yield bars 5000 mm long are provided at mid span. They are in a horizontal arrangement with the main reinforcement
   (iii) Two 12 mm medium yield steel bars with bends at the ends are provided for hanger bars.
   (iv) 10 mm medium yield bars spanning between the faces of the supports at a spacing of 300 mm are provided for stirrups.

Take: -

i. bottom cover to main reinforcement steel bars as 40 mm.
ii. top cover to hanger bars as 30 mm
iii. side cover to main reinforcement and hanger bars as 40 mm.
iv. end covers as 50 mm

a) make detailed reinforcement drawings for the beam **[20]**
b) prepare a bar schedule **[15]**

QUESTION TWO

Mr. Francis Chibisa has recently acquire a piece of farmland. He has decided to start the development with the construction of the servants quarter whose details are given below.

Size and layout

The quarter will be a two-roomed structure with in-house sanitary facilities. Figure 2 is the centre line sketch plan of the quarter. All the outside walls will be 150mm blockwork.

Roof:

The roof will be of traford asbestos roofing sheets on 50*75mm timber purlins at a spacing of 1200mm C/C. The purlins will be supported on 50*150mm timber rafters slanting from the front to the back at 15° The rafters will be spaced at 1200mm C/C and will rest on 38*150mm timber wall plates.

Floor

The floor will have a sand/cement finish on a 100mm thick floor slab. A polythene sheet will be provided between the floor slab and the hardcore to prevent moisture from ascending to the supper structure.

Foundation

A 200*600mm strip foundation will be provided. The foundation trenches will be at least 500mm deep.

(a) Draw a fully dimensioned plan of the servants quarter **[20]**

(b) Draw a suitable section of the servants quarter **[20]**

Where specific information is not given, make and state your assumptions.

QUESTION THREE

Figure 3 is a sketch of a beam to beam connection. The supporting beam is a 610*305*149UB while the connecting beam is a 305*165*40UB. The connection is through a 200*200*18 seating cleat welded to the web of the supporting beam. The cleat is fitted in such a way that the top parts of the beams are at the same level (see figure 3). The bottom flanges of the incoming beam are connected to the seating cleat with 2No. 14mm diameter bolts. The web is connected to the web of the supporting beam by two 90*90*10 angle cleats, one on each side. These angles are welded to the web of the incoming beam and bolted to the web of the supporting beam by 2No 10mm diameter bolts. Detail the connection. You are required to **ONLY GIVE** the view given in figure 3. Where information is not given, make and state your assumptions.

GOOD LUCK!

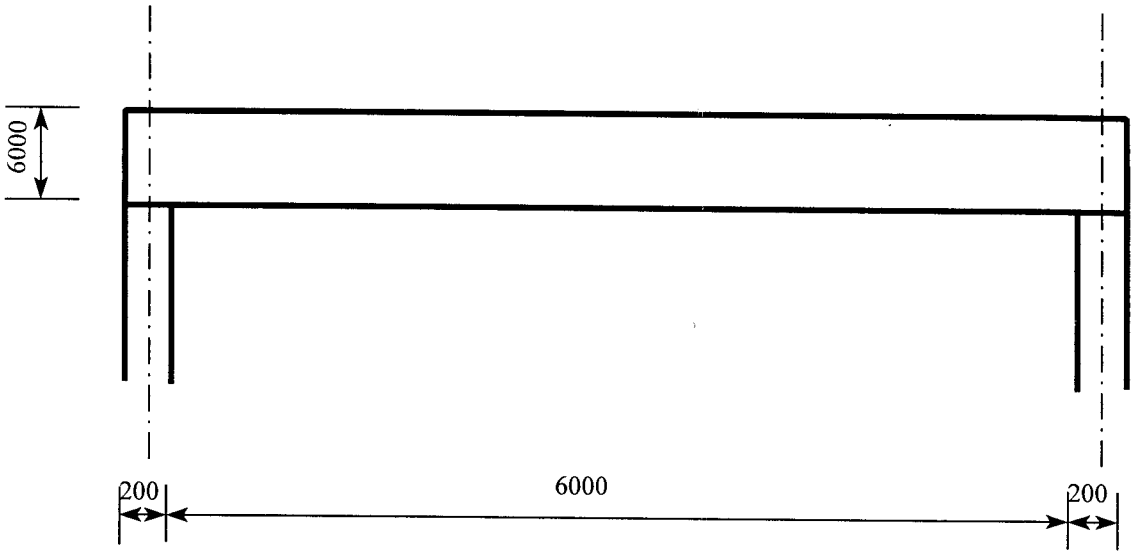


FIG 1: CONCRETE BEAM

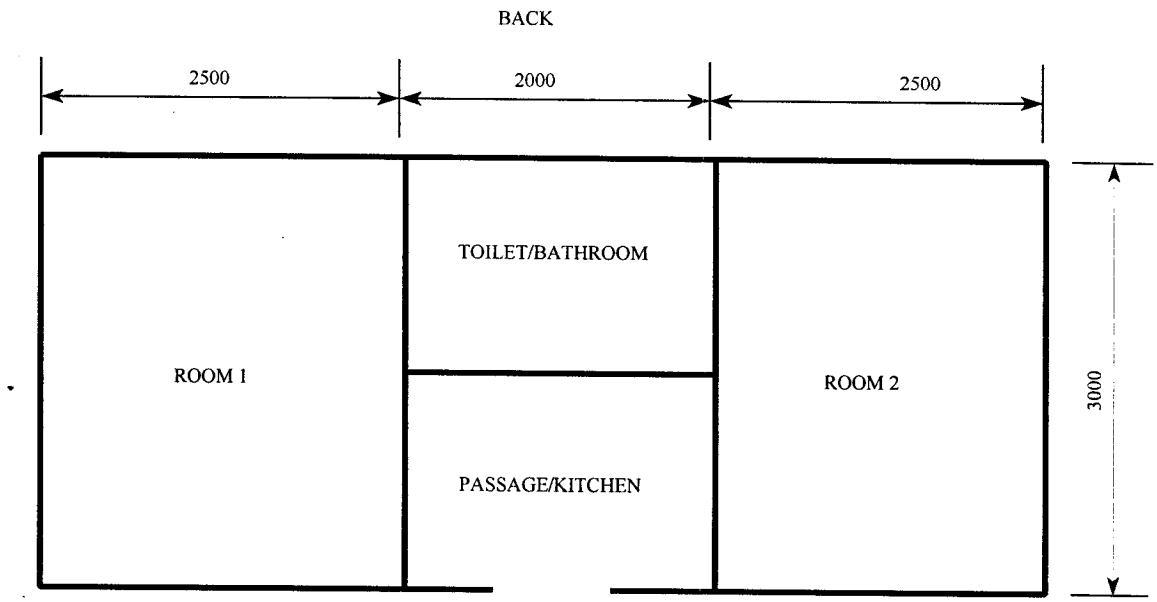


FIGURE 2

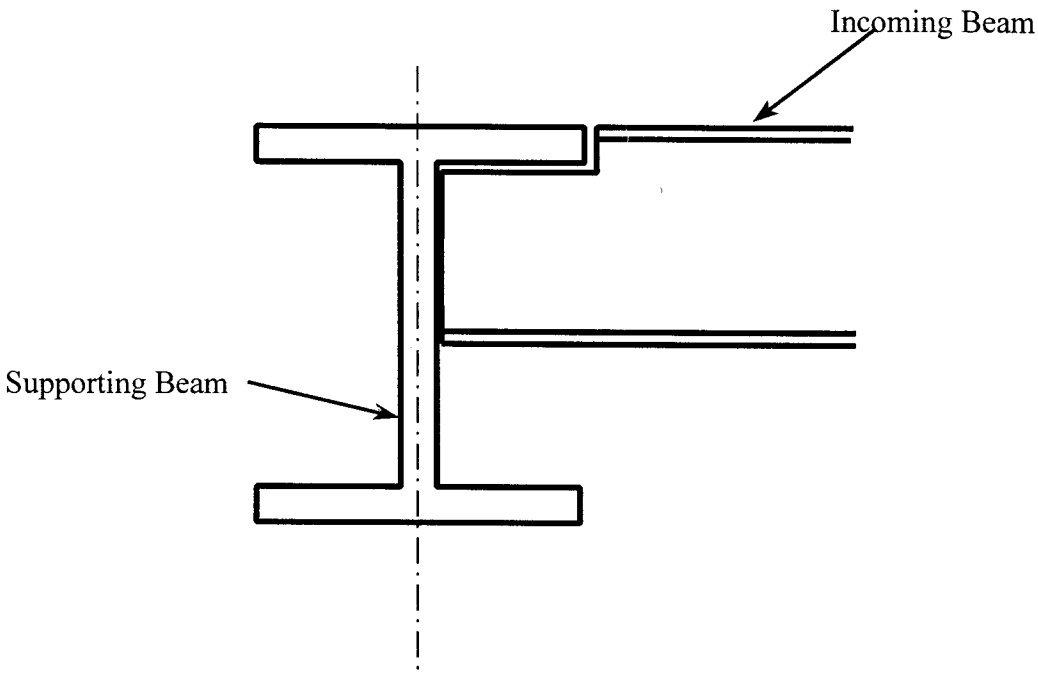


FIGURE 3

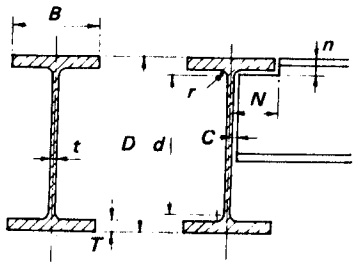


Table 1. Universal beams – dimensions for detailing

Serial size (mm)	Mass per metre (kg)	Depth of section D (mm)	Root radius r (mm)	Flange		Web		End clearance C (mm)	Notch	
				Width B (mm)	Thickness T (mm)	Thickness t (mm)	Depth d (mm)		N (mm)	n (mm)
914 x 419	388	920.5	24.1	420.5	36.6	21.5	799.0	13	210	62
	343	911.4	24.1	418.5	32.0	19.4	799.0	12	210	58
914 x 305	289	926.6	19.1	307.8	32.0	19.6	824.4	12	156	52
	253	918.5	19.1	305.5	27.9	17.3	824.4	11	156	48
	224	910.3	19.1	304.1	23.9	15.9	824.4	10	156	44
	201	903.0	19.1	303.4	20.2	15.2	824.4	10	156	40
838 x 292	226	850.9	17.8	293.8	26.8	16.1	761.7	10	150	46
	194	840.7	17.8	292.4	21.7	14.7	761.7	9	150	40
	176	834.9	17.8	291.6	18.8	14.0	761.7	9	150	38
762 x 267	197	769.6	16.5	268.0	25.4	15.6	685.8	10	138	42
	173	762.0	16.5	266.7	21.6	14.3	685.8	9	138	40
	147	753.9	16.5	265.3	17.5	12.9	685.8	8	138	36
686 x 254	170	692.9	15.2	255.8	23.7	14.5	615.0	9	132	40
	152	687.6	15.2	254.5	21.0	13.2	615.0	9	132	38
	140	683.5	15.2	253.7	19.0	12.4	615.0	8	132	36
	125	677.9	15.2	253.0	16.2	11.7	615.0	8	132	32
610 x 305	238	633.0	16.5	311.5	31.4	18.6	537.2	11	158	48
	179	617.5	16.5	307.0	23.6	14.1	537.2	9	158	42
	149	609.6	16.5	304.8	19.7	11.9	537.2	8	158	38
610 x 229	140	617.0	12.7	230.1	22.1	13.1	547.2	9	120	36
	125	611.9	12.7	229.0	19.6	11.9	547.2	8	120	34
	113	607.3	12.7	228.2	17.3	11.2	547.2	8	120	32
	101	602.2	12.7	227.6	14.8	10.6	547.2	7	120	28
533 x 210	122	544.6	12.7	211.9	21.3	12.8	476.5	8	110	36
	109	539.5	12.7	210.7	18.8	11.6	476.5	8	110	32
	101	536.7	12.7	210.1	17.4	10.9	476.5	7	110	32
	92	533.1	12.7	209.3	15.6	10.2	476.5	7	110	30
	82	528.3	12.7	208.7	13.2	9.6	476.5	7	110	26
457 x 191	98	467.4	10.2	192.8	19.6	11.4	407.9	8	102	30
	89	463.6	10.2	192.0	17.7	10.6	407.9	7	102	28
	82	460.2	10.2	191.3	16.0	9.9	407.9	7	102	28
	74	457.2	10.2	190.5	14.5	9.1	407.9	7	102	26
	67	453.6	10.2	189.9	12.7	8.5	407.9	6	102	24

The dimension N is based upon the outstand from web face to flange edge + 10 mm to nearest 2 mm above, and makes due allowance for rolling tolerance.
The dimension $n = [(D - d)/2]$ to the nearest 2 mm above.
The dimension $C = (t/2) + 2$ mm to the nearest mm.

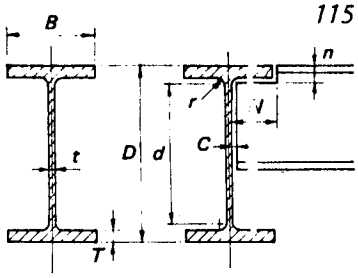


Table 1 (continued). Universal beams – dimensions for detailing

Serial size (mm)	Mass per metre (kg)	Depth of section D (mm)	Root radius r (mm)	Flange		Web		End clearance C (mm)	Notch	
				Width B (mm)	Thickness T (mm)	Thickness t (mm)	Depth d (mm)		N (mm)	n (mm)
457 x 152	82	465.1	10.2	153.5	18.9	10.7	406.9	7	82	30
	74	461.3	10.2	152.7	17.0	9.9	406.9	7	82	28
	67	457.2	10.2	151.9	15.0	9.1	406.9	7	82	26
	60	454.7	10.2	152.9	13.3	8.0	407.7	6	82	24
	52	449.8	10.2	152.4	10.9	7.6	407.7	6	82	22
406 x 178	74	412.8	10.2	179.7	16.0	9.7	360.5	7	96	28
	67	409.4	10.2	178.8	14.3	8.8	360.5	6	96	26
	60	406.4	10.2	177.8	12.8	7.8	360.5	6	96	24
	54	402.6	10.2	177.6	10.9	7.6	360.5	6	96	22
406 x 140	46	402.3	10.2	142.4	11.2	6.9	359.6	5	78	22
	39	397.3	10.2	141.8	8.6	6.3	359.6	5	78	20
356 x 171	67	364.0	10.2	173.2	15.7	9.1	312.2	7	94	26
	57	358.6	10.2	172.1	13.0	8.0	312.2	6	94	24
	51	355.6	10.2	171.5	11.5	7.3	312.2	6	94	22
	45	352.0	10.2	171.0	9.7	6.9	312.2	5	94	20
356 x 127	39	352.8	10.2	126.0	10.7	6.5	311.1	5	70	22
	33	348.5	10.2	125.4	8.5	5.9	311.1	5	70	20
305 x 165	54	310.9	8.9	166.8	13.7	7.7	265.6	6	90	24
	46	307.1	8.9	165.7	11.8	6.7	265.6	5	90	22
	40	303.8	8.9	165.1	10.2	6.1	265.6	5	90	20
305 x 127	48	310.4	8.9	125.2	14.0	8.9	264.6	6	70	24
	42	306.6	8.9	124.3	12.1	8.0	264.6	6	70	22
	37	303.8	8.9	123.5	10.7	7.2	264.6	6	70	20
305 x 102	33	312.7	7.6	102.4	10.8	6.6	275.8	5	58	20
	28	308.9	7.6	101.9	8.9	6.1	275.8	5	58	18
	25	304.8	7.6	101.6	6.8	5.8	275.8	5	58	16
254 x 146	(43)	259.6	7.6	147.3	12.7	7.3	218.9	6	80	22
	37	256.0	7.6	146.4	10.9	6.4	218.9	5	80	20
	31	251.5	7.6	146.1	8.6	6.1	218.9	5	80	18
254 x 102	28	260.4	7.6	102.1	10.0	6.4	225.0	5	58	18
	25	257.0	7.6	101.9	8.4	6.1	225.0	5	58	16
	22	254.0	7.6	101.6	6.8	5.8	225.0	5	58	16
203 x 133	30	206.8	7.6	133.8	9.6	6.3	172.3	5	74	18
	25	203.2	7.6	133.4	7.8	5.8	172.3	5	74	16

The dimension N is based upon the outstand from web face to flange edge + 10 mm to nearest 2 mm above, and makes due allowance for rolling tolerance. The dimension $n = [(D - d)/2]$ to the nearest 2 mm above.

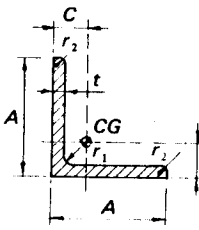


Table 5. Equal angles – dimensions for detailing

Designation		Leg length A (mm)	Thickness t (mm)	Mass per metre (kg)	Radius		Area of section (cm^2)	Distance of centre of gravity C (cm)
Size (mm)	Thickness (mm)				Root r_1 (mm)	Toe r_2 (mm)		
200 x 200	24	200	24	71.1	18	4.8	90.6	5.84
	20		20	59.9			76.3	5.68
	18		18	54.2			69.1	5.60
	16		16	48.5			61.8	5.52
150 x 150	18	150	18	40.1	16	4.8	51.0	4.37
	15		15	33.8			43.0	4.25
	12		12	27.3			34.8	4.12
	10		10	23.0			29.3	4.03
120 x 120	15	120	15	26.6	13	4.8	33.9	3.51
	12		12	21.6			27.5	3.40
	10		10	18.2			23.2	3.31
	8		8	14.7			18.7	3.23
100 x 100	15	100	15	21.9	12	4.8	27.9	3.02
	12		12	17.8			22.7	2.90
	8		8	12.2			15.5	2.74
90 x 90	12	90	12	15.9	11	4.8	20.3	2.66
	10		10	13.4			17.1	2.58
	8		8	10.9			13.9	2.50
	6		6	8.30			10.6	2.41
80 x 80	10	80	10	11.9	10	4.8	15.1	2.34
	8		8	9.63			12.3	2.26
	6		6	7.34			9.35	2.17

Some of the thicknesses given in this table are obtained by raising the rolls. (Practice in this respect is not uniform throughout the industry). In such cases the legs will be slightly longer and the backs of the toes will be slightly rounded.

100 X 100 X 10 mm angle is also frequently rolled; as an ISO size its properties are given in Appendix A (Table A1) to BS 4848: Part 4. Other non-standard sections, particularly other thicknesses of the standard range, may also be available. Enquiries should be made to BSC Sections Product Unit

Name of company

METRIC
BAR SCHEDULE ref. ☐☐☐ ☐☐ ☐ Rev.

Date

Site

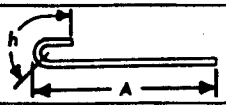
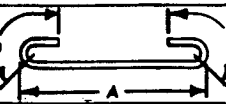
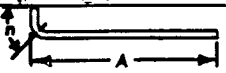
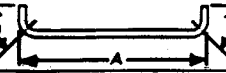
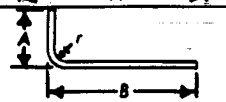
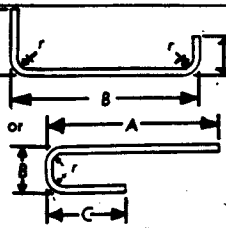
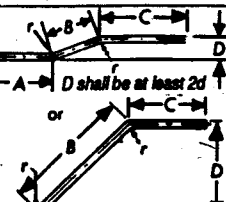
Member	Bar mark	Type & size	No. of mbrs	No. in each	Total no.	Length of each bar* mm	Shape code	A** mm	B** mm	C** mm	D** mm	E/r** mm

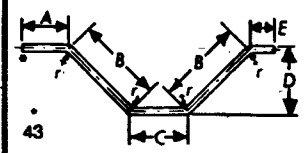
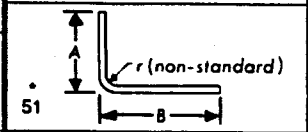
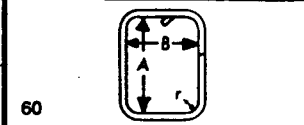
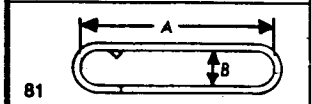
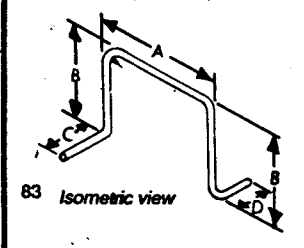
*Specified to the nearest 25 mm. **Specified to the nearest 5 mm.

Figure 6.8 Computer bar schedule

Shonga STEEL DIVISION

STEEL BENDING DIMENSIONS

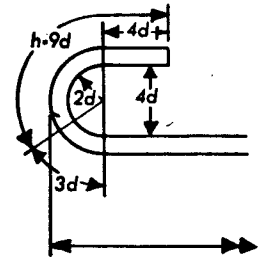
Shape code	method of measurement of bending dimensions	total length of bar (L) measured along centre line	dimensions to be given in schedule
20		A	straight
32		A+h	A
33		A+2h	A
34		A+n	A
35		A+2n	A
37		If r is non standard use shape code 51 A=B-½r-d	A
38		A+B+C-r-2d	A / B / A / B
41		A+B+C	A / B / D / B / D

Shape code	method of measurement of bending dimensions	total length of bar (L) measured along centre line	dimensions to be given in schedule
43		If angle with horizontal is 45° or less A+2B+C+E	A / B / D / B / C
51		If r is standard use shape code 37 A+B-½r-d	A / r
60		2(A+B)+20d	A / B
62		If angle with horizontal is 45° or less A+C	A / B
81		2A+3B+22d	A (I.D.) / B
83	 Isometric view	A+2B+C+D -2r-4d	A (O.D.) / B (O.D.) / C / B (O.D.) Isometric view

Minimum Hook and Bend Allowances for:

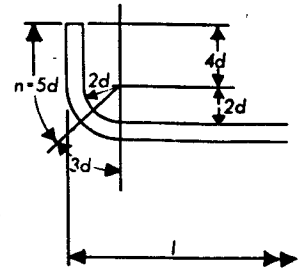
MILD STEEL BARS TO BS 4449*

Semi-circular hooks for use with shape codes 32, 33 and 72 only.



h=hook allowance=9d (min.) taken to the nearest 10 mm over, or not less than 100 mm, to be added to dimension l.
Hook length (min.) =h+3d

Bends forming end anchorages for use with shape codes 34, 35 and 42 only.



n=bend allowance=5d (min.) taken to the nearest 10 mm over, or not less than 100 mm, to be added to dimension l.

In the above sketches, the dimensions are nominal minima. The actual dimensions may vary with the effect of the cutting tolerances.

Bar size	d	6	8	10	12	16	20	25	32	40
Hook allowance (mm)	h	100	100	100	110	150	180	230	290	360
Bend allowance (mm)	n	100	100	100	100	100	100	130	160	200

**BS 4449 'Hot rolled steel bars for the reinforcement of concrete'*

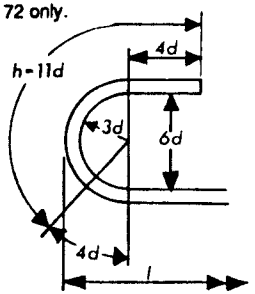
standard radius of bend unless otherwise stated

** For these shapes in particular, the effect of a*

OTHER SHAPES

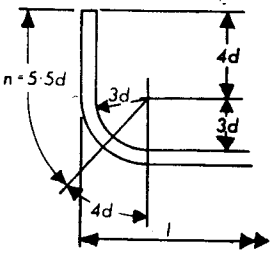
HOT ROLLED AND HIGH YIELD BARS TO BS 4449* AND COLD WORKED HIGH YIELD BARS TO BS 4461+

Semi-circular hooks for use with shape codes 32, 33 and 72 only.



h=hook allwance=11d (min.) taken to the nearest 10 mm over, or not less than 100 mm, to be auded to dimension l.
Hook length (min.) =h + 4d

Bends forming end anchorages for use with shape codes 34, 35 and 42 only.



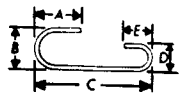
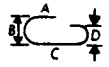
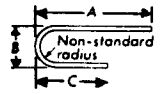
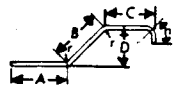
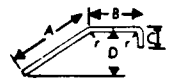
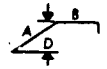
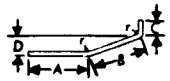
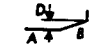
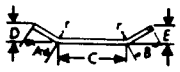
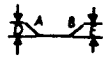
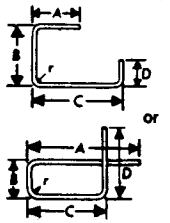
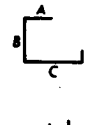
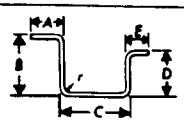
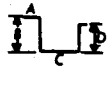
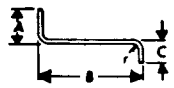
n=bend allowance=5.5d (min.) taken to the nearest 10 mm over, or not less than 100 mm, to be added to dimension l.

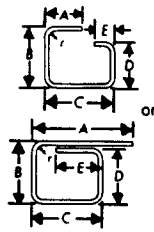
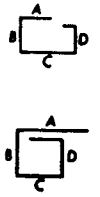
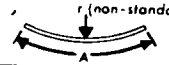
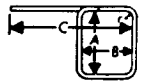
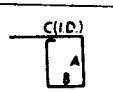
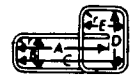
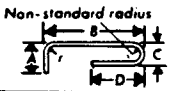
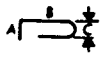
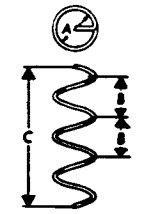
In the above sketches, the dimensions are nominal minima. The actual dimensions may vary with the effect of the cutting tolerances.

6	8	10	12	16	20	25	32	40	d	Bar size
100	100	110	140	180	220	280	360	440	h	Hook allowance (mm)
100	100	100	100	100	110	140	180	220	n	Bend allowance (mm)

**BS 44461 'Cold worked steel bars for the reinforcement of concrete'*

From BS 4466: 1969 Bending dimensions and scheduling of bars for the reinforcing of concrete, reproduced by permission of the British Standards Institution, 2 Park Street, London W1A 2BS, from whom complete copies may be obtained.

Shape code	method of measurement of bending dimensions	total length of bar (L) measured along centre line	dimensions to be given in schedule
36		(A+C+E) +0.57(B+D) -3.14d *where d=size of bar*	
39		A+0.57B+C-1.57d	
• 42		*If angle with horizontal is 45° or less* A+B+C+n	
• 45		A+B+C-½r-d	
• 48		A+B+C	
• 49		*If angle with horizontal is 45° or less* A+B+C	
• 52		A+B+C+D -½r-3d	
• 53		A+B+C+D+E -2r-4d	
• 54		A+B+C-r-2d	

Shape code	method of measurement of bending dimensions	total length of bar (L) measured along centre line	dimensions to be given in schedule
• 55		A+B+C+D+E -2r-4d	
65		A *see table 3-BS 4466: 1969*	
72		2A+B+25d *(25d permits the use of both mild and high yield steel bars)*	
• 73		2A+B+C+10d	
• 74		2A+3B+20d	
• 75		A+B+C+2D +E+10d	
85		A+B+0.57C+D -½r-2.57d	
86		*where B is not greater than A/5* C/B π(A + d) + 8d *where d= size of bar*	Helix A = internal Dia. (mm). B = Pitch of helix (mm). C = Overall height of helix (mm).
99	All other shapes *see note over page*		A dimension sketch of the shape shall be given on the schedule

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

CE 365 – SOIL SCIENCE, ROADS AND HYDROLOGY

INSTRUCTIONS

1. There are separate instructions for the two sections.
2. All questions carry equal marks (20 %). Marks for sub-questions are indicated at the end of each sub-question
3. Answer each section in a separate answer booklet clearly marked as Section A or B
4. Make sure the computer number is clearly indicated on all the booklets together with the questions attempted

TIME: THREE (3) HOURS **CLOSED BOOK EXAM**

SECTION A: ATTEMPT ANY THREE QUESTIONS.

Question 1

The weight of a specimen is 340 g and the dried weight is 230g. The volume of the soil before drying is 210 cc. If the specific gravity of the soil particles is 2.75, determine the following:

a) void ratio (5Marks)

b) Porosity (5Marks)

c) degree of saturation (5Marks)

d) dry density (5Marks)

Question 2

a) Distinguish between the following types of bitumen:

i) Straight run bitumen (5Marks)

ii) Cut Back bitumen (5Marks)

iii) Emulsion (5Marks)

b) In the production of asphalt concrete, course aggregates, fine aggregates and mineral filler having respective specific gravities of 2.58, 2.72, and 2.70 are mixed in the proportion 55.3%, 36.8% and 7.9% percent respectively. What is the average specific gravity of the mix? (5Marks)

Question 3

Define the following terms and cite examples of how there are used.

a) Average annual daily traffic (AADT) (5Marks)

b) Average daily traffic (ADT) (5Marks)

c) Peak Hour Volume (PHV) (5Marks)

Question 4

A two lane two-way road is carrying a traffic of 100 commercial vehicles per day. It is to be strengthened for a the growing traffic needs. The vehicle damage factor has been found to be 3.0. The rate of growth of traffic is 10% per annum. The period of construction is 5 years. The pavement is to be designed for 15 years after completion. Determine the following:

a) Traffic after completion of strengthening (5 Marks)

b) Number of commercial vehicles per day in design lane (5 Marks)

c) Determine the cumulative standard axles to be used in design (10 Marks)

Question 5

a) In a road alignment, a –2% grade is being joined to a –4% grade by means of a parabolic vertical curve of length 1000 m. Determine the vertical offset at the point of intersection of the tangents. (15 Marks)

b) Explain briefly the importance of incorporating a transition curve between the straight portion of the carriage-way and the circular portion. (5 Marks)

SECTION B: ATTEMPT ANY TWO QUESTIONS

Question 6

a) With the help of a simple sketch of a hydrological cycle, give a brief discussion of the components of the cycle. (9 marks)

b) The Bernoulli equation is given by $V^2/2g + (P/\gamma) + Z = C$. Assuming that flow is steady, fluid is incompressible and non viscous, define each term in the equation stating what it represents. (6 marks)

c) A vertical jet of water 7.5cm in diameter leaving the nozzle with a 9.2m/s velocity strikes a horizontal and movable disc weighing 17.2kg. The jet is then deflected horizontally. Determine the vertical distance Y above the nozzle tip at which the disc will be held in equilibrium. (5 marks)

Question 7

a) Define an aquifer and state when it is considered perched. (4 marks)

b) State three factors that affect infiltration capacity. (3 marks)

c) A well of diameter 0.3m in a confined aquifer was pumped at a steady rate of 0.311m^3/s. When the well level remained constant at 85.48m, the observation well level at a distance of 10.4m was 86.52m.

i) Define transmissivity. (2 marks)

ii) Calculate the transmissivity. (6 marks)

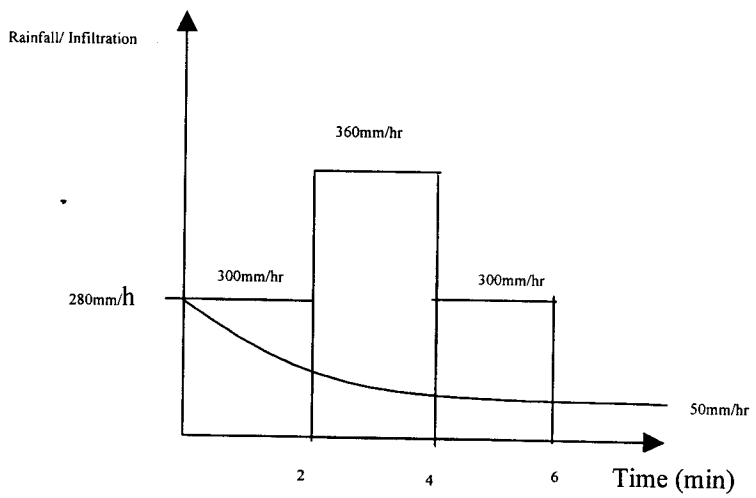
d) A tracer solution of 20mg/l concentration is injected into the stream at a rate of 0.05 l/s. An equilibrium concentration of 0.07mg/l is established for a finite time at a sampling station downstream. What is the discharge of the stream? (5 marks)

Question 8

a) With the help of a simple sketch state and define the components of a hydrograph. (9 marks)

b) State what causes looping effect in rating curves and explain why it is important to have techniques for extension of rating curves at a river gauging station. (4 marks)

c) One procedure for estimating surface runoff resulting from a given storm is to subtract the Infiltration from the total rainfall. For the storm and infiltration curve shown in the figure below, estimate the resulting runoff from a catchment area of 1.0 sq/km.



Assume that the infiltration curve is given by

$f_p = f_c + (f_o - f_c)\, e^{-1.6t}$, where t is in minutes. (7 marks)

END OF EXAMINATION

CE 425

THE UNIVERSITY OF ZAMBIA
UNIVERSITY ~~SECOND~~ FIRST SEMESTER EXAMINATIONS

JUNE, 2004

SOIL MECHANICS AND FOUNDATION ENGINEERING

Time allowed: 3 hours
CLOSED BOOK

Caution: Read all questions carefully before deciding which ones to attempt.

Instructions: Attempt any **THREE** questions from **SECTION A** and both questions from **SECTION B.** All questions carry equal marks (20 %). Marks for sub-questions are indicated at the end of each sub-question.

It is desirable to show the method of calculation and the steps taken to achieve the results. All symbols used in equations and formulae should be clearly defined. Where possible illustrate with sketches in your discussions. Make sure the computer number is clearly indicated on all the booklets together with the numbers of questions attempted.

SECTION A

QUESTION ONE- SLOPE STABILITY

The embankment in the figure (attached) is made up from a soil with angle of internal friction 20 degrees and cohesion 20 kN/sq.m. The soil on which the embankment sits has cohesion of 75 kN/sq.m and angle of shearing resistance is less than the one for the embankment by 13 degrees. Both soils have unit weight of 19.3 kN/sq.m.

Determine the factors of safety by method of slices for the two slip circles shown, with and without tension cracks in both cases. Use four (4) slices for the top slip circle and five (5) slices for the bottom slip circle.

(20 marks)

QUESTION TWO- LATERAL EARTH PRESSURE

a) Explain what is meant by the term state of plastic equilibrium of a soil mass and hence with the aid of a Mohr circle diagram distinguish between active and passive Rankine states in a cohesionless soil mass with a horizontal surface. **(8 marks)**

b) A cantilever retaining wall with a an inclined ground on top is founded on two layer of soil with the given values.

Determine the total forces/unit width of wall and the location of the resultant for the system shown in the figure (attached).

(12 marks)

QUESTION THREE- PERMEABILITY AND SEEPAGE OF SOILS

a) An undisturbed soil sample was tested in a falling head permeameter. Results were:

Initial head of water in stand-pipe	= 1500 mm
Final head of water in stand-pipe	= 605 mm
Duration of test	= 281 sec
Sample length	= 150 mm
Sample diameter	= 100 mm
Stand-pipe thickness	= 5 mm

Determine the permeability of the soil in mm/sec.

(12 marks)

b) Make a neat sketch of a flow net of seepage under the sheet piling with 14 potential drops and 6 flow channels if the water level is 1.25 m above the ground level upstream. The sheet piling is 1.88 m embedded in the sandy material downstream and 1.88 m to the impervious layer; while the ground level upstream is 4.38 m to the tip of the sheet piling

(8 marks)

QUESTION FOUR- SHEAR STRENGTH OF SOIL

a) A series of undisturbed samples from a normally consolidated clay was subjected to consolidated undrained tests. Results were:

CELL PRESSURE (kN/sq.m)	DEVIATOR STRESS AT FAILURE (kN/sq.m)	PORE WATER PRESSURE AT FAILURE (kN/sq.m)
200	118	110
400	240	220
600	352	320

Plot the strength envelope of the soil with respect to both total and effective stresses

(10 marks)

b) A consolidated drained triaxial test was conducted on a normally consolidated clay. The results were both minor principal and deviator stresses were equal to 276 kN/sq.m.

Determine

i) angle of shearing resistance;

ii) angle that the failure plane makes with the major principal plane;
iii) normal and shear stresses on the failure plane.

(10 marks)

QUESTION FIVE- CLASSIFICATION OF SOILS

In a bulk density determination, a sample of clay with a mass of 683 g was coated with paraffin wax. The combined mass of the clay and wax was 690.6 g. the volume of the clay and the wax was found by immersion in water to be 350 ml. The sample was then broken open and moisture content and particle specific gravity tests gave respectively 17% and 2.73. the specific gravity of the wax was 0.89.

Determine the bulk density, unit weight, void ratio and degree of saturation of the soil.

(20 marks)

SECTION B

QUESTION SIX

a) Outline the concept of lateral earth pressure. Show how you understand earth pressure at rest and the Rankine's theory of active and passive earth pressures.

(10 marks)

b) Explain the meaning of slope stability by targeting your concentration to factors of safety in slopes with different characteristics with infancies on forces that act on a soil mass.

(10 marks)

QUESTION SEVEN

a) Indicate the meaning of Soil Mechanics by outlining the problems an engineer would encounter when dealing with the soil material. Indicate also how the soil material is different form other construction materials.

(10 marks)

b) Discuss effective stress and show how it is more important than total stress in the field of Soil Mechanics.

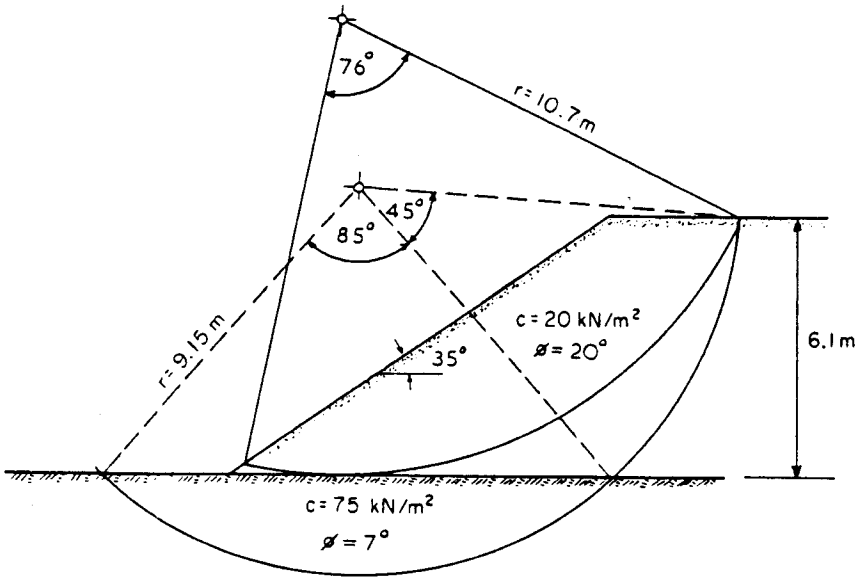
(10 marks)

END OF EXAMINATION
GOOD LUCK!!

SECTION A (FIGURE ATTACHMENTS)

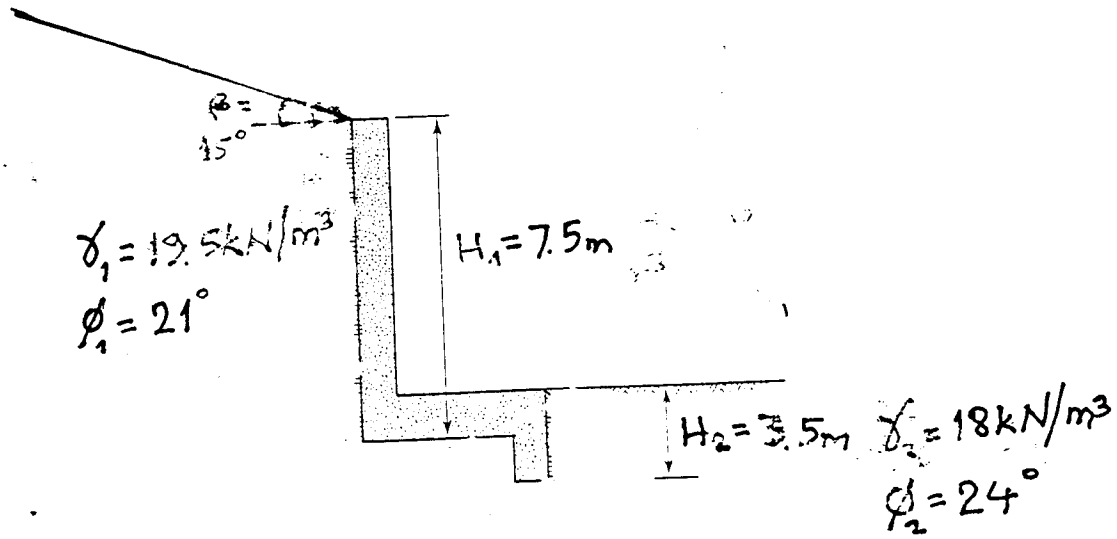
QUESTION ONE- SLOPE STABILITY

The embankment in .....



QUESTION TWO- LATERAL EARTH PRESSURE

A cantilever retaining wall with .....



THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS
DEFERRED EXAMINATIONS

19TH JULY, 2004

SOIL MECHANICS AND FOUNDATION ENGINEERING

Time allowed: 3 hours
CLOSED BOOK

Caution: Read all questions carefully before deciding which ones to attempt.

Instructions: Attempt any **THREE** questions from **SECTION A** and both questions from **SECTION B.** All questions carry equal marks **(20 %).** Marks for sub-questions are indicated at the end of each sub-question.

It is desirable to show the method of calculation and the steps taken to achieve the results. All symbols used in equations and formulae should be clearly defined. Where possible illustrate with sketches in your discussions. Make sure the computer number is clearly indicated on all the booklets together with the numbers of questions attempted.

SECTION A

QUESTION ONE- COMPACTION

In standard compaction test on a soil (Gs=2.70), the following results were obtained:

Water Content (%)	Bulk density (Mg/cu.m)
5	1.89
8	2.13
10	2.20
12	2.21
15	2.16
20	2.08

Plot the dry density against water content relationship. Show the saturation line for the soil and determine; void ratio, porosity and degree of saturation for the soil at its optimum water content.

(20 marks)

QUESTION TWO- LATERAL EARTH PRESSURE

a) Explain what is meant by the term state of plastic equilibrium of a soil mass and hence with the aid of a Mohr circle diagram distinguish between active and passive Rankine states in a cohesionless soil mass with a horizontal surface.

(8 marks)

b) A cantilever retaining wall with an inclined ground on top is founded on two layer of soil with the given values.

Determine the total forces/unit width of wall and the location of the resultant for the system shown in the figure (attached).

(12 marks)

QUESTION THREE- SLOPE STABILITY

The slope of a cutting is 1vertical to 1.5 horizontal and the vertical height is 10m. The soil mass comprises two saturated clay layers as follows:-
Top soil - unit weight is 19kN/cu.m while cohesion is 50kN/sq.m,
Bottom soil – unit weight is 18kN/cu.m and cohesion is 30kN/q.m.
Point 'O' which is the centre of the slip circle has 5.5m horizontal distance and 16m vertical distance to the toe of the slope. The slip circle starts 1.5m away from the toe. Determine the factor of safety against shear failure along the trial slip circle using the total stress ($\phi u=0$) method.

(20 marks)

QUESTION FOUR- SHEAR STRENGTH

a) A drained triaxial compression test carried out on three specimens of the same soil yielded the following results:

Test No.	1	2	3
Cell pressure (kN/sq.m)	100	200	300
Ultimate deviator stress (kN/sq.m)	210	438	644

Draw the shear strength envelope and determine the shear strength parameters, assuming that the pore pressure remains constant during the triaxial loading stage.

(10 marks)

b) A consolidated drained triaxial test was conducted on a normally consolidated clay. The results were both minor principal and deviator stresses were equal to 276 kN/sq.m. Determine

i) angle of shearing resistance;
ii) angle that the failure plane makes with the major principal plane;
iii) normal and shear stresses on the failure plane.

(10 marks)

QUESTION FIVE- CLASSIFICATION OF SOILS

In a bulk density determination, a sample of clay with a mass of 683 g was coated with paraffin wax. The combined mass of the clay and wax was 690.6 g. the volume of the clay and the wax was found by immersion in water to be 350 ml. The sample was then broken open and moisture content and particle specific gravity tests gave respectively 17% and 2.73. the specific gravity of the wax was 0.89.

Determine the bulk density, unit weight, void ratio and degree of saturation of the soil.

(20 marks)

SECTION B

QUESTION SIX

(a) Discuss compaction. In your understanding show how it differs from consolidation and why both are important to Geotechnical Engineers.

(10 marks)

(b) Indicate the meaning of Soil Mechanics by outlining the problems an engineer would encounter when dealing with the soil material. Indicate also how the soil material is different form other construction materials.

(10 marks)

QUESTION SEVEN

a) Discuss effective stress and show how it is more important than total stress in the field of Soil Mechanics.

(10 marks)

b) Explain the meaning of slope stability by targeting your concentration to factors of safety in slopes with different characteristics with infancies on forces that act on a soil mass.

(10 marks)

END OF EXAMINATION
GOOD LUCK!!

CE 431

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS

30 JUNE, 2004

STRUCTURAL MASONRY AND TIMBER STRUCTURES

Time allowed: 3 hours
CLOSED BOOK

Caution: Read all questions carefully before deciding which ones to attempt.

Instructions: Attempt **THREE** questions from **SECTION A** and any **TWO** questions from **SECTION B.** All questions carry equal marks (20 %). Marks for sub-questions are indicated at the end of each sub-question.

It is desirable to show the method of calculation and the steps taken to achieve the results. All symbols used in equations and formulae should be clearly defined. Where possible illustrate with sketches in your discussions. Make sure the computer number is clearly indicated on all the booklets together with the numbers of questions attempted. No names should appear anywhere.

SECTION A
Answer Question 1 and any other 2 (two) questions

QUESTION ONE
Figure Q1 shows a 6m long x 3m high cavity wall panel that is subjected to a 1.5KN/m^2 wind load acting perpendicular to the face of the wall. Design the panel assuming the following:

- The panel is simply supported along the top and bottom edges and continuous along the vertical edges;
- The load safety factor is 1.2 and the material safety factor is 2.8
- μ=0.35

Do not design the brick piers/support columns

(20 marks)

QUESTION TWO

Design the 230mm thick brick wall shown in Figure Q2 with the following loading:

Loading per metre run of wall		
	Dead Load (KN/m)	**Live Load (KN/m)**
Load from above	86.3	27.4
Load from left side slab	21.9	8.4
Load from right side slab	9.2	5.2

The self-weight of the wall may be assumed to be 4.31KN/m^2 while the safety factors should be taken as:

- 1.4 and 1.6 for dead and live loading respectively; and
- 3.5 for the material strength

(20 marks)

QUESTION THREE

Design the 400x200 brick column shown in Figure Q3 that has a clear column height about both axes of 3000mm between the top and bottom lateral supports, which provide enhanced resistance to lateral movement about both axes. Assume that the column carries an ultimate design load of 100KN at an eccentricity of 100mm and 50mm about the major and minor axes respectively. Take the material safety factor as 2.8.

(20 marks)

QUESTION FOUR

Design a 5m long x 3m high x0.23m thick wall panel subjected to a 2.0KN/m^2 load acting perpendicular to the face of the wall. Assume the following:

- The panel has two short (side) edges that are continuous, one long top edge that is unsupported and one long bottom edge that is simply supported;
- The load safety factor is 1.2 and the material safety factor is 3.5

(20 marks)

SECTION B

QUESTION FIVE

Design the timber floor for a dwelling house if it comprises tongued and grooved (T&G) boards carried by 3.6 m span joists at 600 mm centres. The load imposed by the dead weight of the boards is 0.1 kN/m^2, self weight of joists is 0.12 kN/m^2 and plaster ceiling on the underside of 0.18 kN/m^2. The floor is subjected to a domestic imposed load of 1.5 kN/m^2. Use Douglas Fir (British grown) M 50/SS timber.

(20 marks)

QUESTION SIX

A post of height 2.5 m supports a total long term load of 40 kN applied 75 mm eccentric to its x-x axis. Check the adequacy of a 100 x 250 mm section if it is restricted at both ends in position and one end in direction. Use SS grade Scots pine.

(20 marks)

QUESTION SEVEN

Solid timber studs on the figure (attached) of strength class SC 3 with a cross section of 38 x 100 mm spaced at 400 mm centres and effective length of 2300 mm are subjected to the following loading:

(i) axial load of 3.7 kN per stud;
(ii) wind loading of 975 N/m^2.

Assuming that the studs are braced in the weaker direction by sheathing, check the interaction formula to ensure it is less than unity.

(20 marks)

END OF EXAMINATION
GOOD LUCK!!

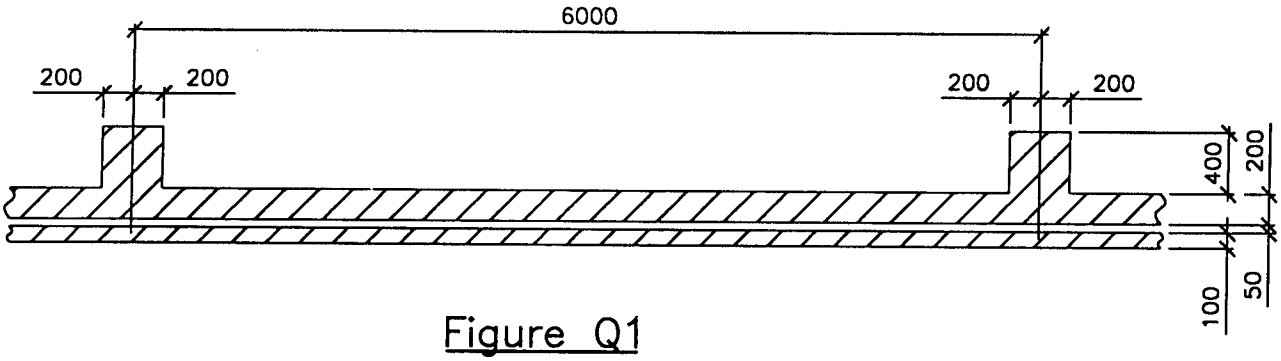


Figure Q1

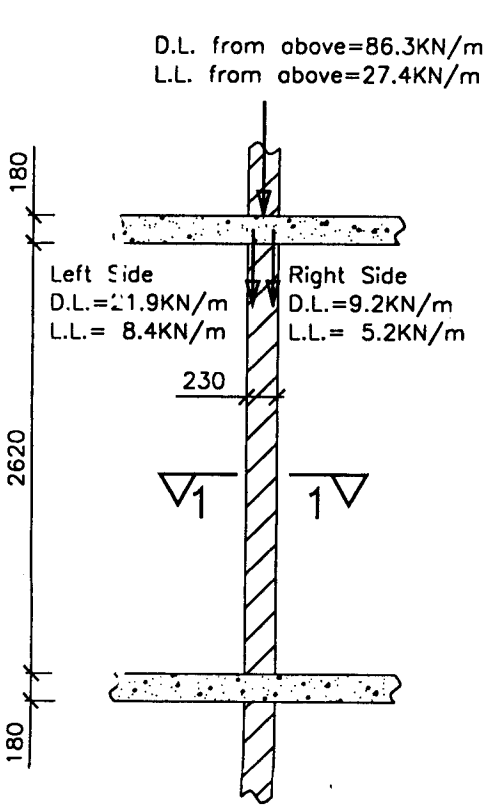
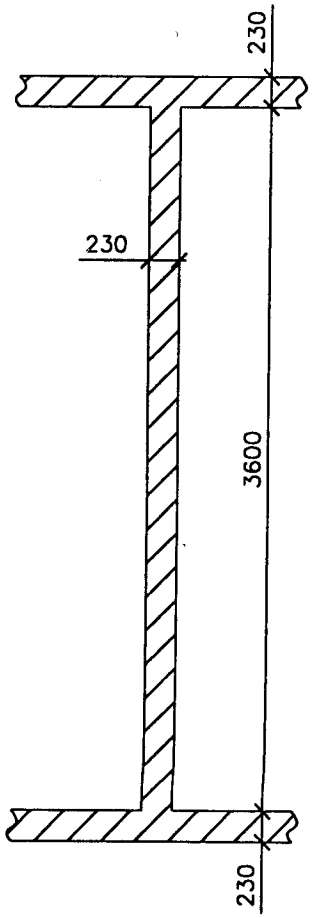


Figure Q2



Section 1–1

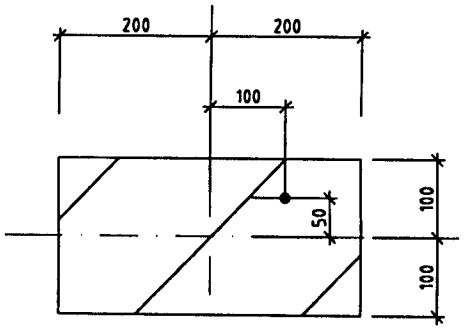
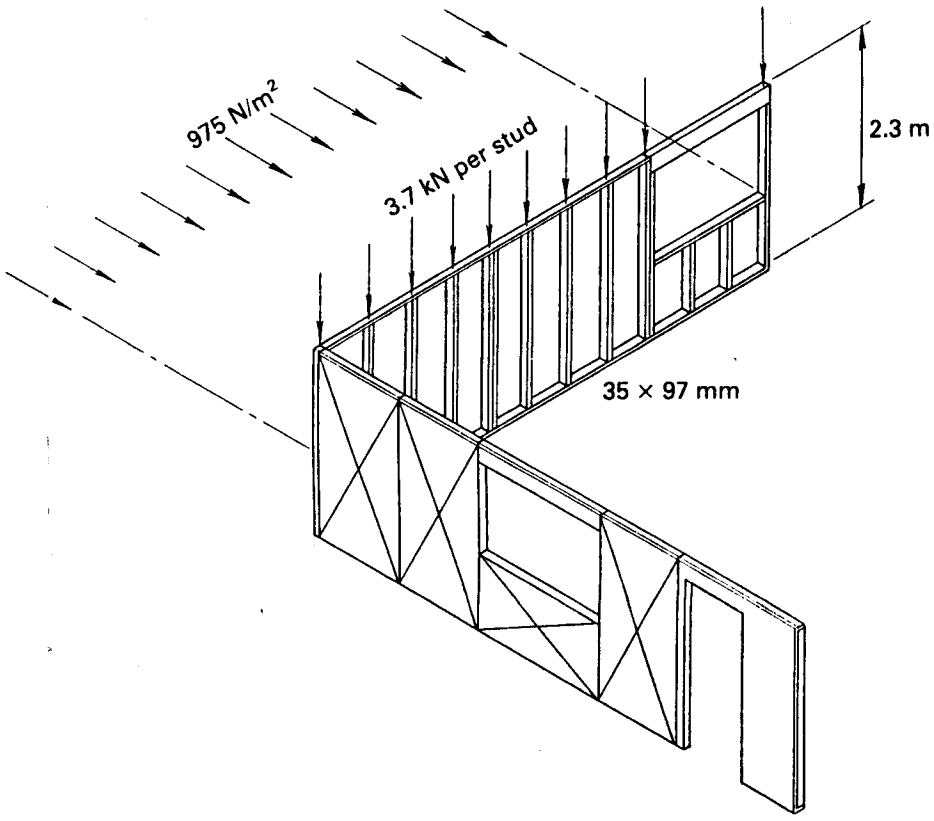


Figure Q3

QUESTION ~~THREE~~ SEVEN

Solid timber studies of.....



The University of Zambia
School of Engineering
2004 Academic Year First Semester
Final Examinations

CE 531 Reinforced and Prestressed Concrete Design

TIME:	**4 HOURS**
INSTRUCTIONS:	**Answer all questions (all questions carry equal marks, 20 marks)**
	Open Notes and Handouts

1 (a) Briefly discuss three major advantages and three main disadvantages of using prestressed concrete.

(b) For the Class 2 prestressed beam shown in Figure 1, check the service stresses at midspan at all stages of loading of the beam. The beam is simply supported and carries a characteristic load of 18 kN/m over a10m span. Concrete grade is C40 and the prestress is two bars of 22mm dia. and post-tensioning is at 7 days. The ducts are located at 125mm from the bottom of the beam and the web thickness is 100mm. Initial jacking is at 70% of the characteristic strength. Assume a loss factor of 0.1 at transfer and a final loss of 0.2 in the prestress. The density of concrete is 25 kN/m^3.

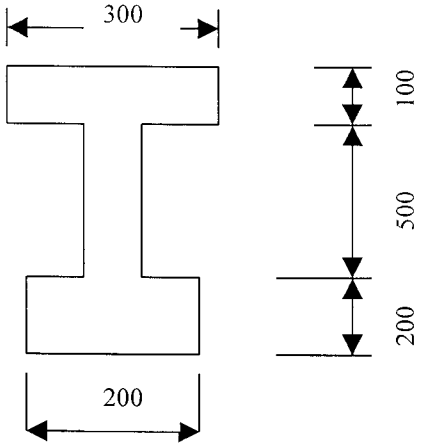


Figure 1

(6+14)

2 Figure 2 shows a plan of an industrial building made of a 200mm thick wall (2.1 kN/m^2 surface) built using modular burnt clay bricks. A rectangular reinforced concrete lintel of dimensions 400x200 spans an 8.0m opening at the gable end of the building. The wall height above the lintel is 4.5m. The pitched roof is supported by three trusses while at the gable end it is supported by purlins. Cover to reinforcement is 30mm and materials are concrete grade C30 of density 24 kN/m^3 and f_y=460 N/mm^2 while shear reinforcement is f_{yv}=250 N/mm^2. The slope of the roof is 25°. Assume no access to the roof other than for maintenance and cleaning (0.75 kN/m^2) for live loading. Unfactored self

weight of the purlins and roof covering may be assumed to be 0.5 kN/m^2 on plan. Neglecting wind loading:

(a) Design the main reinforcement for the lintel
(b) Check the shear and design shear reinforcement if required
(c) Check the deflection of the beam.

Only 16mm dia bars are available for main reinforcement while for stirrups 10mm mild steel bars are available.

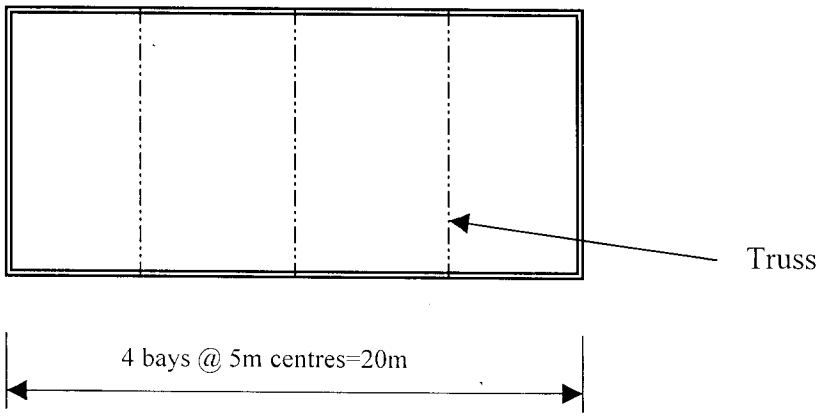


Figure 2

3 Design the longitudinal reinforcement for a 5m reinforced concrete column, of dimensions 400x400mm subjected to biaxial bending. The column is an exterior column at an intermediate level of a 10-storey building. Cover to reinforcement is 40mm. The materials are C30 concrete and f_y=460 for reinforcing steel and only 25mm Dia bars are available. For stirrups, 12mm diameter f_{yv}=250 bars are available. Assume the following factored loads:

N	2500 kN
M_x	400 kN-m
M_y	250 kN-m

(a) Calculate the enhanced moment
(b) Design the reinforcement for the loading given
(c) Design stirrups

(4+12+4)

4 (a)What is the difference between upper-bound and lower-bound solutions for slab analysis? For yield line analysis, briefly explain how the design load is obtained.
(b) Design an internal two-way slab panel for a parking deck. The dimensions of the [illegible]

density is 24 kN/m^3 while cover to reinforcement is 20mm. The Live load is 2.5 kN/m^2. Use 10mm dia. high yield bars for reinforcement and check both deflection and shear requirements.

(2+18)

5 A 4.5m high tied interior column 500x500mm in dimensions carries from above (excluding self weight) unfactored dead load of 1300 kN and a live load of 900 kN. Suitable soil of density 16 kN/m^3 is at a depth of 1.5m from the ground surface and the bearing capacity at this level is 350 kN/m^2. If the footing is made of Grade C30 concrete of density is 24 kN/m^3. ~~Concrete density is 24 kN/m^3~~ Design a rectangular footing if one of the dimensions is limited to 1.5m. Use f_y=460 for reinforcing steel and only 12mm diameter bars are available on the market. Assume a footing depth of 750mm cover to reinforcement is 40mm.

(20)

END

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

CE 565 - WATER MANAGEMENT AND HYDRAULIC STRUCTURES

INSTRUCTIONS

1. Attempt any FIVE questions out of SEVEN.
2. All questions carry equal marks (20 %). Marks for sub-questions are indicated at the end of each sub-question.
3. Make sure the computer number is clearly indicated on all the booklets together with the questions attempted.

TIME: THREE (3) HOURS CLOSED BOOK EXAM

Question 1

a) Why is a spillway necessary on a dam? (2 marks)

b) When does cavitation occur in an overflow spillway? (3 marks)

c) State the reason for including expansion joints in a chute spillway. (3 marks)

d) Mention the most suitable type of spillway you can use in an earth dam. (2 marks)

e) Analysis shows that the resultant reactive force on a cross-section of a gravity dam is 9400kN/m. This force is inclined at an angle of 30° from the vertical and cuts the 65-m base at a point 25m from the toe of the dam. Determine the foundation pressures under these conditions. Express your answer in kN/m^2. (10 marks)

Question 2

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

Calculate values of the following parameters of the model which satisfy the desired conditions:

a) velocity (6 marks)

b) mid-stream depth (7 marks)

c) Manning's n (7 marks)

Question 3

a) What does a trace in reservoir reliability determination represent? (4 marks)

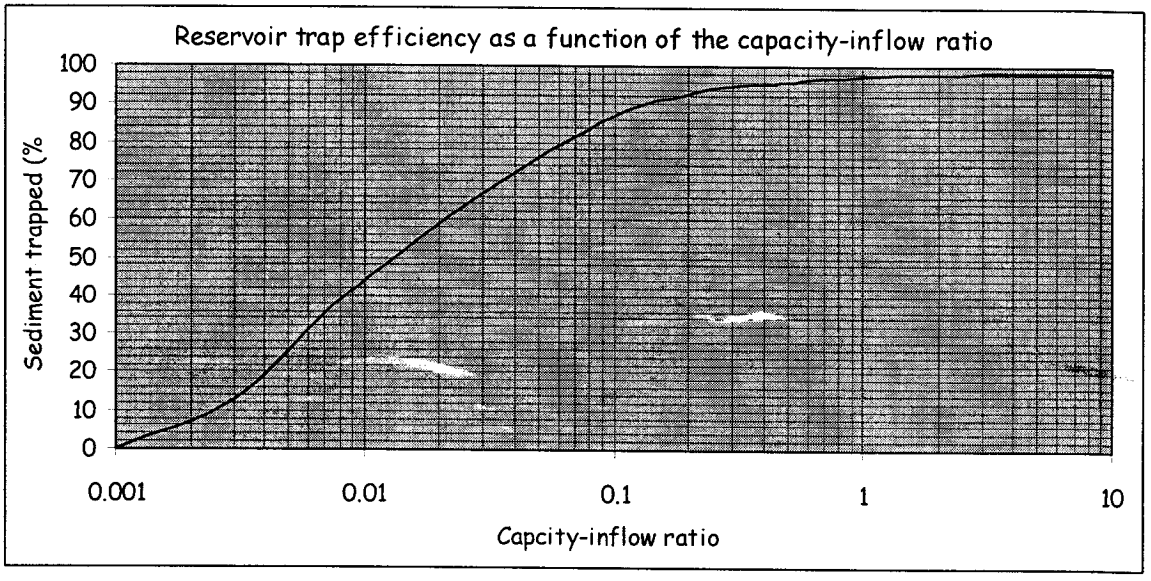
b) What happens to a stream which is denied its normal sediment load? (3 marks)

c) An engineer has identified two areas as possible sites for a reservoir. One site will produce a deep reservoir while the second one a shallow reservoir. If you were the engineer, which one would you select? (1 mark)

d) Explain the reason for your answer in (c) above. (2 marks)

e) A reservoir is contemplated on a stream which has an average annual runoff of 600 million m^3. Measurements indicate that the average sediment inflow is 220,000 metric tons/year. Assuming that a cubic meter of settled sediment will dry out to a weight of 1800 kg/m^3, what is the most probable life of the reservoir to the point where it is 40 per cent full of sediment if its original capacity is 100 x 106 m^3? Use volume intervals of 20% of initial volume. (10 marks)

100 of 10^6 m^3.



Question 4

a) Integrated Water Resources Management takes account of many aspects. Outline three of these aspects. (3 marks)

b) In Water Resources Programmes/Projects, three activities namely Water Resources Planning, Water Resources Development and Water Resources Management are distinguished. Briefly define each of the three activities stated above. 3 marks)

c) In the past, the ever increasing demand projections were being matched with options for water supply oriented approaches e.g. construction of more Dams etc; but demand was found to be ever on the rise. Nowadays demand oriented approach is being advocated world-wide. Briefly distinguish the two approaches and state the advantage(s) of demand oriented approach. (2 marks)

d) Water Resources Planning has nowadays been recognised not to be a matter of optimisation. The uncertainty of scenario makes Water Resources Planning a complex issue. Outline three of these scenarios giving an example in each case. (4 marks)

e) State the principal law relating to Water Resources Management in Zambia and what it does. (2 marks)

f) Outline three main stages followed in conducting an Environmental Impact Assessment and state what is involved in each. (6 marks)

Question 5

a) State two factors that differentiate the Impulse turbine from Reaction Turbine. (2 marks)

b) State how you would design an impulse turbine relating bucket size to jet diameter and also Wheel diameter to jet diameter for optimum efficiency. (2 marks)

c) Some water pumps can be classified as Centrifugal while others as Propeller pumps. State what differentiates the two types of pumps in terms of fluid flow (2 marks)

d) Centrifugal water pump impellers are basically of two types. State which of the two types of impellers you would recommend for each of the following given situation:

i) when at the point of abstraction, water has significant amounts of mud and some weeds (2 marks)

ii) when at the point of abstraction, the water has high amounts of sediment with floating stones and other foreign materials. (2 marks)

e) There are three basic shapes of impeller blades for a centrifugal water pump. Each of these impeller blade shapes gives certain orientation of a Head-Discharge (H-Q) curve. State which of these gives the flattest H-Q curve. Explain why a flatter curve is desired. (5 marks)

f) You have been assigned a task of upgrading a water supply scheme consisting of three pump houses (each consisting of one pump) and each serving a separate suburb. Preliminary investigations show that there is no problem with the water source but probably pump capacities in use.

Facts on the ground indicate that the first Suburb experiences constant shortage in water supply due to increase in the demand. The second Suburb experiences extreme low pressure in the reticulation system due to its topographical location. And the third Suburb constantly experiences bursting of pumps and part of the discharge pipeline whenever there is an electrical power failure.

Given that all the three pumps in the three pump houses are of the same type and operate independently without any link in reticulation system to each other and that there are similar new pumps available in stock:

i) Advise what you could do to solve the problems experienced by each of the first two suburbs above without resorting to purchasing other pumps of different capacities. (3 marks)

ii) State what could be causing the problem for the third suburb and explain the phenomena. (2 marks)

Question 6

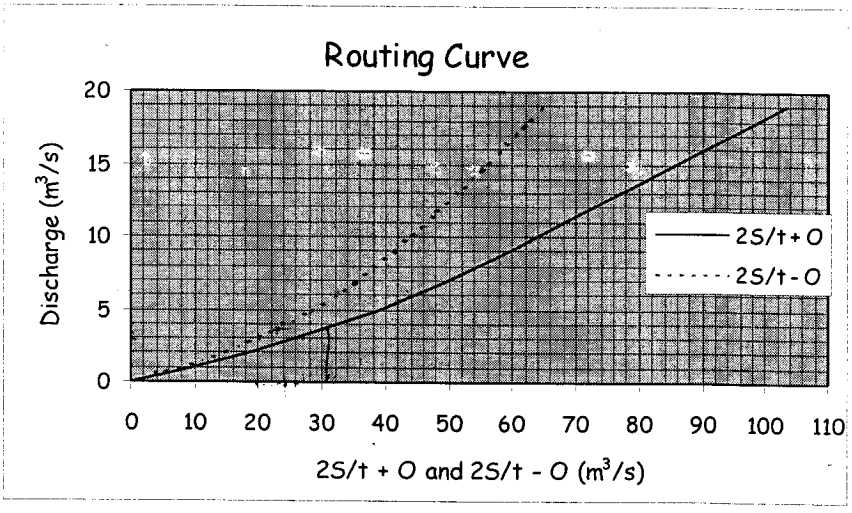
a) Define reservoir routing. (3 marks)

b) Define an overflow spillway. (3 marks)

c) What might cause serious structural damage to overflow spillways on large dams? (4 marks)

d) If the inflow data given in the Table below apply to a reservoir, compute the discharge to be expected on day 2 at midnight using the curves given below. Noon and midnight are denoted as N and M, respectively. (10 marks)

Day	Hour	Discharge (m^3/s)
1	M	3.0
2	N	4.0
	M	6.0
3	N	9.8
	M	16.3
4	N	20.3
	M	21.0
5	N	17.4
	M	12.5
6	N	9.3



Question 7

a) State the formula that defines Sodium Adsorption Ratio (SAR). (1 mark)

b) Explain why SAR is a parameter of great concern to a farmer when it comes to irrigation. (2 marks)

c) In design and management of irrigation systems, name two main issues of great concern. (2 marks)

d) Infiltration rate is one of the main factors when deciding which Irrigation method to use. State which irrigation method you would recommend for each of the following given situation:

i) Soils with low or medium infiltration rates (1 mark)

ii) Soils with high infiltration rate. (1 mark)

e) What do you understand by the following terms:

i) Soil at field capacity (1 mark)

ii) Wilting point (1 mark)

iii) Readily available moisture (1 mark)

f) Determine the maximum practical suction lift for a pump if the discharge is 0.038m^3/s, the water temperature is 20°C, the total frictional losses in pipe and fittings is 1.58m, the NPSH is 4.82m and atmospheric pressure at the water surface is 10m. Assume safety factor of 0.61m and saturation vapour pressure of 0.24m. (4 marks)

g) A young farmer decides to grow soyabeans and chooses to irrigate by furrow irrigation with an application efficiency e_f of 0.60. Given that the crop evaporation ET_c is 5.5mm/day, depth of the rootzone is 900mm, field capacity is at 16%. Assume the readily available moisture is half the available moisture. Determine:

i) the maximum allowable irrigation interval (3 marks)

ii) the gross irrigation depth. (3 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMS

EA 311: FARM POWER AND MACHINERY

TIME: THREE HOURS

INSTRUCTIONS : ATTEMPT: FIVE QUESTIONS ONLY; ONE FROM SECTION A, TWO FROM SECTION B AND THE LAST TWO FROM SECTION C.

ANSWER SECTION A, SECTION B AND SECTION C IN SEPARATE ANSWER BOOKS.

ALL QUESTIONS CARRY EQUAL MARKS.

THIS QUESTION PAPER COMPRISES EIGHT QUESTIONS.

SECTION A: ANSWER ONE (1) QUESTION FROM THIS SECTION.

1. a) Explain why human power cannot be completely replaced in agricultural mechanization. **[4 marks]**

   b) State five factors that have to be considered when selecting an animal for draft power. **[5 marks]**

   c) Define Basal metabolism. **[2 marks]**

   d) List three factors that would encourage mechanization. **[3 marks]**

   e) What information is required in choosing a machinery system? **[6 marks]**

2. a) List two special bulldozer attachments used for tree clearing. Explain briefly how each attachment functions. **[5 marks]**

   b) List in the right sequence the operations that need to be carried out on a heavy forest to prepare it for crop production. **[5 marks]**

   c) Give four advantages and one disadvantage of government owned land development schemes involving earth moving and other heavy machinery. **[5 marks]**

   d) List three factors that affect the selection of land clearing equipment. Explain how two of these factors affect the selection of the equipment. **[5 marks]**

SECTION B: ANSWER TWO QUESTIONS FROM THIS SECTION.

3. a) Make a sketch of the diesel fuel system and label the four **(4)** basic component of this system and describe the primary function of these parts. **[6 marks]**

b) Why is the presence of fuel filters more pronounced in diesel engines than in petrol engines? **[3 marks]**

c) Describe the operations of the mechanism in injector pumps used to meter the amount of fuel delivered to injectors on a diesel engine. **[8 marks]**

d) Name three **(3)** systems of hydraulic controls of hitches on tractors. **[3 marks]**

4. a) What changes do you need in the following parts of a diesel engine so that it can function as a petrol engine?

i) The cylinder block and the cylinder head. **[4 marks]**

ii) The electrical system. **[4 marks]**

iii) The fuel system **[4 marks]**

b) Name four main parts of the combined cooling system. Briefly outline how it functions. **[8 marks]**

5. a) With aid of sketches explain the two stroke cycle of the diesel engine. **[10 marks]**

b) What is the angle between one power stroke and the next in a four cylinder two stroke engine? **[2 marks]**

c) **True** or **False**? "For an engine operated at variable speeds a lighter flywheel is needed." **[1 mark]**

d) Apart from reducing friction and wear, list two functions of the lubrication system in the internal combustion engine. **[2 marks]**

e) List the functions of a governor. **[2 marks]**

f) Explain why it is necessary to have spark advance in a petrol engine. **[3 marks]**

SECTION C: ANSWER TWO QUESTIONS FROM THIS SECTION.

6. Outline the essential field operations required in the production of a crop of maize in their correct sequence of execution. The crop is to be grown in a field where Soya beans has just been harvested. The field has a medium strength hardpan that has developed just below the normal ploughing depth from repeated use of a disk plough over the years. The seed bed thus prepared is expected to be a clean bed due to the limitations of the planter to be used. For each field operation;

   i) State the objective for carrying out the operation.
   ii) Recommend the most appropriate machinery to be used.

[20 marks]

7. a) Why is it important to calibrate a tractor mounted sprayer? **[3 marks]**

   b) List four things that you do in a pre-calibration check. **[4 marks]**

   c) Describe how you can calibrate a tractor-mounted sprayer. **[5 marks]**

   d) State how the following combine losses may be identified and briefly explain how they can be minimised.
   i) Shatter losses
   ii) Threshing losses
   iii) Separation losses
   iv) Cleaning losses

[8 marks]

8. a) Briefly discuss the importance of calibrating a seed drill prior to its use. **[5 marks]**

   b) State **two** problems associated with static or workshop calibration of a seed drill.

[5 marks]

   c) A farmer would like to plant 79 kg/ha of wheat seed using a 10 x 250 mm seed drill (10 rows spaced 250 mm apart). The amount of seed collected during calibration is shown in Table Q8. If the diameter of the drive wheel is 637 mm and the drive wheel was turned 75 revolutions. Determine whether the seed drill is planting the correct amount of seed (kg/ha).

Table Q8: Amount of seed collected from each seed metering unit

Unit	1	2	3	4	5	6	7	8	9	10
kg	0.27	0.27	0.28	0.29	0.29	0.29	0.28	0.29	0.29	0.29

[10 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER
DEFERRED EXAMS

EA 311: FARM POWER AND MACHINERY

TIME: THREE HOURS

INSTRUCTIONS : ATTEMPT: FIVE QUESTIONS ONLY; ONE FROM SECTION A, TWO FROM SECTION B AND THE LAST TWO FROM SECTION C.

ANSWER SECTION A, SECTION B AND SECTION C IN SEPARATE ANSWER BOOKS.

ALL QUESTIONS CARRY EQUAL MARKS.

THIS QUESTION PAPER COMPRISES EIGHT QUESTIONS.

SECTION A: ANSWER ONE (1) QUESTION FROM THIS SECTION.

1. a) In Zambia there is a drive to promote animal draft power by introducing donkeys as sources of draft power. List **three** advantages and **two** disadvantages for using donkeys in Zambia. **[5 marks]**

   b) State **four** factors that have to be considered when selecting an animal for draft power. **[4 marks]**

   c) List **three** factors that influence Basal metabolism energy. **[3 marks]**

   d) List **three** factors that would encourage mechanization. **[3 marks]**

   e) What are the advantages of photo voltaics over solar thermal systems? **[5 marks]**

2. a) Distinguish between land clearing and land forming. **[5 marks]**

   b) List **three** special bulldozer attachments for root clearing. **[3 marks]**

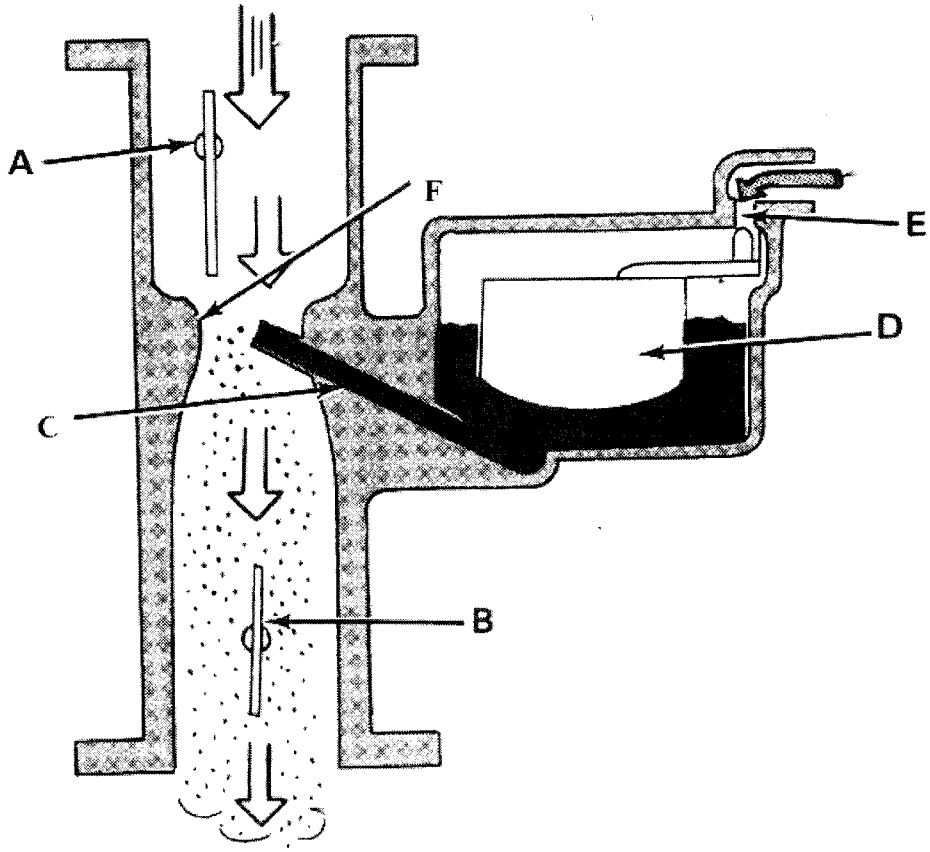
   c) Give **four** advantages and **one** disadvantage of privately owned land development schemes involving earth moving and other heavy machinery. **[5 marks]**

   d) When would chaining be preferred as a method of land clearing. Outline the principles of this method. **[7 marks]**

SECTION B: ANSWER TWO QUESTIONS FROM THIS SECTION.

3. a) Describe the safe and correct way of connecting and disconnecting a battery which is earthed to the negative terminal. **[3 marks]**

b) Label the parts **A, B, C, D, E, F** of the system in the figure below **[3 marks]**



c) What is the function of parts A, B, C and F. **[8 marks]**

d) Describe how the spark is produced in the electronic ignition system. **[6 marks]**

4. a) You are given a six cylinder petrol engine which is being rebuilt and just requires high tension cables to be connected from the distributor to the spark plug. However there is some doubt on the firing order of the engine. Describe the correct way of determining the firing order of the engine. **[6 marks]**

b) Compare and contrast the diesel and petrol engine. **[6 marks]**

c) Name **three** functions of piston rings. **[3 marks]**

d) Given a caterpillar D58 engine with specifications **121mm X 152mm** six cylinders with **CV=PD/14,** calculate the **total cylinder volume** and **engine displacement**. **[5 marks]**

5. a) Why is preventive maintenance necessary when you are running a fleet of tractors. **[4 marks]**

b) Prepare a detailed list of activities that have to be carried out weekly on tractors on a commercial farm . **[8 marks]**

c) List **three** problems that can occur in the diesel fuel system. **[3 marks]**

d) Why is engine power not transmitted directly to the wheels? **[5 marks]**

SECTION C: ANSWER TWO QUESTIONS FROM THIS SECTION .

6. a) List **five** objectives of tillage **[5 marks]**
b) Compare and contrast conservation tillage and convention tillage. **[5 marks]**
c) List and briefly describe **four** parts of a mouldboard plow **[6 marks]**
d) Prepare a schedule of operations and the required implements needed for preparation of a field with heavy clay covered with plant residue to a clean seed bed. **[5 marks]**

7. a) What is integrated pest management? **[2 marks]**

b) List **three** methods of biological control and **two** methods of cultural control. In addition give a brief description of any **three** methods that you have listed. **[8 marks]**

c) List **five** classifications of herbicides. **[5 marks]**

d) List **three** factors that influence the performance of a sprayer. **[2 marks]**

e) On which components of the combine do the following losses occur.
i) Threshing losses
ii) Separation losses
iii) Cleaning losses
[3 marks]

8. a) Briefly discuss the importance of calibrating a fertilizer application equipment prior to its use. **[5 marks]**

b) Describe the procedure for calibrating a tractor operated disc broadcaster. **[6 marks]**

c) List and state the functions of **five** major parts of the tractor drawn planter **[7 marks]**

d) What is the major difference between a planter and a seed drill. **[2 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

EA 401: FARM POWER

TIME: **THREE** HOURS.

INSTRUCTIONS: **ANSWER** ANY **FIVE** QUESTIONS. THIS QUESTION PAPER HAS SIX QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS, (20 MARKS EACH).

QUESTION 1

a) A farmer has a pair of oxen, each weighing 400 kg that he uses for ploughing. The plough cuts furrow slices that are 20 cm wide by 12.5 cm deep. The specific soil resistance is 5 N/cm^2 and the oxen have a working speed of 3.6 km/h. Assume that animals work for 6 hours each day.

i) If the oxen are fed on Sudan grass, show that they would require supplementary feed during ploughing period if they have to meet their total daily energy requirement.

[8 marks]

ii) How much groundnut cake supplement would be required per ox per day to meet the total daily energy requirement?

[7 marks]

Table Q1. Energy content of typical animal feeds

Feed	Dry Matter (%)	Gross Energy of Dry Matter (MJ/kg)	$\frac{DE}{GE}$
Guinea grass	26	7.4	0.50
Sudan grass	31	17	0.65
Hay (average quality)	85	17	0.50
Maize silage	27	18.8	0.75
Maize grain	86	19	0.80
Groundnut cake	90	20.7	0.85

Additional Information

- Maintenance Energy = 8.3 + (0.091W) MJ/day
- Appetite Limit = 0.025W kg of dry matter
- Metabolisable Energy (ME) = 0.8 of Digestible Energy (DE)
- Digestible Energy (DE) range from 0.45 up to 0.90 of Gross Energy (GE)
- Energy Conversion Efficiency of Draft Animals = 20%

b) State the **two** major steps involved in the selection of animals for draft work.

[5 marks]

QUESTION 2

a) A six-cylinder engine has a 127.0 mm stroke and a 107.9 mm bore. According to the engine specifications, the compression ratio should be 20:1. While overhauling the engine, the mechanic unintentionally installs a cylinder head gasket that is 1 mm thicker than the recommended gasket.

i) Calculate the displacement of each cylinder, the clearance volume V_c and the maximum volume, V_1 of each cylinder.

[5 marks]

ii) Calculate the compression ratio of the engine with the thicker head gasket installed.

[5 marks]

iii) Given ambient air temperature of 20°C, polytropic compression with n = 1.3 and auto ignition temperature of diesel fuel of 430°C, all other things being equal, will the engine run?

[5 marks]

b) With the help of a well-labelled indicator (p-v) diagram, outline the operation of a theoretical dual cycle diesel engine.

[5 marks]

QUESTION 3

a) Explain clearly the effect excess valve clearance will have on the operation of an engine.

[6 marks]

b) During a test, a four-cycle, 15.649 litre engine of a tractor consumed 73 L/hr of diesel fuel while running at 2100 rpm and producing 1160 Nm of torque. The imep during the test was 1110 kPa. The fuel density is 0.835 kg/L, and its heating value is 45,434 kJ/kg. Calculate:

i) fuel equivalent power,

ii) indicated power,

iii) brake power,

iv) friction power,

v) indicated thermal efficiency,

vi) mechanical efficiency, and

vii) brake thermal efficiency.

[14 marks]

QUESTION 4

a) Briefly explain the operation of a forced circulation liquid cooling system of an engine that has just been switched on, after being off for 12 hours. Assume an ambient air temperature of 15°C.

[8 marks]

b) Outline the procedure for determining the octane number of a petrol fuel.

[8 marks]

c) Name the reference fuels used in determining the Cetane number of a diesel fuel.

[4 marks]

QUESTION 5

a) Name the **three** basic types of positive displacement pumps used in hydraulic systems.

[3 marks]

b) Draw the JIC symbol and also state the function(s) of each of the following components in a hydraulic circuit.

i) hydraulic Oil Filter

ii) hydraulic accumulator

iii) variable displacement hydraulic pump

iv) pressure relief valve

v) double acting hydraulic cylinder

[10 marks]

c) Sketch the typical volumetric, torque and overall efficiency curves of a hydraulic pump as a function of ($\mu N/\Delta P$), where μ = absolute viscosity, N = pump speed and ΔP = pressure rise across the pump and briefly explain the trend observed in the curves.

[7 marks]

QUESTION 6

a) How does a generator differ from an alternator as a means for electricity power generation?

[5 marks]

b) Give **two** reasons why commercial electricity production is mainly generated using an alternator.

[5 marks]

c) A 240 volts, single phase, 50 Hz induction motor draws 10.6 amperes with a power factor of 0.76. What size of parallel connected capacitor bank would be required to improve the power factor to 0.97?

[10 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

EA 421
FUNDAMENTALS OF FARM STRUCTURES

TIME ALLOWED: 3 Hours

MARKS: 100

INSTRUCTIONS:

i) **Answer all question in section A and any Two (2) in section B.**
ii) **Use of Calculators is permitted**
iii) **A Psychrometric chart will be provided for the question 4.**

SECTION A.

QUESTION 1

A retired Politician decides to go into farming in the Agro – Ecological Zone III. He begins by putting up a house measuring 12m by 8m. In order to protect the walls from the excessive wetness, he builds his roof with an overhang measuring 1m horizontally. The house has a roof which is inclined an angle of 22° to the horizontal plane,

a) Advice the retiree on the type of roof and the most appropriate claddings for this area.

(5 Marks)

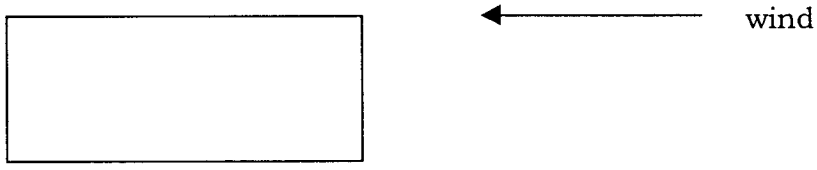
b) How many roofing units is he going to require, if the roofing sheets have the following specification?
   - L = 3 m
   - W = 920 mm
   - Pitch = 177 mm
   - Sidelap = ½ Corrugation
   - Endlap = 200 mm

(12 Marks)

c) List measures you would undertake to prevent leakages associated with roofing screws.

(3 Marks)

d) Indicate how you would proceed to lay the roofing sheets given the roof as shown below. Give the reasons for your procedure.



(5 Marks)

QUESTION 2

A concrete solid slab for Piggery unit is to be constructed and will have the following measurements:

Length= 6m,
Width = 4m and
15cm thick.

The moisture content of the aggregates is as follows:

- Sand = 5 %
- Stones = 2 %

Other properties are listed below:

- Bulk density of Sand = 1.40g/cm^3
- Bulk density of Stones = 1.60 g/cm^3
- Solid density of Aggregates = 2.6 g/cm^3
- Solid density of Cement = 3.1 g/cm^3
- The Nominal mix is: 1:3:6
- Shrinkage ratio = 25%
- Material use efficiency = 95%

a) Determine the amount of:
   i) Cement
   ii) Sand
   iii) Stones

(10 Marks)

b) How much water should be added to the mix for the hydration process to be complete?

(6 Marks)

c) i) What should be the maximum size of the aggregates required?

(2 Marks)

ii) Discuss factors, which may affect the quality of the concrete

(2 Marks)

d) Discuss precautions, which should be observed when working with reinforced concrete.

(5 Marks)

SECTION B

QUESTION 3

a) In the quest to improve the rural sanitation situation for the farming community, Pit latrines were introduced. What precaution needs to be observed when Siting a Pit latrine?

(5 Marks)

b) VIP are preferred to the traditional Pit latrines, list some of the strengths and weakness of the VIP.

(5 Marks)

c) With aid of a well-labelled sketch, discuss the operation of the VIP.

(5 Marks)

d) You are to design a VIP for a family of 6 persons, which is intended to be used for 2 years, if the Sludge accumulation rate is $0.03m^3/Hd/Year$, what will be the depth and the Width/Diameter of the pit?

(10 Marks)

QUESTION 4

Due to the prolonged rain season in the northern part of the Country, Maize was harvested with high moisture content. To bring the moisture content to its optimum, the grain had to be dried using a centrifugal blower. Air initially at a dry bulb temperature of 17° C and at a relative (RH) of 60% was heated to a dry bulb temperature of 50° C.

a) Using the given Psychrometric chart, determine the RH and the Enthalpy levels of the heated air.

(4 Marks)

b) If the airflow into the grain was $1.6m^3/s$, how much moisture would have been removed in the process if the RH of the air-water vapour mixture rises to 90% at the same enthalpy levels, and what would be the rate of moisture removal ($\mathbf{m_{air} = Q/V_{av}}$)?

(6 Marks)

c) What is the rate of sensible heat addition if the heated air is being pumped in at a rate of 1.6 m^3/s (and $\mathbf{m_{air} = Q/V_{av}}$)?

(5 Marks)

d) With aid of a graph Illustrate Sensible heating and cooling and give examples of the application.

(4 Marks)

e) What purposes are fulfilled by Ventilation in farm structures? List two examples of the Common Ventilation types commonly used in farm structures.

(6 Marks)

QUESTION 5

a) Discuss the factors that may affect Farmstead Planning

(5 Marks)

b) What is the rationale behind Zone planning in Agriculture production?

(5 Marks)

c) You are to advice a group of upcoming dairy farmers on the housing requirements. If their target is to acquire 14 cows, how many Calf pens are they going to require if they would like to practice Concentrated Calving?

(10 Marks)

d) In dairy farming list other structures necessary for efficient production.

(5 Marks)

QUESTION 6

a) Discuss the factors affecting the design of crop storage structures.

(4 Marks)

b) Durable crops can be stored either as bulk or in bags. What are the merits and demerits of the two storage practices?

(6 Marks)

c) Compare the improved storage structures to the traditional ones. List some examples of the improved structures.

(8 Marks)

d) Distinguish between Durable crops and Perishable crops in the context of their properties (storage).

(7 Marks)

END OF EXAMINATION

Carrier

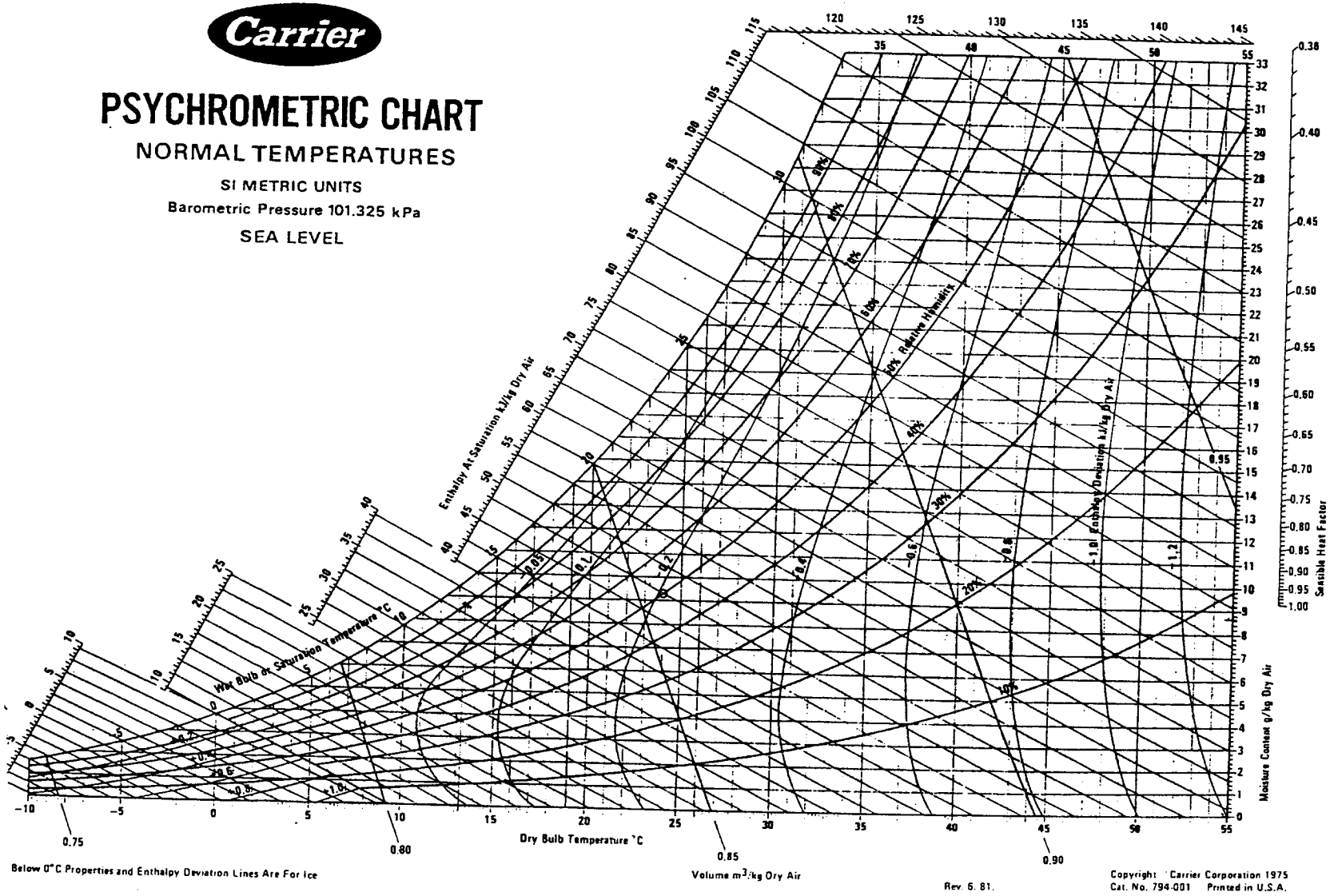
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS

Barometric Pressure 101.325 kPa

SEA LEVEL



Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

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THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER DEFERRED EXAMINATION JULY 2004

EA 421
FUNDAMENTALS OF FARM STRUCTURES

TIME ALLOWED: 3 Hours

MARKS: 100

INSTRUCTIONS:

i) **Answer all question in section A and any Two (2) in section B.**
ii) **Use of Calculators is permitted**
iii) **A Psychrometric chart will be provided for the question 4.**

SECTION A.

QUESTION 1

A Farmer plans to cast a circular shaped concrete floor slab with a diameter of 12 m for his concrete Silo, (figure 1). If the slab where to be 15cm thick and where to be made from a concrete with a nominal mix of 1:2:5, and:

- Shrinkage ratio is 30%
- Material use efficiency of 95 %,

a. Compute the mass of cement, sand and stones required to cast the concrete slab fully,

(10 marks)

b. If the aggregates are dry, how much water needs to be applied to the mix to achieve a concrete slab of the highest strength and quality?

(5 marks)

c. If the moisture content of sand was 5.5% and 2% for stones respectively,

   i. How much water should be added to the mix if the bulky densities of sand and stones are 1.45 g/cm^3 and 1.60g/cm^3 respectively,

   (3 marks)

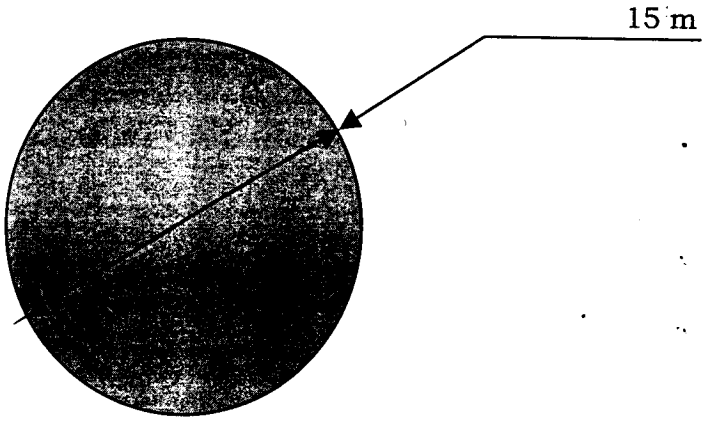
   ii. What is the cement-aggregate ratio?

   (2 marks)

d. f reinforcement bars where to be used, discuss the steps to be followed and precautions, which he must observe.

(5 Marks)

Figure 1 Circular shaped Concrete slab



QUESTION 2

A small scale Poultry is to be roofed with a Monopitched roof using Galvanised Corrugated Steel Sheet with the following Specification: CS 10/100 with a Width of 1000 mm and a length of 3000 mm,

a) Describe this roofing sheet.

(4 marks)

b) How many roofing sheets are required to roof a building with the following dimensions:

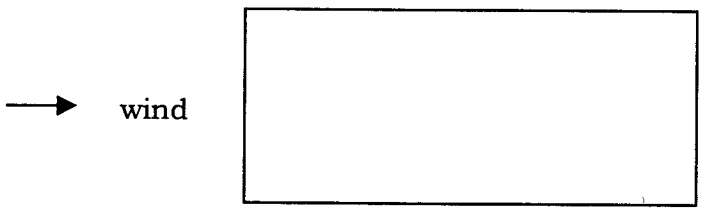
- Length = 8m
- Width = 5m
- Slope of the roof 1:3
- The end lap = 150mm
- Side lap = 1 corrugation

(12 marks)

c) Discuss the merits and demerits of the **GCSS** over the other roofing sheets.

(3 marks)

d) Describe the procedure to follow when placing roofing sheets on the roof given the prevailing wind.



(4 marks)

e) How would you ensure a leak proof roof even after fixing the roof claddings?

(2 marks)

SECTION B

QUESTION 3

a) Describe the treatment process that takes place in a Septic tank.

(6 marks)

b) Find the septic tank dimensions required to treat wastewater from a family of 6 given that the per capita water consumption is 80 litre/person/day.

(7 marks)

c) Calculate the desludging period if the Sludge builds up rate of $0.03m^3/hd/yr$.

(5 marks)

d) Assuming an infiltration rate of 10 $ltr/m^2/day$, determine the size of a Soakage drain required to treat the Septic tank effluent.

(7 marks)

QUESTION 4

At the new Chisamba crop storage warehouse, grain was being dried using heated air flowing at 1.5 m^3/s. The air was initially heated from 10 °C to 35 °C. The initial relative humidity of the air was 60%. Using the Psychrometric chart:-

a) Calculate the amount of sensible heat required to heat the air,

(6 marks)

b) What would be the relative humidity at the end of the heating process?
(2 marks)

c) Quantify the moisture removed from the grain at the end of the drying process, if the RH rose to 90%.
(3 marks)

d) With the aid of a sketch discuss Evaporative-cooling listing an examples of its application.
(6 marks)

a) What purposes are fulfilled by Ventilation in farm structures? List two examples of the Common Ventilation types commonly used in farm structures.
(6 Marks)

QUESTION 5

a) Discuss the factors that influence Farmstead planning.
(5 marks)

b) What is the significance of Zone planning in Agricultural production?
(5 marks)

c) You are a farm Manager in the production of pigs. If you have 15-sow herd where an 8-week weaning period is being practiced:

i) Determine the number of fallowing pens required.
(10 marks)

ii) Other than the fallowing pens which other relevant facilities would you recommend if your production has to be efficient.
(5 marks)

QUESTION 6

a) Distinguish between Durable crops and Perishable crops in the context of their properties (storage).
(7 Marks)

b) Durable crops can be stored either as bulk or in bags. What are the merits and demerits of the two storage practices?
(6 Marks)

c) Compare the improved storage structures to the traditional ones. List some examples of the improved structures.
(8 Marks)

d) Discuss the factors affecting the design of crop storage structures.
(4 Marks)

END OF EXAMINATION

Carrier

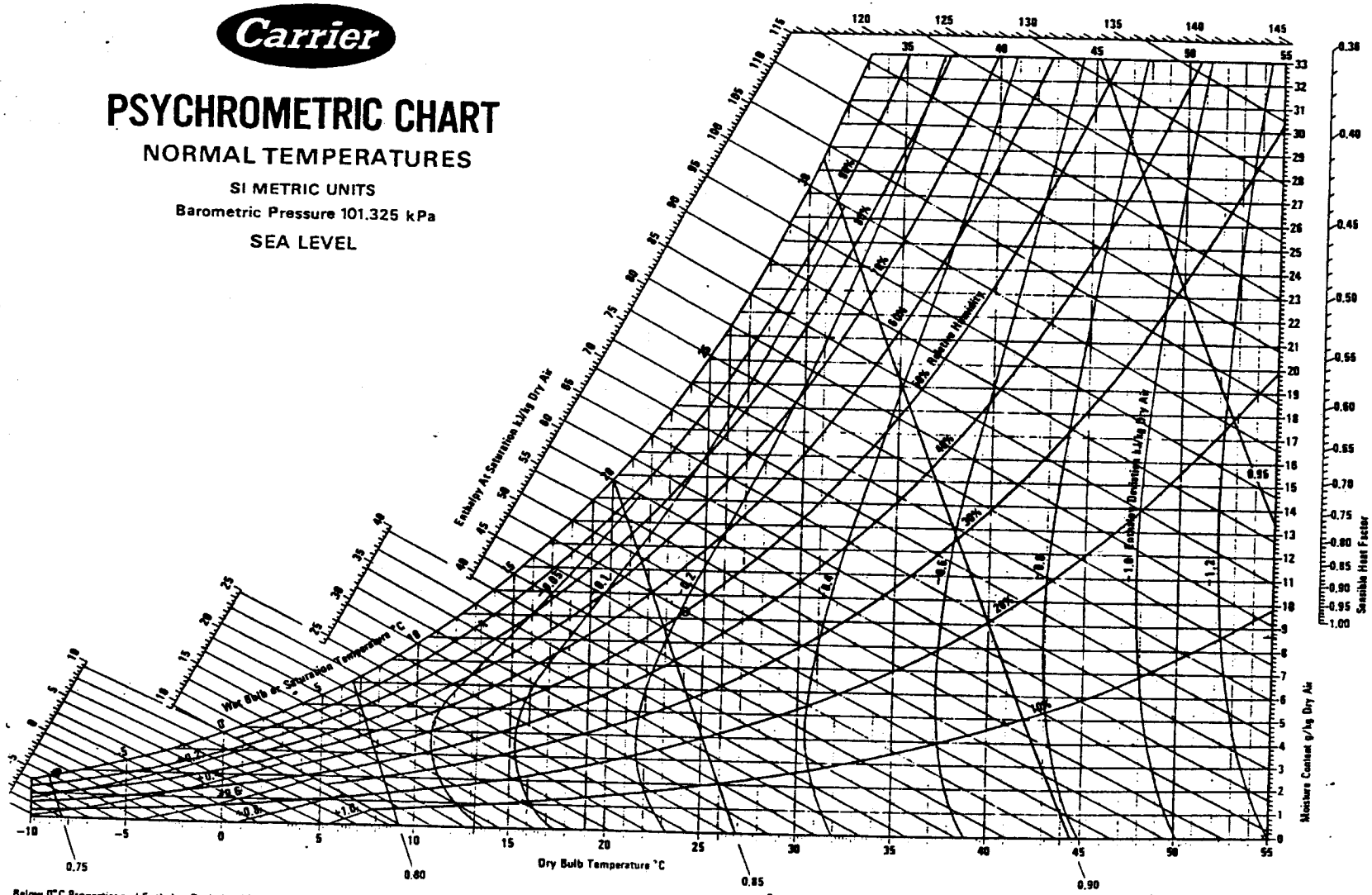
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS

Barometric Pressure 101.325 kPa

SEA LEVEL



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THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

EA521 FARM STRUCTURES I

TIME: THREE (3) HOURS

INSTRUCTIONS:

ANSWER: ANY FIVE QUESTIONS

INFORMATION

1. THIS EXAMINATION PAPER CONTAINS SIX QUESTIONS
2. ALL QUESTIONS CARRY 20 MARKS
3. THE MARKS FOR EACH QUESTION ARE GIVEN IN BRACKETS

QUESTION 1

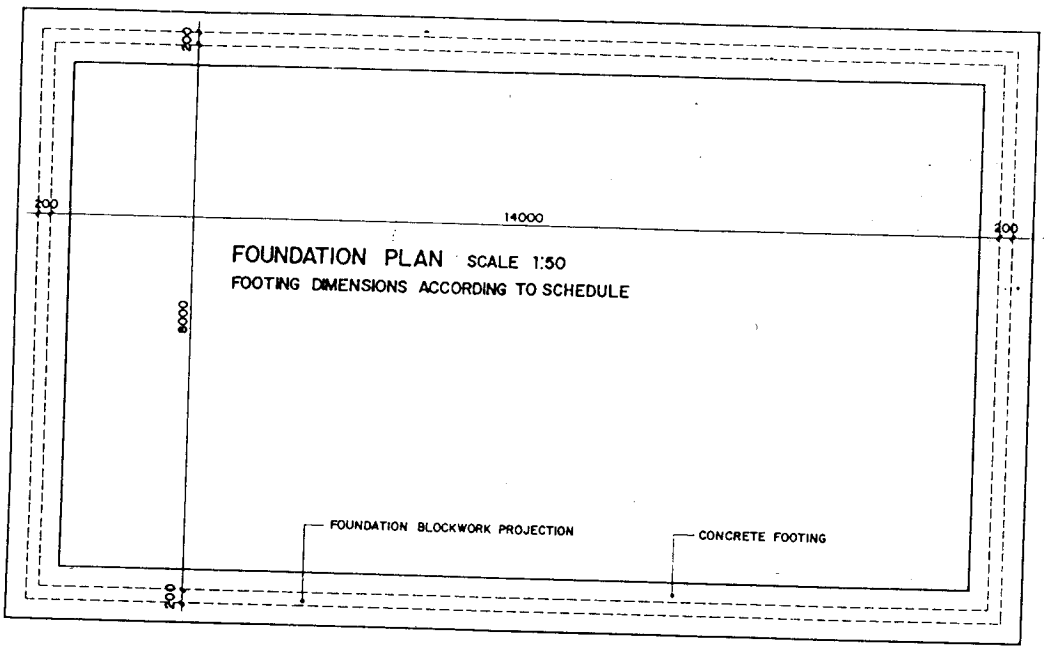
(a) Describe a simple process that may be used to determine the workability of fresh concrete. (6)

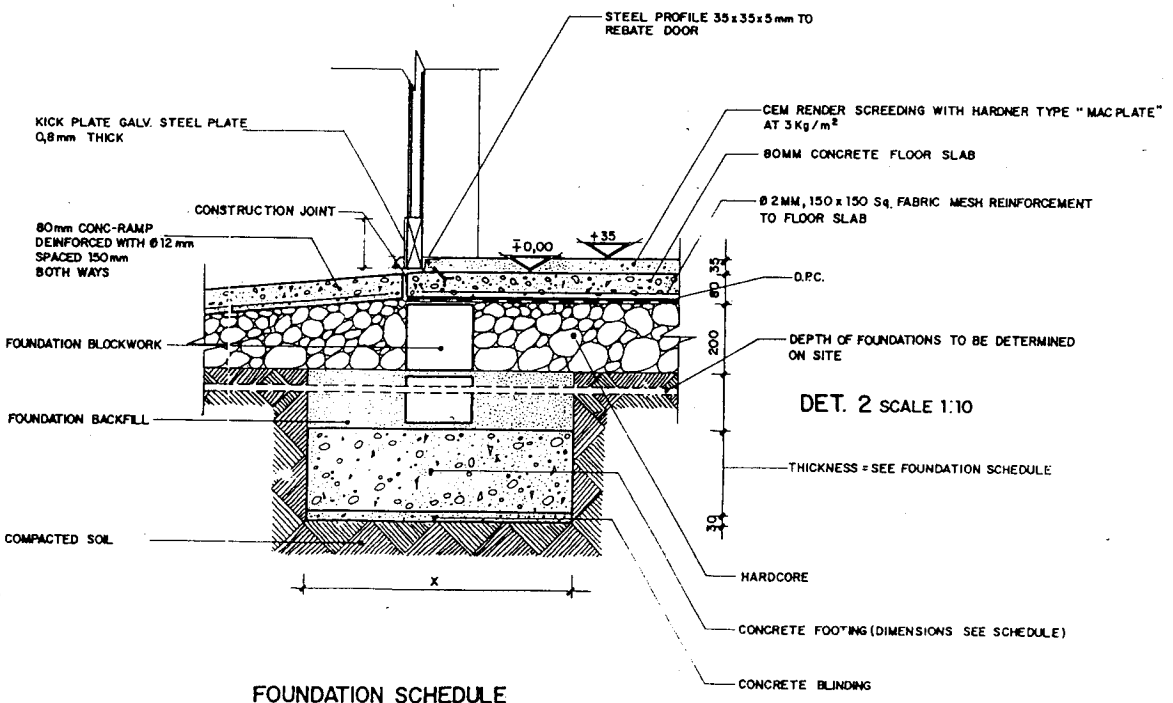
(b) Define briefly the properties of hardened concrete. (NB: please do not give detailed amplifications for each of the properties). (6)

(c) The foundation plan and typical section for a storage shed are shown in Figure 1. The safe bearing capacity of the soil is 11.76N/cm^2. Calculate the amount of constituent materials in terms of bags of cement, tonnes of sand and stone required to construct the foundation and floor slab. Assume a decrease of 30% due to mixing and a further 5% due to wastage. If the water-cement ratio by weight is 0.58, calculate the volume of water required for mixing. The properties of the materials are as follows:

Bulk density of cement	3100kg/m^3
Bulk density of sand	1400kg/m^3 at 4.2% moisture content
Bulk density of stones	1600kg/m^3 at 1.6% moisture content
Density of water	1000kg/m^3

(8)





FOUNDATION SCHEDULE

SAFE BEARING CAPACITY OF SOIL	N/cm²	Kg/cm²	X	
	5,88	0,6	1200	
	6,86	0,7	1000	
	7,84	0,8	900	
	9,8	1	800	
	11,76	1,2	600	
	14,7	1,5	500	

FIGURE 1

QUESTION 2

(a) Discuss briefly the main properties of clay bricks giving approximate values where appropriate. **(10)**

(b) What are the main weaknesses of earth as a building material and how can these be overcome? **(6)**

(c) List the main factors that influence the selection of building materials. **(4)**

QUESTION 3

(a) The steel pin-jointed truss shown in Figure 2 is designed to support the loads shown over the span of 32m. Some of the constraints on design are that (i) all members must be of the same cross-section, (ii) the stress in any member shall not exceed 150N/mm^2, and (iii) the maximum deflection below the supports shall not exceed 40mm. Determine the minimum cross-section area of the members to satisfy these requirements given that the value of the modulus of elasticity E is 200kN/mm^2. **(12)**

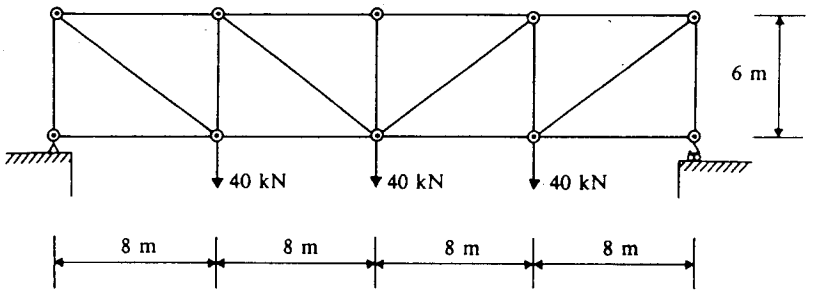


FIGURE 2

(b) A simply supported beam of span L carries a load W at each of the third points. The central half of the beam has a flexural rigidity EI whilst each of the end quarters is of flexural rigidity EI/3. Determine the central deflection using the moment area method. **(8)**

QUESTION 4

(a) A simply supported concrete beam spanning 6m supports the following distributed loads:

Dead load = 32kN/m including self-weight

Imposed load = 18kN/m

The characteristic material strengths are f_{cu} = 30N/mm^2, f_y = 460N/mm^2 and f_{yv} = 250N/mm^2. The effective depth is 560mm and the breadth is 300mm.

(i) Use the bending moment diagram to design different areas of the bending reinforcement for the central part and the ends of the beam.

(ii) Use the shear force diagram to design different areas of the shear reinforcement for the central part and the ends of the beam.

(iii) Detail the reinforcement using an elevation and a typical cross-section of the beam.

The areas of groups of bars are given in Table 1. Values of ultimate shear stress as given in Table 2. **(12)**

Table 1

Cross-sectional areas of groups of bars (mm^2)

Bar size (mm)	*Number of bars* 1	2	3	4	5	6	7	8	9	10
6	28.3	56.6	84.9	113	142	170	198	226	255	283
8	50.3	101	151	201	252	302	352	402	453	503
10	78.5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	566	679	792	905	1020	1130
16	201	402	603	804	1010	1210	1410	1610	1810	2010
20	314	628	943	1260	1570	1890	2200	2510	2830	3140
25	491	982	1470	1960	2450	2950	3440	3930	4420	4910
32	804	1610	2410	3220	4020	4830	5630	6430	7240	8040
40	1260	2510	3770	5030	6280	7540	8800	10100	11300	12600

Table 2

Value of ultimate shear stress v_c (N/mm^2) for a concrete strength of f_{cu} = 30 N/mm^2

$100A_s/bd$	Effective depth (mm) 150	175	200	225	250	300	⩾ 400
⩽ 0.15	0.46	0.44	0.43	0.41	0.40	0.38	0.36
0.25	0.54	0.52	0.50	0.49	0.48	0.46	0.42
0.50	0.68	0.66	0.64	0.62	0.59	0.57	0.53
0.75	0.76	0.75	0.72	0.70	0.69	0.64	0.61
1.00	0.86	0.83	0.80	0.78	0.75	0.72	0.67
1.50	0.98	0.95	0.91	0.88	0.86	0.83	0.76
2.00	1.08	1.04	1.01	0.97	0.95	0.91	0.85
⩾ 3.00	1.23	1.19	1.15	1.11	1.08	1.04	0.97

For characteristic strengths other than 30 N/mm^2 the values in the table may be multiplied by $(f_{cu}/25)^{1/3}/1.06$. The value of f_{cu} should not be greater than 40 N/mm^2.

(b) Design a timber pole to be used as a column. The analysis shows that it supports a compressive load of 40kN and a bending moment of 2.8kNm. The pole is restrained in position and direction at both ends. The clear height of the pole is 3.2m. The material properties of the timber are given in Table 3. The values of the modification factor K_{12} for compression members are given in Table 4. **(8)**

Table 3

Bending parallel to grain $\sigma_{m,g,\|\|}$	*Compression parallel to grain* $\sigma_{c,g,\|\|}$	*modulus of elasticity* E_{min}
5.3	6.8	5800

Table 4

Modification factor K_{12} for compression members (Table 22, BS 5268)

$\frac{E}{\sigma_{c,\|\|}}$	*Values of* K_{12}																
	Values of slenderness ratio λ $(= L_e/i)$																
	<5	*5*	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100*	*120*	*140*	*160*	*180*	*200*
	Equivalent L_e/b *(for rectangular sections)*																
	<1.4	*1.4*	*2.9*	*5.8*	*8.7*	*11.6*	*14.5*	*17.3*	*20.2*	*23.1*	*26.0*	*28.9*	*34.7*	*40.5*	*46.2*	*52.0*	*57.8*
400	1.000	0.975	0.951	0.986	0.827	0.735	0.621	0.506	0.408	0.330	0.271	0.225	0.162	0.121	0.094	0.075	0.061
500	1.000	0.975	0.951	0.899	0.837	0.759	0.664	0.562	0.466	0.385	0.320	0.269	0.195	0.148	0.115	0.092	0.076
600	1.000	0.975	0.951	0.901	0.843	0.774	0.692	0.601	0.511	0.430	0.363	0.307	0.226	0.172	0.135	0.109	0.089
700	1.000	0.975	0.951	0.902	0.848	0.784	0.711	0.629	0.545	0.467	0.399	0.341	0.254	0.195	0.154	0.124	0.102
800	1.000	0.975	0.952	0.903	0.851	0.792	0.724	0.649	0.572	0.497	0.430	0.371	0.280	0.217	0.172	0.139	0.115
900	1.000	0.976	0.952	0.904	0.853	0.797	0.734	0.665	0.593	0.522	0.456	0.397	0.304	0.237	0.188	0.153	0.127
1000	1.000	0.976	0.952	0.904	0.855	0.801	0.742	0.677	0.609	0.542	0.478	0.420	0.325	0.255	0.204	0.167	0.138
1100	1.000	0.976	0.952	0.905	0.856	0.804	0.748	0.687	0.623	0.559	0.497	0.440	0.344	0.272	0.219	0.179	0.149
1200	1.000	0.976	0.952	0.905	0.857	0.807	0.753	0.695	0.634	0.573	0.513	0.457	0.362	0.288	0.233	0.192	0.160
1300	1.000	0.976	0.952	0.905	0.858	0.809	0.757	0.701	0.643	0.584	0.527	0.472	0.378	0.303	0.247	0.203	0.170
1400	1.000	0.976	0.952	0.906	0.859	0.811	0.760	0.707	0.651	0.595	0.539	0.486	0.392	0.317	0.259	0.214	0.180
1500	1.000	0.976	0.952	0.906	0.860	0.813	0.763	0.712	0.658	0.603	0.550	0.498	0.405	0.330	0.271	0.225	0.189
1600	1.000	0.976	0.952	0.906	0.861	0.814	0.766	0.716	0.664	0.611	0.559	0.508	0.417	0.342	0.282	0.235	0.198
1700	1.000	0.976	0.952	0.906	0.861	0.815	0.768	0.719	0.669	0.618	0.567	0.518	0.428	0.353	0.292	0.245	0.207
1800	1.000	0.976	0.952	0.906	0.862	0.816	0.770	0.722	0.673	0.624	0.574	0.526	0.438	0.363	0.302	0.254	0.215
1900	1.000	0.976	0.952	0.907	0.862	0.817	0.772	0.725	0.677	0.629	0.581	0.534	0.447	0.373	0.312	0.262	0.223
2000	1.000	0.976	0.952	0.907	0.863	0.818	0.773	0.728	0.681	0.634	0.587	0.541	0.455	0.382	0.320	0.271	0.230

QUESTION 5

For the cantilever retaining wall shown in Figure 3, determine the factors of safety against:

(i) Sliding
(ii) Overturning
(iii) Bearing on the soil

Unit weight of backfill = $16kN/m^3$
Unit weight of concrete = $24kN/m^3$
Internal angle of friction of backfill = 30^o
Allowable bearing pressure of the soil = $180kN/m^2$
Coefficient of friction between soil and concrete = 0.36. **(20)**

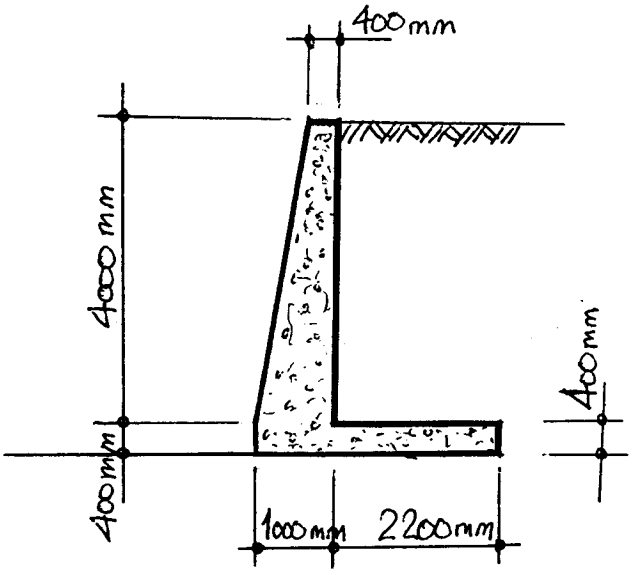


FIGURE 3

QUESTION 6

(a) List the functions of the following building elements
  (i) Floor
  (ii) Foundation
  (iii) Roof **(6)**
(b) Describe using a sketch the details of a typical gable roof design. **(8)**
(c) Discuss the use of thatch as a roofing material giving its properties and treatment, and its disadvantages and advantages in relation to other types roofing materials. **(6)**

END OF EXAMINATION

EXAMINER: Dr. Edward Lusambo, Department of Agricultural Engineering

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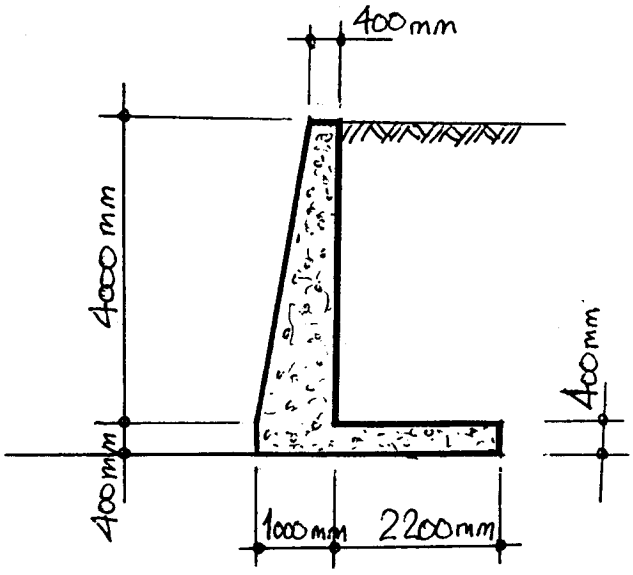

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END OF EXAMINATION

EXAMINER: Dr. Edward Lusambo, Department of Agricultural Engineering

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS 23 JUNE 2004

SEMESTER I

EE209
PRINCIPLES OF ELECTRICITY

Time: Three hours Answer ALL questions Total marks: 100

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1. In Figure Q1. A portion of a circuit is shown for which the following voltages and currents are known: $v_1(t)$, $v_2(t)$, and $i_3(t)$. Find $v_4(t)$. [20 marks]
2. In Figure Q2, given $\beta_{dc} = 250$.
   (a) Find α_{dc}. [2 marks]
   (b) Find I_E. [2 marks]
   (c) Find I_C and I_B. [2marks]
   (d) Find r_e the emitter diode ac resistance. [2 marks]
   (e) Find the dc voltage from the collector to ground. [2 marks]
3. Use the principle of superposition to find V_X in Figure Q3. [20 marks]
4. Given Figure Q4.
   (a) Transform the [R4, R3, R5] star connection into an equivalent delta connection [R_A between nodes Band C, R_B between nodes A and C, R_C between nodes A and B] and redraw the circuit diagram. [6 marks]
   (b) What is R_{AB}, the parallel combination of R1 in Figure Q4 and R_C found in the delta connection of (a). [4 marks]
   (c) Transform [R_{AB} in (b), R_B in (a) , R_A in (a)] delta connection into a star connection [R6, R7, R8]. Where R6 terminates at node B, R7 terminates at node A and R8 terminates at node C. [6 marks]
   (d) What is R9 the series combination of R6 in (c) and R2 in Figure Q4? [4 marks]
5. Given the circuit of Figure 5.
   (a) The switch has been in the closed position for a long time. To what final voltage (VSS1) does the capacitor charge to? [2 marks]
   (b) The switch is opened at $t = 2\mu s^+$. What is the voltage on the capacitor at this instant? [2 marks]
   (c) The switch is left in the open position for a long time. To what new final voltage (VSS2) does the capacitor charge to? [2 marks]
   (d) What is the Thevenin equivalent resistance in (c) with the capacitor removed? [4 marks]
   (e) What is the time constant for VSS1 to exponentially decay to VSS2? [5 marks]
   (f) Write the equation for the transient voltage $V_C(t)$ from $t = 2\mu s^+$ to $t = \infty s$. [5marks]

6. (a) What is the expression for the maximum allowable series-limiting resistance for a zener diode regulator? [3 marks]
   (b) What is the peak inverse voltage across each non-conducting diode in a bridge rectifier? [1 marks]
   (c) What type of diode is used for high frequency signal rectification applications? [1 marks]
   (d) What are the three approximate equivalent circuits of a forward biased diode? [3 marks]
   (e) What is the break-point frequency for a high-pass R-C filter in [rad/s] and [cycles/s] ? [2 marks]

END EE 209 FINAL EXAMINATION

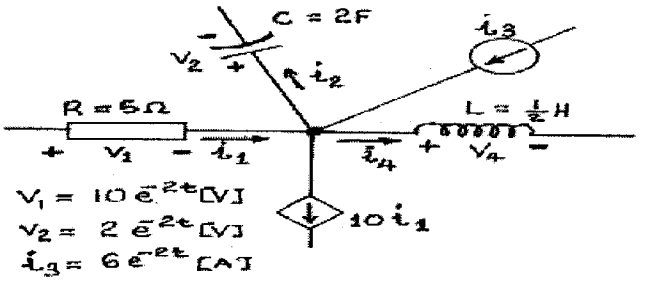

FIG Q1

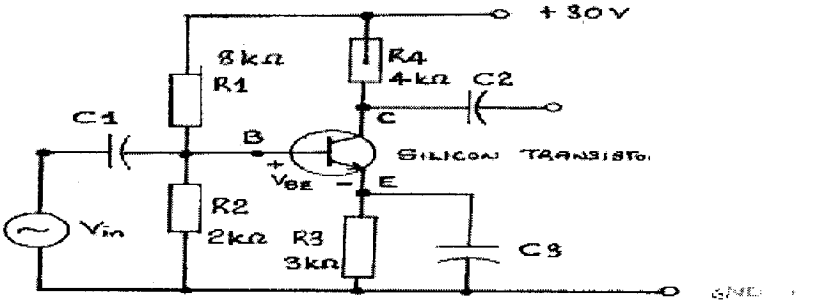

FIG Q2

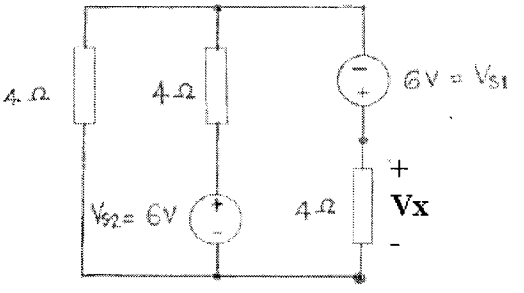

FIG Q3

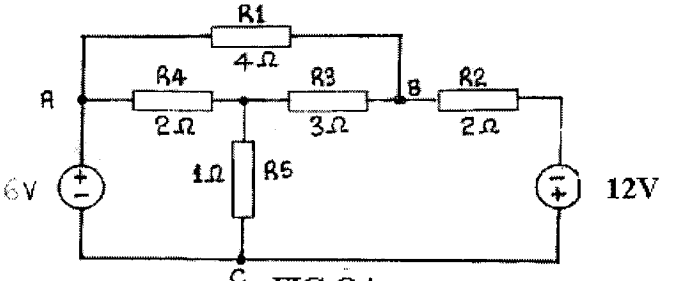

FIG Q4

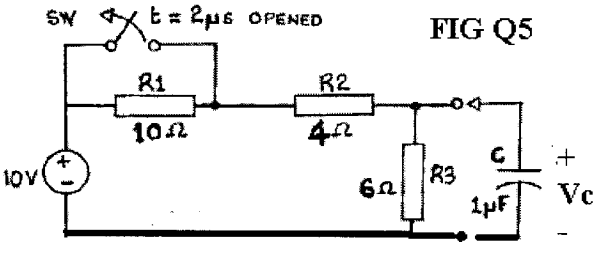

FIG Q5

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
DEFERRED UNIVERSITY EXAMINATIONS 22 JULY 2004
SEMESTER I

EE209
PRINCIPLES OF ELECTRICITY

Time: Three hours Answer ALL questions Total marks: 100

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1. (a) What is voltage? [2 marks]
   (b) What is current? [1 mark]
   (c) What is power? [2 marks]
   (d) What is the time-change or time-rate of change relationship of voltage and current for a resistor, an inductor and a capacitor? [3 marks]
   (e) What is the peak inverse voltage for a center-tap and bridge full wave rectifier? [2 marks]

2. (a) State the three operating modes of transistor switching circuits. [3 marks]
   (b) What is the significance of the Alpha (DC) and the Beta(DC) of a transistor? [4 marks]
   (c) What is the normal biasing configuration of the diode junctions in a transistor? [4 marks]
   (d) Under small ac signals what is the behaviour of a forward biased diode junction? [2 marks]
   (e) If the unregulated supply varies from 12 to 16 volts and the load varies from 100 ohm to 5 thousand ohms. What is the maximum value of the series current limiting resistor if the zener regulator voltage is 6.2 volts? [2 marks]

3. In the circuit of Figure Q3. find:
   (a) nodal analysis: what is (i) V_1; (ii)V_2 ; and (iii) V_3 and V_x? [10 marks]
   (b) mesh analysis: what is (i) I_1 ; (ii) I_2 ; (iii) I_3 ; and V_x ? [10 marks]
   (c) Thevenin's theorem: what is (i) V_{Th} ;(ii) R_{Th}; (iii) V_x ? [5 marks]
   (d) Nortons theorem: what is (i) I_N; (ii) R_N; (iii) I_x; and (iv) V_x ? [5 marks]

4. A 1000 [v] secondary transformer feeds a lighting load of 100 Ω: first, from a 60Hz supply and second from a 50Hz supply.
   (a) Find the instantaneous voltage and current at exactly 6P.M. plus 9.5347 seconds for (i) 60Hz and 50Hz supply frequency. [2 marks]
   (b) Write the instantaneous expression of the voltage waveform for (i) 60Hz and (ii) 50Hz supply frequency, if the voltage wave is zero and going negative at 6 P.M. [4 marks]
   (c) Find how many cycles have occurred since 6 P.M. to 9.5347 seconds for (i) 60Hz and (ii) 50Hz supply frequency. [4 marks]

5. Consider Figure Q5.
   (a) Find $I_x \angle \theta_x$ by Thevenin's theorem. [4marks]
   (b) What is $i_x(t)$ if the supply sinusoid is a cosine wave with a 50Hz frequency. [3 marks]
   (c) What is (i) V_{Th} and (ii) Z_{Th} [5 marks]
   (d) For maximum power transfer what should the inductive impedance load be? [3 marks]

6. (a) What are the two energy storage elements that give rise to first-order transients. [2 marks]
   (b) Give two expressions and their corresponding functions of time for:
      (i) Decreasing decay function [3 marks]
      (ii) Increasing decay function [3 marks]
   (c) For the energy storage elements in (a); what are the expressions of their time constants. [2 marks]

7. (a) Sketch the standard resonance curve for a series RLC circuit. Show the relative magnitudes and frequencies at half power points and the resonance in radians/second. What is the expression for the Q-factor for the series RLC resonant circuit. What is the significance of the Q-factor? [7 marks]
   (b) What is the break-point frequency for a high-pass R-C filter in [rad/s] and [cycles/s] ? [3 marks]

FIGURE Q5

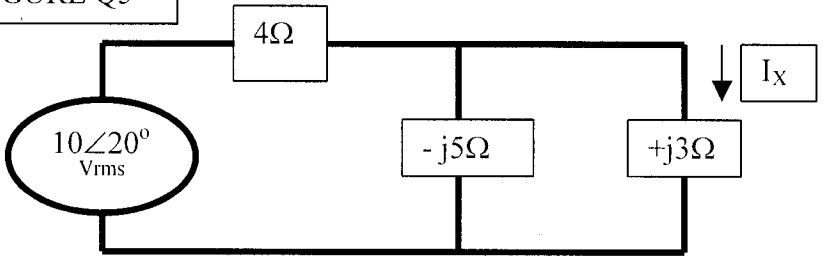
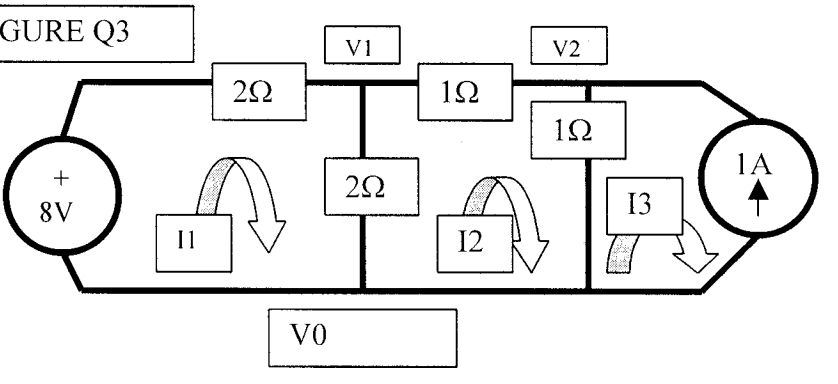


FIGURE Q3



END EE 209 FINAL EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL ENGINEERING

UNIVERSITY END OF SEMESTER EXAMINATION
EE311 NETWORK ANALYSIS
JUNE 2004

ANSWER : ANY FIVE QUESTIONS

Q1.

(a) Given a complex signal $S(t) = Ae^{st}$ where $s = \sigma + j\omega$ is the complex frequency. Draw sketches of rotating phasors and exponential sinusoids for all possible conditions of the complex frequency.

(b) Find response to the excitation shown in the figure when the network is an ideal differentiator and an ideal integrator.

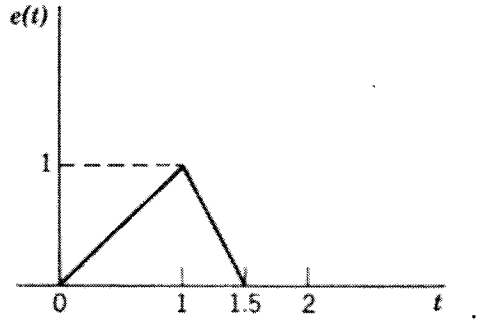


Figure1a.

(c.) For the network shown , write the node equation in terms of i) differential equations and ii) complex differential equation.

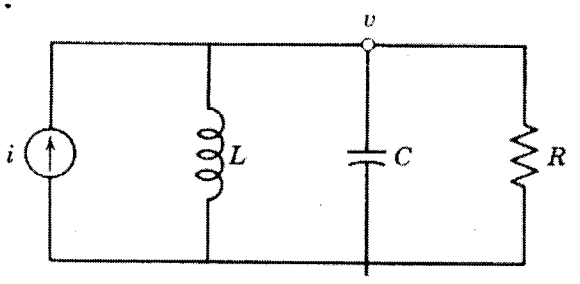


Figure1b.

Q2.

(a) Evaluate the following and draw sketches where required

(i) $S(t) = \sum_{k=0}^{2} u(t - kT)$

(ii) $S(t) = \text{sgn}(\sin \frac{\pi t}{T})$

(b) If the step response of a linear time invariant system is $r_s(t) = 2e^{-t}u(t)$, determine the impulse response h(t).

Q3.

(a) Write expressions for the Fourier series in terms of
- (i) Sinusoidal expression and its coefficients
- (ii) Fourier cosine series and their coefficients
- (iii) Complex form and their coefficients

(b) Given S(f) as shown in figure 3, find the inverse transform of $S_1(f)$ in terms of $s(t) = F^{-1} S(f)$

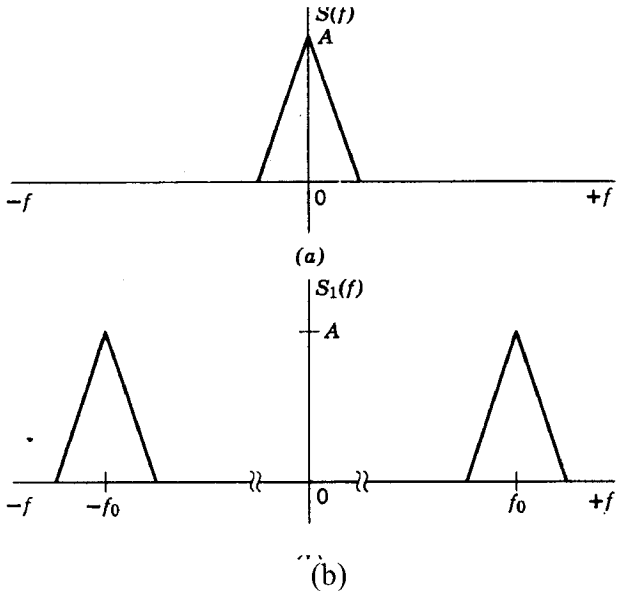


figure3.

(c)

(i) find the Fourier transform for

$f(t) = A \sin j\omega_0 t$

(ii) prove that if f (t) is even , its Fourier function F(jω) is also an even function .

Q4.

(a) Solve completely the following equation
$x''(t) + 3x'(t) + 2x(t) = 4\delta'(t)$

(b) Find only the particular integral for the equation
$x''(t) + 3x'(t) + 2x(t) = 2\sin 3t$

Q5.

Given a network as shown in figure5, find free response for $V_c(t)$ for the differential equation
Draw the responses.

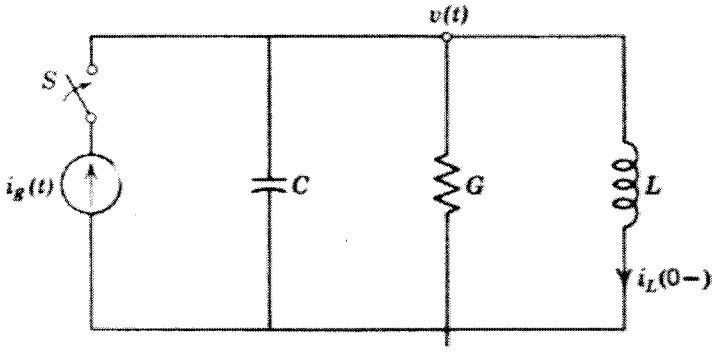
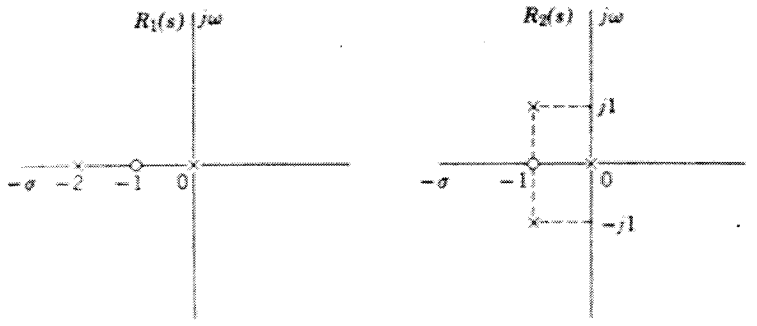


figure5.

Q6.

(a)
Two response transforms, are $R_1(s)$ and $R_2(s)$, have the pole –zero plots shown in (a) and (b) of the figures 6. respectively. In addition, it is known that $r_1(0+) = 4$ and $r_2(t) = 4$ for very large t. Find $r_1(t)$ and $r_2(t)$.



(a) (b)

Figure6.

(b)
Solve the following differential equation using Laplace transforms
$x''(t) + 6x'(t) + 9x(t) = \cos 2t$

(c) Find the inverse transform for

$$F(s) = \frac{s}{(s^2+9)(s+3)}$$

Q7.

(a) for the given circuits in figure 7. show that they represent an integrator and a differentiator.

(b) For the function

$$F(s) = \frac{5}{(s^2 + 2s + 5)}$$

Determine $j\omega_{max}$, $|F(j\omega_{max})|$ and $|F(j\omega)|$

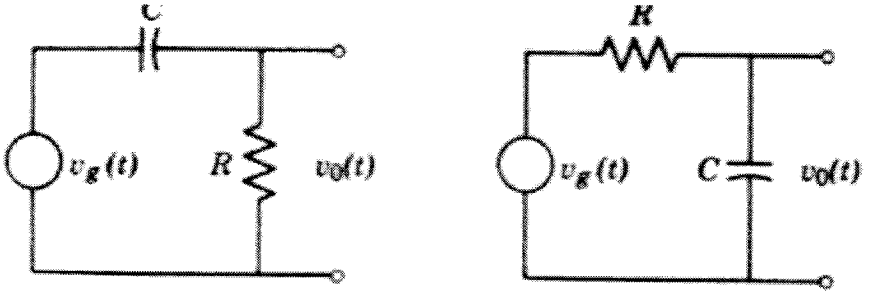


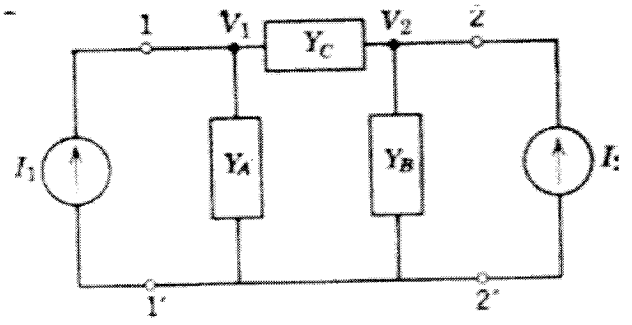
Figure7.

Q8.

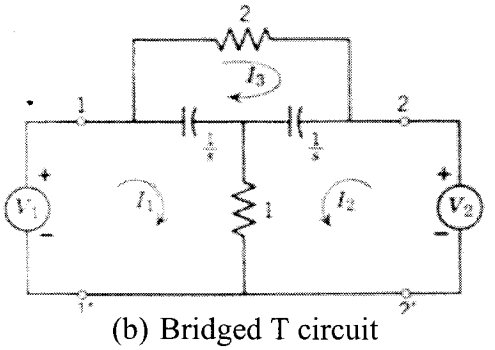
Given expressions for the h- parameters as
$V_1 = h_{11}I_1 + h_{12}V_2$
$I_2 = h_{21}I1 + h_{22}V_2$

And for the y- parameters as
$I_1 = y_{11}V_1 + y_{22}V_2$
$I_2 = y_{21}V_1 + y_{22}V_2$

(a) for the pi- circuit , find the h- parameters
(b) and for the bridged T circuit find the y- parameters



(a) Pi circuit



(b) Bridged T circuit

Figure8.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS JUNE/JULY 2004

EE321

ELECTROMECHANICS & ELECTRICAL MACHINES

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

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

1.

(a) Give the definition of the term illuminance in illumination

[4 marks]

(b) Two lamps with a rating of 500 W each, with a lamp efficacy of 25 lm/W, are mounted on two lamp posts 10 m apart. The posts have heights of 3 m and 5 m, respectively. Calculate the illuminance at a point mid-way between the lamp posts.

[8 marks]

(b) It is required to provide an illumination of 100 lx in a factory hall of area 30 m x 12 m. Assume that the maintenance factor is 0.8 and the utilisation factor is 0.4 and the efficacy of the proposed 100-W lamps is 14 lm/W. Calculate the number of lamps.

[8 marks]

2.

From basic principles and defining all the terms, find the expression of the capacitance of a

(a) parallel-plate capacitor

(b) spherical capacitor, that is, one consisting of two concentric spheres, when the outer sphere is earthed.

[10 marks]

(c) A parallel plate capacitor is immersed in alcohol of relative permittivity 26. The plates are charged to a potential difference of 20 kV and the distance between them is 15 mm. Determine the force per unit area exerted on the plates.

[5 marks]

(d) What is the capacitance of an arrangement of two concentric thin spherical shells in air of radii 8 cm and 10 cm with the outer shell earthed?

[5 marks]

3.

(a) Derive the expression of the reluctance S of a uniform magnetic circuit of constant cross-sectional area A, relative permeability μ_r, length l and excited by a coil of N turns.

[4 marks]

(b) The cross-sectional area for the iron in the magnetic circuit of figure 1 is 200 mm^2. The circuit consists of ten identical portions of steel. The relative permeability is 1000. The length of each portion is 150 mm. Neglecting complications at the corners, calculate

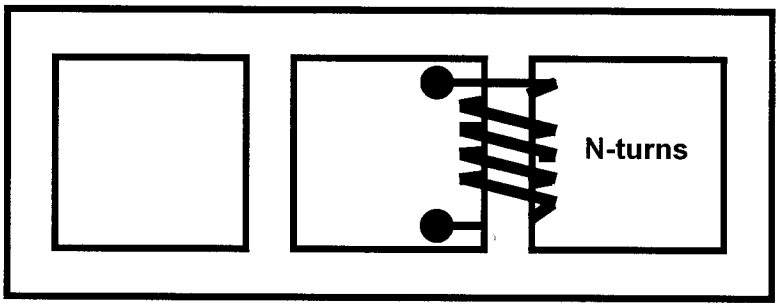


Figure 1

(i) the reluctance of the whole magnetic circuit as seen from the position of the coil,

[6 marks]

(ii) the inductance of the coil which has 2000 turns,

[4 marks]

(iii) the dc current in the coil required to produce a flux of 0.15 mWb.

[4 marks]

(iv) If a 120-V, 50-Hz sinusoidal voltage is supplied to the coil, obtain the maximum value of the magnetic flux density in the portion containing the coil.

[2 marks]

4.

(a) Explain the shape of the waveform of the input current of a transformer on no-load.

[5 marks]

(b) Explain the causes of voltage drop in a power transformer on load.

[5 marks]

(c) A 75-kVA transformer rated at 11000/240 V on no-load requires 310 V across the primary to circulate full-load currents on short-circuit, with the power absorbed being 1.6 kW. Determine the voltage regulation at full-load 0.8 power factor lagging. What is secondary terminal voltage at this condition, when rated primary voltage is used?

[10 marks]

5.

(a) Explain the advantages of having a three-phase system compared to a single-phase system in a power system.

[6 marks]

(b) A star-connected balanced load is supplied from a three-phase supply with a line voltage of 416 V at a frequency of 50 Hz. Each phase of the load consists of a resistance and a capacitor connected in series and the two wattmeters connected to measure load power supplied read 782 W and 1980 W, both positive. Calculate the power factor and the line current of the circuit. What is the capacitance of each capacitor?

[14 marks]

6.

(a) From "$v = Blu$", where l is the length of a conductor, cutting a magnetic field of density B at constant speed u, and experiences an induced voltage v, derive expressions for the brush terminal voltage for a commutator machine and for a slip-ring machine.

[10 marks]

(b) The armature of a 6-pole generator has a wave winding containing 664 conductors. Calculate the generated voltage when the flux per pole is 0.06 Wb and the speed is 250 rpm. At what speed must the armature be driven to generate a voltage of 250 V if the flux per pole is reduced to 0.058 Wb?

[10 marks]

7.

(a) Three phase ac machines operate on the principle of a "rotating" magnetic flux. Describe the principal features which establish the ac machine as either an induction machine or a synchronous machine.

[4 marks]

(b) A 3-phase, 4-pole induction motor operates on a 50-Hz supply. The frequency of the rotor-induced current is 2 Hz.

(i) What is the slip?

[2 marks]

(ii) What is the speed of the rotor?

[2 marks]

(iii) What is the speed of the rotor mmf with respect to the rotor and with respect to the stator?

[2 marks]

(c) With the help of mmf, voltage and current phasor diagrams explain the operation of an ideal synchronous machine in motoring mode.

[10 marks]

8.

(a) Derive the torque-speed characteristic of a dc series motor

[10 marks]

(b) A dc series motor draws a line current of 100 A from the mains while running at 1000 rpm. Its armature resistance is 0.15 Ω and the field resistance is 0.1 Ω. Assuming that the flux corresponding to a current of 25 A is 40% that corresponding to 100 A, what is the speed of the motor when it is drawing 25 A from a 230-V supply?

[10 marks]

END OF EE321 EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

FINAL EXAMINATION – JUNE 2004

EE 342 – ELECTRONIC ENGINEERING I

Time:	Three Hours
Answer:	Five Questions
Boltzman's Constant:	$k = 1.38 \times 10^{-12} J/K$
Electronic Charge:	$q = 1.6 \times 10^{-19} C$
Ambient Temperature:	$T = 300^0 K$

Q1.

(a) Draw the common emitter low frequency hybrid - π equivalent circuit together with two current sources.

(b) Draw the common base low frequency hybrid -π equivalent circuit together with two current sources.

(c) Draw the common collector low frequency hybrid - π equivalent circuit together with two current sources.

(d) Derive expressions, which show the relationships between h and hybrid -π parameters for the circuit in (a).

(e) Show, for the circuit in (b), the relationships between h and hybrid - π parameters.

Q2.

(a) Either a set of curves or set of parameters may be used to specify an active element or device such as a transistor. For the common emitter connection with the collector emitter voltage and base current as independent variables, the relationship among variables for a two port network are:

$\upsilon BE = f(iB, \upsilon CE)$ and
$ic = f(iB, \upsilon CE)$.

Show how the above relationship among variables is related to the equations below.

$\upsilon be = hieib + hre\ vce$
$ic = hfe\ ib + hoe\ vce.$

(b) Draw the equivalent circuit for the two equations in (a) above.

(c) Explain and discuss step technical meanings of the symbols hie, hre, hfe, and hoe and they would be determined experimentally or from the output characteristics of a transistor.

Q3.

(a) Draw the common emitter high frequency hybrid -π model for an npn bipolar junction transistor.

(b) Prove that the expression for high frequency common emitter forward current gain, $\beta(\omega)$ is given as: -

$$\beta(\omega) = \frac{\beta o}{1 + j\omega r\pi(C\pi + C\mu)} \text{ and}$$

state the conditions under which the formula is derived. Define βo.

(c) Define the following terms:-

(i) cut-off frequency and

(ii) transition frequency

Q4.

(a) Draw Elbers – Moll Model for a p-n-p bipolar junction transistor and discuss transportation of holes across it.

(b) Derive, with the help of Ebers – Moll Model, Ebers – Moll equations for an n- p – n bipolar junction transistor and express emitter terminal current, collector terminal current, and base terminal current in terms of base – emitter junction voltage and base –collector junction voltage.

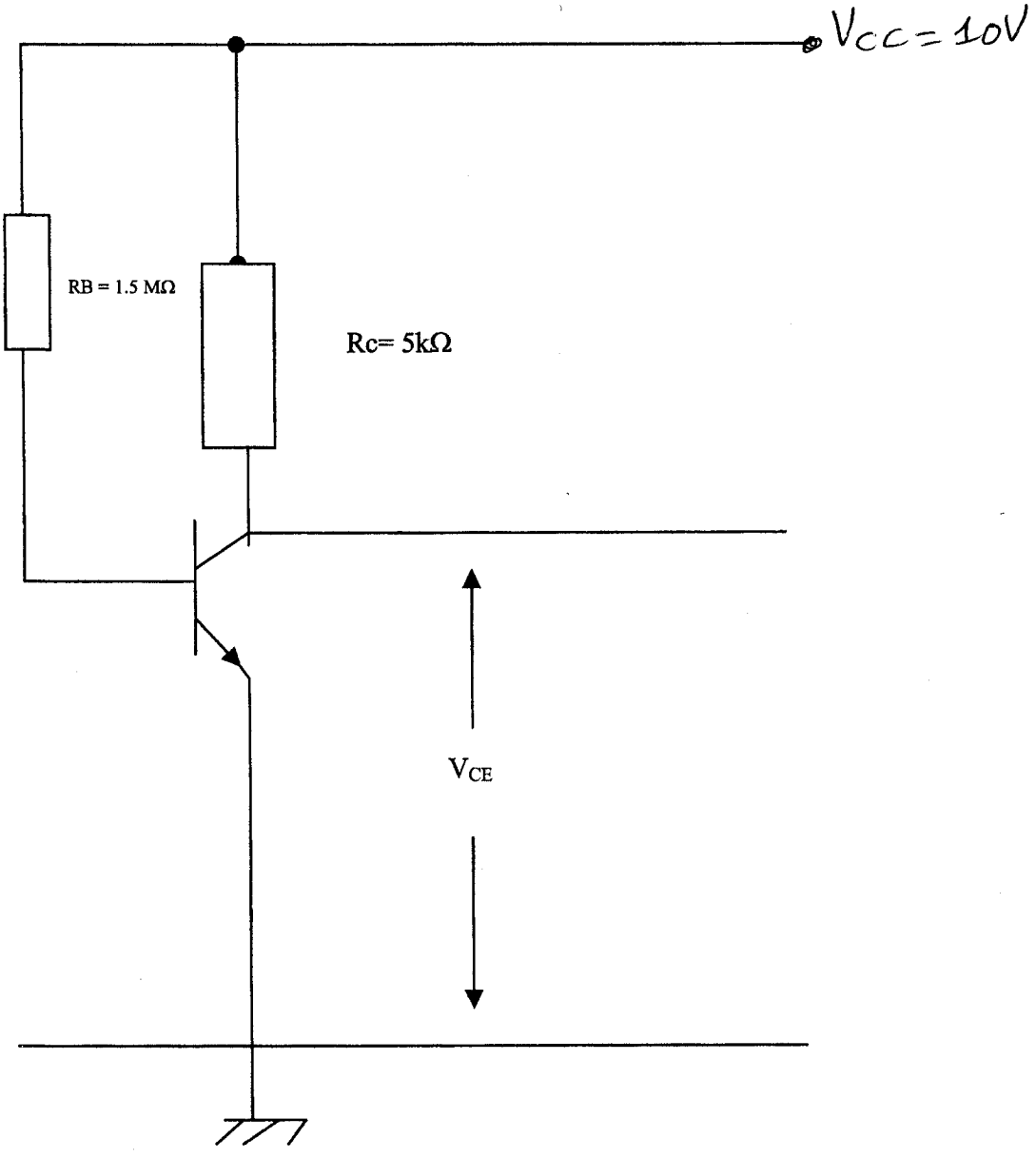
(c) Solve explicitly, using Ebers – Moll equations for a p –n- p bipolar junction transistor, for the base – emitter junction voltage and base – collector junction voltage in terms of emitter terminal current, collector terminal current, emitter leakage current, and collector reverse saturation current.

Q5. For the common emitter (CE) circuit and an npn bipolar junction transistor shown below:

(i) Draw dc load line and

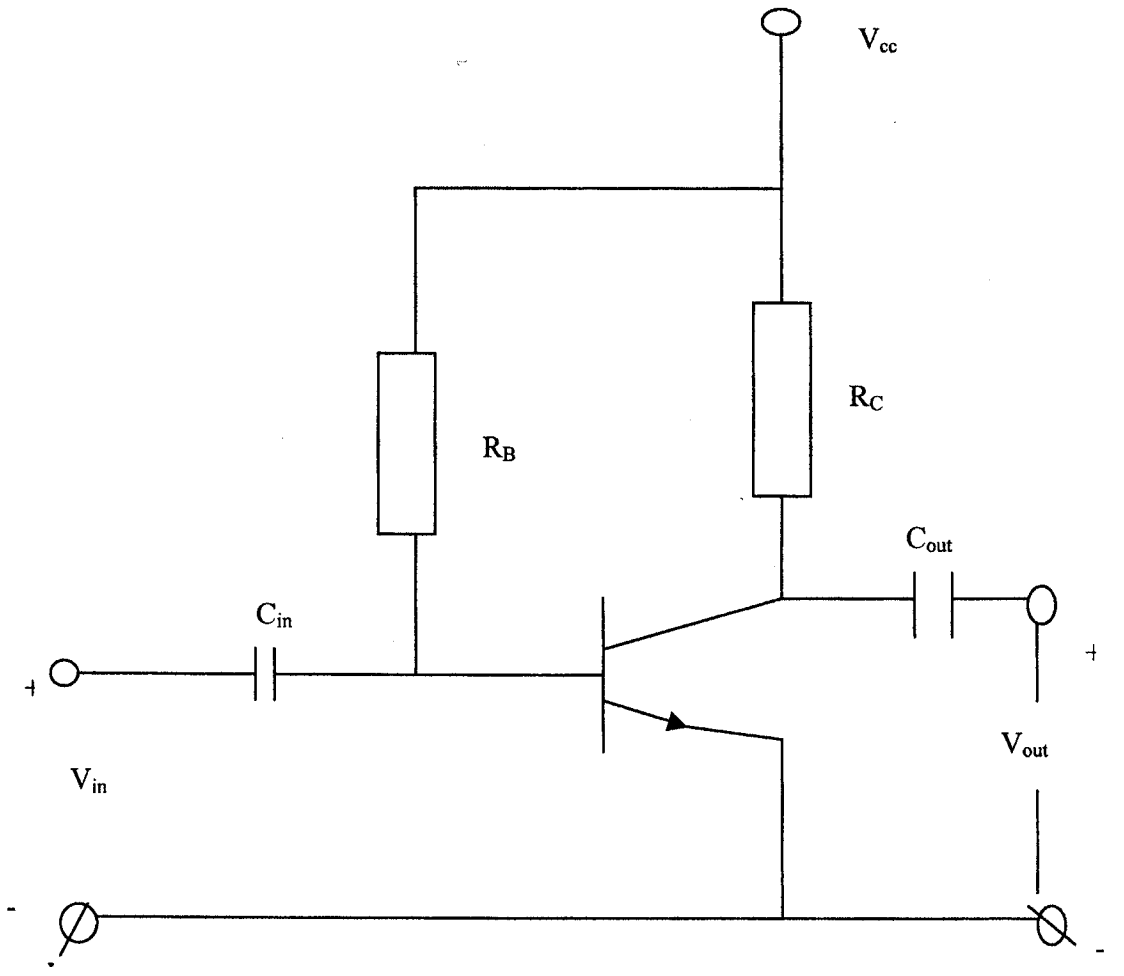
(ii) Find dc working point.

Assume $\beta = 100$ and neglect V_{BE}.



Q6.

(a) The circuit shown below is said to be thermally unstable. Discuss thermal instability of the circuit.



(b) In designing the amplifier circuit we must ensure that the Q – point is in the middle of the dc loadline. We do not only have to choose a bias circuit which stabilizes the working point it also have to prevent thermal runaway.

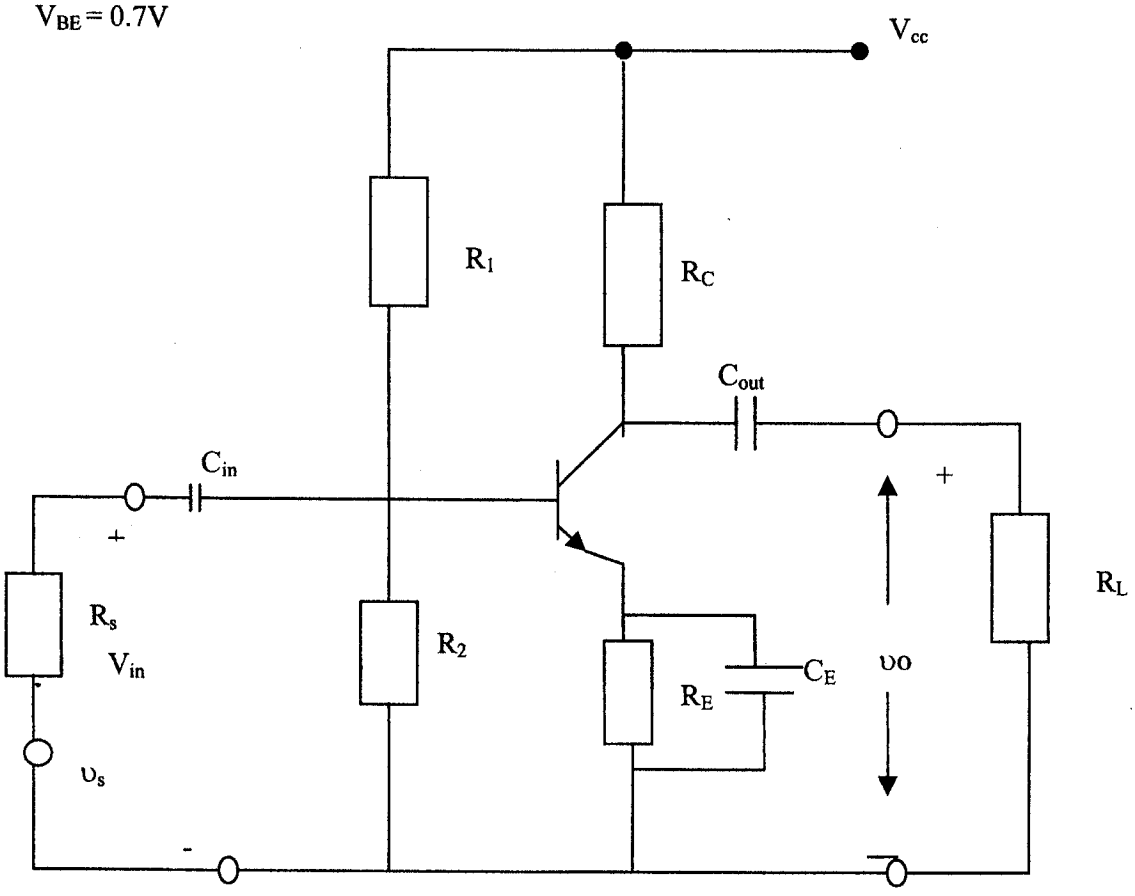
Discuss and explain as to what is understood by the phrase thermal runaway in relation to operations of the pipolar junction transistor.

(c) What are the functions of the two resistors, two capacitors and the supply voltage V_{cc} in the circuit shown above?

Q7. For the circuit shown below calculate for

(i) The base current, I_B
(ii) Collector current, I_c and.
(iii) The collector emitter voltage, V_{CE} and
(iv) Draw the dc loadline.

V_{CC} = ~~9V~~ 10V
R_1 = 30 kΩ
R_2 = 15 kΩ
R_C = 4kΩ
R_E = 2kΩ
R_L = 1kΩ
R_s = 10kΩ
C_{in} = C_{out} = 1μF
C_E = 50μF
β = 50
V_{BE} = 0.7V

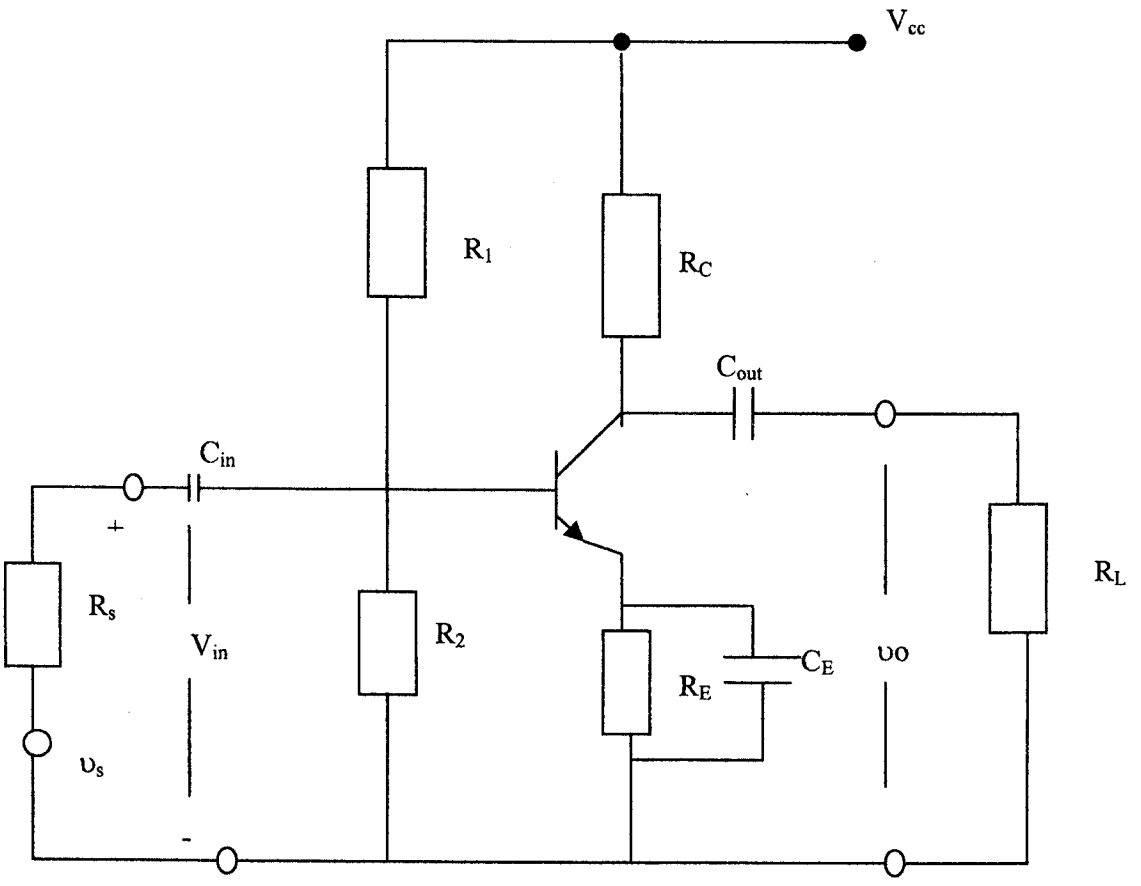


Q8. Find the expression for:

(i) Voltage gain

(ii) Current gain and

(iii) Input resistance of the circuit shown below into which a low varying input signal has been applied.



UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPT OF ELECTRICAL & ELECTRONICS ENGINEERING

FIRST SEMESTER FINAL EXAMINATIONS

EE411-ELECTROMAGNETIC FIELDS-25th JUNE 2004

TIME: THREE HOURS
ANSWER: FIVE (05) QUESTIONS ONLY. THERE ARE EIGHT (8) QUESTIONS

CONSTANTS: $\varepsilon_o = 8.85 \times 10^{-12}$ F/m $\quad \mu_o = 4\pi \times 10^{-7}$ H/m
$Q_e = -1.6 \times 10^{-19}$ C $\quad m_e = 9.1 \times 10^{-31}$ Kg
$g = 981$ m/sec^2

VECTOR OPERATORS: included on the last page.

Q1

(a) According to Faraday's law of electromagnetic induction, a time varying magnetic flux φ penetrating a loop induces an electromotive force (emf) in the loop such that:

$$\text{emf} = -\frac{d\varphi}{dt}$$

- Express the equation above in integral and point form. [4 marks]

(b) A circular loop of 10 cm radius is located in the xy plane in a field **B** given by

$$\mathbf{B} = (0.5\cos 377t)(3\mathbf{a}_y + 4\mathbf{a}_z)\ \text{T}$$

Determine:

(i) The voltage induced in the loop. [8 marks]
(ii) What current would this field establish in the loop if the total resistance of the loop is 10 ohms. [4 marks]
(iii) What is the amplitude of the magnetic flux density that this current establishes at the center of the loop. [4 marks]

Q2

(a) Define self-inductance and mutual inductance. [2 marks]

(b) Find the self inductance of;

(i) A 1-km length of coaxial cable with b/a = 6 and Teflon dielectric. Where a is the inner and b is the outer radii of the cable. [4 marks]

(ii) A 1000 turn toroidal coil wound on a fiberglass form having a circular cross section with a = 1 cm, r_o = 3 cm. [4 marks]

(iii) A 1000 turn solenoid, 50 cm long, with a 3 cm x 3 cm square cross-section [4 marks]

(c) Find the mutual inductance between the solenoid of part b above and a solenoid that is co-axial with it but having 1500 turns, a 4 cm x 4 cm square cross-section and the same length [6 marks]

Q3

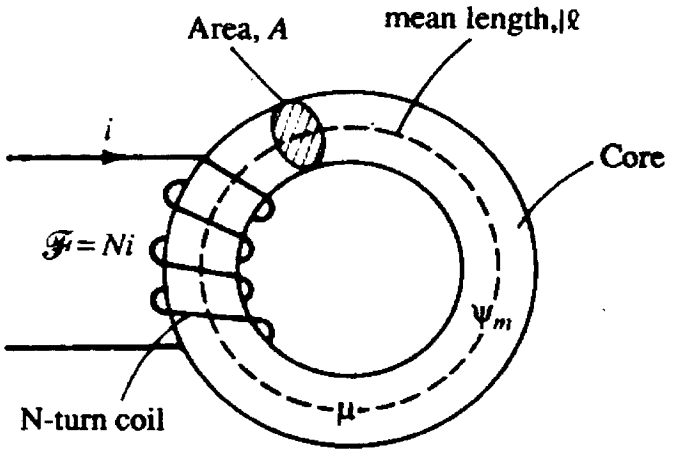


FIG 1

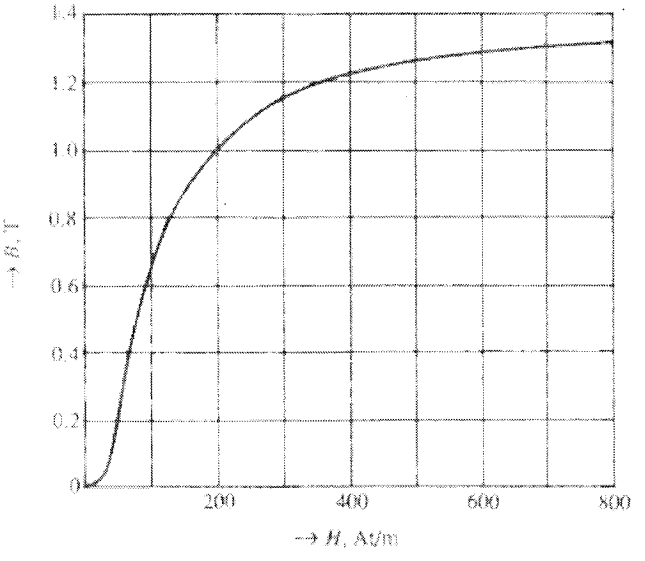


FIG 2

(a)

(i) By comparison with an electrical circuit obtain an expression for the reluctance of the coil in FIG 1. in terms of given parameters [2 marks]

(ii) The core of the magnetic circuit of FIG 1 is made of steel whose B-H characteristics is shown in FIG 2. The core flux is 1.55-mWb. If the core mean length is 300 mm and the core has a circular section of radius 19.5 mm, determine the coil current. The core has 100 turns. [6 marks]

(iii) For the same figure in FIG 1 calculate the core flux if the coil carries 0.6 A of current. [4 marks]

(b) A magnetic circuit with an air-gap is shown in FIG3. How many turns should the exciting coil have to establish a 1.0 Wb/m^2 flux density in the gap. The maximum allowable current in the coil is 10 A. The core has a B-H curve of FIG 2. Neglect any fringing of the magnetic field at the air-gap [8 marks]

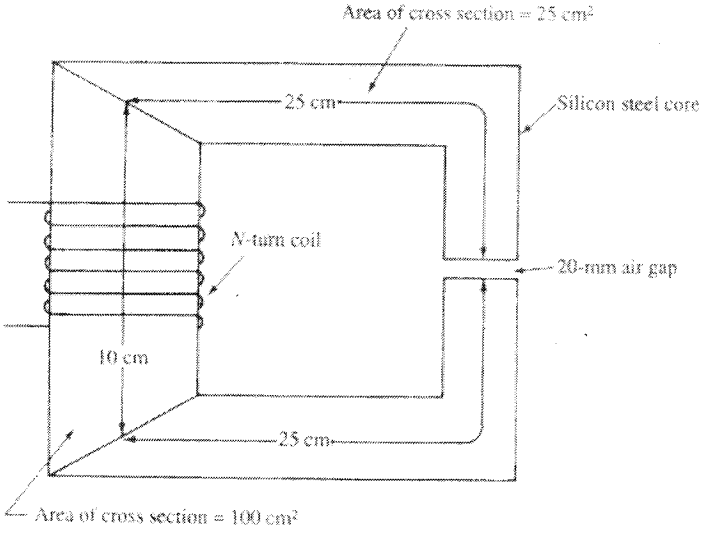


FIG 3

Q4

(a) State Ampere's circuital law and express it both in integral form and point form. [3 marks]

(b) Find **H** at the point (0.1,0,0) in the field of:

(i) Pair of current sheets $5\mathbf{a}_x$ A/m at z = 1 and $-5\mathbf{a}_x$ A/m at z = -1.[3 marks]

(ii) Current filament on the y axis, I =2π A in the $\mathbf{a}_y$ direction [5 marks]

(iii) Co-axial transmission line centred on the z-axis, a = 0.2m, b = 0.3m, c = 0.4 m , I = 4π A in the $\mathbf{a}_z$ direction . Where a is inner diameter, b is the inner diameter of the sheath and c is the outer diameter of the sheathe [3 marks]

(iv) Long solenoid, I = 0.4 A in the $\mathbf{a}_z$ direction, N =2000, a = 0.2, L = 4 m centered at the origin, axis on the z-axis. [4 marks]

(v) Toroid, center at the origin, axis on the z axis, r_o = 0.2, a = 0.15m, N = 2000, I = 0.2π A in the $\mathbf{a}_z$ direction at the outer radius. [3 marks]

Q5

(a) State coulomb's law. [2 marks]

(b)

(i) Calculate the field intensity that would be just sufficient to balance the gravitational force of the earth on an electron. [4 marks]

(ii) If a second electron located below the first one produced this electric field what would be the distance between the two electrons. [4 marks]

(c) A circular disk of charge has a radius R and carries a surface charge density ρ_s. Find the electric field intensity **E** at a point P on the axis at a distance a. What is the value **E** when $a << R$. [10 marks]

Q6

(a) Use Gauss's law to show that no charge can be present in a uniform electric field. [5 marks]

(b) Show that Gauss's law is equivalent to the divergence theorem. [5 marks]

(c) A volume charge density $\rho = k/r$ exists within a sphere of radius a. Determine the magnitude of a point charge placed at the origin which will produce the same electric field at $r > a$. [5 marks]

(d) A 100 μC point charge is located at the origin of a cartesian co-ordinate system. Determine the electric flux passing through the square $-1m < x < 1m$, $-1m < y < 1m$, $-1m < z < 1m$ [5 marks]

Q7

(a) Given the following distribution of dielectrics, ε_o for $x < 0$, $\varepsilon_R = 3$ for $0 < x < 2$, $\varepsilon_R = k$ for $2 < x < 4$ and ε_o for $x > 4$ and find **E** everywhere if k =:

(i) 1

(ii) 2. [6 marks]

(b) A point charge of 1μC is located at the origin of a spherical co-ordinate system. Find the difference in potential between surfaces r = 1, and r = 2 if:

(i) $\varepsilon = \varepsilon_o$ everywhere

(ii) $\varepsilon = 2\varepsilon_o$ everywhere [6 marks]

(c) The cylinder $r < 3$ is a dielectric for which $\varepsilon_{R1} = 2$. The region $r > 3$ is free space.. If $\mathbf{E_1} = 20\mathbf{a}_x - 10\mathbf{a}_y - 40\,\mathbf{a}_z$ at $r = 3^-$, $\varphi = o$, $z = 0$ finf $\mathbf{E_2}$ at $r = 3^+$, $\varphi = 0$, $z = 0$. [8 marks]

Q8

(a) Determine the capacitance of a parallel plate capacitor,where A is the surface area of each plate and d is the separation between them. [4 marks]

(b) Find the capacitance of :

(i) A 1-ft (0.3048 m)length of air-filled co-axial cable with b/a = 4, [3 marks]

(ii) A spherical satellite 5m in diameter. [3 marks]

(c) In FIG4 let $\varepsilon_{R2}=2$,$\varepsilon_{R1}=5$, a = b = 0.5mm, S=10cm^2, and assume 100 V between the conducting plates.

(i) What is ρ_s on the positive plate. [4 marks]

(ii) What voltage is across dielectric 2. [3 marks]

(iii) What is the ratio of W_{E2} toW_{E1}. [3 marks]

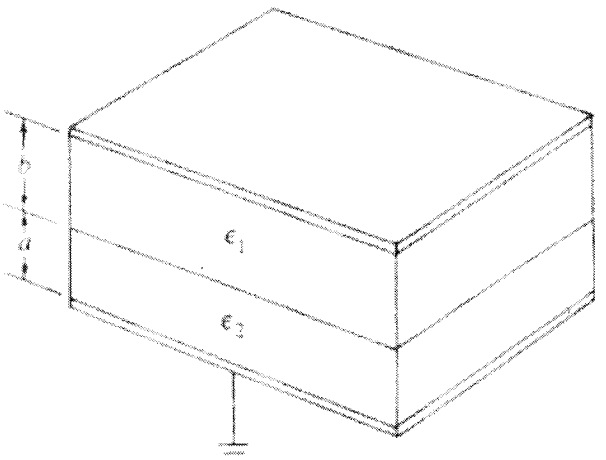


Fig 2.62

FIG4

END OF EE411 EXAM-JUNE 25, 2004
Enos Nsamba

GRADIENT, DIVERGENCE AND CURL

1.0 GRADIENT

$$\nabla V = \frac{\partial V}{\partial x}\mathbf{a}_x + \frac{\partial V}{\partial y}\mathbf{a}_y + \frac{\partial V}{\partial z}\mathbf{a}_z \quad \text{(cartesian)}$$

$$\nabla V = \frac{\partial V}{\partial r}\mathbf{a}_r + \frac{1}{r}\frac{\partial V}{\partial \phi}\mathbf{a}_\phi + \frac{\partial V}{\partial z}\mathbf{a}_z \quad \text{(cylindrical)}$$

$$\nabla V = \frac{\partial V}{\partial r}\mathbf{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\mathbf{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\mathbf{a}_\phi \quad \text{(spherical)}$$

DIVERGENCE

$$\nabla \cdot \mathbf{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z} \quad \text{(cartesian)}$$

$$= \frac{1}{r}\frac{\partial (rD_r)}{\partial r} + \frac{1}{r}\frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z} \quad \text{(cylindrical)}$$

"MSJOB 9"

CURL

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS 2004

SEMESTER I, JUNE 2004

EE 521 : ELECTRICAL MACHINES II

ANSWER : *Any FIVE (5) Questions*

TIME : *Three (3) hours*

QUESTION 1

a) i) Define the term "linear current density". ***(2 marks)***

ii) Show that linear current density "a" is given by:

$$a = g/\mu_o \, . \, dB/dx$$

defining all terms. ***(8 marks)***

b) An electrical machine with a uniform air gap has its stator winding supplied with a d.c. current, the resulting linear current density "a" being a function of angle θ such as to give a symmetrical 2-pole field. If the rotor has a distributed winding with full-pitch coils and speed of rotation is n, derive an expression for the induced voltage between two tapping points π apart (for $0 \leq \alpha \leq \pi/2$), defining all terms. ***(10 marks)***

QUESTION 2

a) i) Derive an expression for field current build-up in a separately excited field of a d.c. machine on switching on field to a constant supply V_f. Assume constant inductance. ***(6 marks)***

ii) Sketch the field current curve. ***(2 marks)***

iii) Show that the induced voltage in the armature builds-up in the same way as the field current ***(2 marks)***

b) i) Derive an expression for terminal voltage in a separately excited d.c. generator on switching on load stating any assumptions. ***(8 marks)***

ii) Sketch the terminal voltage curve ***(2 marks)***

QUESTION 3

a) i) Derive an expression for torque, T, in a 3-phase induction motor with a stator supply phase voltage V_s and a voltage V_{ex} injected into the rotor in terms of slip s, the ratio V_{ex}/V_s (a real number) and machine parameters. Define all terms and state any assumptions. ***(10 marks)***

ii) Determine the no-load slip s_o. ***(2 marks)***

b) Starting with the torque equation in a) i) above, show that the initial speed droop is given by:

$$-dn/dT = \frac{2\pi n_s^2 s}{3V_s^2}(R'_2 + eR_1)$$

State any assumptions ***(8 marks)***

QUESTION 4

a) State two (2) main differences between an induction machine and a synchronous machine. ***(4 marks)***

b) A 4-pole, 50-Hz, star-connected, 3-phase synchronous motor has negligible armature resistance, a synchronous reactance of 15 Ohms per phase and operates from a constant line voltage of 3300V. At rated load the motor takes a line current of 100A at a p.f. of 0.85 leading.

i) Sketch the phasor diagram ***(4 marks)***

ii) Calculate the load angle (δ) in electrical degrees ***(6 marks)***

iii) Calculate the torque for rated load ***(6 marks)***

QUESTION 5

a) i) Show that the torque of a salient pole synchronous motor is given by:

$$T = 3/2\pi n_s \left[V_s V_f / X_{sd} + V_s^2 \left(1/ X_{sq} - 1/ X_{sd} \right) \right]$$

defining all terms and stating any assumptions. ***(10 marks)***

ii) Why is a salient pole synchronous machine known as a "stiffer" machine? ***(4 marks)***

b) With the aid of an operating chart, describe three (3) main limits on the operating region of a synchronous generator. ***(6 marks)***

QUESTION 6

a) Define transformer efficiency. ***(2 marks)***

b) Show that efficiency in a transformer is a maximum when the variable I^2R loss is equal to the constant core loss. ***(8 marks)***

c) A 500-kVA, 11000V/415V transformer has the following parameters:

R1 = 0.42Ω, R2 = 0.0019Ω, Core loss = 2.9 kW ***(5 marks)***

i) Calculate the efficiency at full load 0.8 p.f.

ii) Determine the output at which the efficiency is maximum and calculate its value, assume p.f. of the load to be 0.8. ***(5 marks)***

QUESTION 7

a) i) State four advantages of three-phase transformers over single-phase transformers. ***(4 marks)***

ii) State two disadvantages of three-phase transformers over single-phase transformers. ***(2 marks)***

b) i) Define the term "inherent voltage regulation" in a transformer. ***(2 marks)***

iii) Show that the p.u. regulation is given by:

$$\text{Regulation p.u} = I_{p.u.}R_{p.u.}\cos\varphi + I_{p.u.}X_{p.u}\sin\varphi$$

defining all terms. ***(12 marks)***

QUESTION 8

ANSWER ALL

a) Discuss any five (5) considerations in design of an electromagnetic machine. ***(10 marks)***

b) Describe the power flow in an induction motor with the help of a clearly marked diagram. ***(5 marks)***

c) Explain why most transmission and distribution transformers are fitted with tap changers. ***(5 marks)***

END OF EXAMINATION EE 521

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPT. OF ELECTRICAL AND ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS
EE561-SYSTEMS AND CONTROL ENGINEERING-JUNE 2004.

TIME : **THREE HOURS**
ATTEMPT FIVE QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS

---

1. For a unity feedback system:
   Given:
   Loop transfer function: $L(s)= K/ ((1+a)S^2 + 2S +1)$
   Natural angular frequency: $\omega_n=2$ (rad./Sec.)
   Damping coefficient $\zeta=0.8$

   Question:
   Find the values of the parameters K and a. ***(20 Marks)***

2. The following characteristic equation is given:

   $$d(S)=S^4+S^3-S^2+5S+6=0 .$$

   Question:
   a) Judge the stability by applying the Routh`s Criterion.
   b) If it is unstable, find how many unstable poles there are and calculate them.
   (20 Marks)

3. Draw the Bode Diagrams for the transfer function given below:

   $$G(s)= 10*(1+2S) /S(S^2 + 2S +1)$$

   Question:
   a) Show the approx. straight line
   b) Synthesize all.
   (20 Marks)

4. The following stable loop transfer function for a unity feedback system given:

$$L(s) = K / S(S+1)(S+2)$$

Question:

a) Draw the Vector Locus, in case K=1 and K=6.

b) Find frequency at the intersecting point , Vector Locus and Real axis, when K=1, and calculate the gain margin.

(20 Marks)

5 For the unity feedback system, the loop transfer function is given:

$$L(s)= 100 /((0.2S +1)(S+5))$$

Find the steady state error (ε_p, ε_v, ε_a).

(20 Marks)

6. Given is the loop transfer function for the unity feedback system:

$$L(S)= 6K /S(S+15) .$$

Question:

For K=50, 100 and 200, find parameters:
T_r, T_s and A_p.

(20 Marks)

7. Explain all parameters as shown in Fig. Q7.:-

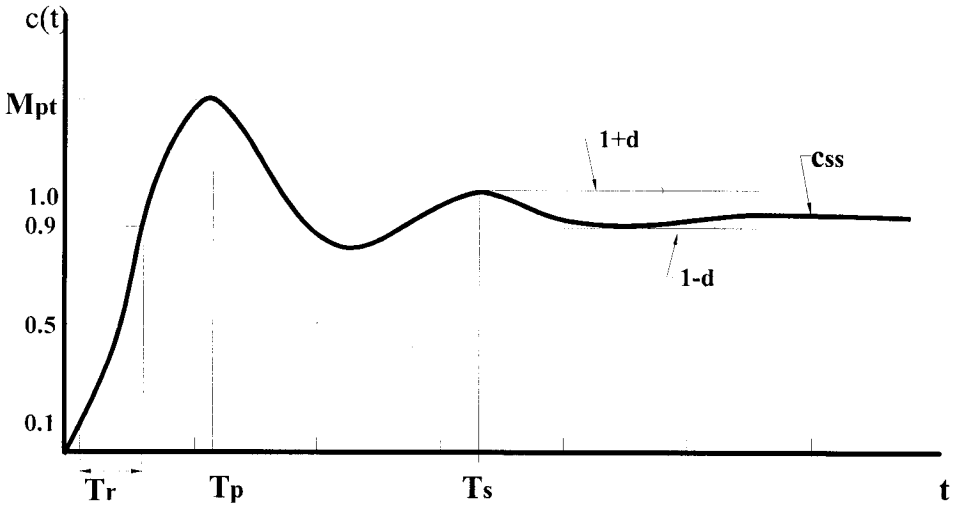


Fig Q7

(20 Marks)

8. Describe the purpose of the various terms found in the equation of a PID compensator (controller).

(Remark: Transfer function for a PID controller: $C(s)= Kp\ (1+ 1/ T_i S + T_d S)$)

(20 Marks)

END OF EE561 EXAMINATION JUNE 2004

Terumasa Iwakuma

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

UNIVERSITY EXAMINATIONS FOR FIRST SEMESTER
TUESDAY (PM) – 29TH JUNE 2004

ELECTRONICS (EE 431) & ELECTRONIC ENGINEERING I (EE441)

TIME ALLOWED: THREE (03) HOURS *TOTAL MARKS: 100*

ANSWER: THIS PAPER HAS EIGHT QUESTIONS. YOU MUST ANSWER ANY FIVE (05) QUESTIONS. EACH QUESTION CARRIES 20 MARKS AND THEIR BREAKDOWN ARE INDICTED IN ITALICS. USEFUL CONSTANTS & VARIABLES ARE GIVEN AT THE END OF THE QUESTION PAPER.

Q1.

A.

(i) **Identify two main sources of noise in electronic devices and discuss their origins.** *(4 marks)*

(ii) **Write brief notes on Recombination, Partition, Intermodulation and Flicker noise in electronic devices.** *(4 marks)*

(iii) **Define noise factor? Sketch a general graph showing variation of noise factor with frequency in an electronic amplifier (clearly explain how noise factor varies with amplifier operating frequency). In which region must an amplifier be operated and why?** *(4 marks)*

B. **An amplifier of effective resistance 10kΩ operates at a current of 5mA over a bandwidth of 20 MHz. If the amplifier is operating at room temperature, determine the square mean:**

(i) **Shot noise current.** *(4 marks)*

(ii) **Thermal noise current.** *(4 marks)*

Q2.

A. Operation of optoelectronic devices is based on interaction of light energy with electrons.

(i) **Name three devices in which light is absorbed to produce an electrical output and three devices in which light is generated due to an electrical input.** *(3 marks)*

(ii) **A photodiode is a p-n junction diode cased in a transparent cover. Detail the construction of a basic p-n junction photodiode and describe its operation.** *(3 marks)*

(iii) **Differentiate between a p-n and a p-i-n photodiode.** *(1 mark)*

(iv) **Describe the construction and operation of a basic direct-coupled optoisolator.** *(3 marks)*

B. An n-type silicon solar cell with donor density $10^{20}cm^{-3}$ is irradiated with visible light at room temperature that result in the generation of excess minority carriers of concentration $10^{10}cm^{-3}$.

(i) Determine the minority carrier concentration in the cell at time 1 μs after the light source is suddenly shut off. *(5 marks)*

(ii) Calculate the minimum light frequency at which the charge carrier pairs are generated in the cell. *(5 marks)*

Q3.

A. Fabrication of modern silicon bipolar junction transistors (BJT's) employs the planar process in which the device is formed only on one side of the silicon wafer as shown in figure 01 below.

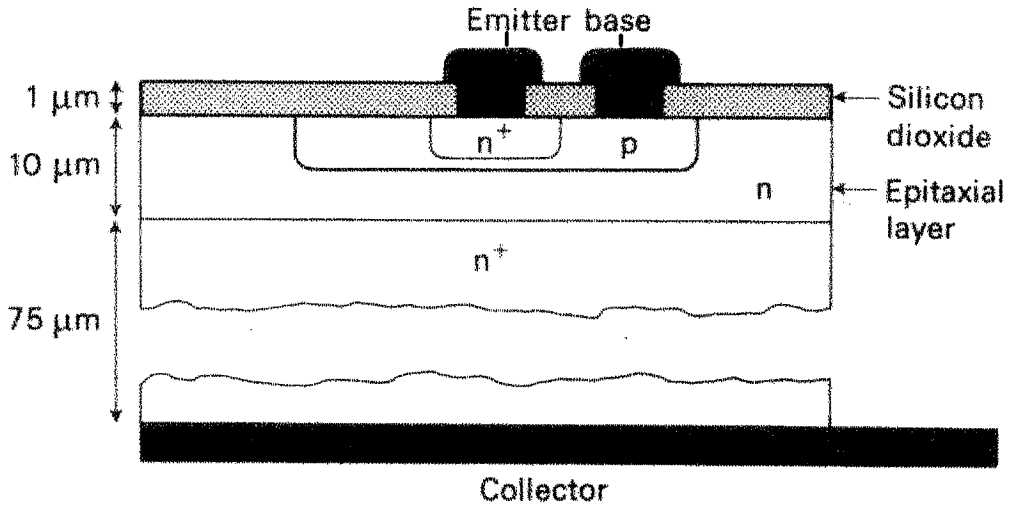


Figure 01. Sectional view of a planar process n^+-p-n silicon bipolar junction transistor

(i) Briefly describe the processes involved in fabricating the above BJT. *(3 marks)*

(ii) Name any two commonly used metals for interconnections in silicon BJTs and briefly discuss their merits or demerits. *(3 marks)*

(iii) In the above BJT what metal would you use for the emitter, base and collector contacts? Discuss the type of contact formed in each case. *(3 marks)*

(iv) Give any two reasons why silicon dioxide is preferably used in silicon devices processing? *(2 marks)*

B. An ideal n^+-p-n transistor has a current gain of 95 and is operated on a base current of 20 μA. The recombination time of charge carriers in the base is 0.1μs.

(i) Find the emitter current. *(3 marks)*

(ii) Determine the time taken by minority carriers to cross the base region. *(3 marks)*

(iii) Determine excess minority charge in the base. *(3 marks)*

Q4.

A. **A bipolar junction transistor (BJT) has several modes of operation subject to certain conditions. For a p^+-n-p transistor:**

(i) **Identify all the modes of operation and state junction(s) biasing polarities.** *(4 marks)*

(ii) **Detail or describe the electron and hole current components in the emitter, base and collector regions when the BJT is in transistor action.** *(5 marks)*

(iii) **It is given that P_{no} is the equilibrium minority carrier concentration in the neutral (or field free) base region whose width W is defined by $0 \le x \le W$. Determine minority carrier concentration $P_n(x)$ as a function of biasing voltage and operating temperature at the base boundary x = 0 and x = W, for all modes identified at (i) above.** *(4 marks)*

B. **A silicon p^+-n-p transistor has impurity concentrations $5\times10^{18}cm^{-3}$, $10^{16}cm^{-3}$ and $10^{15}cm^{-3}$ in the emitter, base and collector regions respectively. The transistor is operated at room temperature with the emitter-base junction forward biased to 0.5V and base-collector junction reverse biased to 5V. Calculate:**

(i) **The equilibrium minority carrier concentrations in the emitter, base and collector.** *(3 marks)*

(ii) **The minority carrier concentration at the edge of emitter-base junction.** *(2 marks)*

(iii) **The minority carrier concentration at the edge of the collector-base junction.** *(2 marks)*

Q5.

A. **The concept of crystal formation is central in the development semiconductor electronics.**

(i) **Discuss forces that hold atoms in their respect positions to form the crystal structure?** *(3 marks)*

(ii) **Discuss any two important bonds in electronic engineering materials naming an example for each case.** *(3 marks)*

(ii) **Briefly discuss the origins and nature of any two types of charge carrier scattering in a semiconductor crystal.** *(4 marks)*

B. **When doping silicon, both acceptor and donor impurities may be added until the desired semiconductor composition is obtained. Calculate the majority and minority carrier concentrations at room temperature in silicon doped with the following impurities: (Assume all impurities are ionised and clearly state the type of semiconductor obtained. N_d and N_a are donor and acceptor impurity atom concentrations respectively).**

(i) $N_d = 10^{18}\,cm^{-3}$, $N_a = 10\,cm^{-3}$ *(2½ marks)*

(ii) $N_d = 10^{20}\,cm^{-3}$, $N_a = 10^{20}\,cm^{-3}$ *(2½ marks)*

(iii) $N_d = 10\,cm^{-3}$, $N_a = 10^{14}\,cm^{-3}$ *(2½ marks)*

(iv) $N_d = 0$, $N_a = 0$ *(2½ marks)*

Q6.

A. Silicon is the most widely used raw material for manufacture of present day electronic devices and this eptomised by so many 'Silicon Valleys and Parks' worldwide.

(i) Briefly discuss quantum numbers that completely describe the electronic structure of a silicon atom and state the limiting principle. *(2½ marks)*

(ii) Determine the electronic configuration of a silicon atom. *(1 mark)*

(iii) Using the electronic configuration obtained in (ii) above, explain the formation of energy bands in a silicon crystal composed of Y number of atoms where Y is a very large number. *(5 marks)*

(iv) Using the concept developed in (iii), describe a metallic conductor, semiconductor and insulator. *(1½ marks)*

B. In a pure silicon crystal specimen:

(i) Discuss conditions that determine whether electrons obey Fermi-Dirac and Maxwell-Boltzmann statistics. *(4½ marks)*

(ii) Determine chances of a Fermi-Dirac electron and Maxwell-Boltzmann electron appearing in the conduction band at room temperature. *(3½ marks)*

(iii) Compare the nature of conduction in metals with that taking place in semiconductors. *(2 marks)*

Q7.

A. Briefly discuss the following:

(i) The concept and consequence of effective mass of charge carriers in a semiconductor. *(2 marks)*

(ii) Drift current in a semiconductor specimen to which an external a low electric field is applied. *(2 marks)*

(iii) Origin and nature of diffusion current in a semiconductor specimen. *(2 marks)*

(v) Any three commonly used semiconductors in respect of their production methods and device fabrication suitability. *(6 marks)*

B. Electrons are injected into one end of a bar of p-type silicon at room temperature. The initial concentration of excess electrons is $10^{24}\,m^{-3}$. Determine the distance along the bar at which the

minority carrier concentration drops to half its equilibrium value. *(8 marks)*

Q8.

A. There are several methods used to introduce controlled amounts of dopants into semiconductors.

(i) Briefly describe any two of these doping methods. *(4 marks)*
(ii) How can pure GaAs be converted into n-type and p-type semiconductor materials? *(4 marks)*
(iii) Distinguish between an intrinsic and degenerate semiconductor. *(2 marks)*

B. When static characteristics of a transistor are not known a popular means of deriving them is to make use of the Ebers-Moll Transistor Model.

i. Sketch the general circuit model labeling it appropriately *(4 marks)*
ii. Using the model at (i) derive expressions for emitter, collector and base currents as a function of biasing voltages and operating temperature*(6 marks)*

END OF EXAMINATION

LIST OF USEFUL CONSTANTS AND VARIABLES

1. Boltzmann constant $= 1.38\times10^{-23}\,JK^{-1}$
2. Electronic charge $= 1.602\times10^{-19}\,C$
3. 1 electron volt $= 1.602\times10^{-19}\,J$
4. Room temperature $= 27^{\circ}C$
5. Silicon intrinsic carrier concentration $= 1.5\times10^{16}\,m^{-3}$ at room temperature
6. Lifetime of electrons in silicon $= \sout{10\mu s}$ 0.1 ms
7. Silicon energy gap = 1.12eV at room temperature & 1.16eV at 0K
8. Absolute Temperature $= -273^{\circ}C$
9. Planck's constant $= 6.63\text{x}10^{-34}\,Js$
10. Speed of light $= 3.0\times10^{8}\,m/s$
11. Silicon atom atomic number = 14
12. Electron mobility in silicon = 1450 $cm^2V^{-1}s^{-1}$
13. Assume room temperature if not specified.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS
EE581 : Telecommunication Theory

TIME : 3 hours
ANSWER : Any five questions
TOTAL MARKS : 100

Q1. (a) What is convolution ? Show that convolution of two signals in time domain corresponds to the multiplication of their Fourier transforms in the frequency domain.

(b) Find the Fourier transform of a rectangular pulse. Sketch the amplitude and phase spectrum. Comment on them.

(c) What is Dirac delta function ? State its properties.

(d) Show a two message communication system. The messages are m_0 and m_1. The received bits are r_0 and r_1. Develop an algorithm for an optimum receiver.

Apply the optimum receiver algorithm to the case $P(m_0) = 0.7$, $P(m_1) = 0.3$, $P(r_0 | m_0) = 0.9$, $P(r_1 | m_0) = 0.1$, $P(r_0 | m_1) = 0.4$, $P(r_1 | m_1) = 0.6$. $P(m_0)$, $P(m_1)$, $P(r_0 | m_0)$ etc. are the probability terms, which have their usual meanings.

Calculate also P(c) and P(e), where P(c) is the probability that a correct determination will result and P(e) is the probability of an error.

[3+7+3+7]

Q2. (a) Discuss a frequency domain model for an aperiodic power signal x(t). Show the detailed derivation of its power spectral density. What is Wiener - Khintchine Theorem ?

(b) Consider a random process X(t). Discuss in detail its stationarity, time averages and ergodicity with necessary mathematical expressions.

(c) The input to a binary communication system, denoted by a random variable X, takes on one of two values 0 or 1 with probabilities 2/3 and 1/3, respectively. Due to errors caused by noise in the system, the output Y differs from the input X occassionally. The behaviour of the communication system is modeled by the conditional probabilities.

$P(Y = 1 \mid X = 1) = 3/4$ and $P(Y = 0 \mid X = 0) = 7/8$

(i) Find $P(Y = 1)$ and $P(Y = 0)$ (ii) Find $P(X = 0 \mid Y = 0)$.

[8 + 6 + 6]

Q3. (a) Discuss briefly the Markoff's statistical model for information sources. Present a discrete Stationary Markoff source in a graph form. The source emits one of three symbols A,B,C. The state transition and symbol generation can also be illustrated using a tree diagram for the source. Show the procedure for calculating the probability of generating various symbol sequences taking an example, say the symbol sequence AB. Make any necessary assumptions.

(b) Consider a telegraph source having two symbols, dot and dash. The dot duration is 0.2 second. The dash duration is 3 times the dot duration. The probability of the dot's occurring is twice that of the dash, and the time between symbols is 0.2 second. Calculate the entropy and the information rate of the telegraph source.

(c) A CRT terminal is used to enter alphanumeric data into a computer. The CRT is connected to the computer through a low pass communication channel with a usable bandwidth of 3000 Hz and an output S/N of 10 dB. Assume that the terminal has 128 characters and the data sent from the terminal consists of independent sequences of equiprobable characters.

(i) Find the capacity of the channel

(ii) Find the maximum (theoretical) rate at which data can be transmitted from the terminal to the computer without errors.

[9 +5 + 6]

Q4 (a) What is Hamming's distance ? Calculate the Hamming's distance of a code for correcting triple errors. How many errors it can detect ?

(CONTINUED IN PAGE 2)

Q4. (b) The generator matrix for a (6,3) block code is given below.

$$G = \begin{bmatrix} 100110 \\ 010100 \\ 001011 \end{bmatrix}$$

Find the code for the message blocks D = (111) and D = (011). Show the procedure for the computations.

(c) What do you mean by error syndrome ? Show that the syndrome of a received vector R is zero if R is a valid code vector.

(d) Calculate the syndrome if the received vector in a (7,4) block code is R = (1001001). The parity check matrix H is given as

$$H = \begin{bmatrix} 1110100 \\ 1101010 \\ 1011001 \end{bmatrix}$$

If a single bit is in error, determine which bit ? Write down the transmitted code vector.

[4 + 6 + 5 + 5]

Q5. (a) Draw a schematic diagram to show the Hosts and IMP's in a computer communication network. Discuss the functions of Hosts and IMP's. Show the modular design of a host using the ISO/OSI architecture. What is a communication subnetwork ?

(b) Define: (I) Protocol (ii) Peer processes (iii) Network architecture

(c) Explain circuit switching, message switching and packet switching. Compare them.

(d) What are SAPs (Service Access Points) ? Show the interface, layers and SAPs in a suitable diagram. Show the Interface Data Unit (IDU) in the diagram. What are Protocol Data Units ? What are the SAP addresses in FM radio broadcasting ?

[5 + 3 + 5 + 7]

Q6. (a) Explain the principles of Pulse Code Modulation (PCM). Draw the block diagram of a PCM system. Explain the diagram.

(b) What is a T1 carrier ? Show a T1 frame in a suitable diagram.

(c) What are T2. T3, T4 and T5 carriers ? Show the Bell System TDM-PCM telephone system.

(d) Discuss thermal noise. What is white noise ? Comment on white noise.

[6 + 5 + 4 + 5]

Q7. (a) Present pure and slotted ALOHA protocols. Deduce the throughput relations for both. Show the throughput versus offered traffic characteristics for ALOHA systems. State their effeciencies.

(b) Explain the CSMA protocols. Show the throughput versus offered traffic characteristics for different CSMA protocols and ALOHA protocols in the same diagram. Compare them.

(c) A group of N stations share a 56-kbps pure Aloha channel. Each station outputs a 1000-bit frame on an average of once every 100 second, even if the previous one has not been sent (e.g., the stations are buffered). What is the maximum value of N ? If the channel was a slotted ALOHA instead of pure ALOHA, find the maximum value of N when all the other conditions remained the same as before.

[8 + 7 + 5]

Q8. Write short notes on any four:

(a) Spectrum Analyzer (b) DQDB (c) Virtual communication between peer layers in a computer network (d) Gaussian probability density function (e) ASK and FSK

(f) ISO/OSI and TCP/IP reference models (g) Scaling-uncertainty principle.

[20]

END OF QUESTION PAPER.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

SEMESTER I FINAL EXAM – JUNE 2004

EG 211 WORKSHOP TECHNOLOGY

TIME: **THREE (3) HOURS ALLOWED** **CLOSED BOOK**

ANSWER: SECTIONS A, B, C, D AND E **AS STATED**

NOTE: **EACH SECTION SHOULD BE ANSWERED IN A SEPARATE ANSWER BOOKLET CLEARLY LABELED AS SECTION A, B, C, D, or E**

SECTION A: AGRICULTURAL ENGINEERING **ANSWER: Question 1**

Question 1

a) Given a Massey Ferguson tractor with the following specifications

Engine Specifications:

Make/type	Perkins/A4.248
Number of cylinders	6
Bore	101.0mm (3.975 in)
Stroke	127.0mm (5.0 in)
Compression ratio	16.0:1:

(i) Determine:

a) The piston displacement
b) The total cylinder volume
c) The engine displacement [6 Marks]

(ii) What is the purpose of the following engine parts:

(a) a cam shaft
(b) a flywheel
(c) radiator
(d) governor
(e) carburettor
(f) alternator [6 Marks]

b) Sketch the operation of a four-stroke cycle petrol engine, explaining the events in each stroke at every stage? [8 Marks]

SECTION B: CIVIL ENGINEERING

ANSWER: Question 2 OR Question 3

Question 2

a) Suppose that you are working for a civil engineering consultancy firm and you are designing a building. Discuss how you would protect the door and window frames from being crushed by the wall above them. [5 Marks]

b) Mention two reasons for adding coarse aggregate when making concrete. [3 Marks]

c) Give two basic requirements of roof coverings. [2 Marks]

d) Why is coarse aggregate added to sand and cement when making concrete? [4 Marks]

e) With the aid of a sketch, distinguish between a beam and a column [4 Marks]

f) What is a pitched roof? [2 Marks]

Question 3

a) You are working at the New Computer Science building site at the University of Zambia. Two batches of concrete, with mix ratios of 1:2:4 and 1:3:5, have been delivered to you by a firm which makes concrete. One of the mixes is supposed to be for the **wall** and the other for the **floor (slab)**. You have misplaced the drawings and are wondering where to use each batch.

i) Which batch will you use for each purpose? [3 Marks]

ii) Give the reason(s) for your answer in (i) above [4 Marks]

b) Explain (briefly) the need to have an eave in a roof? [3 Marks]

c) Give the reason for using clean sand when making concrete. [2 Marks]

d) What is the function (s) of wall plates? [3 Marks]

e) Does concrete lose strength when sand and cement separate in already mixed concrete? [2 Marks]

f) What is the dual function of ceiling joists? [3 Marks]

SECTION C: ELECTRICAL ENGINEERING

ANSWER: Question 4

Question 4

a) I) Define the following terms as used in earthing practice:

i) Circuit Protective Conductor (CPC).

ii) Solidly Earthed.

iii) Earthing Conductor.

II) State three main functions of earthing. [5 Marks]

b) I) Draw a diagram of a three-core power cable, labeling all the essential parts.

II) Describe the function of each of the parts labeled in (I). [5Marks]

c) Define what failure rate is and give its mathematical expression. [4 Marks]

d) Draw a graph of classification of electrical components, and list two sub-classifications under each main classification. [6 Marks]

SECTION D: GEOMATIC ENGINEERING

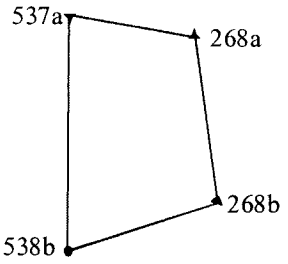
ANSWER: Question 5 or Question 6

Question 5

The points listed below were identified during a recent survey as suitable control points for the subsequent Cadastral survey of three small plots in the same area.

Table 1.

	Coordinates	
Point	*Y (m)*	*X (m)*
268a	637581.818	8297292.464
268b	637632.098	8297334.494
537a	637588.973	8297263.330



Bearing in mind that bearings in the Zambian cadastral system are measured with reference to the south, compute the following:

a) The distances and bearings of lines **537a – 268a and 268a – 268b**. Give bearings in both the sexagesimal (degrees, minutes and seconds) and the centesimal systems.
b) The coordinates of point **538b**, given that the clockwise angle **268a – 268b – 538b** and horizontal distance from **268b** are 261 40'08'' and 28.114m, respectively.
c) Describe the survey operations carried out in (a) and (b) [6+10+4 Marks]

Question 6

Explain the following and where applicable use diagrams in aid of your explanation.

a) the seven disciplines that make up Geomatics
b) the two major branches of surveying
c) whole Circle bearing (WBC) [8+4+6+2 Marks]

SECTION E: MECHANICAL ENGINEERING

ANSWER: Question 7 or 8

Question 7

a) Discuss risks associated with factory work environments.
b) What are the responsibilities associated with each one of the under-listed personnel or institution with respect to the provision of safe working conditions in factories:
   (i) Government
   (ii) Management
   (iii) Employees [20 Marks]

Question 8

Give an outline of the following workshop metal removal processes. Your answer should include clearly labelled sketches to illustrate the various processes.

(i) Turning
(ii) Milling
(iii) Drilling [20 Marks]

END OF EXAM

University of Zambia
School of Engineering
Department of Geomatic Engineering

2004 Academic Year First Semester Examinations
GE 321: Cartography I

Time Allowed: Three (3) hours
Answer: All questions in Part **A** and **One** in Part **B**

Part A

Question One

Explain briefly the following cartographic terms:

(a) Graphicacy
(b) Graticule
(c) Abscissa
(d) Indicatrix
(e) Dimensional stability

[5 + 5 + 5 + 5 + 5]

Question Two

Majority of the maps form part of a series, which therefore means that they must have identification marks.

(a) What are the three different sheet-numbering systems in common use?
(b) Briefly explain each of these systems.
(c) What is the sheet number for a 1:50,000 map covering the proposed site for the transmitter for Radio Zambezi FM in Livingstone if its geographical coordinates are $\varphi = 17^{\circ}35'$ S and $\lambda = 25^{\circ}35'$ E?

[6 + 15 + 4]

Question Three

There are three common surfaces that are used to come up with a projection in a traditional way.

(a) What are the other three mathematically constructed projection surfaces?
(b) Explain the 'two-step-evolution' idea used in coming up with a map projection in a traditional way.
(c) What projection did the Zambia Survey Department employ when constructing the basic map series of Zambia?

[9 + 12 + 4]

Good Luck and Happy Semester Holidays!! *Thursday, 24th June 2004*

Part B

Question Four

(a) There are three recognised levels of transformation of the earth's surface within which different amounts of generalisation take place; namely primary, secondary and tertiary. Explain each of the named three levels and show how much generalisation takes place in each of them.

(b) Cartographic generalisation is also affected by source material and symbol specification among other things. Explain how these two factors affect cartographic generalisation.

[15 + 10]

Question Five

You are in a reproduction unit, which is equipped with a process camera, a contact printer, a diazo copier and a copy proof system (max. size A3). In stock you have wash-off and diazo materials as well as photographic copying materials plus all the necessary chemicals. A customer has brought you an ordinary printed map (size: 50 cm by 50cm) to produce for him a transparent Right Reading (RR) copy at an appropriate scale you will suggest to the customer.

Describe what should be done to produce the product your customer desires.

[25]

End of Examination

The University of Zambia
School of Engineering
Department of Geomatic Engineering
2004 Academic Year First Semester
Final Examination
GE371: Surveying I

Time : 3 hrs
Marks : 100
Instructions: Answer Any four (4) Questions

Question 1 [3, 3, 6, 8, 5]

a. State three horizontal plane coordinate systems that are used in Zambia?
b. Why is it important to start the traverse from known horizontal control points?
c. Mention any three sources of errors and how to minimize or eliminate them in point positioning.
d. Define the following terms
   i) datum
   ii) taping in catenary
   iii) misclosure in levelling
   iv) contour/vertical interval (CI)
e. A baseline precisely known to be 100.000m long was measured by a tape with nominal length of 50m. The measured length of the baseline was found to be 0.045m shorter than what is known. What is the actual length of tape?

Question 2 [7,9,9]

In order to survey a section of an existing road, three points A, B and C on the centreline of a circular curve were chosen. A theodolite was set at A from which readings as shown in the table below were taken to a staff held on point B and then on C.

Staff Position	Staff Readings U M L	Vertical Circle Readings	Horizontal Readings
B	1.691, 1.233, 0.774	91° 11′ 20″	00° 00′ 00″
C	2.184, 1.524, 0.862	92° 26′ 00″	2° 30′ 00″

The height of the instrument was 1.475m above A and the instrument constants are 100 and 0. Calculate

a. the distances to A and B
b. the height difference between A and B & B and C (state which point is highest)
c. the coordinates of C if A has coordinates (100,100) and that the horizontal reading to C is taken as a bearing.

Hint: Take into consideration the effects of curvature and refraction where necessary.

Question 3 [2,3,20]

a. Why is it important to have the levelling instrument almost half way the levelling stalves?

b. State the two errors and their effects (values) that should be considered for longer line of sights in levelling.

c. A levelling loop was run around a particular site for vertical control works. Points 1 to 4 are to be established with pegs while points 3A to 3D are cross sectional points on the road where a cross section has to be made. The distances of the points from the centre line are indicated in the remarks column in the table 1 below. Use any of the two methods for reductions.

Point	BS	IS	FS	Distance		Remarks
				BS	FS	
BM	1.576			49.6		1200.000m
1	2.010		0.894	46.8	49.1	CP
2	1.097		1.131	38.3	47.4	
3	1.045		1.786	30.1	38.2	
3A		3.268				-6m
3B		2.187				-3m
3C		2.240				+3m
3D		3.339				+6m
4	0.962		1.179	65.6	39.5	CP
BM			1.712		56.1	

Table 1

i) Carry out the necessary computations and checks.

ii) Calculate the misclosure of the loop and state whether it is acceptable or not (assume σ =20mm).

iii) Adjust the levelling loop.

NB: Booking forms are on the last page

Question 4 [15,10]

a.

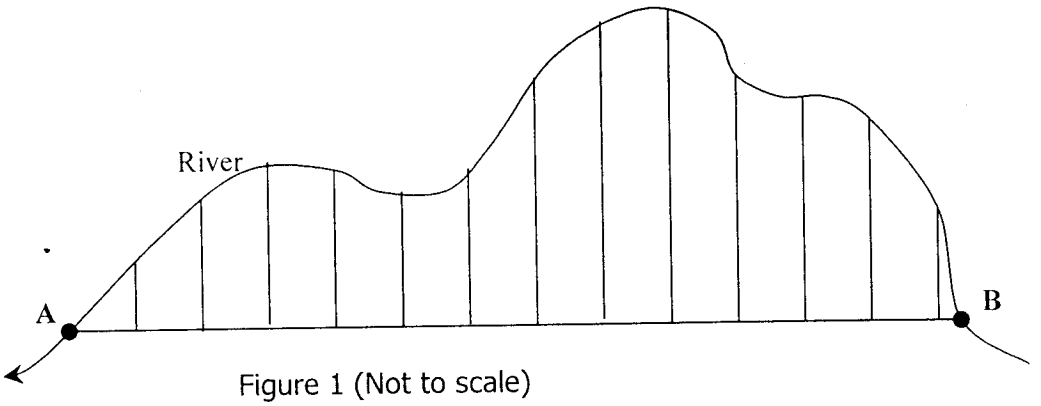


Figure 1 (Not to scale)

Chainage from A (m)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	66.5
Offsets (m)	0	2.6	3.9	4.2	4.1	3.9	4.0	6.0	6.6	6.9	5.9	5.7	5.5	3.4	0

Table 2

Figure 1 shows a river boundary surveyed by the method of perpendicular offset measurements from a straight line AB. Table 2 shows the chainage from point A to point B and the offsets at each chainage. Calculate the area by either trapezoidal method or Simpson's rule.

b. Figure 2 below shows describes a levelled gridnet of 5m squares. Excavation for a building at the indicated position (with continuous lines) is to be carried out to the level of 35m above datum. The values that are indicated are reduced levels for the grid points. Calculate the volume of earth to be excavated.

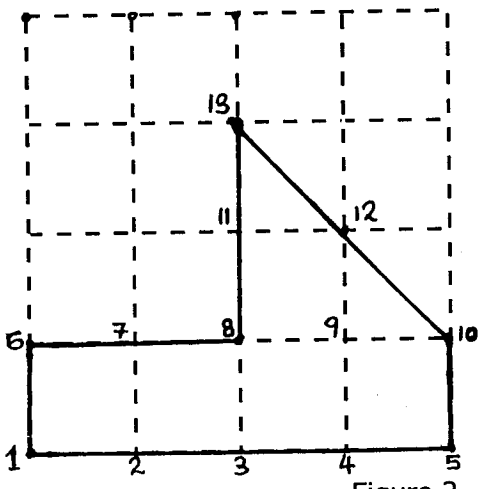


Figure 2

Grid point No.	R levels
1	36.90
2	36.80
3	36.75
4	36.70
5	36.50
6	37.10
7	36.90
8	36.70
9	36.75
10	36.76
11	37.25
12	36.85
13	36.95

Question 5 [25]

A small traverse according to figure 3 below was run between points ~~UZ1~~ UZ5 and ~~UZ2~~ UZ3 to coordinate points A and B. The measured angles and distances are shown in the table below. You are required to

a. determine and adjust
   i. angular misclosure
   ii. linear misclosure
b. determine relative accuracy of the traverse
c. determine the new coordinates

Hint: show your working and use the traverse form provided.

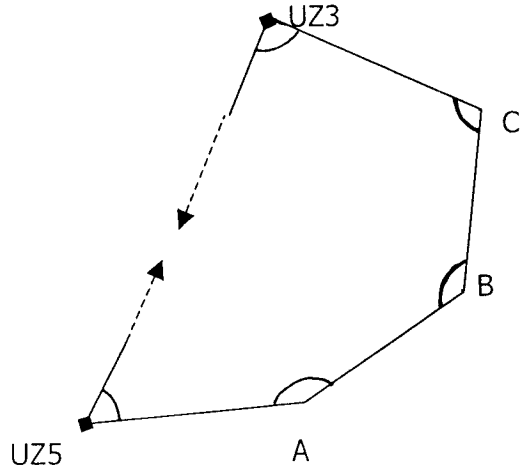


Figure 3

Point	Y	X
UZ3	3101.863	8040.530
UZ5	2845.241	7711.598

Station	Inside Angle	Distance (m)	
UZ 5	50° 25′ 48″		
A	156° 02′ 12″	UZ5-A	157.301
B	122° 21′ 27″	A-B	152.923
C	148° 24′ 45″	B-C	140.264
UZ3	62° 46′ 34″	C-UZ3	131.320

End of Exam
Wishing You a Nice Semester Break!

Qn. 2 3

Computer No:.....

Rise and Fall Method

Pt.	Readings			Distance		Ht. Diff		Reduced Level	Adj.RLs	Remarks
	BS	IS	FS	BS	FS	Rise	Fall			

Height of Collimation Method

Pt.	Readings			Distance		Instrument Height	Reduced Level	Adj.RLs	Remarks
	BS	IS	FS	BS	FS				

For Question 5

Computer No:.....

TRAVERSE COMPUTATION FORM

Date:.....Venue:.....

Stn Pnt	Angles			Bearing			Hor. Dist.	COORDINATE DIFFERENCES						CORDINATES	
								Computed		Corrections		Adjusted			
	°	′	″	°	′	″		ΔY	ΔX	δY	δX	ΔY	ΔX	Y	X

The University of Zambia
School of Engineering
Department of Geomatic Engineering

2004 Academic Year First Semester
Final Examinations

GE 411: Error Analysis and Network Adjustment

Time: Three hours
Instructions:
Part A (Questions 1-3) - **Answer All** questions.
Part B (Questions 4-5) - **Answer One** of the questions.
Total: 100

Part A

Question 1 (12+5+5+3)

Point	**Local System**		**Reference System**	
	y(m)	x(m)	Y(m)	X(m)
100	569.77	814.19	6661.91	5843.35
101	814.44	336.52	6924.59	5376.11
102	711.12	701.16	6807.38	5735.84
103	604.08	483.55	6708.85	5514.51
104	655.51	655.51		

A cadastral survey has been conducted in a local coordinate system in which the coordinates of point 104 have been determined. It is required to determine the coordinates of this point in the reference system.

There are four points common to both coordinate systems, so the Helmert transformation parameters can be calculated using Least Squares Adjustment.

a) Determine the least squares estimate of the transformation parameters between the local system and the reference system.
b) Calculate the co-ordinates of point 104 in the reference system.
c) What are the differences between Helmert transformation and Affine transformation concerning the number of parameters and the minimum number of common points required in the different coordinate systems (in the two-dimensional case)?
d) When would one use Affine transformation instead of Helmert transformation?

Question 2 (8+5+12)

a) Give a description of the following terms, include appropriate sketches:
   i) Great circle ii) Spherical triangle
   iii) Lune iv) Spherical excess

b) State the Napier's rule and draw a sketch.

c) An aeroplane flies from a place A on the equator along a great circle, which makes an angle of 60° with the equator.
   (i) Find the difference in longitude of A and the place B on the path of the aeroplane where it reaches the latitude 30°N for the first time.
   (ii) Find also the area included by the path of the aeroplane, the meridian through B and the equator, giving your answer to three significant figures (take R=6360km).

Question 3 (7+2+8+8)

a) Describe the two techniques of least squares adjustment namely adjustment of observations only and adjustment of indirect observations, include their respective models.

b) A triangular piece of land has all three of its interior angles observed using a second theodolite. These three angles including their respective standard deviations are tabulated below:

	Observed Angle	**Standard Deviation**
θ_1	$56°21'32''$	$1''$
θ_2	$49°52'09''$	$2''$
θ_3	$73°46'28''$	$3''$

   (i) Compute the number of redundancies in the underlying model.
   (ii) Compute the least squares estimates for the three angles.
   (ii) Compute the standard error of the least squares estimate of the respective angles.

Part B

Question 4(6+6+3+10)

a) Define the following terms
   (i) Square matrix (ii) Triangular matrix
b) Define an orthogonal matrix and state at least two of its properties.
c) Given below is a set of normal equations obtained during an adjustment of a levelling net.

$$\begin{aligned} 8v_1 + 4v_2 + v_3 &= -8 \\ 4v_1 + 10v_2 + 3v_3 &= -4 \\ v_1 + 3v_2 + 7v_3 &= 5 \end{aligned}$$

(i) Write the above system of equations in matrix format.
(ii) Solve the resulting equations by Choleski decomposition (show all the steps).

Question 5 (6+2+2+10+5)

a) Describe briefly how to adjust a trialateration network using variation of coordinates.
b) What is the effect of weights on any least squares adjustment results?
c) What does it mean when it is said that a matrix is invertible?
d) Use Gauss-Jordan elimination to find the inverse, A^{-1} of matrix A.
   Given

$$\mathbf{A} = \begin{bmatrix} -1 & 1 & 2 \\ 3 & -1 & 1 \\ -1 & 3 & 4 \end{bmatrix}$$

e) From the result in (d) show that $\mathbf{A}^{-1}\mathbf{A} = \mathbf{I}$.

END OF EXAMINATION QUESTIONS

University of Zambia
School of Engineering
Department of Geomatic Engineering

2004 Academic Year First Semester Examinations
GE 422: Cartography II

Time Allowed: Three (3) hours
Answer: All questions in Part **A** and **One** in Part **B**

Part A

Question One

Explain briefly the following cartographic terms:

(a) Supportive content of the map
(b) Colour cube
(c) Visual variable texture
(d) Map projection aspect
(e) Extension map inset

[5 + 5 + 5 + 5 + 5]

Question Two

(a) The scale of the map is the ratio of the distance on the map to the actual distance on the ground. List any three factors that need to be considered in choosing a map scale.
(b) How does the scale of the map influence positional accuracy?
(c) A map projection is a systematic portrayal of the earth's curved surface upon a plane. List any three factors that need to be considered in choosing a map projection.

[9 + 7 + 9]

Question Three

(a) Munsell and Ostwald are two of the common colour matching systems upon which some colour charts are based.
   i) What is a colour matching system?
   ii) What is a colour chart?
(b) Some phenomenon may be described or measured using the ration and interval scales which give specific amounts about that phenomenon. Briefly explain what ratio and interval measurement scales are giving two examples of each in the process.

[10 + 15]

Part B

Question Four

Map layout is the spatial arrangement of the various map elements that make up a map.

(a) Briefly describe visual balance and contrast as map layout goals.

(b) List and briefly describe three main types of map layout.

[10 + 15]

Question Five

(a) Cartographers use type to communicate some aspects of a map because it symbolizes the human voice. What are the four basic variations of type?

(b) The selection criterion of type depends on legibility of the typeface, reproduction capabilities and nature of the information to be presented. Briefly describe each of the list type selection criteria items.

[10 + 15]

End of Examination

University of Zambia
School of Engineering
Department of Surveying

2004 First Semester University Examinations
GE 441 -Geodesy I

Time : 3 Hrs
Answer all questions.

Q1. (6 + 5 + 5 + 4)

a) Describe three classical triangulation figures used to establish a network

b) Describe the general procedure for establishing a control network for the first time using classical methods.

c) How can scale and azimuth be maintained in a horizontal control network?

d) Describe the Shoran and Hiran methods of trilateration

Q2. (5 + 7 + 3+5)

a) The movement of a body in space is described by the three Keplerian Laws. What does Kepler's Third Law state? Explain its meaning.

b) Using a sketch, define the orbital geometry, mentioning all the parameters of the orbit with regard to the Earth – satellite system.

c) Discuss the term relative point positioning using GPS.

d) Discuss the four advantages of satellite surveying methods compared to conventional terrestrial surveying methods.

Q3. (6 + 5+5+4)

a) Two coordinate systems are employed in astronomical geodesy, these are the star-fixed equatorial system and the horizon system. Using a sketch, describe the horizon coordinate system.

b) Define the six elements of an astronomical triangle. Use a sketch in your answer.

c) Explain hour you would obtain the hour angle of the sun. Write the relevant formula explaining the parameters.

d) What do you understand by mean solar day and sidereal time?

Q4. (4+ 6)

(a) The latitude of ZT31 is 15° 32′ 15″S and its longitude is 28° 45′ 06″E. Compute the mean radius of curvature for this point on WGS84 1880 ellipsoid with a = 6378137.0, and 1/f = 298.257

(b) Express the above coordinates in Cartesian coordinates given the above reference ellipsoid. The orthometric height of ZT31 is 1278.096m.

Q5. (4+ 6)

(a) List the main features of precise levelling instruments (staves and levels)

(b) Describe six sources of errors in levelling

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF GEOMATIC ENGINEERING

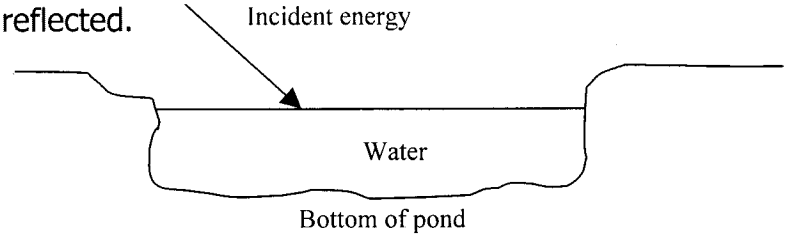
2004 ACADEMIC YEAR FIRST SEMESTER EXAMINATION
GE 461: REMOTE SENSING

TIME: THREE HOURS
INSTRUCTIONS: ANSWER **ALL** QUESTIONS IN SECTION A AND **ONE** QUESTION IN SECTION B

SECTION A

Question 1 (12+8+5 points)

(a) Explain with the help of a diagram, the process that the radiation from the Sun may take before being recorded by a sensor such as MSS.
(b) Explain the remote sensing phenomena that occur when the sky appears blue or reddish?
(c) Compute the total amount of energy reflected from the pond shown below if 30% of the energy incident on the water surface is reflected, 10% is absorbed, 60% is transmitted, and 20% of what hits the bottom of the pond is reflected.



Question 2 (10+7+8 points)

(a) Define the following remote sensing terms:
  (i) Ground pixel size
  (ii) Repeat cycle
  (iii) Revisit time
  (iv) Sun synchronous orbit
  (v) Spatial resolution
(b) Explain with an example why the repeat cycle is not necessarily the same as the revisit time.
(c) Ground pixel size is not equal to spatial resolution. Explain.

Question 3 (15+10)

(a) With illustrations, show how an image with DN values ranging from 25 to 180 would be enhanced using
  (i) Linear contrast stretch
  (ii) Histogram equalisation
(b) Compare and contrast density slicing and image classification.

SECTION B

Question 4 (6+15+4 points)

(a) List three major differences between optical and microwave remote sensing.
(b) Explain the following terms: foreshortening, layover, shadow, and speckle. How do these constrain the visual interpretation of radar images?
(c) What kind of processing is necessary to prepare radar images for interpretation? Which steps are obligatory and which are optional?

Question 5 (10+10+5 points)

(a) Explain the terms image space and feature space in relation to digital image classification.
(b) Explain the principle of digital image classification.
(c) What is a classification algorithm? Give two examples.

Question 6 (15+5+5 points)

(a) The success of image classification is usually assessed using the error (or confusion) matrix. Explain the table below and compute the individual and overall accuracies.

Classification data	Reference data						
		Water	**Sand**	**Forest**	**Urban**	**Maize**	**Hay**
	Water	226	0	0	12	0	1
	Sand	0	216	0	92	1	0
	Forest	3	0	360	228	3	5
	Urban	2	108	2	397	8	4
	Maize	1	4	48	132	190	78
	Hay	1	0	19	84	36	219

(b) What are the main problems in digital image classification?
(c) How can you solve these problems?

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF GEOMATIC ENGINEERING

2004 ACADEMIC YEAR FIRST SEMESTER EXAMINATION
GE 561: PRINCIPLES OF GIS/LIS

TIME: THREE HOURS
INSTRUCTIONS: ANSWER **ALL** QUESTIONS IN SECTION A AND **ONE** QUESTION IN SECTION B

SECTION A

Question 1 (10+10+5 points)

(a) What is spatial referencing? Give three examples of the spatial referencing items you can find on the Zambian 1:50,000 scale topographic map.
(b) What is the International Terrestrial Reference System (ITRS)?
(c) How can the ITRS be of use to Zambia within the field of GIS?

Question 2 (9+6+10 points)

(a) What are the different digitising techniques? Explain how they are performed.
(b) Which technique would you apply in each of the following cases?
    1. a map with only one type of information
    2. an image with few types of information that require some interpretation
    3. an image full of details and symbols e.g. a topographic map
(c) Assuming vector data, mention five clean-up operations that are possible after digitising a paper map.

Question 3 (5+5+5+5+5 points)

In Lusaka, a number of areas that were once wetlands have been converted into residential areas. The effect is that the City has been losing its biodiversity, which could have adverse effects not only on the physical environment itself but also on the health of the people.

As a GIS professional, you are assigned the task of solving this problem by identifying suitable sites for residences.
(a) What is the GIS problem here?
(b) What are the data required to solve the problem for the whole City of Lusaka?
(c) From which sources (or organisations) would you get the data?
Assuming you have all the data in analogue form, what are the activities required to solve the problem?

SECTION B

Question 4 (20+5 points)

Spread and seek functions are types of neighbourhood functions.
(a) Explain with clear illustrations how each of the function works in a GIS.
(b) In which case in reality is each function applied?

Question 5 (20+5 points)

Various classical spatial analysis functions on networks are supported by GIS software packages. The important ones are optimal path finding and network partitioning.
(a) Explain with clear illustrations how each of the function works.
(b) In which case in reality does each function apply?

Question 6 (5+10+10)

3D GIS is not yet fully functional today although there are serious application domains.
(a) What are the most important factors that have constrained 3D GIS development?
(b) There are various data structures that may be employed for 3D data representation. However, in practice two approaches are followed: geometric and volumetric modelling. Briefly, discuss these approaches.
(c) Briefly, discuss the four different possible approaches for computing volumes in 3D.

END OF EXAMINATION

University of Zambia
School of Engineering
Department of Geomatic Engineering

2004 Academic Year First Semester
Final Examinations
GE571-Engineering Surveying

Time: 3 hours
Instructions: Answer Both Questions in Section A and Any Three Questions from Section B

Section A: Answer All Questions

Question 1

a. Most Surveying Engineering jobs come in form of projects. What characteristics distinguish projects from routine work? **(5)**

b. Identify and explain the key issues which a project manager must take into account when managing a surveying project **(7)**

c. Some of the main determinants relating to the strength of internal competition and rivalry within an industry suggested by Porter are:

- Many equally balanced competitors
- Slow rate of industrial growth
- Lack of differentiation
- High fixed costs in the industry
- There are many diverse competitors.

Pick any three and demonstrate their relevance to the Zambian surveying industry today. **(8)**

Question 2

a. There are four stages between exploration for minerals and mine abandonment. Mention the role of a surveyor at each of the stages. **(8)**

b. Outline the steps that you would follow when establishing a control network for a large construction project. **(7)**

c. During the last rainy season, a lot of bridges were washed away. What role do you think a surveyor can play in preventing such disasters? **(5)**

Section B Answer Any Three Questions

Question 3

a. Briefly explain the effect of curvature and atmospheric refraction on the results of trigonometric levelling. **(7)**

b. From station A, a station B 29800.3m away is observed with a depression angle of 04′08″ and a reciprocal observation from B to A gave a depression angle of 09′41″; in both cases the sights were taken to signals at the same height above the ground as observing theodolite.

Calculate

i. The refractive coefficient **(8)**

ii. The difference in level **(5)**

Question 4

a. Give any three properties of a mass haul curve.(**3**)

b. The figure attached shows a mass haul diagram for a 1.5km stretch of a road.

i. Calculate the total haul included between 0 and 1150m (**5**)

ii. Given a free haul distance of 300m calculate the overhaul distance (**5**)

iii. If the cost of moving earth within free haul is $0.50 per m^3 and that of overhaul is $0.03 per stn.m, find the cost of moving earth within the section 0-1150m (**6**)

iv. In what direction does the earth at chainage1500m move. (**1**)

Question 5

a. What is the convergence of meridian? **(3)**

b.Grid bearing of a line AB is 26°16′30″. A gyrotheodolite was calibrated on line AB giving the gyroazimuth of the line equal to 27°14′00″. The same gyrotheodolite was used at station C in order to determine the grid azimuth of the line CD. The gyroazimuth of CD was 72°20′00″.

What is the grid bearing of the line CD if E_a=300,250m, E_c=300,416m and their latitudes are 43°20′30″S and 43°21′00″S respectively? R=6360km**. (17)**

Question 6

A reservoir is to be formed in a river valley by building a dam across it. The entire area that will be covered by the reservoir has been contoured and contours drawn at 1.5m intervals. The lowest point in the reservoir is at reduced level of 249m above datum, whilst the top water level will not be above a reduced level of 264.5m. The area enclosed by each contour and upstream face of the dam is shown in the table below.

a. Estimate by trapezoidal rule the capacity of the dam when it is full. **(8)**
b. What will be the reduced level of the water surface if, in time of drought this volume is reduced by 25% **(12)**

Contour (m)	250	251.5	253	254.5	256	257.5	259	260.5	262	263.5	26
Area enclosed (m^2)	1874	6355	11070	14152	19310	22605	24781	26349	29830	33728	37

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY SEMESTER I EXAMINATIONS 2004
JUNE 2004

ME 209 – ENGINEERING DRAWING I

TIME ALLOWED: FOUR (4) HOURS

CLOSED BOOK EXAM: TEXT BOOKS AND MARKED TUTORIAL SHEETS ARE NOT ALLOWED

INSTRUCTIONS

1. Answer a total of FOUR (4) questions in the following order:

   SECTION A Question One (Compulsory) to be answered separately on the title block paper face.
   SECTION B Any two (2) questions to be answered on the reverse paper side.
   SECTION C Any one (1) Question to be answered on a separate drawing paper.

2. Indicate your computer number just above the title block & Clearly Label each answered question.

3. Construction lines should not be erased and should be clearly visible.

4. Do not dimension unless otherwise stated.

5. Marks will be awarded for: Correct Solution, Accuracy, Neatness, Layout and Good Line Work

6. All dimensions are in millimeters.

SECTION A (Compulsory)

Q1. **Fig Q1** shows the front and end elevations of a Shift Fork. Draw scale 1-1:

(i) A sectional end elevation along B-B plane and direction in the given angle projection

(ii) In place of the given front elevation, a sectional front elevation along A-A plane a direction

(iii) Show six (6) important dimensions and state the angle of projection.

[40Mark

SECTION B (Answer any TWO (2) questions from this section)

Q2. **Fig Q2** shows the front elevation of a Branch Pipe consisting of a large curved pi interpenetrated by a smaller pipe, concentric with the large circular base. Draw using t same scale,

i) The front elevation showing the curve of interpenetration
ii) The plan view
iii) The development of the smaller pipe.

[15 Mark

Q3. **Fig Q3** shows a front elevation of a Solid Sphere of diameter 100mm. It is cut alo plane X-X as shown in the given view and remains only the bottom section. Draw, scale of 1/1 in first angle

i) the given view
ii) project the plan and
iii) the right end view.

[15 Mark

Q4. **Fig. Q4** shows an arm labeled *"A"* rotating about fixed center point *O*. Attached to it a two(2) rubber wheels of the same radius r , rotating freely without slipping with respe to each other about their respective centers O_1 and O_2. The wheel with center O_1 mov along curved plane X-X_1 without slipping. On the circumference of the two respecti wheels lie points P_1 and P_2 respectively, as shown in the enlargement. You are asked to

i) Trace the loci of points P_1 and P_2 as wheel "*1*" rotates one complete revolution
ii) Name the two (2) loci generated by the same points.

[15 Mark

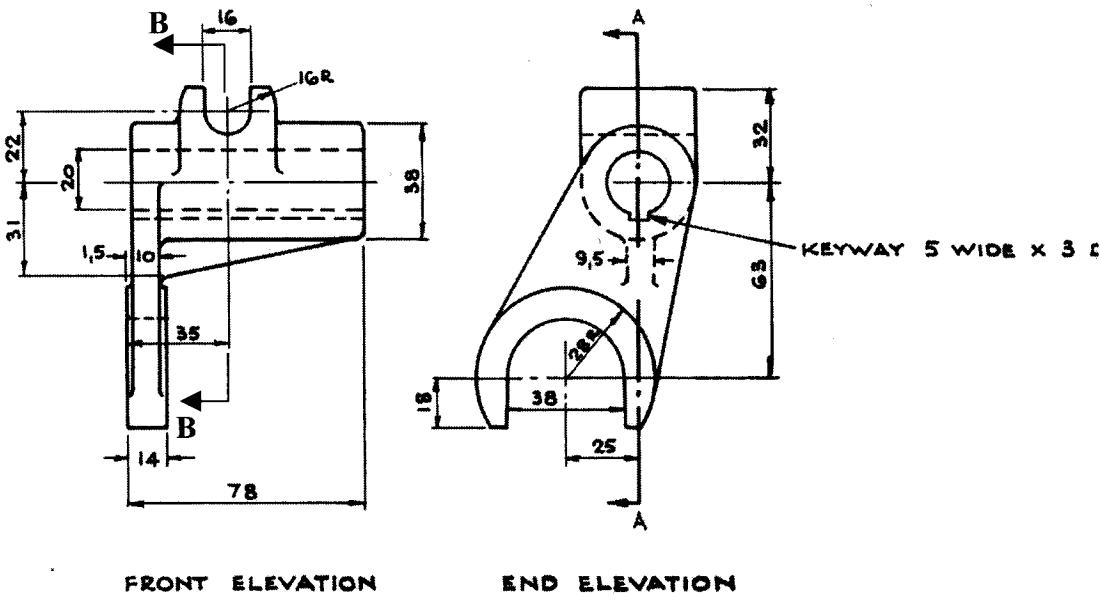


Fig Q1

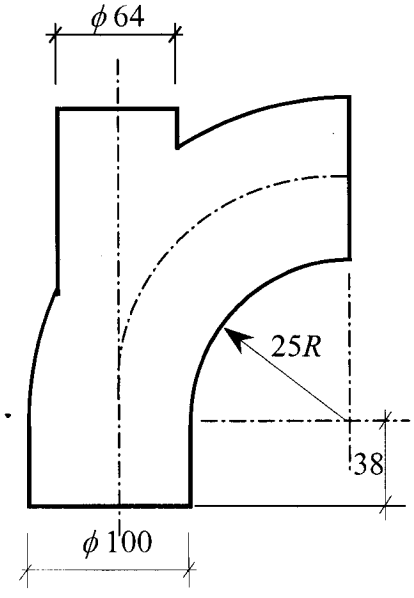


Fig. Q2

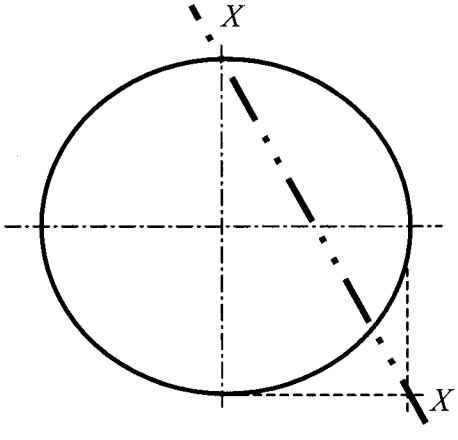


Fig. Q3

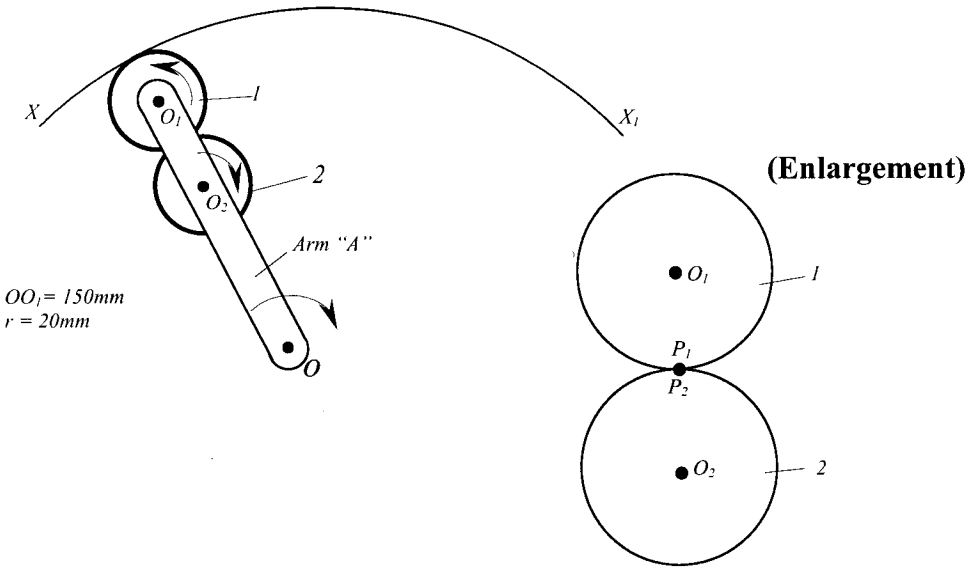


Fig.Q4

UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

SEMESTER I EXAMINATIONS JUNE 2004

SECTION C: ME 209 ELECTRICAL COMPONENT

TIME AS GIVEN IN THE MECHANICAL COMPONENT
ATTEMPT ONE QUESTION 15 MARKS
ANSWER SECTION C ON A SEPERATE SHEET_OF DRAWING PAPER

---

1. The diagram Fig. Q1C shows part of a circuit used to control a DC Motor driven mechanism for opening and closing a sliding door.PS1(NO) is a Pressure Mat switch and PS2 (NO) is a Push Button switch. The relay coil C operates a set of four pole change over contacts. The power supply is 6 VDC. The other components not shown are:-

   i) A permanent magnet DC Motor ,M, which drives the mechanism for operating a sliding door.

   ii) MS1 (NC) - a limit switch which is activated when the door is fully closed.

   iii) MS2 (NC) - a limit switch which is activated when the door is fully open.

   Using standard symbols and dimensions given in class complete Fig. Q1C on A2 paper,with the following criteria:-

   a) Insert the relay latch circuit
   b) Add the motor control circuit such that when the relay coil is de-energised the motor closing operation is initiated. Include MS1 and MS2 switches for automatic operation. ***[15 Marks]***

2. Fig Q2C is a circuit which utilizes Transistor Q (NPN) as a switch Draw the circuit, and the associated Truth Table., on part of the A2 size paper.It is now desired to use this circuit as a building block,to design a NAND LOGIC GATE . Draw the circuit, and the associated Truth Table on the rest of the drawing paper. ***[15 Marks]***

DIAGRAMS Fig Q1C & Fig Q2C FOLLOW ON NEXT PAGE

ME209 SEMESTER II EXAMINATION-JUNE 2004

DIAGRAM FOR SECTION C

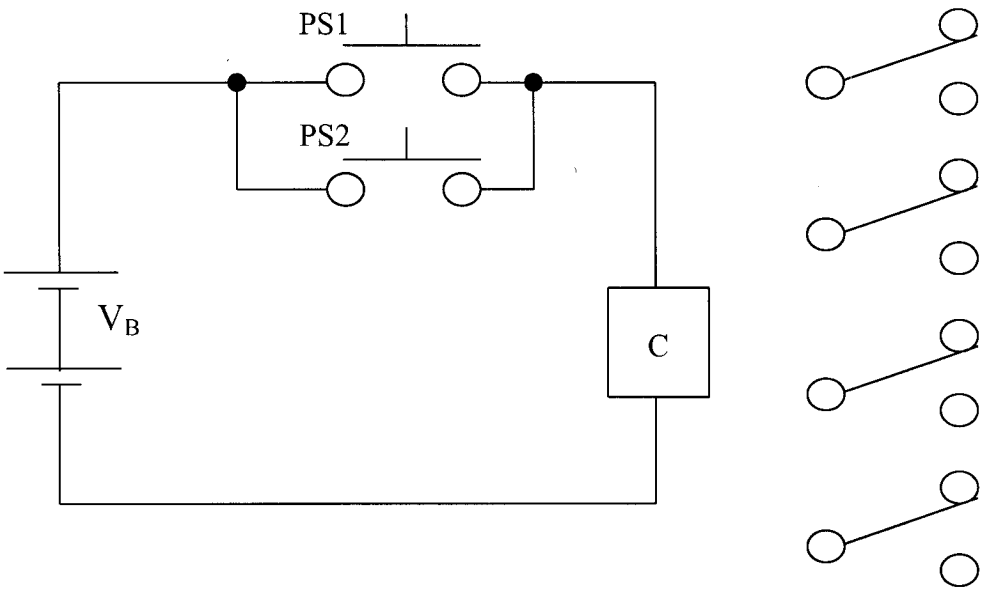


Fig Q 1 C

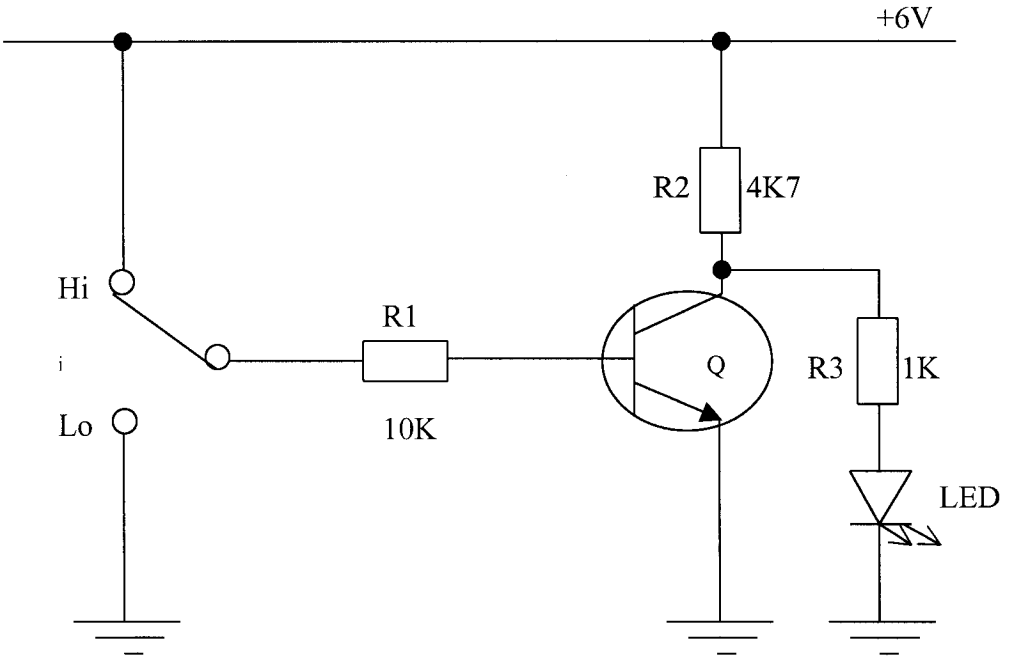


Fig Q 2 C

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DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS **SEMESTER I 2004**

ME 331 Properties of Engineering Materials

Answer: **Five Questions**
All Questions carry equal marks

Time: Three Hours **Closed Book**

Q1 (a) Discuss in detail

(i) Glass formers
(ii) Intermediates
(iii) Glass-Ceramics

(b) Give some examples of practical applications of composite materials.

Q2 (a) Describe and state the differences between thermosetting and thermo plastic polymers.

(b) Discuss in detail:
(i) Low temperature creep
(ii) High temperature creep

Q3 (a) What is synthetic rubber. Give 3 examples of synthetic rubber outlining the main application areas of each type.

(b) What is vulcanisation? Discuss.

Q4 (a) Describe and state the differences between the following hardening methods.

(i) Dispersion hardening
(ii) Precipitation hardening

(b) What is devitrified glass? Explain.

Q5 (a) Discuss how the following factors affect the creep resistance of a metallic material

(i) Alloy composition
(ii) Grain size
(iii) Environment

(b) What is the fatigue endurance limit?

Q6 (a) Give the four main groups into which ceramics may be classified; in terms of composition and structure.

(b) Discuss the following types of engineering ceramics, with emphasis on their structure and properties.

(i) Silicon Nitride and 'Sialons'
(ii) Alumina
(iii) Zirconia

Q7 Discuss the following

(a) The plastic bunting process for the growth of stage II fatigue cracks.
(b) Cyclic softening
(c) Cyclic hardening

END OF EXAMINATION

Dr. C.K. Wamukwamba
June 2004

UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER I FINAL EXAMINATION
JUNE 2004

ME 341 – ENGINEERING THERMODYNAMICS

TIME ALLOWED: THREE (3) HOURS **CLOSED BOOK**

INSTRUCTIONS

1. Answer a **total of FOUR (4) questions**: Any **TWO (2)** questions from each section. Questions in Section A carry 20 marks each, while those in Section B carry 30 marks each.
2. Answer **Q3** in a **separate** booklet.
3. Draw sketches and graphs where necessary and state clearly any assumptions made.

SECTION A
(Answer any TWO Questions)

Q1. Briefly discuss and distinguish between the following,

(a) A non-flow and flow process [4 marks]
(b) State and property [4 marks]
(c) Steady and unsteady flow [4 marks]
(d) Heat engine, heat pump and refrigerator [8 marks]

Q2. (a) What is combustion? Explain its importance in internal combustion engines and steam plant applications. [6 marks]

(b) As referered to engine perfomance, define, and distingush, between indicated power and brake power, and mechanical efficiency and thermal efficiency. [8 marks]

(c) Explain what the dryness quality (x) is, detailing its importance in determination of heat and work transfers in a steam plant. [6 Marks]

Q3. (a) Discuss the local and global concerns assciated with use of fossil fuels arising from combustion process. [10 marks]

(b) Suggest options and technologies that Zambia can implement to reduce dependence on fossil fuels, in particular transport fuels. [10 marks]

SECTION B
(Answer any TWO Questions)

Q4. (a) Design of temperature measuring devices depends on one of the laws of thermodynamics. Explain. [5 Marks]

(b) Substantiate the statement: "Work is a more valuable form of energy than heat". [3 Marks]

(c) In a thermodynamic cycle, $0.025m^3$ of air at 15°C and 5.5bar is heated isobarically to a temperature of 204°C and then expanded adiabatically a temperature of 120°C. The working fluid is then cooled isochorically to 15°C and restored to its initial volume by an isothermal compression. Determine:

(i) the heat supplied or rejected during the four phases of the cycle [16 Marks]
(ii) the work done [2 Marks]
(iii) the thermal efficiency of the cycle [2 Marks]

Draw the cycle in a P-V diagram. [2 marks]

For air, assume c_p=1kJ/kg, and adiabatic index as 1.4. Consider air as an ideal gas.

Q5. (a) Explain what differentiates a Rankine Vapour Cycle from a Carnot Vapur Cycle. [4 marks]

(b) Calculate the cycle efficiency, work ratio, and specific steam consumption of the Carnot Cycle in Fig Q5. The pressure gauges show that the boiler and condenser pressures are 30bars and 0.04bar, respectively. The calorimetry tests revealed that the dryness fraction at states 3 and 4 are 0.716 and 0.276 respectively. Consider the following cases:

(i) The Ideal Cycle [12 Marks]
(ii) The actual cycle when irreversibilities result in efficiencies of expansion and compression processes to be each 0.80. [10 Marks

Discuss the results obtained in (i) and (ii). [3 Marks]

Draw the T-s diagram to show the cycle processes. [1 Mark]

Q6. (a) Discuss why reciprocating engines more desirable than gas turbines in some instances. State the advantages and disadvantages of reciprocating engine cycles. [5Marks]

(b) Briefly discuss the three air standard cycles that form the basis of practical reciprocating engines. [7 Marks]

(c) An engine running on a diesel cycle underwent an engine characteristics test. The following parameters were obtained:

Crankshaft speed	1750rpm
Load on dynamometer	220N
Radius of dynamometer	1.5m
Fuel consumption	18.7kg/hr
Calorific value	42,300kJ/kg
Mechanical Efficiency	83%

Determine:

(a) the brake power [5 marks]
(b) the brake specific fuel consumption [4 marks]
(c) indicated thermal efficiency [9 marks]

END OF EXAMINATION
Prepared by

2004

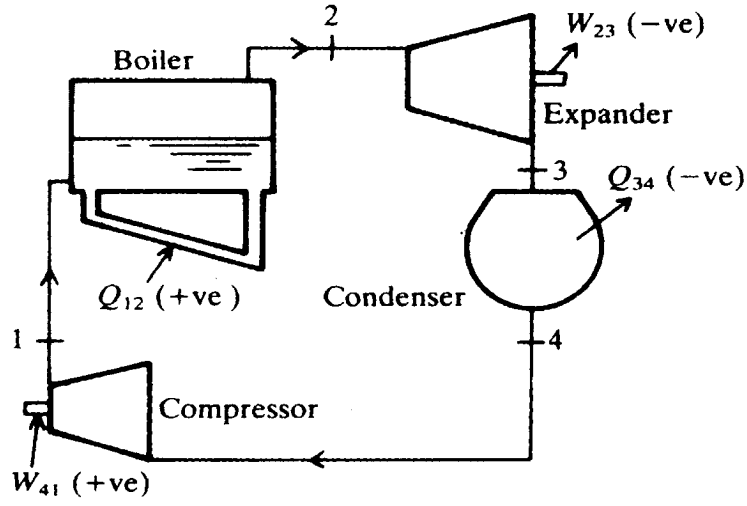

Fig Q5: Carnot Vapour Cycle

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2004 UNIVERSITY SEMESTER I EXAMINATIONS – JULY 2004

ME 375 – DYNAMICS

Time: THREE (3) HOURS **CLOSED BOOK**

Instructions: Answer Five (5) Questions Only
QUESTION 4 CARRIES 24 MARKS. ALL OTHER QUESTIONS CARRY EQUAL MARKS.

SECTION A: ANSWER TWO QUESTIONS ONLY

Q1. (a) A particle of mass 3 kg slides down a frictionless chute and enters a 'Loop-the loop" of diameter d = 300 mm, as shown in figure 1(a). If the angle of the inclined plane $\theta = 50°$, calculate the height h at the start in order that the particle makes a complete circuit in the loop.

[10 marks]

(b) An airplane makes complete half circle of 50m radius, towards left, when flying at 200 Km/hr. The rotary engine and the propeller of the plane weight 400 N with a radius of gyration of 30cm the engine runs at 2,400 rpm, clock wise, when vied from the rear. Find the gyroscopic couple on the aircraft and state its effect on it.

[9 marks]

Q2. The vertical motion of the 60 kg cylinder (see fig. Q2) is controlled by two forces P applied to the bottom rollers of the symmetrical frame. The links are very light, so that their mass may be neglected.

(i) Calculate the constant force P, which applied when the frame is at rest with $\theta = 120°$, will give the cylinder an upward velocity of 3 m/s when the position $\theta = 60°$ is passed.

[10 marks]

(ii) For the instant when the upward acceleration of the cylinder is 20 m/s^2, find the corresponding force R under each of the supporting rollers.

[9 marks]

Q3. A rotating shaft varies four masses, A, B, C, and D, rigidly attached to it; the mass centres are at 30mm, 36mm, 39mm and 33mm respectively form the axis of rotation; A, C and D are 7.5kg and 4kg; the axial distance between A and B is 400mm and that between B and C is 500mm; the eccentricities of A and C are at 90° to one another. Find, for complete balance:

(a) the angles A, B and D
(b) the axial distance between the planes of revolution of C and D and
(c) the mass B.

[19 marks]

SECTION B: Answer <u>Question 5 AND any two (2) Others</u> i.e. From this section, answer <u>Three</u> (3) Questions Only.

Q4. In the Whitworth quick return mechanism shown in Figure Q4, OA is a crank rotating at 30 rpm in the clockwise direction. The dimensions of the various links are: $OA = 150$ *mm*; $OC = 100$ *mm*; $CD = 125$ *mm* and $DR = 500$ *mm*. Determine the acceleration of the sliding block R and the angular acceleration of the slotted lever CA. **[24 marks]**

Q5. The 120-mm slender bar, shown in Figure Q5, has a mass of 20 kg with the mass center at B and is released from rest in the position for which θ is essentially zero. Point B is confined to move in the smooth vertical guide, while end A moves in the smooth horizontal guide and compresses the spring as the bar falls. Given that the mass moment of inertia for a rod is $\frac{1}{12}ml^2$, determine:

a) The angular velocity of the bar as the position $\theta = 30°$ is passed, **[9 marks]**

b) The velocity with which B strikes the horizontal surface if the stiffness of the spring is 5 kN/m. **[10 marks]**

Q6. A slender uniform rod of weight W is pivoted at the bottom end and is held in equilibrium by two springs, as shown in Figure Q6.

a) If $I_o = \frac{1}{3}ml^2$, show that for small vibrations, the natural frequency is given by:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{6kg}{W} - \frac{3g}{2l}}$$

[9 marks]

b) Determine the <u>angular displacement</u> of the rod, as a function of time, and the <u>amplitude of the motion</u> given that at time $t = 0$ s, the angle θ (between the rod and the vertical) is 0.035 radians to the right of the vertical (i.e. clockwise), while at the same time the angular velocity is 2 rad/s in the counter-clockwise direction. The following additional information is also given: $k = 2$ kN/m; $l = 1500$ mm; $W = 49.05$ N **[10 marks]**

Q7. At a certain instant, an unbalanced drum (Figure Q7) is rotating at an angular velocity of 2 rad/sec clockwise. The drum, which has a mass of 30 kg, has an inextensible rope wrapped around its circumference, supporting a 145 N weight. Point c is the center of mass of the drum. The radius of gyration of the drum about an axis perpendicular to O is 0.61 m. Find the reactions at the support O. **[19 marks]**

Q8. a) At the instant shown in Figure Q8(a), ball P moves downwards along the smooth slot with a velocity of 2 m/s and an upwards acceleration of 3 m/s^2. At the same time, the disk rotates with an angular velocity of 3 rad/s clockwise and an angular acceleration of 8 rad/s^2 counter-clockwise. Determine the acceleration of ball P. **[7 marks]**

b) The wheel of a car of radius b rolls without slipping on a horizontal surface as shown in Figure Q8b. Determine the velocity and acceleration of points A and C at the instant when the angular velocity and angular acceleration of the wheel are ω (counter-clockwise) and α (counter-clockwise), respectively. **[12 marks]**

END OF EXAMINATION – ME 375

Dr A N Ng'andu and Mr. C Siakachoma

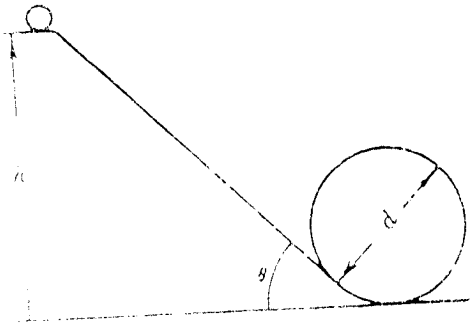

Figure Q1 (a)

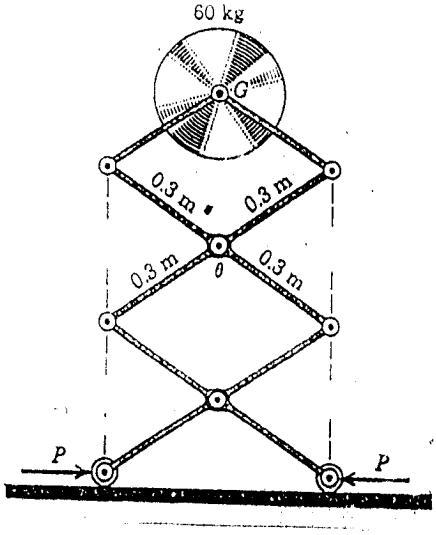

Figure Q2

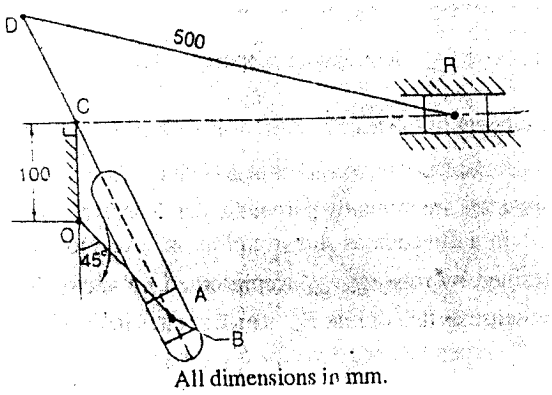

Figure Q4

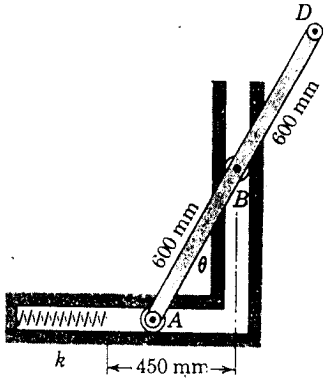

Figure Q5

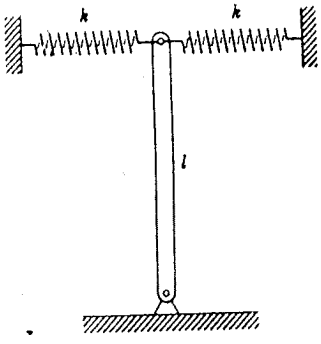

Figure Q6

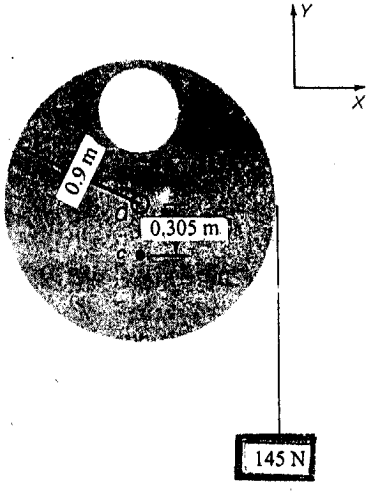

Figure Q7

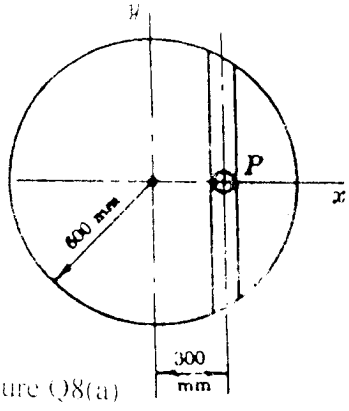

Figure Q8(a)

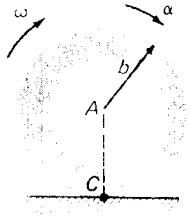

Figure Q8(b)

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UNIVERSITY EXAMINATIONS

SEMESTER I EXAMINATIONS 2004
JUNE/JULY 2004

ME 431 – STRENGTH OF MATERIALS II

TIME ALLOWED: THREE HOURS **CLOSED BOOK**

ANSWER ANY FIVE QUESTIONS, WITH AT LEAST TWO FROM EACH SECTION

HAND IN SECTIONS A AND B SEPARATELY. ALL QUESTIONS CARRY EQUAL MARKS

SECTION A: Answer at least TWO Questions from this Section

Q1. Draw the Bending Moment diagram and Sear Force diagram for the beam shown in Figure Q1 below. Support *B* settles by 1.0 cm on the loading. Moment of inertia of the beam is 10000 cm^4 throughout and E=2000t/cm^2. [20 marks]

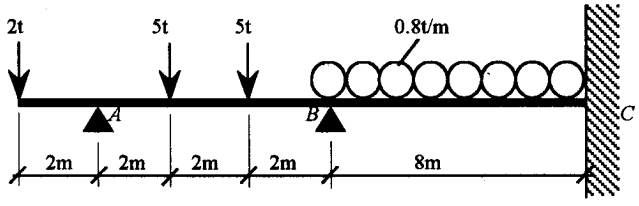
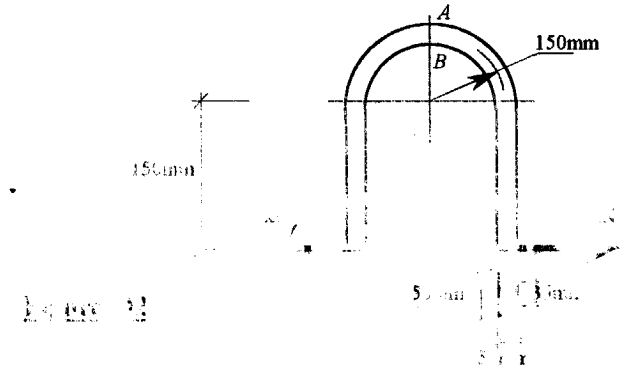


Figure Q1

Q2. Find the maximum tensile and compressive stresses at the section *A-B* of the curved bar shown in the Figure Q2 below. [20 marks]



Q3. A [illegible] external diameter [illegible] to transmit [illegible] at 100 rpm is [illegible] joined to a [illegible] diameter 200 mm. Fi

a) [illegible] [illegible]

b) [illegible] [illegible]

A straight elastic floating wooden bridge of uniform cross section rests on four (4) similar 1m long floating wooden logs running across at *A, B, C* and *D* which are spaced *l* metres apart as shown in Figure Q4 below. The buoyancy of each float is such that every additional tonne of load increases its immersion by *d.* Initially all the floats are equally immersed. If two loads, each of *W* tonnes, are placed on the girder at *B* and *C*, show that proportion of the load carried by the central floats is

$$W\left(\frac{5l^3+6EId}{5l^3+12EId}\right)$$

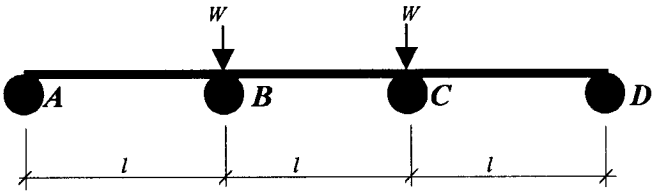


Figure Q4

where *EI* is the flexural rigidity of the girder. [20 marks]

TION B: Answer at least TWO Questions from this Section

A disc of inside and outside radii R_1 and R_2 is made up in two parts, which are shrunk together, the common radius being *r*. From the general equations below for a rotating disc,

$$\sigma_1^2 = A + \frac{B}{r^2} - \frac{\rho\omega^2 r^2}{8}(1+3\nu) \text{ and } \sigma_2^2 = A - \frac{B}{r^2} - \frac{\rho\omega^2 r^2}{8}(3+\nu),$$

show that the hoop stresses at R_1 and R_2 will be equal at a rotational speed given by

$$\omega^2 = \frac{4pr^2}{\rho(1+\nu)(r^2-R_1^2)(R_2^2-r^2)}$$

where *p* is the pressure due to shrinkage at the common surface. [20 marks]

(a) A thick-walled steel cylinder having an inside diameter of 150 mm is to be subjected to an internal pressure of 40 MPa. Find to the nearest mm the outside diameter required if the hoop tension in the cylinder wall is not to exceed 125 MPa. [5 marks]

(b) Calculate the actual hoop stresses at the inner and outer surfaces of the cylinder and plot a graph of the variation of hoop tension across the cylinder wall. [15 marks]

(a) A steel cylinder 200 mm external diameter and 150 mm internal diameter has another cylinder, 250 mm external diameter, shrunk on it. If the maximum tensile stress in the outer cylinder is 80 MPa, find the compressive stress between the cylinders. [8 marks]

(b) Determine the circumferential stresses at the inner and outer diameters of both cylinders. [10 marks]

(c) Calculate the shrinkage allowance at the common surface. [2 marks]

Take $E = 207$ GPa and $\nu = 0.304$.

The load on a bolt consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Taking the elastic limit in tension as 207 MPa, Poisson's ratio is 0.3and applying a factor of safety of 3, estimate the diameter of the bolt required according to:

(a) The Maximum Principal Stress theory. [5 marks]

(b) The Maximum Shear Stress theory. [4 marks]

(c) The Strain Energy theory. [5 marks]

(d) The Shear Strain Energy theory. [4 marks]

(e) With reasons, which bolt diameter would you specify for the application? [2 marks]

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

SEMESTER I FINAL EXAM – JUNE 2004

ME 415 WORKSHOP TECHNOLOGY

TIME: **THREE (3) HOURS ALLOWED** **CLOSED BOOK**

ANSWER: **ANY FIVE (5) QUESTIONS WITH A MINIMUM OF TWO (2) QUESTIONS FROM EACH SECTION**

NOTE: **EACH SECTION SHOULD BE ANSWERED IN A SEPARATE ANSWER BOOKLET CLEARLY LABELED AS SECTION A or B**

SECTION A:

Question 1

A coil of steel, 250mm wide by 3 mm thick is to be drawn through dies of semi-angle 10° to a fina thickness of 1mm by a single pass. The outlet speed of the drawn strip is 20 m/min, μ is about 0 .0 and the average yield stress is 350 N/mm^2. If any spreading of the width is negligible, determine th power required to make this reduction. [20 marks]

Question 2

A material with a true stress-true strain curve of $\bar{\sigma} = 70\bar{\varepsilon}^{0.7} Nmm^{-2}$ is used in wire drawing. If th friction and redundant work comprise a total of 30% of the ideal work of deformation, calculate th maximum possible reduction in cross-sectional area per unit pass. [20 marks]

Question 3

The following values were obtained from a series of straightness tests made to assess the flatness o a surface. The unit is 0.05mm, the results have already been summated, and they are all given witl reference to the same datum. Determine, for the intersecting points of the grid, the errors of flatnes of the surface tested measured from a mean true plane. [20 marks]

Flatness DATA				
A-A'	0	-0.5	0.1	-0.5
B-B'	0.4	0.5	0.5	0
C-C'	0	-0.3	-0.4	-0.5
D-D'	-0.3	-0.3	0.4	0
a-a'	0	0.3	-0.3	0.3

Question 4

A back pressure air gauging system has a linear range between values of the pressure ratio from 0.55 to 0.75, the linear relationship being represented by:

$$\frac{P_2}{P_1} = -0.4\frac{A_m}{A_c} + 1.1$$

The control jet has 0.5 mm diameter, the measuring jet 0.7 mm diameter. Air is supplied at a pressure of 3.6 bars and the measuring indicator displaces 2.4 mm per 10^{-3} bar change in pressure.

a) Determine the linear range of the gauge. [6 marks]

b) Find the overall sensitivity of the equipment within this range. [7 marks]

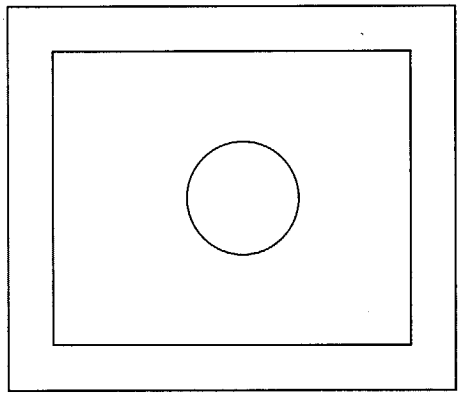
c) If a sensitivity of 30,000 was required what adjustment would be required to the supply pressure. [7 marks]

SECTION B:

Question 5

(a) The stages in the cooling of a sand casting result in certain volume and size changes. Name these changes, explaining clearly when they occur, their effect and how they are compensated for in casting practice. [8 marks]

(b) The component shown (200 x 150 x 60 mm in size) is required as a sand casting in limited quantity and the material is cast iron. Redesign the component with a view to simplifying the casting and machining of the part. Comment generally on your redesign. Note that the top and bottom surfaces of the component are to be machined all over. [12 marks]



Question 6

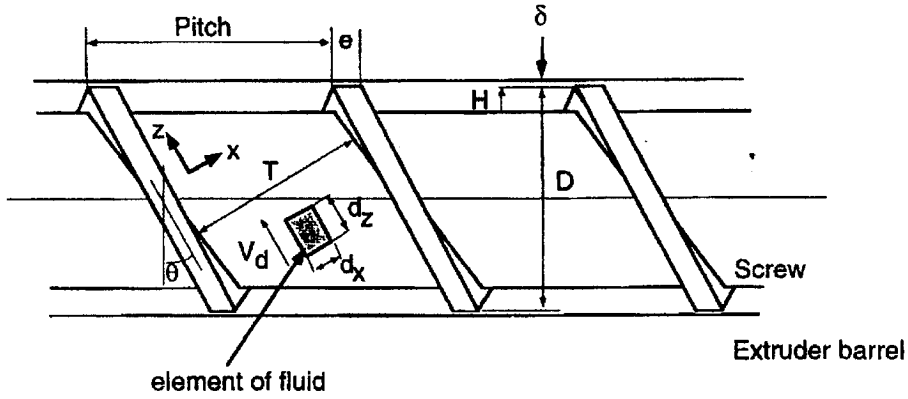
(a) Outline the important considerations involved in the choice of casting process for a particular part. [8 marks]

(b) Alloy road wheels for cars have grown in popularity. They are predominantly produced in aluminium alloy although there is some production in magnesium.

(i) List the advantages and disadvantages of using cast alloy wheels from the design and customer viewpoints. [6 marks]

(ii) List the problems associated with the production of such castings, assuming that they are to be die cast (using the term generically). [6 marks]

Question 7



The above schematic figure shows the details of an extruder screw and barrel.

(a) The expressions given below are for the drag, pressure and leakage flows, respectively, that occur in an extruder. Using these equations and making any suitable approximations give the explicit expressions of Q_{max} and P_{max} and show how the output rate of an extruder can be expressed in terms of Q_{max} and P_{max}. [10 marks]

$$Q_{drag} = \tfrac{1}{2}\pi^2 D^2 NH \sin\theta\cos\theta$$

$$Q_{pressure} = -\frac{\pi DH^3 \sin^2\theta}{12\eta}\frac{dP}{dL}$$

$$Q_{leakage} = -\frac{\pi^2 D^2 \delta^3}{12\eta e}\frac{dP}{dL}\tan\theta$$

(b) A single screw extruder has the following characteristics:

L/D ratio = 20, screw flight angle = 17.7°, screw diameter = 40 mm, flight depth in the metering zone = 3 mm, maximum screw speed = 120 rpm.

If the extruder is to be used to process polymer melts with a maximum viscosity of 500 Ns/m^2, calculate a suitable wall thickness for the extruder barrel based on the von Mises yield criterion, given that the tensile yield stress for the barrel metal is 900 MN/m^2 and the desired factor of safety is 2. [10 marks]

Question 8

[8 marks]

(a) What is meant by the term polymerisation? Describe the structure and properties of the three main polymer groups – thermoplastic polymers, thermosetting polymers, and elastomers.

[12 marks]

(b) Define the following as related to plastics technology:

(i) Stabilisers,
(ii) Antistatic agents,
(iii) Plasticizers, and
(iv) Coupling agents.

END OF EXAM

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER I FINAL EXAMINATION, JUNE 2004

ME 461 – FLUID MECHANICS II

TIME ALLOWED: THREE (3) HOURS **CLOSED BOOK**

INSTRUCTIONS

1. Answer a total of **FIVE (5)** questions.
2. Submit Questions 1 to 4 separately and Questions 5 to 7 separately.
3. Draw neat sketches and graphs where necessary and State clearly any assumptions made.

Question 1

(a) Define the following:

(i) A Fluid
(ii) Viscosity of a fluid

(b) State *"Newton's Law of Viscosity"* and its significance in Fluid Mechanics with regard to a rheological diagram.

(c) A square plate of 1.8m side and 1.8mm thickness, weighing 64N is to be lifted at a constant velocity of 0.14m/s through a vertical gap of 36mm of infinite extent. If the oil in the gap has a specific gravity of 0.96 and viscosity of $3N.s/m^2$, find the force and power required.

[2+6+12 = 20 Marks]

Question 2

(a) Give a brief qualitative description of *"the boundary layer"*.

(b) A stream of oil having specific gravity 0.933 and kinematic viscosity of 0.92 stoke flows with a velocity of 6m/s past a plate of dimensions 600mm x 200mm, placed longitudinally in the direction of flow. Calculate:

(i) The friction drag on the plate
(ii) Boundary layer thickness at the trailing edge
(iii) Shear stress at the trailing edge

[5+15 = 20 Marks]

Question 3

(a) Explain with the aid of a well-labelled experimental rig how the *"lift"* and *"drag"* coefficients on an aerofoil can be measured in a laboratory. State relevant mathematical expressions to support your answer.

(b) An aeroplane weighing 42.6 kN flies in a horizontal direction at 377km/hr. If the plane wing has a span of 16m, and a surface area of $36m^2$ and that the drag coefficient, C_d, air temperature and pressure are known to be 0.036, 4.4°C and 0.9 bar, determine:

(i) Coefficient of drag
(ii) Power required to drive the plane
(iii) Theoretical value of the boundary layer circulation

[10+10 = 20 Marks]

Question 4

(a) Outline three characteristics of turbulent flow in pipes.

(b) Two reservoirs located at a surface level difference of 23m are to be connected using a 1m diameter pipe 6.3km long. Determine the:

(i) Discharge when a cast iron pipe of roughness $k = 0.29$mm is used
(ii) Percentage increase in discharge if the cast iron pipe is replaced by a steel pipe of roughness $k = 0.11$mm
(iii) Power required to maintain the flow for both cases

Given: For turbulent flow,

$$\frac{1}{\sqrt{f}} = 2\log_e\left(\frac{R_o}{k}\right) + 1.74$$

[6+14 = 20 Marks]

Question 5

A centrifugal water pump has an impeller of outer diameter of 60cm and inner diameter of 20cm. It is 2cm wide at the outlet and 5cm wide at the inlet. The blade angles at the inlet and outlet are 20° and 10° respectively. If the impeller rotates at 1800 rpm, neglecting losses and vane thickness, determine the following:

(i) Discharge for shock-less radial entry
(ii) Theoretical head
(iii) Power required
(iv) Pressure rise through the impeller

[20 Marks]

Question 6

(a) A supersonic transport plane has a pitot tube attached to allow the pilot to determine when supersonic speed is reached. When flying at an altitude of 12,200 m, the temperature and pressure are –52.1 °C and 20.25 kPa respectively, the gauge to which the pitot tube is attached reads 42 kPa. Determine the Mach number and absolute velocity of the plane.

(b) The diameter of a pipe changes from 200 mm at a section 5 meters above datum to 50 mm at a section 3 meters above datum. The pressure of water at the first section is 500 kPa. If the velocity of flow at the first section is 1 m/s, determine the intensity of pressure at the second section.

(c) Under what circumstance are the Bernoulli's and Momentum equations reduced to the same expression.

[20 Marks]

Question 7

Discuss in detail the principle operation of a Particle Image Velocimetry

[20 Marks]

END OF ME 461 – Fluid Mechanics (II) Semester I Final Examination – June 2004,

Prepared by

Dr. P. C. Chisale and Mr. S. S. Virdy

GOOD LUCK!!!

TABLE D.1 (continued)

M	p/p_t	T/T_t	A/A^*	M	p/p_t	T/T_t	A/A^*
3.50	0.1311^{-1}	0.2899	6.790	4.00	0.6586^{-2}	0.2381	10.72
3.51	0.1293^{-1}	0.2887	6.853	4.01	0.6499^{-2}	0.2372	10.81
3.52	0.1274^{-1}	0.2875	6.917	4.02	0.6413^{-2}	0.2363	10.91
3.53	0.1256^{-1}	0.2864	6.982	4.03	0.6328^{-2}	0.2354	11.01
3.54	0.1239^{-1}	0.2852	7.047	4.04	0.6245^{-2}	0.2345	11.11
3.55	0.1221^{-1}	0.2841	7.113	4.05	0.6163^{-2}	0.2336	11.21
3.56	0.1204^{-1}	0.2829	7.179	4.06	0.6082^{-2}	0.2327	11.31
3.57	0.1188^{-1}	0.2818	7.246	4.07	0.6002^{-2}	0.2319	11.41
3.58	0.1171^{-1}	0.2806	7.313	4.08	0.5923^{-2}	0.2310	11.51
3.59	0.1155^{-1}	0.2795	7.382	4.09	0.5845^{-2}	0.2301	11.61
3.60	0.1138^{-1}	0.2784	7.450	4.10	0.5769^{-2}	0.2293	11.71
3.61	0.1123^{-1}	0.2773	7.519	4.11	0.5694^{-2}	0.2284	11.82
3.62	0.1107^{-1}	0.2762	7.589	4.12	0.5619^{-2}	0.2275	11.92
3.63	0.1092^{-1}	0.2751	7.659	4.13	0.5546^{-2}	0.2267	12.03
3.64	0.1076^{-1}	0.2740	7.730	4.14	0.5474^{-2}	0.2258	12.14
3.65	0.1062^{-1}	0.2729	7.802	4.15	0.5403^{-2}	0.2250	12.24
3.66	0.1047^{-1}	0.2718	7.874	4.16	0.5333^{-2}	0.2242	12.35
3.67	0.1032^{-1}	0.2707	7.947	4.17	0.5264^{-2}	0.2233	12.46
3.68	0.1018^{-1}	0.2697	8.020	4.18	0.5195^{-2}	0.2225	12.57
3.69	0.1004^{-1}	0.2686	8.094	4.19	0.5128^{-2}	0.2217	12.68
3.70	0.9903^{-2}	0.2675	8.169	4.20	0.5062^{-2}	0.2208	12.79
3.71	0.9767^{-2}	0.2665	8.244	4.21	0.4997^{-2}	0.2200	12.90
3.72	0.9633^{-2}	0.2654	8.320	4.22	0.4932^{-2}	0.2192	13.02
3.73	0.9500^{-2}	0.2644	8.397	4.23	0.4869^{-2}	0.2184	13.13
3.74	0.9370^{-2}	0.2633	8.474	4.24	0.4806^{-2}	0.2176	13.25
3.75	0.9242^{-2}	0.2623	8.552	4.25	0.4745^{-2}	0.2168	13.36
3.76	0.9116^{-2}	0.2613	8.630	4.26	0.4684^{-2}	0.2160	13.48
3.77	0.8991^{-2}	0.2602	8.709	4.27	0.4624^{-2}	0.2152	13.60
3.78	0.8869^{-2}	0.2592	8.789	4.28	0.4565^{-2}	0.2144	13.72
3.79	0.8748^{-2}	0.2582	8.870	4.29	0.4507^{-2}	0.2136	13.83
3.80	0.8629^{-2}	0.2572	8.951	4.30	0.4449^{-2}	0.2129	13.95
3.81	0.8512^{-2}	0.2562	9.032	4.31	0.4393^{-2}	0.2121	14.08
3.82	0.8396^{-2}	0.2552	9.115	4.32	0.4337^{-2}	0.2113	14.20
3.83	0.8283^{-2}	0.2542	9.198	4.33	0.4282^{-2}	0.2105	14.32
3.84	0.8171^{-2}	0.2532	9.282	4.34	0.4228^{-2}	0.2098	14.45
3.85	0.8060^{-2}	0.2522	9.366	4.35	0.4174^{-2}	0.2090	14.57
3.86	0.7951^{-2}	0.2513	9.451	4.36	0.4121^{-2}	0.2083	14.70
3.87	0.7844^{-2}	0.2503	9.537	4.37	0.4069^{-2}	0.2075	14.82
3.88	0.7739^{-2}	0.2493	9.624	4.38	0.4018^{-2}	0.2067	14.95
3.89	0.7635^{-2}	0.2484	9.711	4.39	0.3968^{-2}	0.2060	15.08
3.90	0.7532^{-2}	0.2474	9.799	4.40	0.3918^{-2}	0.2053	15.21
3.91	0.7431^{-2}	0.2464	9.888	4.41	0.3868^{-2}	0.2045	15.34
3.92	0.7332^{-2}	0.2455	9.977	4.42	0.3820^{-2}	0.2038	15.47
3.93	0.7233^{-2}	0.2446	10.07	4.43	0.3772^{-2}	0.2030	15.61
3.94	0.7137^{-2}	0.2436	10.16	4.44	0.3725^{-2}	0.2023	15.74
3.95	0.7042^{-2}	0.2427	10.25	4.45	0.3678^{-2}	0.2016	15.87
3.96	0.6948^{-2}	0.2418	10.34	4.46	0.3633^{-2}	0.2009	16.01
3.97	0.6855^{-2}	0.2408	10.44	4.47	0.3587^{-2}	0.2002	16.14
3.98	0.6764^{-2}	0.2399	10.53	4.48	0.3543^{-2}	0.1994	16.28
3.99	0.6675^{-2}	0.2390	10.62	4.49	0.3499^{-2}	0.1987	16.42

TABLE D.1 (continued)

M	p/p_t	T/T_t	A/A^*	M	p/p_t	T/T_t	A/A^*
4.50	0.3455^{-2}	0.1980	16.56	4.75	0.2543^{-2}	0.1814	20.41
4.51	0.3412^{-2}	0.1973	16.70	4.76	0.2512^{-2}	0.1808	20.58
4.52	0.3370^{-2}	0.1966	16.84	4.77	0.2482^{-2}	0.1802	20.75
4.53	0.3329^{-2}	0.1959	16.99	4.78	0.2452^{-2}	0.1795	20.92
4.54	0.3288^{-2}	0.1952	17.13	4.79	0.2423^{-2}	0.1789	21.09
4.55	0.3247^{-2}	0.1945	17.28	4.80	0.2394^{-2}	0.1783	21.26
4.56	0.3207^{-2}	0.1938	17.42	4.81	0.2366^{-2}	0.1777	21.44
4.57	0.3168^{-2}	0.1932	17.57	4.82	0.2338^{-2}	0.1771	21.61
4.58	0.3129^{-2}	0.1925	17.72	4.83	0.2310^{-2}	0.1765	21.79
4.59	0.3090^{-2}	0.1918	17.87	4.84	0.2283^{-2}	0.1759	21.97
4.60	0.3053^{-2}	0.1911	18.02	4.85	0.2255^{-2}	0.1753	22.15
4.61	0.3015^{-2}	0.1905	18.17	4.86	0.2229^{-2}	0.1747	22.33
4.62	0.2978^{-2}	0.1898	18.32	4.87	0.2202^{-2}	0.1741	22.51
4.63	0.2942^{-2}	0.1891	18.48	4.88	0.2177^{-2}	0.1735	22.70
4.64	0.2906^{-2}	0.1885	18.63	4.89	0.2151^{-2}	0.1729	21.88
4.65	0.2871^{-2}	0.1878	18.79	4.90	0.2126^{-2}	0.1724	23.07
4.66	0.2836^{-2}	0.1872	18.94	4.91	0.2101^{-2}	0.1718	23.25
4.67	0.2802^{-2}	0.1865	19.10	4.92	0.2076^{-2}	0.1712	23.44
4.68	0.2768^{-2}	0.1859	19.26	4.93	0.2052^{-2}	0.1706	23.63
4.69	0.2734^{-2}	0.1852	19.42	4.94	0.2028^{-2}	0.1700	23.82
4.70	0.2701^{-2}	0.1846	19.58	4.95	0.2004^{-2}	0.1695	24.02
4.71	0.2669^{-2}	0.1839	19.75	4.96	0.1981^{-2}	0.1689	24.21
4.72	0.2637^{-2}	0.1833	19.91	4.97	0.1957^{-2}	0.1683	24.41
4.73	0.2605^{-2}	0.1827	20.07	4.98	0.1985^{-2}	0.1678	24.60
4.74	0.2573^{-2}	0.1820	20.24	4.99	0.1912^{-2}	0.1672	24.80
				5.00	0.1890^{-2}	0.1667	25.00

Note: $0.9956^{-1} = 0.9956 \times 10^{-1} = 0.09956$.

Source: NACA Report 1135, "Equations, Tables and Charts for Compressible Flow," 1953.

TABLE D.2 *Normal Shock Tables for a Gas Having* $\gamma = 1.4$

M_1	M_2	p_2/p_1	ρ_2/ρ_1	T_2/T_1	p_{t2}/p_{t1}	p_1/p_{t2}
1.00	1.000	1.000	1.000	1.000	1.000	0.5283
1.01	0.9901	1.023	1.017	1.007	1.000	0.5221
1.02	0.9805	1.047	1.033	1.013	1.000	0.5160
1.03	0.9712	1.071	1.050	1.020	1.000	0.5100
1.04	0.9620	1.095	1.067	1.028	0.9999	0.5039
1.05	0.9531	1.120	1.084	1.033	0.9999	0.4980
1.06	0.9444	1.144	1.101	1.039	0.9997	0.4920
1.07	0.9360	1.169	1.118	1.046	0.9996	0.4861
1.08	0.9277	1.194	1.135	1.052	0.9994	0.4803
1.09	0.9196	1.219	1.152	1.059	0.9992	0.4746
1.10	0.9118	1.245	1.169	1.065	0.9989	0.4689
1.11	0.9041	1.271	1.186	1.071	0.9986	0.4632
1.12	0.8966	1.297	1.203	1.078	0.9982	0.4576
1.13	0.8892	1.323	1.221	1.084	0.9978	0.4521
1.14	0.8820	1.350	1.238	1.090	0.9973	0.4467

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY SEMESTER I FINAL EXAMINATIONS – JUNE 2004

ME 515 PRODUCTION TECHNOLOGY II – PAPER I

Time allowed: THREE hours **CLOSED BOOK**

ANSWER: Q1, Q3 and any other THREE questions

ALL QUESTIONS CARRY EQUAL MARKS.

Question Q1 should be answered in a separate answer book.

Q1. **Fig. Q1** is a plan and side view of a product to be machined using a CNC Vertical Milling Centre (VMC).

(i) Suggest a process plan on which to base CNC programming for the product shown in Fig. Q1.

(ii) Develop a manual programme using G-Code to execute the different material removal processes that will yield the product features.

The following technical information should be used in developing the process plan and manual programme:

- Workpiece material is protowax.
- Cutting velocity at tool/workpiece interface = 100 m/min.
- Contour depth 5 mm.

- **Tool No. 4** Slot mill Ø 10 mm with 2 cutting edges;
  Slot mill tool maximum feed = 0.05 mm/tooth;
  Slot mill tool length 50 mm.

- **Tool No. 7** Drilling Ø 8 mm with 2 cutting edges;
  Drill maximum plunge feed = 0.05 mm/cutting edge;
  Drill plunge feed should be similarly calculated as for slotting feed;
  Drilling tool length 90 mm.

- VMC range of spindle speeds 0 to 6000 revs/minute.

The G-codes to be used are appended. **[20 marks]**

Q2.

(a) Define Yielding and explain what a Yield Criterion indicates.

[3 marks]

(b) You are the Chief Engineer in a manufacturing company making storage tanks. You have been given a task to design a cylindrical storage tank for a chemical processing plant to contain a gas at a pressure of 15 atm. The tank should have a radius of 2 m, and should be 15 m long. To be certain that the tank will not fail, you decide to use a safety factor of 5.

(i) Using the Tresca Yield Criterion, determine the minimum wall thickness of the storage tank.

[5 marks]

(ii) Determine by what percentage this differs from using the Von-Mises Criterion

[2 marks]

(iii) Using the Tresca Yield Criterion, determine the minimum wall thickness of the storage tank when you decide to use the following materials:

- Copper and
- Aluminum

[6 marks]

(iv) When you compare the three materials, which one would you decide to use for your design.

Materials	Elastic Modulus (GPa)	Poisson ratio	Yield stress (MPa)
Steel	207	0.3	180
Aluminum	69	0.33	350
Copper	110	0.349	69

[4 marks]

Q3.

(a) Name the two mechanisms of melting plastics in a reciprocating-screw injection-molding machine?

[4 marks]

(b) What is premature gellation and in which processes can it happen. Name some of its consequences.

[4 marks]

(c) What are some of the differences between cold and hot runner molds.

[4 marks]

(d) Illustrate the geometry of the single screw extrusion process for polymers. In your diagram clearly indicate details including flight, pitch, barrel, screw, channel and flight angle.

[8 marks]

Q4.

(a) Name four important process parameters in Rolling of metals.

[4 marks]

(b) You are the Chief Engineer in a certain manufacturing company in Lusaka. Your company is planning a rolling operation and has installed a

new rolling mill for the purpose. The Mill is to be used for cold rolling A1-1100 aluminum plate from 25 mm to 20 mm thickness. The rollers of the Rolling Mill are each capable of producing 764 kW of power when the rolls are rotating at 100 RPM. The Mill has a lubrication system that reduces the friction to a negligible value. The diameter of the rolls is 60 cm. For this material (A1-1100), the strength coefficient K = 140 MPa, and the strain hardening exponent, n = 0.25.

Your task as the Chief Engineer in the company, is to determine the maximum width of a sheet of aluminum plate that can be rolled at full power.

[16marks]

Q5.

(a) Define the terms

(i) punching

(ii) blanking

[3 marks]

(b) Explain, using sketches, the principle of operation of the punching process. In your explanation make particular reference to the fundamental mathematical relationships involved for calculating shearing pressure.

[5marks]

(c) During the bending laboratory experiment, you are presented with a bent piece of sheet metal with a 90^0 bend, that is 3 mm thick, with a bend radius of 6 mm. The metal follows the following equation $\sigma = [250 + 1500e]MPa$. The metal has a modulus (E) of 200 GPa. The length " into the board" (b) of the bent sheet metal is 1000 mm. The friction coefficient (μ) = 0.1. The die width ("distance between the shoulders") is 75 mm.

(i) Determine the required punch angle to make this part

(ii) Determine the punch force

[12 marks]

Q6.

(a) Name and describe five secondary and finishing operations that can be applied in powder metallurgy.

[5 marks]

(b) Give an outline of the basic steps for producing conventional density parts by the powder metallurgy process. List its advantages, limitations and typical products.

[10 marks]

(a) List two reasons for removing air from Powder Metallurgy products, for example a "can" prior to hot isostatic pressing.

[5 marks]

Q7.

(a) Draw sketches to illustrate the stages of "flash" formation in forging.

[4 marks]

(b) Explain what purpose the flash serves in impression die forging operation.

[4 marks]

(c) A new manufacturing process, which involves cold forging a rectangular piece of 1112 cold -rolled steel, is being introduced in your company. The initial dimensions of the steel are 50 mm x 50 mm x 500 mm. Your task is to reduce it's height by 25%. The coefficient of friction is 0.05.

What is the maximum pressure on the die?

[12 marks]

Q8.

(a) Name two instances when non-traditional methods of machining should be used in preference to traditional methods of machining.

[4 marks]

(b) With a well-labelled diagram, explain the principle of operation of Abrasive Water Jet Machining. List its limitations and advantages.

[10 marks]

(c) (i) Explain the necessity of surface treatment of finished products

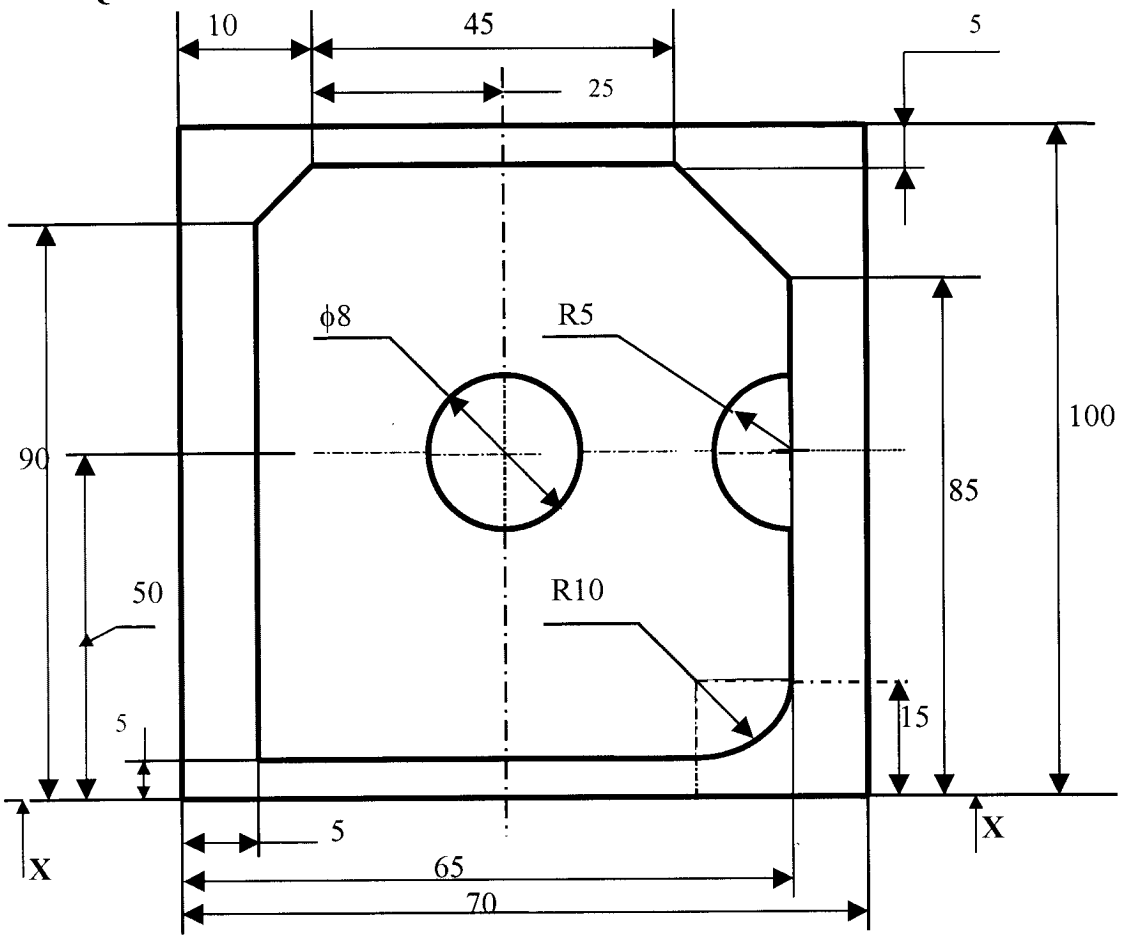
(iii) Describe the principle of operation of a vibratory finisher.

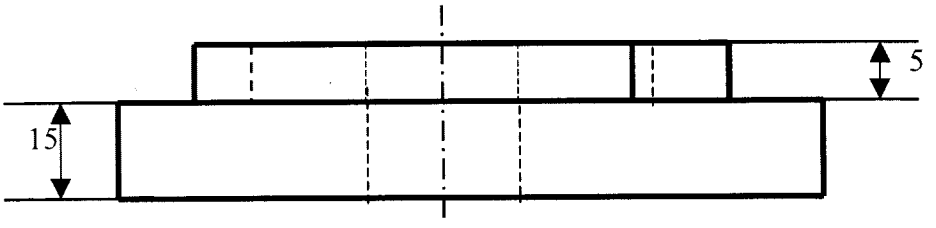
[6 marks]

Dr. J. Phiri / Dr. H.M. Mwenda

END OF EXAMINATION

FIG. Q1. ME515 PAPER 1 JUNE 2004





VIEW X - X

MATERIAL PROTOWAX

DIMENSIONS IN MM

DRAWING NOT TO SCALE

APPENDIX Q1. MANUAL PROGRAMME CODES

G-CODE MOVEMENT INSTRUCTIONS

G00	RAPID SPEED
G01	LINEAR INTERPOLATION (in feed)
G02	CIRCULAR INTERPOLATION CW (in feed)
G03	CIRCULAR INTERPOLATION CCW (in feed)
G04	DWELL
G17	CIRCULAR MOVEMENT XY PLANE
G18	CIRCULAR MOVEMENT XZ PLANE
G19	CIRCULAR MOVEMENT YZ PLANE
G28	RETURN TO REFERENCE POINT
G40	TOOL RADIUS COMPENSANTION CANCEL
G41	TOOL RADIUS COMPENSANTION LEFT (climb)
G42	TOOL RADIUS COMPENSANTION RIGHT (conventional)
G43	TOOL LENGTH COMPENSATION
G49	TOOL LENGTH COMPENSATION CANCEL
G53	MACHINE ZERO POINT
G54 – G59	WORKPIECE ZERO POINT
G90	ABSOLUTE COMMAND
G91	INCREMENTAL COMMAND

MISCELLANEOUS COMMANDS M-CODES

M0	PROGRAM STOP
M3	SPINDLE CLOCKWISE START
M4	SPINDLE COUNTER CLOCKWISE START
M5	SPINDLE STOP
M6	TOOL CHANGE COMMAND
M8	COOLANT ON
M9	COOLANT OFF
M19	SPINDLE ORIENTATION
M30	PROGRAM END

OTHER CODES

O	PROGRAMME NUMBER
N	SEQUENCE NUMBER FOR INSTRUCTION
F	FEED RATE
S	SPINDLE SPEED
R	RADIUS DESIGNATION
H	TOOL LENGTH DESIGNATION
D	TOOL RADIUS DESIGNATION
T	TOOL DESIGNATION

TYPICAL VALUES FOR **k** AND **n** AT ROOM TEMPERATURE

MATERIAL	K (MPa)	N
Aluminum, 1100-0	180	0.20
2024-T4	690	0.16
5052-0	210	0.13
6061-0	205	0.20
6061-T6	410	0.05
7075-0	400	0.17
Bass, 60-39-1Pb, annealed	800	0.33
70-30, annealed	895	0.49
85-15, cold-rolled	580	0.34
Bronze (phosphor), annealed	720	0.46
Cobalt-base alloy, heat treated	2070	0.50
Copper, annealed	315	0.54
Molybdenum, annealed	725	0.13
Steel, low-carbon annealed	530	0.26
1045 hot-rolled	965	0.14
1112 annealed	760	0.19
1112 cold-rolled	760	0.08
4135 annealed	1015	0.17
4135 cold-rolled	1100	0.14
4340 annealed	640	0.15
17-4 P-H annealed	1200	0.05
52100 annealed	1450	0.07
302 stainless annealed	1300	0.30
304 stainless, annealed	1275	0.45
410 stainless	960	0.10
AISI 1020 carbon steel	700	0.15

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY SEMESTER 1 FINAL EXAMINATIONS, JUNE 2004

ME 515 PRODUCTION TECHNOLOGY II, PAPER II

ME: THREE hours. **OPEN BOO**
NSWER: ALL questions.
lected ISO FITS HOLE BASIS have been appended for use in the solutions.

INTRODUCTION

Design and function of mechanism

The attached drawing shows part of an emergency trip gear for a machine. The trip rod, **Detail** supported in the body, **Detail 1**, by fitting at the right hand end into a Ø19 mm hole in the cylinder, **Detail 4**, and at the left hand end into a Ø13 mm hole in the lever bracket, **Detail 2**. trip rod which is integral with the valve is retained in the set position by a trigger, **Detail 7**, car on a pin fitted into a pair of brackets integral with **Detail 4**. A compression spring, **Detail** housed in a recess in **Detail 2**. The spring is compressed by means of the resetting lever, **Deta** which bears on to the spring cap, **Detail 8**, through a cylindrically sided fork. The spring always maintains compression in the spring, **Detail 9**. The resetting lever, **Detail 3**, is carried pin fitted into a pair of brackets integral with **Detail 2**.

The mechanism can be tripped either from the machine by means of the trigger, **Detail 7**, o means of the hand operated trip lever, **Detail 6**, in order to cut off the supply of high pressure o the cylinder.

Production quantity

The production requirement for the mechanism is three (3) units per hour.

QUESTIONS

Before commencing the solutions, ensure that the operation of the mechanism is ful understood.

(a) Make freehand orthographic sketches of **Details 1, 2, 4 and 5**, each on a separate page of the answer book approximately to scale. **[7 marks]**

(b) Indicate on the sketches by using a standard machining symbol those surfaces which must be machined between limits. Name the machining process by means of letter denotation.

On the first page of the answer book give a legend defining the machining symbol and process definition. **[12 marks]**

(a) By use of the scale on the given drawing sheet, select suitable mm values for all importa **axial dimensions** on the sketches of **Details 1, 2, 4 and 5** as in Q1(a) which direc affect the trip gear operation. Give a general tolerance for the selected axial dimensions. **[7 marks]**

(b) Identify **important diameters** on **Details 1, 2, 4 and 5** indicated in Q1(a) and gi appropriate limits of size conforming to ISO recommendations so that the mechanism w function correctly; give both letter and figure values of tolerances and give an outline of t type of tolerance. **[6 marks]**

(a) Examine the possibility of tolerance limit stacks in the assembly resulting from the genera tolerance you have suggested in Q2(a). Suggest remedial tolerances where necessary. **[20 mark**

(b) Give an outline of the factors which affect the alignment of **Detail 2** and **4**, and hence t satisfactory fit of **Detail 5**. **[4 mark**

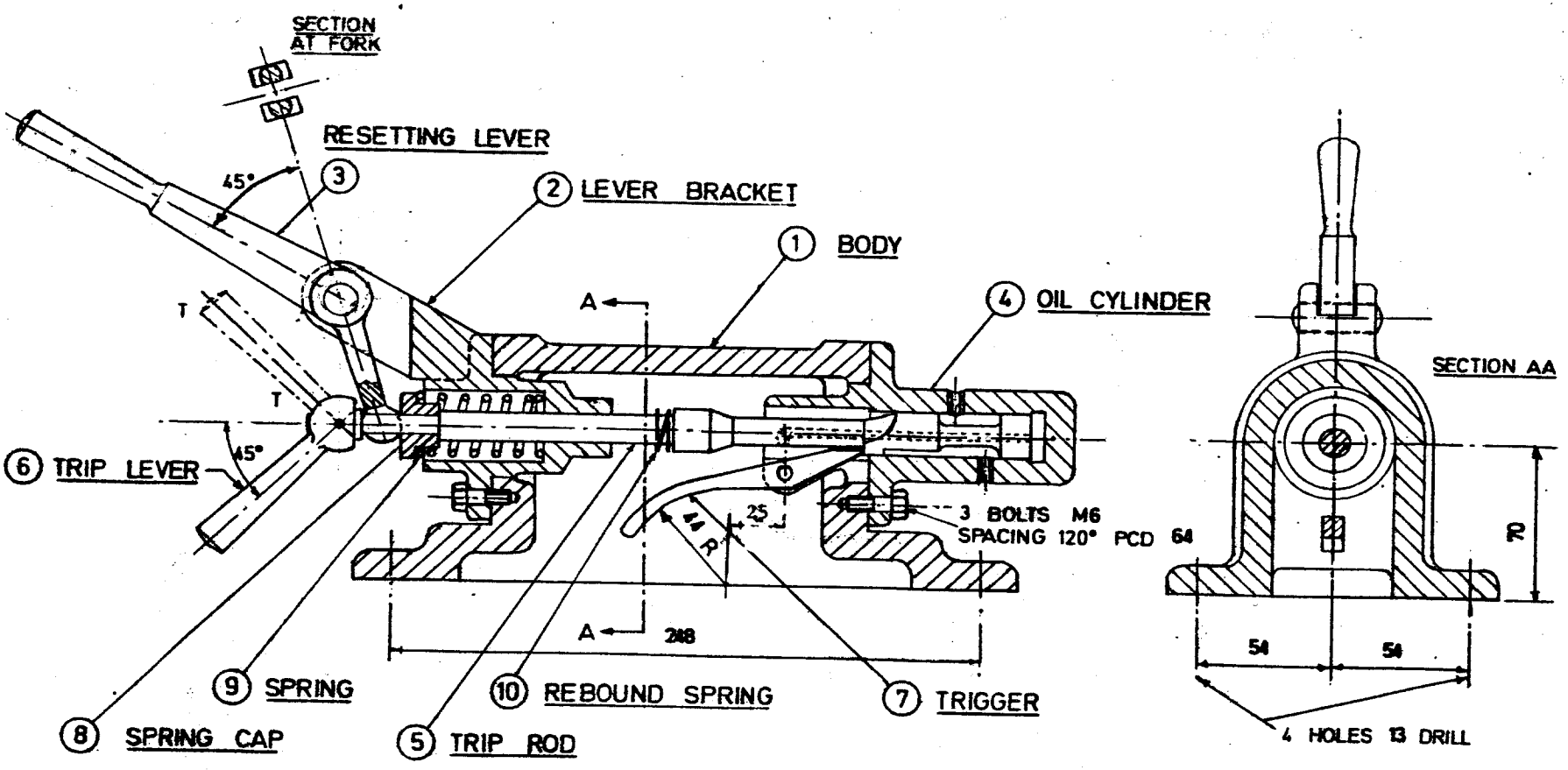
(a) Indicate graphically on the sketch of **Detail 1** the correct number and best positions for the locators and holding force(s) for machining the co-axial Ø60 mm holes. **[10 mark**

(b) Develop an idea sketch for the jig/fixture based on the locator/clamp choice in Q4(a). **[16 mark**

Give logical sequence and classifications of production processes to be used in the manufacture o **Detail** 1. Briefly explain/comment on each classification. What material should be used for **Detail** **[18 marks**

END OF EXAMINATION

Dr. H. M. Mwenda

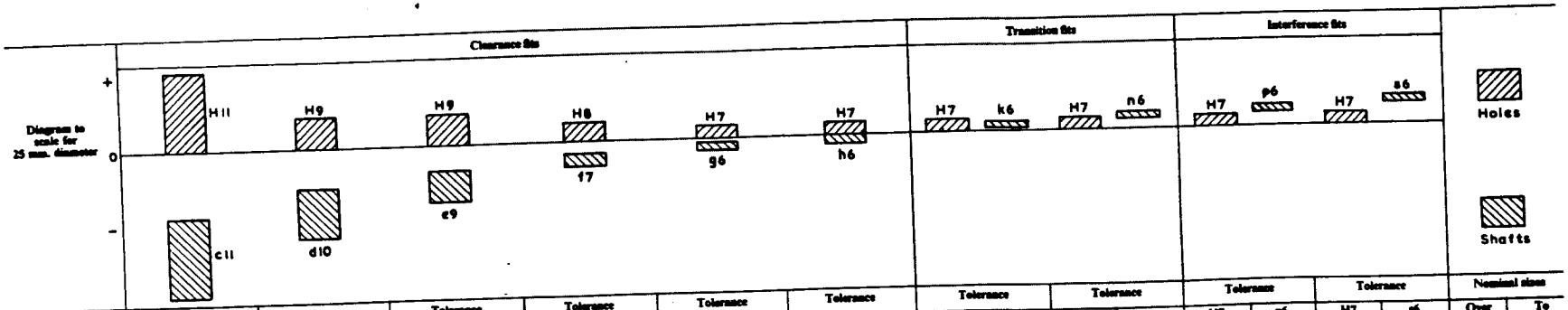

SECTION AT FORK
RESETTING LEVER
3
45°
2 LEVER BRACKET
1 BODY
4 OIL CYLINDER
A
T
T
45°
6 TRIP LEVER
3 BOLTS M6
SPACING 120° PCD 64
25
44 R
A
248
9 SPRING
10 REBOUND SPRING
7 TRIGGER
8 SPRING CAP
5 TRIP ROD
SECTION AA
R
54
54
4 HOLES 13 DRILL
SCALE
0
50
100
150
200
250
300 mm

Extracted from BS 4500 1969

BRITISH STANDARD

SELECTED ISO FITS—HOLE BASIS

Data Sheet
4500A
Issue 1. February 1970
Confirmed August 1986



Nominal sizes		Clearance fits										Transition fits				Interference fits				Nominal sizes	
		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance			
Over	To	H11	c11	H9	d10	H9	e9	H8	f7	H7	g6	H7	h6	H7	k6	H7	n6	H7	p6	H7	s6	Over	To
mm	mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	0·001 mm	mm	mm
—	3	+ 60 0	− 60 − 120	+ 25 0	− 20 − 60	+ 25 0	− 14 − 39	+ 14 0	− 6 − 16	+ 10 0	− 2 − 8	+ 10 0	− 6 0	+ 10 0	+ 6 + 0	+ 10 0	+ 10 + 4	+ 10 0	+ 12 + 6	+ 10 0	+ 20 + 14	—	3
3	6	+ 75 0	− 70 − 145	+ 30 0	− 30 − 78	+ 30 0	− 20 − 50	+ 18 0	− 10 − 22	+ 12 0	− 4 − 12	+ 12 0	− 8 0	+ 12 0	+ 9 + 1	+ 12 0	+ 16 + 8	+ 12 0	+ 20 + 12	+ 12 0	+ 27 + 19	3	6
6	10	+ 90 0	− 80 − 170	+ 36 0	− 40 − 98	+ 36 0	− 25 − 61	+ 22 0	− 13 − 28	+ 15 0	− 5 − 14	+ 15 0	− 9 0	+ 15 0	+ 10 + 1	+ 15 0	+ 19 + 10	+ 15 0	+ 24 + 15	+ 15 0	+ 32 + 23	6	10
10	18	+ 110 0	− 95 − 205	+ 43 0	− 50 − 120	+ 43 0	− 32 − 75	+ 27 0	− 16 − 34	+ 18 0	− 6 − 17	+ 18 0	− 11 0	+ 18 0	+ 12 + 1	+ 18 0	+ 23 + 12	+ 18 0	+ 29 + 18	+ 18 0	+ 39 + 28	10	18
18	30	+ 130 0	− 110 − 240	+ 52 0	− 65 − 149	+ 52 0	− 40 − 92	+ 33 0	− 20 − 41	+ 21 0	− 7 − 20	+ 21 0	− 13 0	+ 21 0	+ 15 + 2	+ 21 0	+ 28 + 15	+ 21 0	+ 35 + 22	+ 21 0	+ 48 + 35	18	30
30	40	+ 160 0	− 120 − 280	+ 62 0	− 80 − 180	+ 62 0	− 50 − 112	+ 39 0	− 25 − 50	+ 25 0	− 9 − 25	+ 25 0	− 16 0	+ 25 0	+ 18 + 2	+ 25 0	+ 33 + 17	+ 25 0	+ 42 + 26	+ 25 0	+ 59 + 43	30	40
40	50	+ 160 0	− 130 − 290																			40	50
50	65	+ 190 0	− 140 − 330	+ 74 0	− 100 − 220	+ 74 0	− 60 − 134	+ 46 0	− 30 − 60	+ 30 0	− 10 − 29	+ 30 0	− 19 0	+ 30 0	+ 21 + 2	+ 30 0	+ 39 + 20	+ 30 0	+ 51 + 32	+ 30 0	+ 72 + 53	50	65
65	80	+ 190 0	− 150 − 340																	+ 30 0	+ 78 + 59	65	80
80	100	+ 220 0	− 170 − 390	+ 87 0	− 120 − 260	+ 87 0	− 72 − 159	+ 54 0	− 36 − 71	+ 35 0	− 12 − 34	+ 35 0	− 22 0	+ 35 0	+ 25 + 3	+ 35 0	+ 45 + 23	+ 35 0	+ 59 + 37	+ 35 0	+ 93 + 71	80	100
100	120	+ 220 0	− 180 − 400																	+ 35 0	+ 101 + 79	100	120
120	140	+ 250 0	− 200 − 450	+ 100 0	− 145 − 305	+ 100 0	− 84 − 185	+ 63 0	− 43 − 83	+ 40 0	− 14 − 39	+ 40 0	− 25 0	+ 40 0	+ 28 + 3	+ 40 0	+ 52 + 27	− 40 0	+ 68 + 43	+ 40 0	+ 117 + 92	120	140
140	160	+ 250 0	− 210 − 460																	+ 40 0	+ 125 + 100	140	160
160	180	+ 250 0	− 230 − 480																	+ 40 0	+ 133 + 108	160	180
180	200	+ 290 0	− 240 − 530	+ 115 0	− 170 − 355	+ 115 0	− 100 − 215	+ 72 0	− 50 − 96	+ 46 0	− 15 − 44	+ 46 0	− 29 0	+ 46 0	+ 33 + 4	+ 46 0	+ 60 + 31	+ 46 0	+ 79 + 50	+ 46 0	+ 151 + 122	180	200
200	225	+ 290 0	− 260 − 550																	+ 46 0	+ 159 + 130	200	225
225	250	+ 290 0	− 280 − 570																	+ 46 0	+ 169 + 140	225	250
250	280	+ 320 0	− 300 − 620	+ 130 0	− 190 − 400	+ 130 0	− 110 − 240	+ 81 0	− 56 − 108	+ 52 0	− 17 − 49	+ 52 0	− 32 0	+ 52 0	− 36 − 4	+ 52 0	+ 66 + 34	+ 52 0	+ 88 + 56	+ 52 0	+ 190 + 158	250	280
280	315	+ 320 0	− 330 − 650																	+ 52 0	+ 202 + 170	280	315
315	355	+ 360 0	− 360 − 720	+ 140 0	− 210 − 440	+ 140 0	− 125 − 265	+ 89 0	− 62 − 119	+ 57 0	− 18 − 54	+ 57 0	− 36 0	+ 57 0	+ 40 + 4	+ 57 0	+ 73 + 37	+ 57 0	+ 98 + 62	+ 57 0	+ 226 + 190	315	355
355	400	+ 360 0	− 400 − 760																	+ 57 0	+ 244 + 208	355	400
400	450	+ 400 0	− 440 − 840	+ 155 0	− 230 − 480	+ 155 0	− 135 − 290	+ 97 0	− 68 − 131	+ 63 0	− 20 − 60	+ 63 0	− 40 0	+ 63 0	+ 45 + 5	+ 63 0	+ 80 + 40	+ 63 0	+ 108 + 68	− 63 0	+ 292 + 232	400	450
450	500	− 440 0	− 880																	+ 63 0	+ 292 + 252	450	500

BRITISH STANDARDS INSTITUTION, 2 Park Street, London, W1A 2BS
SBN: 580 05766 6

Selected ISO fits—hole basis (extracted from BS 4500)

UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER I FINAL EXAMINATION
JUNE 2004

ME 545 – ALTERNATIVE ENERGY SOURCES

TIME ALLOWED: THREE (3) HOURS **CLOSED BOOK**

INSTRUCTIONS

1. Answer a **total of FIVE (5) questions**. Any **TWO (2)** questions from SECTION A and any **THREE (3)** questions from SECTION B.
2. Draw sketches and graphs where necessary and clearly state any assumptions made.

SECTION A
(Answer any TWO Questions)

Q1. (a) What is the goal for undertaking energy efficiency, and describe why you need energy efficiency on both macro and micro-levels. [10 marks]

(b) Describe the tasks you need to undertake under the "Energy Conservation Measures Categories", and quantify the extent of saving. [10 marks]

Q2. (a) Substantiate the statement "the current increase of the frequency in flood and drought occurances, and sealevel rise, are largely due to **energy production and utilisation processes**". [6 marks]

(b) Due to the high cost of the diesel produced from fossil fuels, ZESCO is contemplating replacement of a continous-operating 750kW diesel electric generation station in Mwinilunga with other sources of energy. As an energy and environment expert, you have recommended that the current fuel be replaced by biodiesel produced from Jatropha plant, which readily grows in and around Mwinilunga.

The electricity generation sets, with a fuel index of 0.28litres/kWh, use diesel having an energy conversion factor of 42.75 GJ/tonne, carbon factor of 20.2 kg/GJ and specific gravity of 0.84.

(i) Determine the standardised emission factor of CO_2 (tCO_2/kWh). Assume that 99% of carbon is oxidised. [5 Marks]

(ii) Calculate, and graphically (sketch) show the amount of CO_2 savings over the initial 10-year project life, assuming constant annual power demand. [5 Marks]

(iii) From the global perspective, as an **energy and environmental** expert, justify the choice of biodiesel as opposed to continued use of the fossil fuel based diesel. Do you think it would be a good GHG abatement project? Why? [4 Marks]

Q3. Describe, with the help of diagrams, how heat from solar energy could be utilised for the following purposes:

(a) Preserving 1000kg of tomatoes
(b) Providing hot water for domestic use

SECTION B
(Answer any THREE Questions)

Q4. (a) State along with the criteria of choice, the types of turbines generally used for hydro-electric power stations. [6 marks]

(b) A hydroelectric power project is envisaged at a site which has a catchment area of $900km^2$, receives an annual amount of rainfall of 160cm, and has a reservoir offering a head of 360m. If the average runoff for the site is estimated to be about 72%, determine:

(i) The power potential of the site assuming a plant efficiency of 86%. [6 marks]

(ii) The number of turbines having a specific speed of 100rpm, that can be installed given an acceptable design frequency of generation of 50 cycles/s, and the number of poles used as 20, when both the turbine and generator are directly coupled such that their speed is synchronous. [8 marks]

5. (a) Describe and contrast features of a Solar Refrigerator. [5 marks]

(b) Provide a suitable solar powered system design for a rural health centre situated in an area receiving 5.5kWh/m^2.day, having the following needs:

- Lighting for 4 fluorescent lamps, 40W each.
- One 50 litre water tank connected to a pump having 60% efficiency and head of 18m
- Two solar refrigerators having ¼ HP compressor motor, 24V
- Powering two fans of 75W each

The system is expected to be powered by sunlight during the day but should have a 3- day autonomy during periods of overcast. While the whole system is expected to run for a period of 12hrs during the night, the installed water tank fills to the top in one hour. (Available components: Panels having an output current of 5.5 Amps, Battery rating of 102 amps and Depth of Discharge of 40%) [15 marks]

6. A village in Eastern Province is growing maize in excess of 30,000 tonnes per annum. To improve its well being, it decides to use this resource to produce electricity and serve the following energy demand centres.

Serial No.	Centre	Power demand
1	Rural health centre	10kW
2	School	2kW
3	Hammer mills	20kW
4	Two new clinics	4kW
5	Houses	5kW
6	Shops	10kW
7	Safari Camp	20kW
8	Small holder farms	400kW
9	Timber pocessing	100kW

(a) Based on the resource available, what type of energy supply would you recommend? [2 marks]

(b) Briefly describe the system design involved. What maximum power and energy would you recommend? [9 marks]

(c) Is the design you have selected sustainable? If yes, please quantify and prove this sustainability. [9 marks]

The calorific value of maize and its residue ratio are given as 14,000 kJ/kg and 0.3, respectively.

7. (a) As a renewable energy consultant, you are required to design a wind-mill for a farmer with a two hectare plot, who wishes to go into irrigation. His water requirement is $40m^3$/day. During the assignment provide a schematic diagram of your design and ensure that you select an optimum total hydraulic head for your design to be economic.

The following additional information is given on the average monthly wind speed:

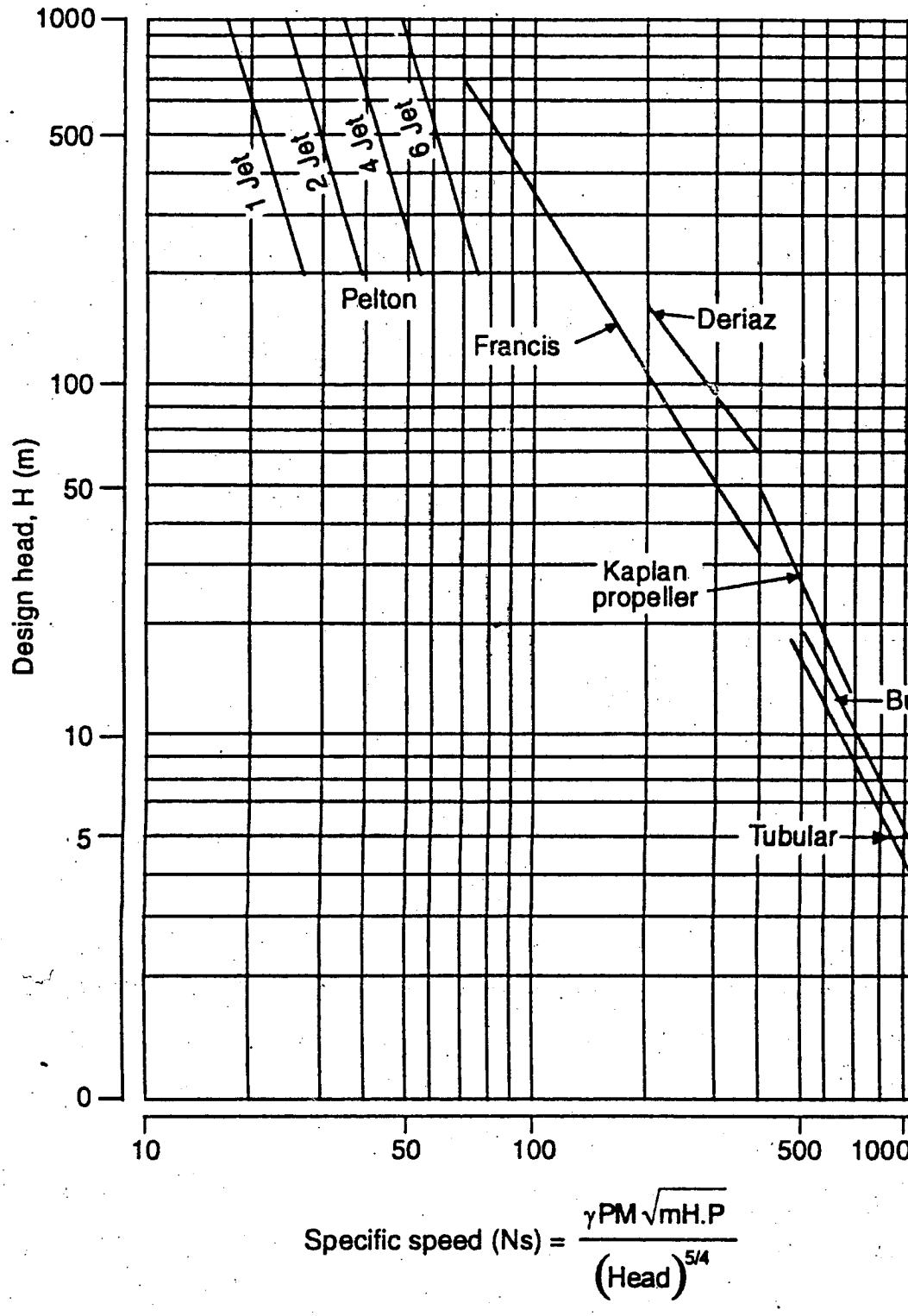
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Speed (m/s)	2.9	2.8	3.1	3.2	3.4	3.5	3.5	3.4	3.5	3.5	3.5	3.1

[16 marks]

(i) What type of rotor would you recommend in terms of "solidity". [2 marks]
(ii) Estimate the average cost of your design. [2 marks]

END OF EXAMINATION

Prepared by



Relation between head and specific speed (IS: 12837-1

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
ME 541-HEAT TRANSFER
SEMESTER I FINAL EXAMINATION JUNE 2004

Time: Three (3) Hours **Closed Book**

Instructions: Answer Two (2) Questions from Section A and Three (3) Questions fro Section B. State all assumptions, draw sketches and graphs where necessar All questions carry 20 marks.

SECTION A

Question 1

1.1 The furnace wall consists of 120 mm wide refractory brick and 120 mm wide insulatir fire brick separated by an air gap. The outside wall is covered with a 12 mm thic plaster. The inner surface is at 1200 °C and the room temperature is 20 °C. The hea transfer coefficient, from the outside wall to the air in the room, is 18 W/m^2 °C and th air gap resistance to the heat flow is 0.16 K/W. If the thermal conductivities of th refractory brick, insulating brick, and plaster are 1.6, 0.3, and 0.14 W/m respectively. Determine:

(I) The rate at which heat is lost per square meter of the wall surface;
(II) Each interface temperature;
(III) Temperature of the outside surface of the wall

1.2 A spherical container having an outer radius of 500 mm is insulated by a 100 mm thic layer material with a thermal conductivity K = 0.03(1+0.006t) W/m°C, where t is in °(If the surface temperature of the sphere is -200 °C (Minus two hundred deg. Cel.) ar the outer surface is 30 °C, determine the amount of heat flowing into the sphere.

Question 2

A piece of metal 5 mm thick and 45 mm long has its base attached on a furnace pla which is maintained at 125 °C. The ambient air is at 25 °C. The thermal conductivity the metal piece is 55 W/m°C and the heat transfer coefficient is 145 W/m^2 °C. Assu that heat loss at the end of the metal piece tip is by convection, determine:

(I) Temperature at the end of the metal piece
(II) Temperature at the middle of the metal piece, and
(III) Heat dissipated by the metal piece (per meter width)

Question 3

3.1 Steam condensing on the outer surface of a thin-walled circular tube of 50 m diameter and 6 m long maintains a uniform surface temperature of 100 °C. Wa flows through the tube at a rate of 0.25 Kg/s, and its inlet and outlet temperatures a $T_{m,i}$ =15 °C and $T_{m,o}$ =57 °C. What is the average heat transfer coefficient associat with the water flow?

Note: Use both the Log Mean Temperature Difference (LMTD) and Arithmetic Me Temperature Difference (AMTD) and comment on the answers.

3.2 Atmospheric air at $T\infty$ = 275 K flows across a 1 mm diameter electric wire that maintained at a uniform temperature Tw = 325 K. If the wire dissipates 70 W/ calculate the free stream velocity $U\infty$ of the air.

Question 4

4.1 The heat transfer coefficients for the flow of air at 28 °C over a 12.5 mm diame sphere are measured by observing the temperature time history of a copper ball of t same dimension. The temperature of the copper ball, of density 8850 Kg/m^3 a specific heat capacity 0.4 KJ/kgK, was measured using two thermocouples. C thermocouple was located in the centre and the other near the surface. Be thermocouples registered the same temperature at a given instant. In one test t initial temperature of the ball was 65 °C and in 1.15 minutes the temperatu decreased by 11 °C. Calculate the heat transfer coefficient for the said case.

4.2 An aluminium pipe caries steam at 110 °C. The pipe (K= 185 W/m °C) has an in diameter of 100 mm and outer diameter of 120 mm. The pipe is located in a ro where the ambient air is 30 °C and the convective heat transfer coefficient betwe the pipe and the air is 15 W/m^2 °C. Determine the heat transfer rate per unit length the pipe.

To reduce the heat losses from the pipe, it is covered with a 50 mm thick layer insulation (K= 0.20 W/m °C). Determine the heat transfer rate per unit length of insulated pipe. Take it that the steam convective heat resistance is negligible.

SECTION B

Question 5

5.1 Calculate the heat transfer rate per m^2 area by radiation between the surfaces of tw long cylinders having radii 10 cm and 5 cm respectively. The smaller cylinder being i the larger cylinder. The axes of the cylinders are parallel to each other and separate by a distance of 2 cm. The surfaces of inner and outer cylinders are maintained a 127°C and 27°C respectively. The emissivity of both surfaces is 0.5. Assume th medium between the two cylinders is non-absorbing.

5.2 A surface emits radiation at 2000 K. Considering the furnace as black body, calculate;

(i) Monochromatic radiant flux at 1 μ m wavelength.

(ii) Wavelength at which emission is maximum and the corresponding radiar heat flux.

(iii) Total emissive power.

Question 6.

6.1 State and prove Kirchhoff's law of radiation.

6.2 For a hemispherical furnace, the flat floor is at 700 K and has an emissivity of 0.5. Th hemispherical roof is at 1000 K and has emissivity of 0.25. Find the net radiative hea transfer from roof to floor.

Question 7

Two large parallel planes with emissivities 0.3 and 0.8 exchange heat. Find th percentage reduction in heat flow when a polished aluminium shield of emissivit 0.04 is placed between them. Use the method of electrical analogy.

Question 8

At the Zambian National Breweries plant, alcohol is produced and allowed to flow a 0.2 kg/sec inside the pipes. It is required that the alcohol flowing inside the pipes b cooled from 75°C to 35°C in a counter flow heat exchanger using water at 12°C ar at the rate of 0.16 kg/sec. The convection coefficient between alcohol and tub wall is 0.34 kW/m^2 K and that between wall and water is 0.225 kW/m^2 K. Determir the area of the heat exchanger assuming tube is thin and take; C_p (alcohol) = 2.5 kJ/kg-K, and C_p (water) = 4.18 kJ/kg K.

Question 9

Heated oil enters a heated exchanger at 155°C and is to be cooled by water enteri at 32°C. If the two fluids flow in parallel, the exit temperature of the oil and water a 85°C and 67°C respectively. Determine the exit temperatures of oil and water if t two fluids flow counter to each other. Assume no change in overall heat trans coefficient and mass flow rates.

End of ME 541 Semester I Examinations June 2004
Prepared by Dr. P C Chisale & Mr C. Siakachoma.

ABLE A-11

roperties of gases at 1 atm pressure

Tempera-ure, T K	Density, ρ kg/m^3	Specific heat, C_p J/kg · °C	Thermal conductivity, k W/m · °C	Thermal diffusivity, α m^2/s	Dynamic viscosity, μ kg/m · s	Kinematic viscosity, ν m^2/s	Pr nu Pr
			Air				
200	1.766	1003	0.0181	1.02×10^{-5}	1.34×10^{-5}	0.76×10^{-5}	
250	1.413	1003	0.0223	1.57×10^{-5}	1.61×10^{-5}	1.14×10^{-5}	
280	1.271	1004	0.0246	1.95×10^{-5}	1.75×10^{-5}	1.40×10^{-5}	
290	1.224	1005	0.0253	2.08×10^{-5}	1.80×10^{-5}	1.48×10^{-5}	
298	1.186	1005	0.0259	2.18×10^{-5}	1.84×10^{-5}	1.55×10^{-5}	
300	1.177	1005	0.0261	2.21×10^{-5}	1.85×10^{-5}	1.57×10^{-5}	
310	1.143	1006	0.0268	2.35×10^{-5}	1.90×10^{-5}	1.67×10^{-5}	
320	1.110	1006	0.0275	2.49×10^{-5}	1.94×10^{-5}	1.77×10^{-5}	
330	1.076	1007	0.0283	2.64×10^{-5}	1.99×10^{-5}	1.86×10^{-5}	
340	1.043	1007	0.0290	2.78×10^{-5}	2.03×10^{-5}	1.96×10^{-5}	
350	1.009	1008	0.0297	2.92×10^{-5}	2.08×10^{-5}	2.06×10^{-5}	
400	0.883	1013	0.0331	3.70×10^{-5}	2.29×10^{-5}	2.60×10^{-5}	
450	0.785	1020	0.0363	4.54×10^{-5}	2.49×10^{-5}	3.18×10^{-5}	
500	0.706	1029	0.0395	5.44×10^{-5}	2.68×10^{-5}	3.80×10^{-5}	
550	0.642	1039	0.0426	6.39×10^{-5}	2.86×10^{-5}	4.45×10^{-5}	
600	0.589	1051	0.0456	7.37×10^{-5}	3.03×10^{-5}	5.15×10^{-5}	
700	0.504	1075	0.0513	9.46×10^{-5}	3.35×10^{-5}	6.64×10^{-5}	
800	0.441	1099	0.0569	11.7×10^{-5}	3.64×10^{-5}	8.25×10^{-5}	
900	0.392	1120	0.0625	14.2×10^{-5}	3.92×10^{-5}	9.99×10^{-5}	
1000	0.353	1141	0.0672	16.7×10^{-5}	4.18×10^{-5}	11.8×10^{-5}	
1200	0.294	1175	0.0759	22.2×10^{-5}	4.65×10^{-5}	15.8×10^{-5}	
1400	0.252	1201	0.0835	27.6×10^{-5}	5.09×10^{-5}	20.2×10^{-5}	
1600	0.221	1240	0.0904	33.0×10^{-5}	5.49×10^{-5}	24.9×10^{-5}	
1800	0.196	1276	0.0970	38.3×10^{-5}	5.87×10^{-5}	29.9×10^{-5}	
2000	0.177	1327	0.1032	44.1×10^{-5}	6.23×10^{-5}	35.3×10^{-5}	
			Ammonia (NH_3)				
200	1.038	2199	0.0153	0.67×10^{-5}	6.89×10^{-6}	0.66×10^{-5}	
250	0.831	2248	0.0197	1.05×10^{-5}	8.53×10^{-6}	1.03×10^{-5}	
300	0.692	2298	0.0246	1.55×10^{-5}	10.27×10^{-6}	1.48×10^{-5}	
350	0.593	2349	0.0302	2.17×10^{-5}	12.06×10^{-6}	2.03×10^{-5}	
400	0.519	2402	0.0364	2.92×10^{-5}	13.90×10^{-6}	2.68×10^{-5}	
450	0.461	2455	0.0433	3.82×10^{-5}	15.76×10^{-6}	3.42×10^{-5}	
500	0.415	2507	0.0506	4.86×10^{-5}	17.63×10^{-6}	4.25×10^{-5}	
550	0.378	2559	0.0580	6.00×10^{-5}	19.5×10^{-6}	5.16×10^{-5}	
600	0.346	2611	0.0656	7.26×10^{-5}	21.4×10^{-6}	6.18×10^{-5}	
700	0.297	2710	0.0811	10.1×10^{-5}	25.1×10^{-6}	8.45×10^{-5}	
800	0.260	2810	0.0977	13.4×10^{-5}	28.8×10^{-6}	11.1×10^{-5}	
			Argon				
200	2.435	523.6	0.0124	0.98×10^{-5}	1.60×10^{-5}	0.66×10^{-5}	
250	1.948	522.2	0.0152	1.49×10^{-5}	1.95×10^{-5}	1.00×10^{-5}	
300	1.623	521.6	0.0177	2.09×10^{-5}	2.27×10^{-5}	1.40×10^{-5}	
350	1.392	521.2	0.0201	2.78×10^{-5}	2.57×10^{-5}	1.85×10^{-5}	
400	1.218	521.0	0.0223	3.52×10^{-5}	2.85×10^{-5}	2.34×10^{-5}	
450	1.082	520.9	0.0244	4.33×10^{-5}	3.12×10^{-5}	2.88×10^{-5}	

TABLE A-9

Properties of saturated water

Temperature, T °C	Saturation pressure, P kPa	Density, ρ kg/m³		Enthalpy of vaporization, h_{fg} kJ/kg	Specific heat, C_p J/kg · °C		Thermal conductivity, k W/m · °C		Dynamic viscosity, μ kg/m · s		Prandtl number, Pr		Volume expansion coefficient, β 1/K
		Liquid	Vapor		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid
0.01	0.6113	999.8	0.0048	2501	4217	1854	0.561	0.0171	1.792×10^{-3}	0.922×10^{-5}	13.5	1.00	-0.068×10^{-3}
5	0.8721	999.9	0.0068	2490	4205	1857	0.571	0.0173	1.519×10^{-3}	0.934×10^{-5}	11.2	1.00	0.015×10^{-3}
10	1.2276	999.7	0.0094	2478	4194	1862	0.580	0.0176	1.307×10^{-3}	0.946×10^{-5}	9.45	1.00	0.733×10^{-3}
15	1.7051	999.1	0.0128	2466	4186	1863	0.589	0.0179	1.138×10^{-3}	0.959×10^{-5}	8.09	1.00	0.138×10^{-3}
20	2.339	998.0	0.0173	2454	4182	1867	0.598	0.0182	1.002×10^{-3}	0.973×10^{-5}	7.01	1.00	0.195×10^{-3}
25	3.169	997.0	0.0231	2442	4180	1870	0.607	0.0186	0.891×10^{-3}	0.987×10^{-5}	6.14	1.00	0.247×10^{-3}
30	4.246	996.0	0.0304	2431	4178	1875	0.615	0.0189	0.798×10^{-3}	1.001×10^{-5}	5.42	1.00	0.294×10^{-3}
35	5.628	994.0	0.0397	2419	4178	1880	0.623	0.0192	0.720×10^{-3}	1.016×10^{-5}	4.83	1.00	0.337×10^{-3}
40	7.384	992.1	0.0512	2407	4179	1885	0.631	0.0196	0.653×10^{-3}	1.031×10^{-5}	4.32	1.00	0.377×10^{-3}
45	9.593	990.1	0.0655	2395	4180	1892	0.637	0.0200	0.596×10^{-3}	1.046×10^{-5}	3.91	1.00	0.415×10^{-3}
50	12.35	988.1	0.0831	2383	4181	1900	0.644	0.0204	0.547×10^{-3}	1.062×10^{-5}	3.55	1.00	0.451×10^{-3}
55	15.76	985.2	0.1045	2371	4183	1908	0.649	0.0208	0.504×10^{-3}	1.077×10^{-5}	3.25	1.00	0.484×10^{-3}
60	19.94	983.3	0.1304	2359	4185	1916	0.654	0.0212	0.467×10^{-3}	1.093×10^{-5}	2.99	1.00	0.517×10^{-3}
65	25.03	980.4	0.1614	2346	4187	1926	0.659	0.0216	0.433×10^{-3}	1.110×10^{-5}	2.75	1.00	0.548×10^{-3}
70	31.19	977.5	0.1983	2334	4190	1936	0.663	0.0221	0.404×10^{-3}	1.126×10^{-5}	2.55	1.00	0.578×10^{-3}
75	38.58	974.7	0.2421	2321	4193	1948	0.667	0.0225	0.378×10^{-3}	1.142×10^{-5}	2.38	1.00	0.607×10^{-3}
80	47.39	971.8	0.2935	2309	4197	1962	0.670	0.0230	0.355×10^{-3}	1.159×10^{-5}	2.22	1.00	0.653×10^{-3}
85	57.83	968.1	0.3536	2296	4201	1977	0.673	0.0235	0.333×10^{-3}	1.176×10^{-5}	2.08	1.00	0.670×10^{-3}
90	70.14	965.3	0.4235	2283	4206	1993	0.675	0.0240	0.315×10^{-3}	1.193×10^{-5}	1.96	1.00	0.702×10^{-3}
95	84.55	961.5	0.5045	2270	4212	2010	0.677	0.0246	0.297×10^{-3}	1.210×10^{-5}	1.85	1.00	0.716×10^{-3}
100	101.33	957.9	0.5978	2257	4217	2029	0.679	0.0251	0.282×10^{-3}	1.227×10^{-5}	1.75	1.00	0.750×10^{-3}
110	143.27	950.6	0.8263	2230	4229	2071	0.682	0.0262	0.255×10^{-3}	1.261×10^{-5}	1.58	1.00	0.798×10^{-3}
120	198.53	943.4	1.121	2203	4244	2120	0.683	0.0275	0.232×10^{-3}	1.296×10^{-5}	1.44	1.00	0.858×10^{-3}
130	270.1	934.6	1.496	2174	4263	2177	0.684	0.0288	0.213×10^{-3}	1.330×10^{-5}	1.33	1.01	0.913×10^{-3}
140	361.3	921.7	1.965	2145	4286	2244	0.683	0.0301	0.197×10^{-3}	1.365×10^{-5}	1.24	1.02	0.970×10^{-3}
150	475.8	916.6	2.546	2114	4311	2314	0.682	0.0316	0.183×10^{-3}	1.399×10^{-5}	1.16	1.02	1.025×10^{-3}
160	617.8	907.4	3.256	2083	4340	2420	0.680	0.0331	0.170×10^{-3}	1.434×10^{-5}	1.09	1.05	1.145×10^{-3}
170	791.7	897.7	4.119	2050	4370	2490	0.677	0.0347	0.160×10^{-3}	1.468×10^{-5}	1.03	1.05	1.178×10^{-3}
180	1002.1	887.3	5.153	2015	4410	2590	0.673	0.0364	0.150×10^{-3}	1.502×10^{-5}	0.983	1.07	1.210×10^{-3}
190	1254.4	876.4	6.388	1979	4460	2710	0.669	0.0382	0.142×10^{-3}	1.537×10^{-5}	0.947	1.09	1.280×10^{-3}
200	1553.8	864.3	7.852	1941	4500	2840	0.663	0.0401	0.134×10^{-3}	1.571×10^{-5}	0.910	1.11	1.350×10^{-3}
220	2318	840.3	11.60	1859	4610	3110	0.650	0.0442	0.122×10^{-3}	1.641×10^{-5}	0.865	1.15	1.520×10^{-3}
240	3344	813.7	16.73	1767	4760	3520	0.632	0.0487	0.111×10^{-3}	1.712×10^{-5}	0.836	1.24	1.720×10^{-3}
260	4688	783.7	23.69	1663	4970	4070	0.609	0.0540	0.102×10^{-3}	1.788×10^{-5}	0.832	1.35	2.000×10^{-3}
280	6412	750.8	33.15	1544	5280	4835	0.581	0.0605	0.094×10^{-3}	1.870×10^{-5}	0.854	1.49	2.380×10^{-3}
300	8581	713.8	46.15	1405	5750	5980	0.548	0.0695	0.086×10^{-3}	1.965×10^{-5}	0.902	1.69	2.950×10^{-3}
320	11,274	667.1	64.57	1239	6540	7900	0.509	0.0836	0.078×10^{-3}	2.084×10^{-5}	1.00	1.97	—
340	14,586	610.5	92.62	1028	8240	11870	0.469	0.110	0.070×10^{-3}	2.255×10^{-5}	1.23	2.43	—
360	18,651	528.3	144.0	720	14,690	25,800	0.427	0.178	0.060×10^{-3}	2.571×10^{-5}	2.06	3.73	—
374.14	22,090	317.0	317.0	0	∞	∞	∞	∞	0.043×10^{-3}	4.313×10^{-5}	—	—	—

Source: Viscosity and thermal conductivity data are from J. V. Sengers and J. T. R. Watson, *Journal of Physical and Chemical Reference Data* 15 (1986), pp. 1291–1322. Other data are obtained from various sources or calculated.

Note: Kinematic viscosity ν and thermal diffusivity α can be calculated from their definitions, $\nu = \mu/\rho$ and $\alpha = k/\rho C_p = \nu/\text{Pr}$. The temperatures 0.01°C, 100°C, and 374.14°C are the triple-, boiling-, and critical-point temperatures of water, respectively. The properties listed above (except the vapor density) can be used at any pressure with negligible error except at temperatures near the critical-point value.

Table 3.4 Temperature distribution and heat loss for fins of uniform cross section

CASE	TIP CONDITION ($X = L$)	TEMPERATURE DISTRIBUTION θ/θ_b	FIN HEAT TRANSFER RATE q_f
A	Convection heat transfer: $h\theta(L) = -k\, d\theta/dx\|_{x=L}$	$\dfrac{\cosh m(L-x) + (h/mk)\sinh m(L-x)}{\cosh mL + (h/mk)\sinh mL}$ (3.70)	$M\dfrac{\sinh mL + (h/mk)\cosh mL}{\cosh mL + (h/mk)\sinh mL}$ (3.72)
B	Adiabatic: $d\theta/dx\|_{x=L} = 0$	$\dfrac{\cosh m(L-x)}{\cosh mL}$ (3.75)	$M \tanh mL$ (3.76)
C	Prescribed temperature: $\theta(L) = \theta_L$	$\dfrac{(\theta_L/\theta_b)\sinh mx + \sinh m(L-x)}{\sinh mL}$ (3.77)	$M\dfrac{(\cosh mL - \theta_L/\theta_b)}{\sinh mL}$ (3.78)
D	Infinite fin ($L \to \infty$): $\theta(L) = 0$	e^{-mx} (3.79)	M (3.80)

$\theta \equiv T - T_\infty$ $\qquad m^2 \equiv hP/kA_c$

$\theta_b = \theta(0) = T_b - T_\infty$ $\qquad M \equiv \sqrt{hPkA_c}\,\theta_b$

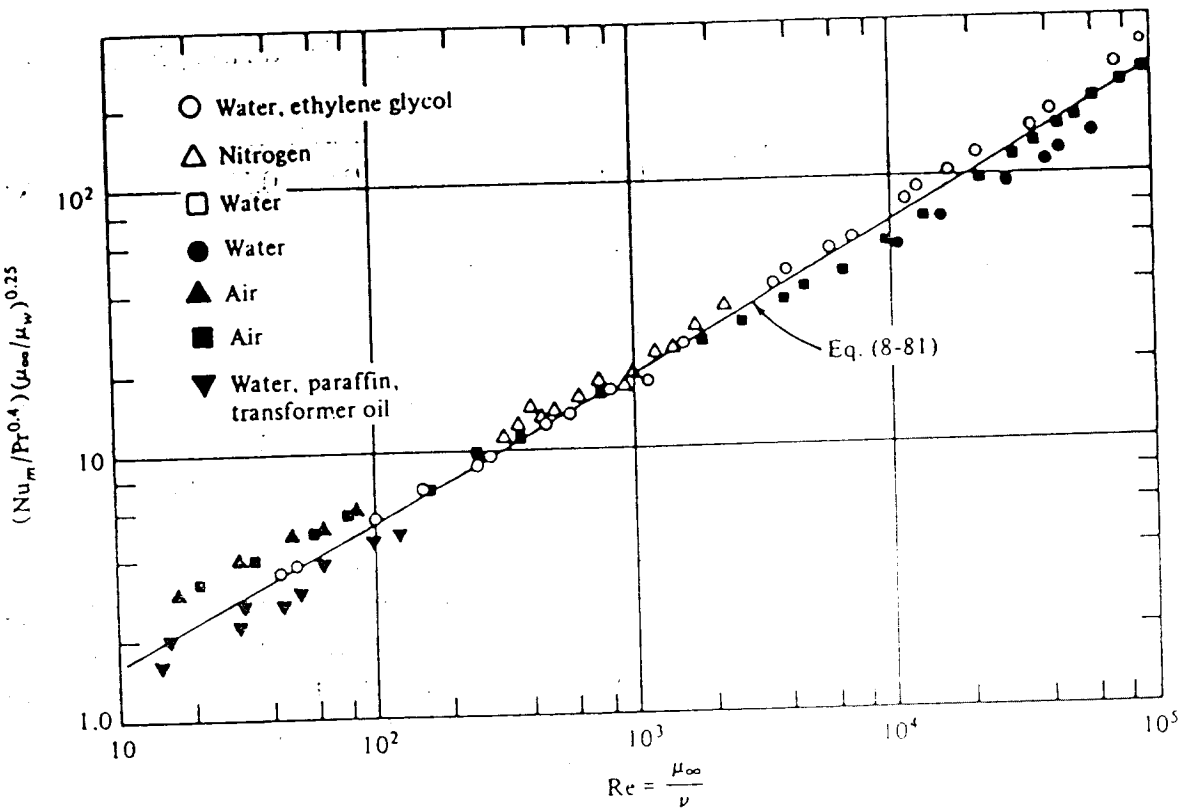


Figure 8-7 Nusselt number for flow across a single circular cylinder. (*From Whitaker* [*18*].)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS

SEMESTER I EXAMINATIONS 2004
JUNE/JULY 2004

ME 595 – MAINTENANCE ENGINEERING

TIME ALLOWED: THREE HOURS **CLOSED BOOK**

ANSWER FIVE QUESTIONS, WITH AT LEASE TWO FROM EACH SECTION

HAND IN SECTIONS A AND B SEPARATELY. ALL QUESTIONS CARRY EQUAL MARKS

SECTION A: Answer at least TWO Questions from this Section

Q1. (a) Give a definition of maintenance. What is the difference between Preventive and Corrective maintenance? [8 marks]

(b) Give an outline of each one of the following:

(i) Service [4 marks]

(ii) Inspection [4 marks]

(iii) Repair [4 marks]

Q2. Discuss the following with respect industrial plant and equipment:

(a) Primary functions of maintenance. [10 marks]

(b) Secondary functions of maintenance [10 marks]

Q3. Give an outline for each one of the following maintenance strategies:

(a) Risk Based Inspection [10 marks]

(b) Instrumented Protective Functions [10marks]

Q4. Discuss the possible range of applications of computers in maintenance engineering. [20 marks]

SECTION B: Answer at least TWO Questions from this Section

Q5. (a) Define reliability. [5 marks]

(b) State and explain five design aspects of reliability improvement. [10 marks]

(c) How is the availability of reliability information beneficial to the various personnel in an industrial setup? [5 marks]

Q6. (a) Name 10 broad classifications of condition monitoring. [10 marks]

(b) Mention and briefly explain any five methods used in crack detection. [10 marks]

Q7. (a) "Random failures can be reduced by improving designs: making them more robust with respect to the environment to which they are subjected." Explain how this can be achieved in relation to the bathtub curve representation of a time-dependent failure rate? [5 marks]

(b) The reliability of a cutting tool is given by

$$R(t) = \begin{cases} (1-0.4t)^2, & 0 \le t \le 10 \\ 0, & t > 10 \end{cases}$$

where t is in hours.

(i) What is the MTTF? [5 marks]

(ii) How frequently should the tool be changed if failures are to be held to no more than 5%? [5 marks]

(iii) Is the failure rate increasing or decreasing? Justify your result. [5 marks]

Q8. (a) How does the Weibull Distribution compare and contrast with the normal distribution as used to model failures in Maintenance Engineering? [5 marks]

(b) The diameter of a shaft in an optical storage drive is normally distributed with a mean of 6.370 mm and a standard deviation of 0.013 mm. The specifications on the shaft are 6.350 ± 0.038 mm.

(i) What proportion of the shafts conforms to specifications? State with reasons whether most of the shafts rejected would be too large or too small. [10 marks]

(ii) If the process were centred so that the process mean is equal to the target of 6.350 mm, what then would be the proportion of the shafts conforming to the specifications? [5 marks]

END OF ME 595 EXAMINATION
Dr H M Mwenda / G M Munakaampe

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

MINING ENGINEERING DEPARTMENT
END SEMESTER EXAMINATION – JUNE 2004
MI 315 ROCK MECHANICS 1

TIME : THREE (3) HOURS **FULL MARKS :100**

INSTRUCTIONS FOR STUDENTS

- **ANSWER QUESTION NO 4 AND ANY OTHER FIVE. IN TOTAL SIX (06) QUESTIONS TO BE ANSWERED**
- **USE SUPPLIED GRAPH PAPER FOR QUESTION NO 4**
- **CALACULATINGS MUST BE SHOWN IN FULL**

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1. (a) "The strength determinations of rock require specimen preparation and the results are highly sensitive to the method and style of loading. "Comment on the above statement citing examples.

(08 marks)

(b) what type of specimen required for the determination of flexural strength of a rock sample?

(02 marks)

Calculate the modulus of rupture of a rock sample from the data given below

- length of specimen = 150 mm
- diameter of specimen = 54 mm
- load at failure = 100 kN
- length between load reactions= 40 mm
- moisture content and void ratio 2% and 10% respectively

(06 marks)

2. (a) Describe, step by step, how shear strength of a rock can be determined in the laboratory using triaxial methods of loading?

(08 marks)

(b) In a series of a traixial compression tests on a limestone, the following represent the stresses at a peak load conditions:

TEST	σ 3 (MPa)	σ 1 (Mpa)
1	0.0	10.0
2	5.0	30.0
3	10.0	50.0
4	15.0	75.0

Determine the value of (i) uniaxial compressive strength (ii) shear strength and (iii) angle of internal friction that best fit the carve (graph paper supplied).

(08 marks)

3. (a) List the parameters on which the value of Stress Concentration Factor (SCF) depends. What is the significance of SCF in mining?

(08 marks)

(b) A rectangular opening g2.0 m high by 6.0 m wide at 800m depth is in biaxial stress field. The uniaxial compressive and tensile strength of the host rock 1 which the opening exists are 100 MPa and 10 MPa respectively.

Comment on the stability of the opening if the value of SCF are as follows:

In compression = -1.7
In tension = 1.0

Average unit weight of overlying rock is 26 kN $^{m-3}$

(08 marks)

4. (a) Explain the "tributary area" principle used in the design of room and pillar mining. Can this principle be used in every methods of mining?

(10 marks)

(b) (i) A horizontal stratiform, 3.0 m thick located at 300m depth is to be mined by room and pillar mining. The proposed layout is based on 6.0 m room spays and 5.0 square pillars. It has been decided to leave 0.5m are in the roof because of weak immediate roof. The av. unit weight of overlying rock is 26 kN^{m-3} .

Determine factor of safety against compression failure and tensile failure of pillars in the planned layout and comment on their stability.

(05 marks)

(ii) If your calculations show that the pillars in the above example are not likely to be stable suggest possible method (s) to make them stable.

(05 marks)

(a) What is meant by (i) the liquid limit (Lw) (ii) the plastic limit (Pw) and (iii) the shrinkage limit (Sw)

(07 marks)

(b) A sample of saturated clay weights 1500 gm in its natural state and 1000 gm after drying .

Determine (i) natural water content
(ii) void ratio
(iii) porosity of the above sample

(3x3=09 marks)

(a) Explain with the help of neat diagrams the difference in supporting actions between the "conventional type" of supports and "rock bolting"

(08 marks)

(b) (i) List a few advantages and the limitations of rock bolting as compared to conventional type

(ii) A 3.0 m thick seam is being extracted at a depth of 500 m below the surface. Calculate the caving height if the bulk factor of fragmental rock is likely to be 1.2

(04 marks)

(a) (i) List the principal parameter on which the subsidence due to mining depends.

(05 marks)

(ii) Explain with the help of diagrams how the subsidence may differ incase of bedded and non-bedded (veins) deposits

(05 marks)

(b) A 6.0 m long lathe machine housed in a workshop on the surface under which coal mining at a depth of 400m is taking place. If the extraction height of coal seam is 3.0 m calculate the drop m the lathe machine. The expected subsidence is likely to be approx. 0.85% of the extracted height

(05 marks)

END OF EXAM