THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER EXAM PAPER 2002/2003
SCHOOL OF ENGINEERING

1. CE 282 - Construction Materials
2. CE 369 - Fluid Mechanics I
3. CE 452 - Environmental Engineering I
4. CE 465 - Hydrology
5. CE 535 - Structural Steel Design
6. EA 242 - Soil and Water Conservation Engineering
7. EA 402 - Energy Sources and Utilization in Agriculture II
8. EA 415 - Agricultural Mechanisation
9. EA 452 - Post Harvest Technology
10. EA 512 - Farm Machinery Design
11. EA 522 - Farm Structures II
12. EA 542 - Irrigation Engineering
13. EE 209 - Principles of Electrical Engineering I
14. EE 342 - Electronics Engineering I
15. EE 392 - Electrical Engineering Practice
16. EE 422 - Electrical Machines I
17. EE 442 - Electronic Engineering II
18. EE 462 - Instrumentation
19. EE 532 - Power Electronics
20. EE 552 - Electrical Power Systems II
21. EE 562 - Systems and control Engineering II
22. EE 572 - Telecommunication Systems
23. EG 269 - Information Technology
24. EG 475 - Engineering Management and Society I
25. EG 575 - Engineering Management and Society
26. EM 312 - Engineering Mechanics II
27. GE 212 - Final Exams. Geometric
28. GE 215 - Introduction to Computing for Geometric
29. GE 352 - Land Law and Land Resource Management
30. GE 431 - Photogrammetry
31. GE 472 - Principles of Surveying II
32. ME 209 - Engineering Drawing I
33. ME 232 - Properties of Engineering Materials I
34. ME 312 - Machine Tools and Principles of Electricity II
35. ME 332 - Strength of Materials I
36. ME 405 - Machine Design I
37. ME 472 - Vibrations and Control Engineering I
38. ME 585 - Automobile Engineering

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY, 2004

CONSTRUCTION MATERIALS – CE 282

TIME: 3 HOURS
ANSWER ALL QUESTIONS

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1. Name the two groups of woods found and how do they differentiate. What are the names given for the outer and inner layers of a tree. What are the factors affecting the strength of timber. Describe each one and how do they influence the strength of timber. **10 MARKS**

2. Describe the various tests carried out on timber samples and the purposes they serve. How is timber treated against insects and fire. Describe the differences between wet and dry rot. **10 MARKS**

3. Name the building materials we derive from silica. What is the difference between bricks and blocks and detail the commonly used dimensions for bricks. Name the three basic subdivisions of brick types and describe their uses. **6 MARKS**

4. What are the properties of clay. How do we determine the strength of bricks and blocks. Describe the test procedures. Describe efflorescence. **4 MARKS**

5. What are the two groups of plastic materials we generally use in the construction industry? Describe the different types under each group and their uses. **6 MARKS**

6. Describe bitumen and the different materials made from bitumen and other admixtures generally used in the construction industry. **10 MARKS**

7. How and where do we obtain glass from. What are the basic forms of glass and their application we generally use in construction. **4 MARKS**

THE UNIVERSITY OF ZAMBIA

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The University of Zambia
Department of Civil and Environmental Engineering
CE 369-Fluid Mechanics I

Semester 2 - Academic Year 2003
FINAL EXAM

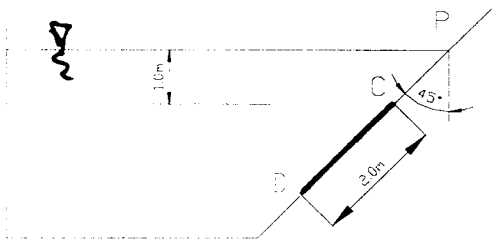
CLOSED BOOK Examination
TIME: THREE HOURS

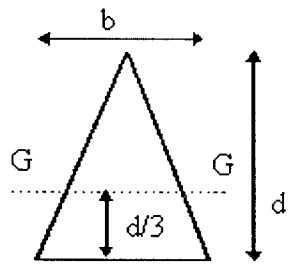
Instructions to candidates:

1. Candidates must ensure that their computer numbers are clearly written on each answer sheet used.
2. Answer ANY FIVE questions. All questions carry equal mark (20 %).

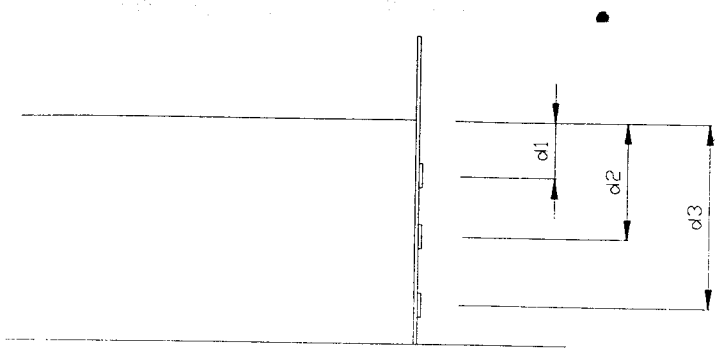
1.0 The velocity distribution of a viscous liquid (dynamic viscosity $\mu = 0.9$ Ns/m2) flowing over a fixed plate is given by $u = 0.68y - y2$ (u is velocity in m/s and y is the distance from the plate in m).
What are the shear stresses at the plate surface and at y=0.34m? Present your solution with a neat sketch of the scenario.

2.0 Determine the resultant force (*including its point of action*) due to the water acting on the 1.25m by 2.0m triangular area CD shown in the figure below. The apex of the triangle is at C.





3.0 A dock gate is to be reinforced with three horizontal beams (*See figure below*). If the water acts on one side only, to a depth of 6m, find the positions (d1,d2, and d3) of the beams measured from the water surface so that each will carry an equal load. Give the load per meter.



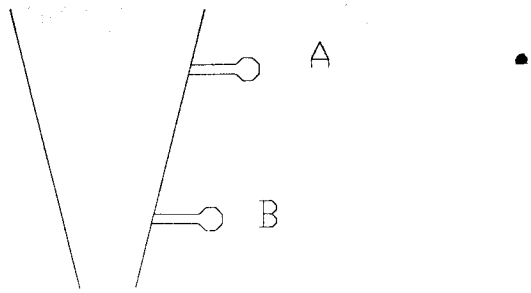
4.0 A reservoir is circular in plan and the sides slope at an angle of $\tan^{-1}(1/5)$ to the horizontal. When the reservoir is full the diameter of the water surface is 50m. Discharge from the reservoir takes place through a pipe of diameter 0.65m, the outlet being 4m below top water level. Determine the time for the water level to fall 2m assuming the discharge to be $0.75a\sqrt{2gH}$ cumecs where a is the cross sectional area of the pipe in m^2 and H is the head of water above the outlet in m.

5.0

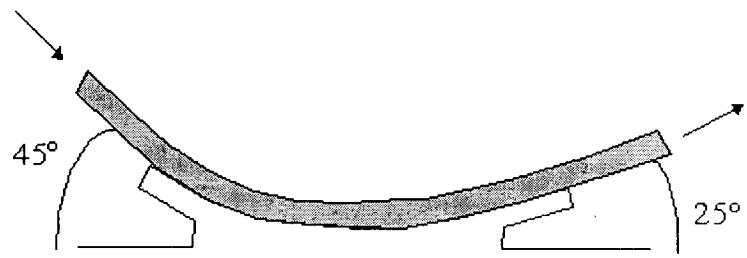
(a) In a vertical pipe carrying water, pressure gauges are inserted at points A and B where the pipe diameters are 0.15m and 0.075m respectively (***See Figure below***). The point B is 2.5m below A and when the flow rate down the pipe is 0.02 cumecs, the pressure at B is 14715 N/m^2 greater than that at A.

Assuming the losses in the pipe between A and B can be expressed as $k\frac{v^2}{2g}$ where v is the velocity at A, find the value of k.

(b) If the gauges at A and B are replaced by tubes filled with water and connected to a U-tube containing mercury of relative density 13.6, give a sketch showing how the levels in the two limbs of the U-tube differ and calculate the value of this difference in metres.



6.0 The figure below shows a smooth curved vane attached to a rigid foundation. The jet of water, rectangular in section, 75mm wide and 25mm thick, strike the vane with a velocity of 25m/s. Calculate the vertical and horizontal components of the force exerted on the vane and indicate in which direction these components act.



7.0 A reservoir with vertical sides has a plan area of 56000m^2. Discharge from the reservoir takes place over a rectangular weir, the flow characteristic of which is $Q=1.77BH^{3/2}$ m^3/s. At times of maximum rainfall, water flows into the reservoir at the rate of 9m^3/s. Find a) the length of weir required to discharge this quantity if head must not exceed 0.6m; b) the time necessary for the head to drop from 60cm to 30cm if the inflow suddenly stops.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATION
THURSDAY, JANUARY 8TH , 2004
CE 452 - ENVIRONMENTAL ENGINEERING I

INFORMATION AND INSTRUCTIONS:

1. Duration: Three (3) hours
2. The paper contains two sections and two appendices
3. Section A is compulsory and contains two questions
4. Section B contains 4 questions. You are required to attempt any three
5. Some information and formulas have been given appendix 2
6. You can answer the questions in any order
7. Remember to clearly number your solutions
8. Marks will be lost for untidy and unorganised presentation
9. The examination is strictly closed book

SECTION A - COMPULSORY - ATTEMPT BOTH QUESTIONS

QUESTION ONE

(a) List the general components of a water supply system.

(b) State and explain factors that govern the choice a water source.

(c) What factors affect the choice of a water treatment process?

(d) A treatment plant is to be designed for a population of 10,000 inhabitants with a daily per capita water consumption of 100 liters. The population increases linearly at a rate of 2.5% per annum. A source has been identified with the following qualitative and quantitative characteristics:

Parameter (unit)	Source	WHO Guideline
pH (-)	7.2	6.5 - 9.0
Total Dissolved solids (mg/l)	970	1000
Total suspended solids (mg/l)	110	0.1
Turbidity (NTU)	75	5
BOD (mg O_2/l)	4	-
Total Coliforms (No./100ml)	34	0
Maximum yield (l/s)	0.016	-
Other information	Pilot sedimentation investigations revealed that only 50% of the suspended solids could settle in 2 hours	

i. What unit operation(s) would you recommend for the treatment of this water? Give reasons for your recommendation.

ii. Would this source be a suitable source if the treatment plant were to have a design period of 15 years and if the losses are 10% and 15% for the treatment plant and distribution system respectively?

[4+3+3+10]

QUESTION TWO

(a) State the treatment stages in a conventional wastewater treatment plant.

(b) Explain how BOD is reduced in conventional wastewater treatment plant from the time the wastewater enters the plant to the time it is discharged to a receiving water body.

(c) Explain how wastewater rich in nutrients would negatively impact on the environment.

(d) A town of 10,000 inhabitants is to be provided with a wastewater treatment plant employing primary sedimentation tanks, trickling filters and secondary sedimentation tanks. The per capita water consumption is 100l/day of which 75% ends up in sewers. The average BOD concentration of the wastewater is 300mg/l. If BOD reduction in primary sedimentation tanks is 33.33%, design the trickling filters that will produce an effluent of 45mg/l given that:

i) the temperature is $16^{o}C$.
ii) There is no possibility of population increase.
iii) Maximum permissible filter depth = 1.8m
iv) Maximum permissible filter diameter = 30m

[3+4+3+10]

SECTION B - ATTEMPT ANY THREE QUESTIONS FROM THIS SECTION

QUESTION THREE

a) Briefly discuss the causes and significance of hardness of water.

b) Discuss the general principles of water softening by ion-exchange using a Sodium bed.

c) What do you understand by the term "regeneration" as it applies to water softening?

d) Figure B1 in appendix 1 is a graph of the influent and effluent hardness against time in minutes for water softening pilot experiment using 12ml of resins. The flow rate in this experiment was 25 ml/min. Water is considered to be treated if the effluent hardness is 0mg $CaCO_3$ /l.

Calculate how much water with a hardness 300mg $CaCO_3$ /l the resins of the same capacity would treat if the resin bed is 100ml.

[4+4+2+12]

QUESTION FOUR

(a) What is a unit operation?

(b) Why are coliform organisms suitable indicators for the microbiological water quality?

(.c) What is filtration? Briefly explain the following treatment mechanisms as they apply to filtration:

i. Screening
ii. Interception
iii. Adsorption

(d) How is filtration affected by the following?

i. Depth of filter bed
ii. Fineness of the filter sand

(e) Explain the principle and significance of air binding as it applies to slow sand filters and explain how it can be prevented.

[2+4+6+4+4]

QUESTION FIVE

(a) Explain how is BOD reduced in

i. Anaerobic ponds;

ii. Facultative ponds;

(b) A wastewater treatment plant is designed to handle $100m^3/h$ of domestic wastewater. The BOD concentration in the influent is 300mg/l. Given that the lowest average ambient temperature for the coldest month is $15^{O}C$ and the information below.

Minimum monthly ambient temperature (^{0}C)	Volumetric organic loading rate λ_v (in g $BOD_5/m^3.d$)	BOD_5 removal (%)
< 10	100	40
10 - 20	20T - 100	2T + 20
> 20	300	60

Table 1: Design volumetric organic loading rates for anaerobic ponds as a function of the monthly average ambient temperature.

Also given that the permissible surface loading rate (λ_s) of facultative ponds is given by:

$\lambda_s = 2T-12$

Where T is the monthly average ambient temperature

Design the facultative pond for this wastewater. Take depth as 1.2m and the length to breadth ratio as 3.

(c) If for the same treatment plant, four maturation ponds are to be provided each with a retention time of 6 days, what will the faecal coliform concentration in the effluent be if the influent has a faecal coliform concentration of $1*10^8/100ml$?

[4+12+4]

QUESTION SIX

(a) Distinguish between on-site and off-site sanitation systems.

(b) Explain the treatment and disposal of the particulate component of the wastewater in a wastewater treatment system employing septic tanks.

(c) State two major problems associated with conventional pit-latrines. How have these problems been addressed in VIP latrines?

(d) In which way(s) are septic tanks different from aqua privies?

(e) Design a septic tank for a small community of 100 inhabitants whose per capita sewage production is 70 liters per day. The effective depth is to be 2.0m. The length to width ratio is to be 3 and free board is to be 0.5m. State your assumptions clearly (if any!!!).

[2+4+4+2+8]

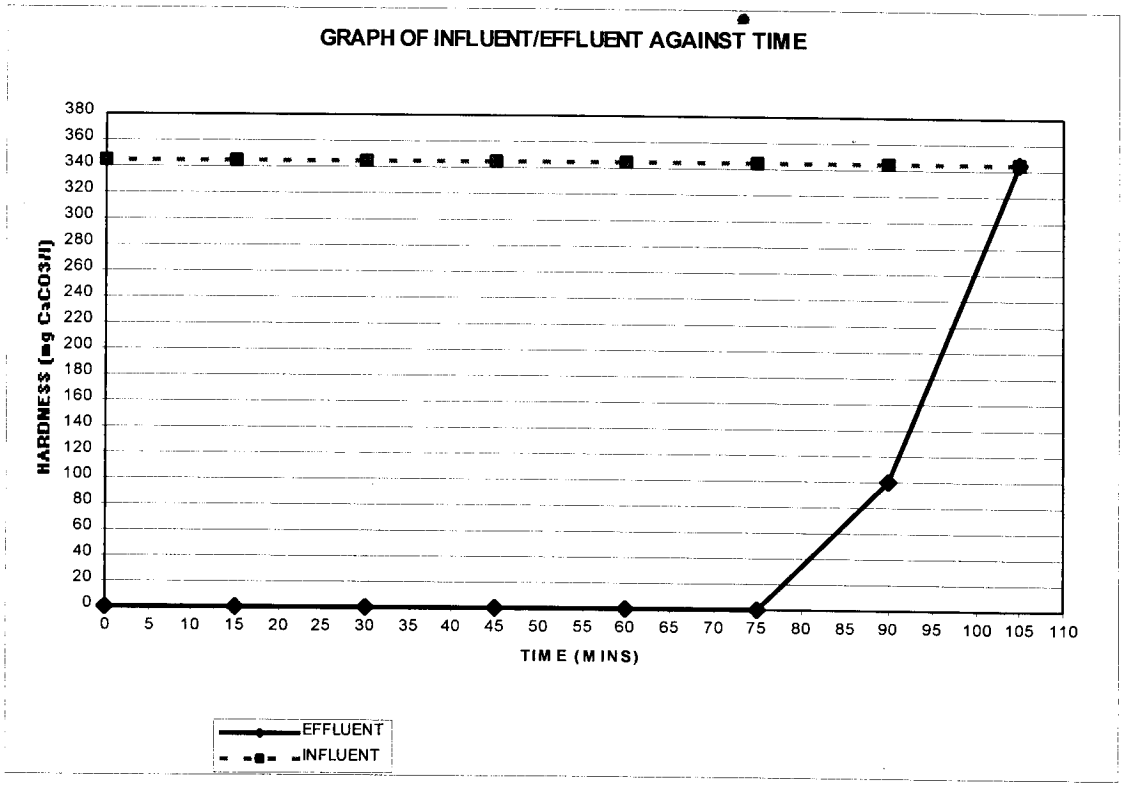
END OF EXAMINATION

GOOD LUCK!

JMT/CE452/EXAM/2004

APPENDIX 1

Figure B1



APPENDIX 2 - INFORMATION AND FORMULAE

National Research Council Equation (NRC).

Influent temperature	100 mg BOD/ l	150 mg BOD/ l	200 mg BOD/ l
12	0.50	0.46	0.42
16	0.44	0.40	0.36
20	0.38	0.34	0.30

Table: "a" values corresponding to temperature and sewage strength

Equation for determination of anaerobic pond area

where

Q = hydraulic loading (m^3/d)
S_i = influent BOD_5 concentration (mg/l)
λ_v = Volumetric organic loading rate (g $BOD_5/m^3.d$)
D = Average pond depth (m)
A = Surface area of anaerobic pond (m^2)

The organic surface loading rate λ_s

)

Where
L = BOD influent (mg/l)
Q = Sewage flow (m^3/day)
A = Pond area (m^2)

Also

$\lambda_s = 2T - 12$

where T is the mean monthly ambient temperature of the coldest month in ^{O}C.

Equation for the design of maturation ponds

Where

N_i and N_e = number of faecal coliforms in the effluent and influent respectively

τ = hydraulic retention time

K_b = the die off rate coefficient (in day^{-1}) which is temperature dependent and is given by

Where T is temperature in ^{O}C.

Information on Filter classification

ITEM	LOW RATE	INTERMEDIATE RATE	HIGH RATE
Hydraulic loading (m^3/m^2.day)	1.2-3.5	3.5-9.4	9.4-38
organic loading (kg BOD/m^3.day)	0.08-0.4	0.24-0.48	0.48-0.96

Two models commonly used in calculation of demand trends are: -

a) Linear model

b) Exponential model

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
UNIVERSITY SEMESTER II EXAMINATIONS 2003
(JANUARY 2004)

CE 465 - HYDROLOGY

INSTRUCTIONS

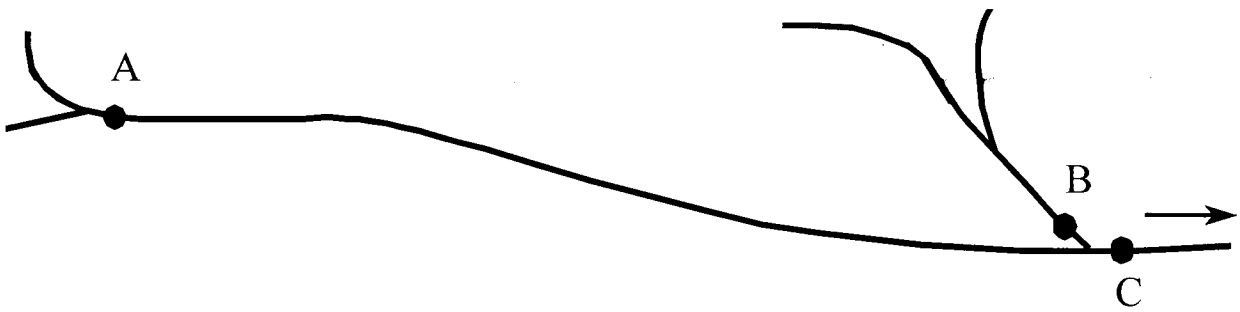
1. There are separate instructions for the two sections
2. All questions carry equal marks (20 %). Marks for sub-questions are indicated at the end of each sub-question
3. Make sure the computer number is clearly indicated on all the booklets together with the questions attempted
4.

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

SECTION A: ATTEMPT BOTH QUESTIONS.

Question 1

A storm over the catchment shown in the figure below generates simultaneously at A and B the hydrograph listed below:



Hour	discharge (m^3 / s)
00.00	30
04.00	83
08.00	175
12.00	123
16.00	105
20.00	83
24.00	50

Use the Muskingum stream routing technique to determine the combined discharge at C at 04:00 hours. The travel time for the centre of mass of the flood between A and C is 8 hours and the factor x = 0.12. Ignore the travel time between B and C. Any local inflow is neglected. (20 marks)

Question 2

a) How does wind speed affect evaporation? (2 marks)

b) An adjacent land area to Lake Kariba is saturated during the rainy season. Compare the evaporation rates between the lake and the adjacent land area. (2 marks)

c) Define consumptive use. (2 marks)

d) Briefly explain how temperature affects infiltration rate. (2 marks)

e) What advantage(s) do sprinklers have over infiltrometers in infiltration measurements? (2 marks)

f) What is the basis of using the PHI index in modelling infiltration? (2 marks)

g) What type of precipitation causes late afternoon thunderstorms on hot days? (2 marks)

h) What causes pressure differences on the earth's surface? (2 marks)

i) Name the front which occurs when cold air displaces warm air. (1 mark)

j) How is the measurement error due to tipping of the bucket in the tipping bucket gauge reduced? (2 marks)

k) The rainfall data for April 2003 given below for a catchment were obtained from the Meteorological Department.

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rainfall (mm)	10	3	0	0	0	7	0	0	0	0	0	0	0	10	0

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Rainfall (mm)	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0

What difficult could arise in using the above data in computing river discharge using the unit hydrograph method? (3 marks)

SECTION B: ATTEMPT ANY THREE QUESTIONS.

Question 3

a) What assumption is made in the Thiessen method? (2 marks)

b) Distinguish between the acoustic level gauge and the echo sounder. (2 marks)

c) What discharge measurement method (s) would you use in the Kaleni Hills to measure the flow of the Zambezi River near its source? (2 marks)

d) Distinguish between a weir and a flume. (2 marks)

e) Given below are flow data for March 2002 for a river in Zambia obtained form the Department of Water Affairs.

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Discharge (m^3/s)	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0

Date	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Discharge (m^3/s)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

You are supposed to use the data for computing the available water for water supply. What problem (s) are you likely to encounter? (2 marks)

f) Why is it necessary to verify a rating curve after some time? (2 marks)

g) Name 2 hydraulic conditions which lead to ideal steady state conditions for rating curves not being met in nature. (2 marks)

h) What is groundwater? (2 marks)

i) Distinguish between an aquifer and an aquiclude. (2 marks)

j) Name 2 ways you can tell that there is unsteady groundwater flow. (2 marks)

Question 4

The 1 mm 4 hour unit hydrograph ordinates for a certain catchment are:

Time (hrs)	0	3	6	9	12	15	18
UH (m^3/s.mm)	0	4	8	6	3	1	0

a) Calculate the catchment area. (4 marks)

b) The storm below, recorded over the catchment on 30 April 2003, marked the end of the rainy season. The baseflow in the river on 30 April 2003 was constant at 15 m^3/s and the Φ-index for the catchment is 5 mm. What is the flow at 12:00 hours in the river resulting from the given storm? (10 marks)

c) What was the flow on 30 September 2003 if the flow on 30 June 2003 was 12 m^3/s? (6 marks)

Time (hrs)	0	3	6	9	12
Rainfall (mm)	0	10	0	15	15

Question 5

a) Define residual drawdown. (2 marks)

b) What is the purpose of a recovery test? (4 marks)

c) State situations when well interference occurs. (2 marks)

d) A well 100 meters deep is proposed in an aquifer having a transmissivity of 200 cubic meters/day/meter width of the aquifer and with a storage coefficient of 0.06. The static water level is expected to be 20 meters below the ground. The well is to be pumped at 100 l/s and the well diameter is to be 0.3m. What will be the pumping lift from this well at the end of ten years? (12 marks)

$$u = \frac{r^2 S}{4 T t} \qquad s = \frac{Q}{4 \Pi T}\left[-0.5772 - LN\, u + u - \frac{u^2}{2 \times 2!} + \frac{u^3}{3 \times 3!} - \frac{u^4}{4 \times 4!} + \ldots\ldots\right]$$

Question 6

a) What is plotting position? (2 marks)

b) Define return period. (2 marks)

c) 100 highway culverts have been designed for Luapula Province by the Roads Department. The culverts have been designed to pass flows of annual probability of 20%. Calculate how many culverts on average will be overtopped each year. (3 marks)

d) A concrete dam with a design life of 100 years is to be constructed. There is need to first construct a cofferdam to divert the river. The cofferdam is designed to be secure against a 5-year flood.

i) How long should the cofferdam remain in the river with a chance of not being overtopped of 6 in 10? (7 marks)

ii) What is the probability of a 20-year flood occurring 5 times during the life of the concrete dam? (6 marks)

Question 7

a) Why is a pan coefficient applied to measurement of evaporation by pans? (2 marks)

b) Why does the plot of logarithms of discharge against time for the recession limb of the hydrograph give 2 slopes? (2 marks)

c) Why is it necessary to determine the factors x and k for stream routing? (2 marks)

d) Why are simplified solutions used to model infiltration? (2 marks)

e) State possible causes for the decline of annual precipitation at a station. (2 marks)

f) What instrument (s) would you use to measure water level in a borehole? (2 marks)

g) How does a dense river network affect groundwater? (2 marks)

h) What does Darcy's law state? (2 marks)

i) Explain why it is said that the pressure in the tube is equal to the hydrostatic pressure at the end of the tube in the gas purge-bubbler technique (pneumatic water level gauge). (2 marks)

j) When can there be 2 different discharges for the same depth of water at a particular river cross section? (2 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JANUARY, 2004

CE 535 - STRUCTURAL STEEL DESIGN

TIME: 3 HOURS
ANSWER ALL QUESTIONS

PART 1

1. Design the rafter (top chord) and bottom chord of the truss shown in Fig 1.0 with the following data:

   a) Dimensions
      Span of truss 12.0m
      Height of truss 2.5m
      Spacing of vertical chords 1.5m

   b) Loading
      Point loads at connections 5.0kN on the top chord

The steel is grade 43. Use double angles back to back for the top and bottom chords and single angles for the vertical and diagonal chords. All chords are connected by single gusset plates placed between the angles and connected by two 20mm black bolts at each end.

(i) Determine the sizes of angles for all the chords. ***10 marks***

2. A Plate girder shown in Fig. 2.0 is chosen on a trial basis to carry maximum coincident values of moment and shear 650 kN-m and 3600kN, respectively. The steel grade is 43 and the beam is to be fully braced against lateral instability.

(i) Check whether the chosen section is capable of carrying the applied moment and shear.

(ii) check the need for vertical stiffeners and determine the spacing assuming 15mm stiffness utilizing
   (a) tension field action
   (b) without tension field action ***15 marks***

3. A 3.1m long 203 x 203 x 60uc of grade 43 steel is subjected to a compressive load of 400 kN which acts at an effective eccentricity of 100mm from the face of the column in the y-y direction, at both ends.

   Taking Lex = L and Ley = L

   (i) Check the local capacity of the column

(ii) Check whether overall buckling of the column is satisfactory (in the y-y axis) ***15 marks***

PART TWO

4.0. The simply supported beam as shown in fig. 3.0 is loaded at B & C by secondary beams which transmit loads of 45 kN and 50kN respectively on it at these points.

(i) Determine the size of a suitable UB to carry the loads assuming it is restrained at points A,B,C, & D.

5.0 A 3.0m long discontinuous strut is to the carry a compressive load of 100kN. Design the strut using angle sections in grade 43, for the following:

(i) Single angle discontinuous strut with double bolted connections.

(ii) Double angle discontinuous strut, back to back, connected to one side of a gusset plate.

(iii) Double angle discontinuous strut back to back, connected to both sides of a gusset plate with not less than two bolts in line.

10 marks

6.0 Using the same girder given in Question 2, check whether the girder can carry a reactive load of 3600 kN which acts through a cleat of 15mm thickness and if inadequate design a load bearing stiffener assuming initial $p_c = 200N/mm^2$ for determining the area required of stiffener and take the thickness of stiffener as 20 mm. Assume grade 43 steel and $p_y = 265N/mm^2$. ***15 marks***

7.0 A beam as shown in Fig 4.0 is simply supported over a span of 4.0m carrying a uniformally distributed load of 100kN/m. Assuming no laterally restraints:

(i) determine size of the beam using hot rolled universal beam section
(ii) check for adequacy against lateral torsional bucking.

15 marks

8.0 Calculate the strength of bolts as shown in Fig. 5.0. The grade of steel in 43 and the gusset plate is 18 mm thick. The bolts are M20 grade 4.6 black bolts, in 22mm clearance holes. ***10 marks***

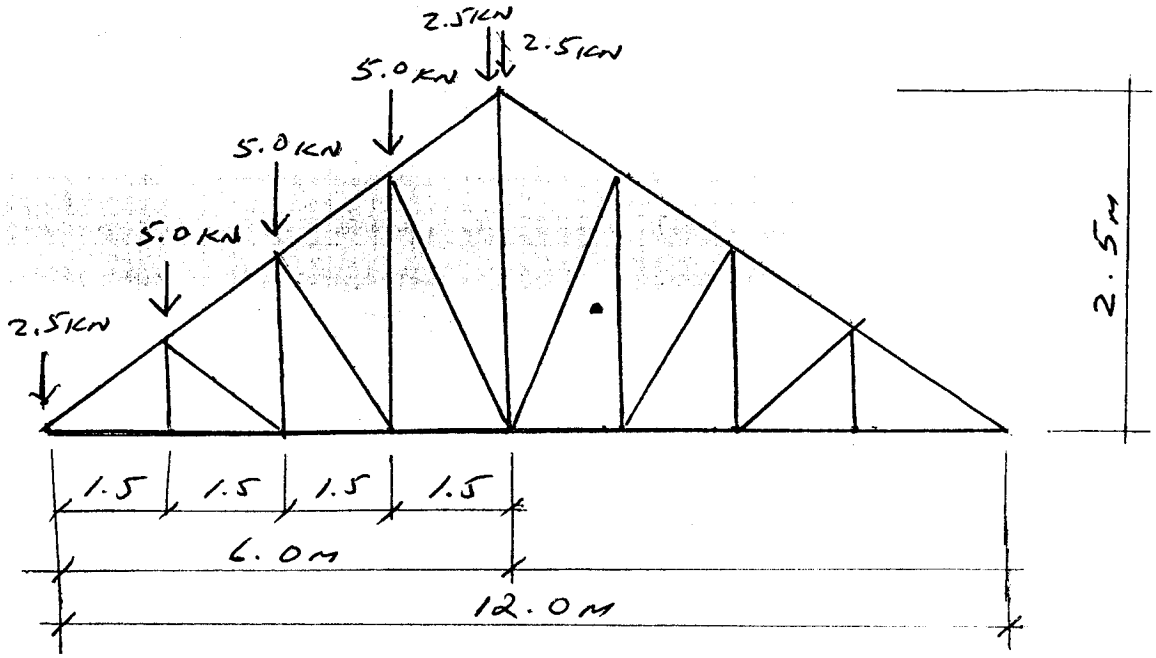


FIG. 1.0

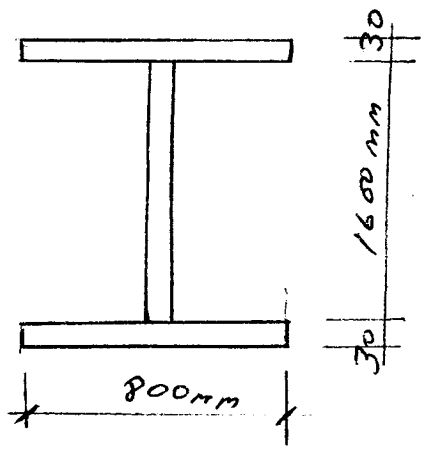


FIG. 2.0

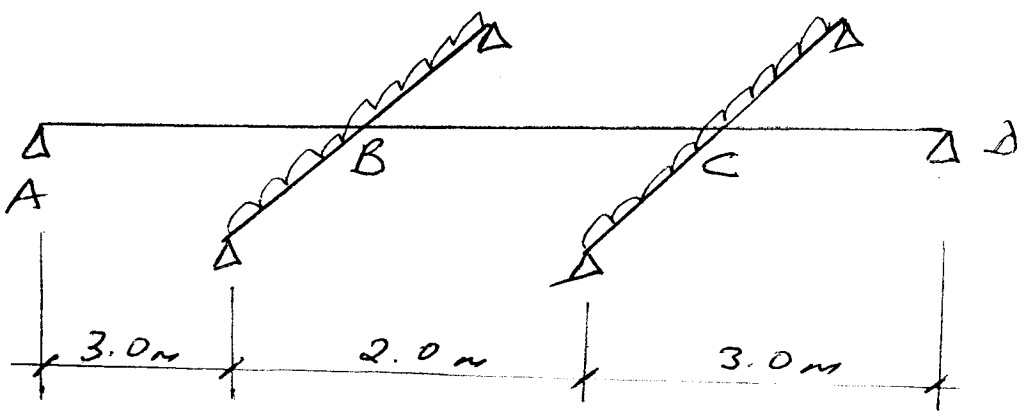


FIG 3.0

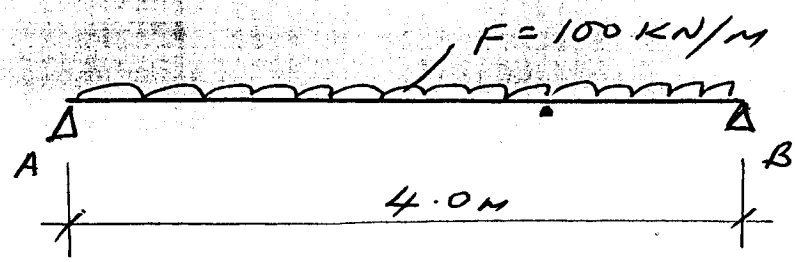

F = 100 KN/M
A
B
4.0M

FIG. 4.0

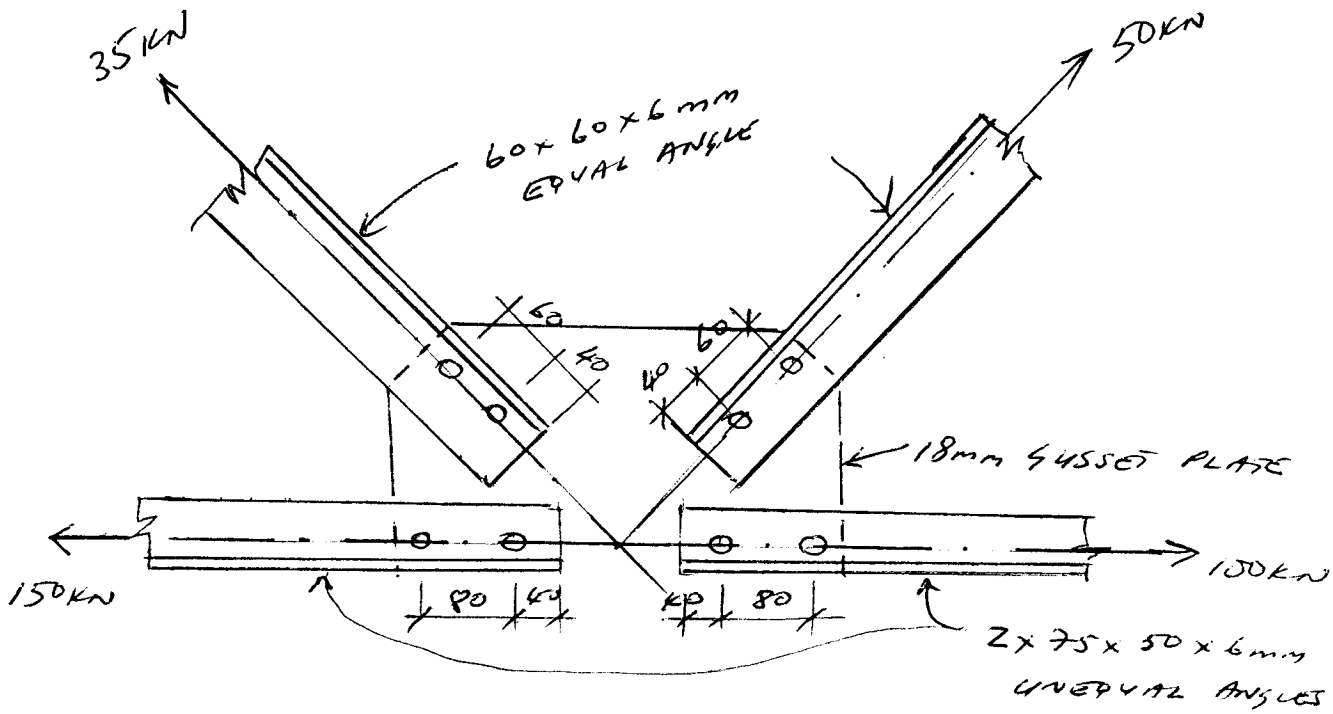

35KN
50KN
60 x 60 x 6 mm
EQUAL ANGLE
60
40
60
40
18mm GUSSET PLATE
150KN
100KN
80
40
40
80
2 x 75 x 50 x 6mm
UNEQUAL ANGLES

FIG 5.0

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF AGRICULTURAL ENGINEERING

SOIL AND WATER CONSERVATION ENGINEERING
EA242

FINAL EXAMINATION

CLOSED BOOK

DATE: 12th January, 2004

DURATION: 3 HOURS

TOTAL MARKS: 100 MARKS

INSTRUCTION: You are required to answer any *five* questions

QU ESTION 1

(i) What is the storage of water S (mm) in a soil when we have determined the water content w by weight and the bulk density D_b at the following depths?

Depth z (mm)	Gravimetric content w	Bulk density D_b (g/cm^3)
0-20	0.21	1.15
20-30	0.28	1.37
30-50	0.30	1.41

(ii) Provide a sketch of the soil moisture profile.

(10 marks)

(Question 1 continued)

(iii) What was the amount of water (m^3/ha) that drained down from the top 60 cm of the soil profile when the surface was protected from evaporation by sheets of plastic and a mulch? The first and last day readings of count ratio CR using a neutron probe at depths z were:

Z (cm)	First day CR	Last day CR
20	0.731	0.559
40	0.668	0.583
60	0.675	0.621

The calibration equation for the neutron meter is given as: $\theta = 0.712\ CR - 0.025$

(10 marks)

QUESTION 2

(a) Determine the textural class designations for soils with the following distribution of particle sizes *(refer to figure1).*

Soil	<0.0002 (mm)	0.0002 – 0.002 (mm)	0.002 - 0.01 (mm)	0.01 - 0.05 (mm)	0.05 - 0.25 (mm)	0.25 - 2.0 (mm)
A	10%	30%	30%	10%	10%	10%
B	4%	6%	10%	20%	30%	30%

(8 marks)

(b)

i. Using ***Stokes' Law***, and table 1, calculate the time needed for all sand particles (diameter ~50 μm) to settle out of a depth of 20cm in an aqueous suspension at 30°C.

ii. How long will it take for all silt particles (diameter ~ 2μm) to settle out?

iii. How long will it take for all 'coarse' clay (diameter ~1μm) to settle out?

(12 marks)

QUESTION 3

(a) Define the following soil parameters:

- Field capacity
- Wilting point
- Capillarity
- Saturated hydraulic conductivity
- Infiltration

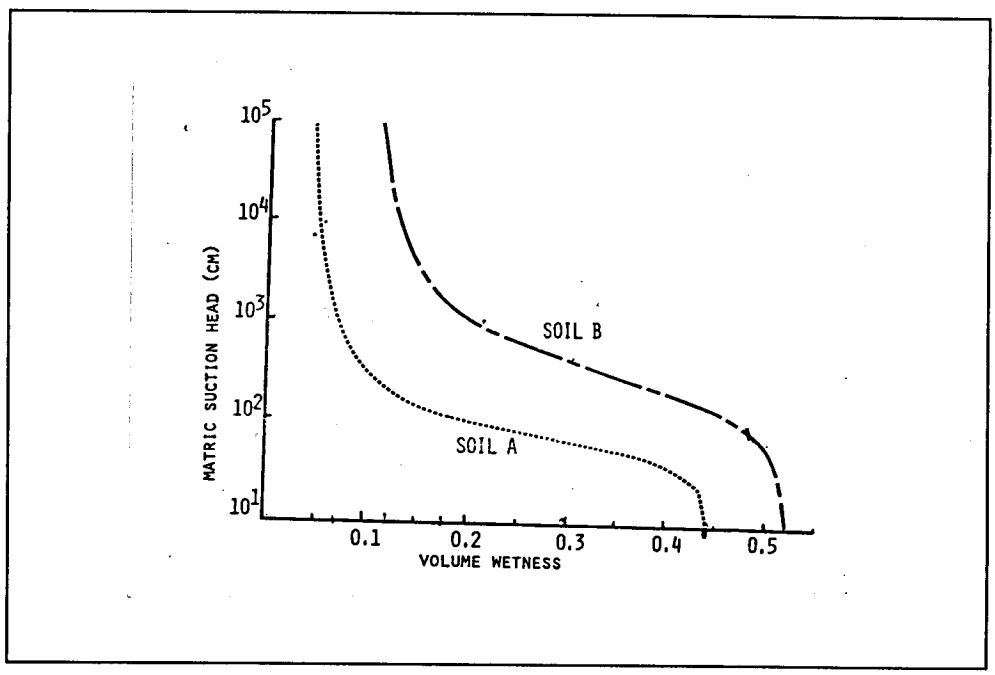
(5 marks)

(b) Briefly explain the following soil processes:

- Sorption
- Desorption
- Hysteresis

(6 marks)

(c) The accompanying soil moisture characteristic curves were obtained based on data from tension plate and pressure plate extraction devices for two soils A and B of unknown texture.



(Question 3 continued)

(i) Estimate the bulk density for both soils A and B assuming that the soils do not swell or shrink

(ii) Estimate the volume and mass wetness values for both soils A and B at suctions of 1/3 bar and 15 bar,

(iii) How much water in depth units (mm) can each soil release per 1m depth of profile in transition from 1/3 bar to 15 bar of suction?

(iv) What are the likely textures for soils A and B.

(9 marks)

[Assume the particle density of a typical mineral soil Ds = 2.65 g/cm^3]

QUESTION 4

(a) Briefly describe the *stages* in the surface development of gully erosion,
(5 marks)

(b) Mention five mechanical protection methods, used to control soil erosion.
(5 marks)

(c) Feasibilities were carried out during a soil conservation project on a *100 m* long slope of 3% for a fine granular soil of slow to moderate permeability, under maize cultivation with contour bunds, near Bulawayo. The Mean Annual Precipitation (MAP) for Bulawayo is 2,695mm and the rainfall erosivity index is 0.5 of MAP. Mechanical analysis using sieves reviewed that soils in the area have an average composition of 5% course sand, 65% fine sand and silt fraction and 3% organic matter. Of the MAP 32% falls between January to April, 10% in May, 6% in June, 7% in July and 45% between August and December, as shown in Table below.

(i) Using the erodibility nomograph *(figure2)*, estimate the soil erodibility Index K,

(ii) Calculate the topographic factor LS, as used in the Universal Soil Loss Equation,

(iii) Using the data in table below, for Mean Annual Precipitation distribution, calculate the crop factor C.

Months	***C value***	***(%) rainfall***
Jan – April	*0.001*	*0.32*
May	*0.9*	*0.10*
June	*0.4*	*0.06*
July	*0.7*	*0.07*
August - Dec	*0.1*	*0.45*

(iv) Assuming the conservation practice factor P for contour bunds is equal to 0.3, compute the Mean Annual soil loss in kg/m^2
(10 marks)

QUESTION 5

(a) With the aid of a diagram illustrate the primary and secondary processes of a domestic roof water harvesting system.

(6 marks)

(b) Calculate the largest storage requirement given the following specifications:

- Consumption per capita per day, 20 litres
- Number of people per household, 6
- Longest average dry period, 25 days

(4 marks)

(c) The following specifications are given for a medical dispensary in Biharamulo District, Kagera in Tanzania:

- Number of staff: 7
- Staff consumption: 45 litres per day
- Patients: 40
- Patient consumption : 10 litres per day
- Total Roof area: 190m^2
- Runoff coefficient (for new corrugated GI roof): 0.9
- Average annual rainfall: 1056mm per year

(i) Use the *demand side approach method* to calculate the total daily demand for the dispensary

(ii) Use the *supply side approach method* to calculate the available harvested water per day

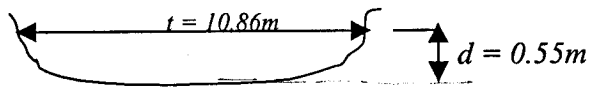
(iii) So, if we want to supply water all the year round to meet the needs of the dispensary, does the water supply meet the demand?

(iv) What interventions can be taken to adequately meet the water demand at the dispensary?

(10 marks)

QUESTION 6

(a) A parabolic grass waterway is being designed to convey a peak flow of $6m^3/s$ on a 1 percent slope, over an erodible sand soil with Bermuda grass vegetation in a good stand cut to a height of 60mm. The channel and flow cross-section is given in figure below:



(i) Calculate the Hydraulic radius, R *(refer to figure 3),*

(ii) Calculate the wetted perimeter Pw,

(iii) Using values for Mannings Roughness factor, in table 2, calculate the mean velocity of flow in the channel.

(iv) Calculate the flow cross- section area.

(10 marks)

(b) A catchment of 500ha is 2km long and 2.5 km wide. It occurs in a 800mm rainfall area and comprises cultivated lands on shallow soils with impeded drainage in steep topography. The dam is to be built to a freeboard of 1.25m. Refer to tables 3,4 and 5 to.

(i) Design the embankment of the dam

(ii) Design the spillway

(10 marks)

********GOOD LUCK*************

FORMULAE AND TECHNICAL DATA

1.0 FORMULAE:

1. Bulk density, $\rho_b = Ms/Vt$
2. Porosity, $f = Vf/ Vt$
3. Particle density, $\rho_s = Ms/ V_s$
4. Void ratio, $e = V_f/ V_s$
5. Gravimetric content, $\theta w = Mw/Ms$
6. Degree of saturation, $s = V_w/V_f$

7 Stokes Law: $t = 18h\eta/ d^2g(\rho_s - \rho_f)$

8. Specific Surface Equation: $a_m = (6/\rho_s) \Sigma(c_i/d_i)$

9. Thin platelet formula: $a_m = 2/\rho_s L$, $Å = 10^{-10}m$

10. Universal Soil Loss Equation: $E = R \times K \times LS \times P \times C$

$$LS = (\sqrt{L}/ 22.3)[0.065 + 0.045S + 0.0065S^2]$$

11. Annual Soil loss Factor: $(t\ ac^{-1}\ y^{-1}/ 4.46) = kgm^{-2}$

12.Rational formula $Q = C*R*A$

13.Mannings formula, $V = R^{0.667}S^{0.5}/n$

Table 1.

T1

Temperature (°C)	Density (gm/cm³)	Specific heat (cal/gm deg)	Latent heat (vaporization) (cal/gm)	Surface tension (gm/sec²)	Thermal conductivity (cal/cm sec deg) × 10^{-3}	Viscosity (gm/cm sec) × 10^{-2}	Kinematic viscosity (cm²/sec)
−10	0.99794	1.02	603.0	—	—	—	—
−5	0.99918	1.01	600.0	76.4	—	—	—
0	0.99987	1.007	597.3	75.6	1.34	1.787	0.0179
4	1.00000	1.005	595.1	75.0	1.36	1.567	0.0157
5	0.99999	1.004	594.5	74.8	1.37	1.519	0.0152
10	0.99973	1.001	591.7	74.2	1.40	1.307	0.0131
15	0.99913	1.000	588.9	73.4	1.42	1.139	0.0114
20	0.99823	0.999	586.0	72.7	1.44	1.002	0.01007
25	0.99708	0.998	583.2	71.9	1.46	0.890	0.00897
30	0.99568	0.998	580.4	71.1	1.48	0.798	0.00804
35	0.99406	0.998	577.6	70.3	1.50	0.719	0.00733
40	0.99225	0.998	574.7	69.5	1.51	0.653	0.00661
45	0.99024	0.998	571.9	68.7	1.53	0.596	0.00609
50	0.98807	0.999	569.0	67.9	1.54	0.547	0.00556

Table 1 : Physical properties of liquid water

MONTHS	C VALUE	ADJUSTMENT FACTOR (% R VALUE)	WEIGHTED C VALUE (col 2 × col 3)
January – April	0.001	0.32	0.000 32
May	0.9	0.10	0.09
June	0.4	0.06	0.024
July	0.7	0.07	0.049
August – December	0.1	0.45	0.045

Table Mean Annual Precipitation distribution for Bulawayo

2 FIGURES AND TABLES

T2

Values of Manning's n for vegetated channels

CI	*Description*	*n*
10.0	Very long dense grass (over 600 mm)	0.06–0.20
7.6	Long grass (250–600 mm)	0.04–0.15
5.6	Medium grass (150–200 mm)	0.03–0.08
4.4	Short grass (50–150 mm)	0.03–0.06
2.9	Very short grass (less than 50 mm)	0.02–0.04

T3

Table 3.
Flood discharge factor (F)

Free board (m)	Area in hectares (ha)										
	50	75	100	150	200	250	300	350	400	450	500
1.00	17	28	38	57	76	94	113	132	152	170	190
1.25	13	21	27	41	54	67	80	94	107	120	134
1.50	9	14	18	28	39	47	57	66	75	85	95

T4

Table 4.
Rainfall intensity factor (R)

Catchment Length (km)	Mean annual rainfall		
	400mm	800mm	1200mm
1	0.82	0.88	0.90
2	0.61	0.65	0.66
3	0.50	0.52	0.53
4	0.40	0.43	0.44
5	0.34	0.36	0.38
6	0.29	0.31	0.33

T5

Table 5.
Topographical factor (T) = (a) + (b) + (c)

(a) = Surface cover	(b) = Soil type	(c) = Slope
(i) Thick bush – 0.05	(i) Deep well-drained soils – 0.10	(i) Very flat to gentle – 0.05
(ii) Heavy grass – 0.10	(ii) Deep, moderately pervious soil – 0.20	(ii) Moderate – 0.10
(iii) Scrub or medium grass – 0.15	(iii) Soil for fair permeability and depth – 0.25	(iii) Rolling – 0.15
(iv) Cultivated lands – 0.20	(iv) Shallow soils with impeded drainage – 0.30	(iv) Hilly or steep – 0.20
(v) Bare or eroded – 0.25	(v) Medium – heavy clays or rocky surfaces – 0.40	(v) Mountainous – 0.25
	(vi) Impervious surfaces and water logged soils – 0.50	
	In (i) to (iv) above add 0.05 for t1 and 0.15 for t2 soils	

FIGURE 1

F1

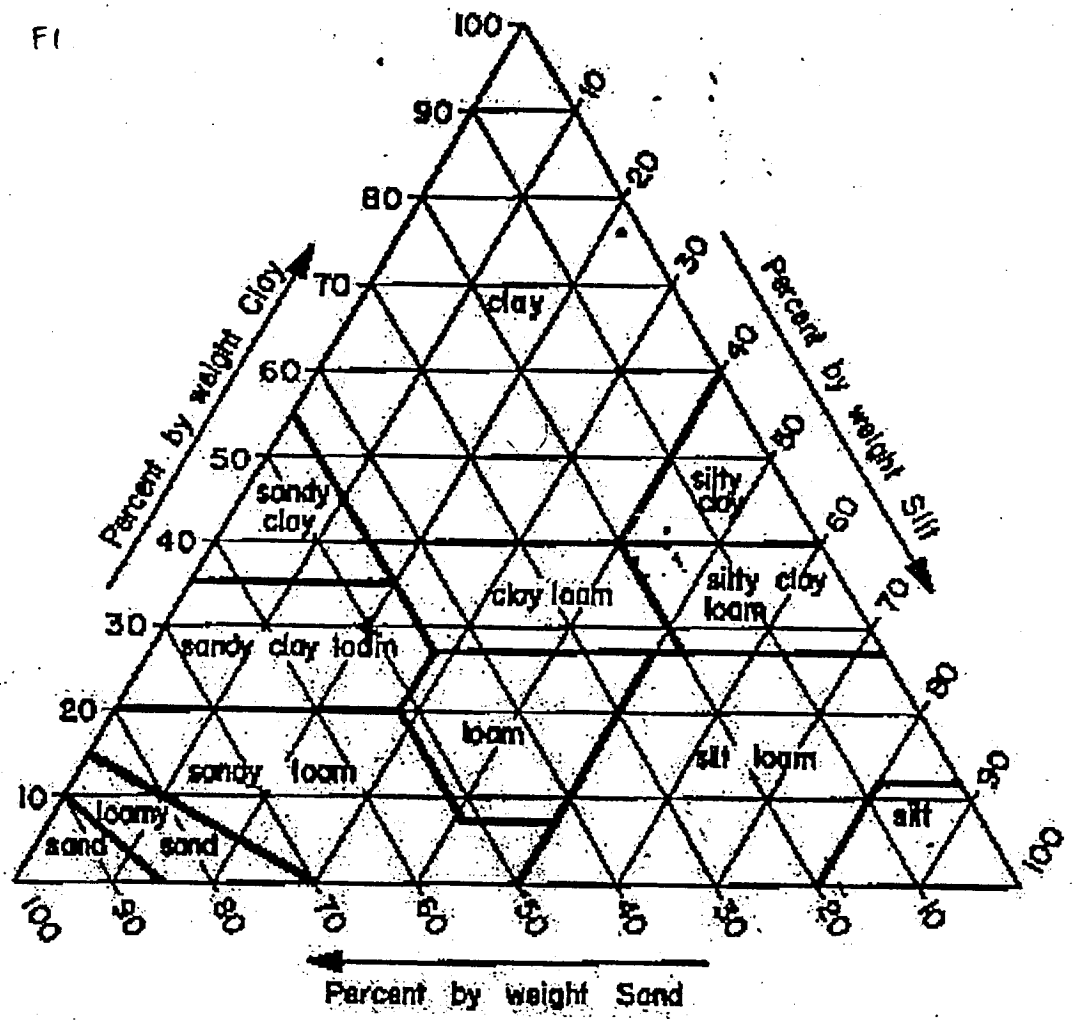


FIGURE 2

F2

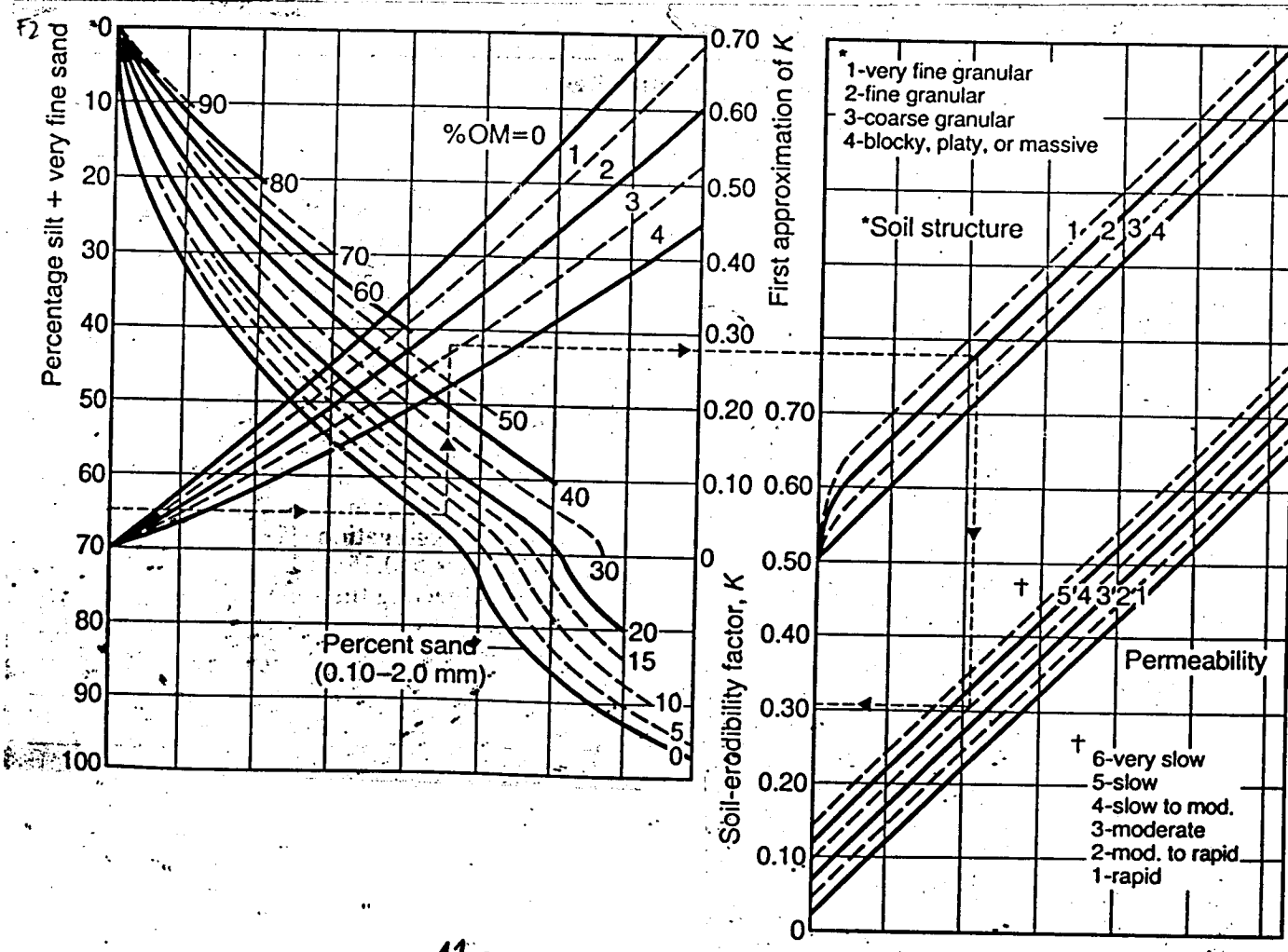
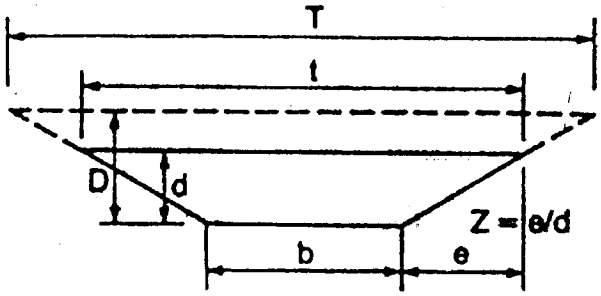
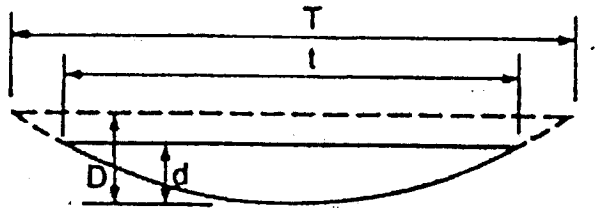


FIGURE 3

F3



Area	$bd + Zd^2$
Wetted perimeter	$b + 2d\sqrt{1 + Z^2}$
Hydraulic radius	$\frac{bd + Zd^2}{b + 2d\sqrt{1 + Z^2}}$
Top width	$t = b + 2dZ$ $T = b + 2DZ$



Area	$\frac{2}{3}td$
Wetted perimeter	$t + \frac{8d^2}{3t}$
Hydraulic radius	$\frac{t^2d}{1{\cdot}5t^2 + 4d^2}$ (approx.) $\frac{2d}{3}$
Top width	$t = \frac{3a}{2d}$ $T = t(\frac{D}{d})^1$

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF AGRICULTURAL ENGINEERING

October 2003 - January 2004 Semester

FINAL EXAMINATION

EA 402 ENERGY SOURCES AND UTILIZATION IN AGRICULTURE II

Date: 13th January 2004 **Time: 3 hours**

INSTRUCTIONS

1. This examination consists of seven questions.
2. Attempt any FIVE questions.
3. All questions carry equal marks.

Question ONE

(a) Complete reliance on fossil-fuel and nuclear energy resources is increasingly getting considered as a non-logical approach in solving World wide energy crisis by many Nations. Discuss this with particular reference to the developing nations.

(12 marks)

(b) Write short notes on solar radiation.

(8 marks)

Question TWO

(a) Differentiate pyrheliometers from pyranometers and give TWO examples in each case.

(6 marks)

(b) Determine the average value of solar radiation on a horizontal surface for January 15th at a latitude of 20^0 N if constants **a** and **b** are given as 0.35 and 0.55 respectively and the ratio $\bar{n}/N = 0.6$.

(9 marks)

(c) With the aid of a labeled diagram show the main components of a flat-plate solar energy collector.

(5 marks)

Question THREE

(a) The following data is for a flat- plate solar energy collector used for heating at a certain locality:

Factor	Specification
Latitude	10^0 N
Day	February 5th
Solar hour angle	0
Annual average Intensity of Solar Radiation	350 W/m^{2}hr
Collector tilt factor	1.4
Number of glass covers	2
Transmittance of the glass	0.88
Absorptance of the glass	0.90
Useful gain	33.21 W/m^{2}hr

Calculate:

(i) Solar altitude angle
(ii) Incident angle
(iii) Effective transmittance-absorptance product
(iv) Collector efficiency

(8 marks)

(b) List TWO advantages and TWO disadvantages of concentrating types of solar energy collectors compared to the non-concentrating or flat-plate types.

(4 marks)

(c) Briefly discuss solar energy applications with specific emphasis on the following:

(i) Photovoltaics
(ii) Satellite Power Systems (SPS)

(8 marks)

Question FOUR

(a) List THREE factors which determine the output from a wind energy converter.

(3 marks)

(b) Write short notes on "lift and drag" as used in wind energy.

(6 marks)

(c) Wind at 1 standard atmospheric pressure and 15^0C has velocity of 20 m/s. A propeller type turbine of diameter 125 m and operating at a speed of 60 r.p.m at maximum efficiency is used for collecting energy from the wind.
Calculate:

(i) The total power density in the wind stream.
(ii) The maximum obtainable power density
(iii) A reasonable obtainable power density (assuming efficiency of 35%)
(iv) The total power
(v) The torque and axial thrust

(7 marks)

(d) Sketch and outline the importance of the following curves as used in wind energy:
(i) Velocity - duration curve
(ii) Frequency - duration curve

(4 marks)

Question FIVE

(a) Briefly explain the environmental impacts of wind energy.

(5 marks)

(b) Explain the term "biomass conversion".

(6 marks)

(c) With the aid of labeled diagrams differentiate the following types of biogas digesters:
(i) Floating gas holder / drum type
(ii) Fixed dome type.

(9 marks)

Question SIX

(a) Outline FOUR factors which must be considered while selecting a site for a biogas plant.

(6 marks)

(b) Given below is data for a family biogas digester suitable for the output of six cows:

Retention time ---------- 40 days
Temperature ---------- 20^0C
Dry matter consumed per day ---------- 2 kg
Biogas yield ---------- 0.24 m^3 per kg
The efficiency of the burner ---------- 70%
Methane fraction ---------- 0.7
Heat of combustion of methane ---------- 28 MJ/m^3

Calculate:
(i) The volume of the biogas digester
(ii) The power available from the digester

(8 marks)

(c) Briefly discuss the potential environmental impacts of biomass energy with specific emphasis on agricultural crops.

(6 marks)

Question SEVEN

(a) List THREE classifications of hydropower plants and give TWO examples in each case.

(6 marks)

(b) Derive a mathematical expression for the power P imparted on a Pelton turbine bucket.

(6 marks)

(c) With the aid of a labeled diagram explain the operation of a hydraulic ram pump (hydram).

(8 marks)

----------*e n d*----------

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AGRICULTURAL ENGINEERING DEPARTMENT

SUPPLEMENTARY EQUATIONS

$$\cos\theta = \sin\phi(\sin\delta\cos S + \cos\delta\cos\gamma\cos\omega\sin S) + \cos\phi(\cos\delta\cos\omega\cos S - \sin\delta\cos\gamma\sin S) + \cos\delta\sin\gamma\sin\omega\sin S$$

$$\cos\theta_z = \cos\phi\cos\omega\cos\delta + \sin\phi\sin\delta$$

$$\cos\gamma_s = \sec\alpha(\cos\phi\sin\delta - \cos\delta\sin\phi\cos\omega)$$

$$\sin\gamma_s = \sec\alpha\cos\delta\sin\omega$$

$$<\tau\alpha> = \frac{\tau.\alpha}{1-(1-\alpha)\rho_d}$$

$$H_o = \frac{24}{\pi} I_{sc}\left[\left\{1+0.033\cos\left(\frac{360n}{365}\right)\right\}\left(\cos\phi\cos\delta\sin\omega_s + \frac{2\pi\omega_s}{360}\sin\phi\sin\delta\right)\right]$$

$$P_{max} = \frac{8}{27}\rho A V^3$$

$$\Im = \frac{P_m^{1/2} W}{\rho^{1/2}(g H_o)^{5/4}}$$

$$W_s = Cos^{-1}(-\tan\phi\tan\delta)$$

$$\delta = 23.45\ Sin\ [\ 360/365(284 + n)\ ]$$

$$T_{max} = [\ 2/27g\ x\ \rho D V_i^3/N\ ]$$

$$F_{xmax} = \pi/2g\ x\ \rho D^2 V_i^2$$

$\therefore$ Dg

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
AGRICULTURAL ENGINEERING DEPARTMENT
SECOND SEMESTER EXAMINATIONS, JANUARY 2004
EA 415 (AGRICULTURAL MECHANISATION)

TIME ALLOWED: **THREE** HOURS
INSTRUCTIONS: ATTEMPT **FOUR** QUESTIONS ONLY, **AT LEAST** ONE FROM EACH OF THE **THREE** SECTIONS.
ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A

Question 1

a) Outline field operations, in their right sequence of execution, which would be required in commercial wheat production, starting with a field with sparsely scattered crop residue from the previous season. The soils are predominantly clay loam (i.e. have a fairly high content of clay, which has a reduced tendency to crumble during tillage). Tests with a penetrometer reveal that the field has a medium strength hardpan at a depth of about 50 cm. The whole operation is to start sometime in September and each operation is suppose to be carried out only once due to limited time since the crop is to be grown under rain-fed condition. For each operation, briefly state the objective(s) and also identify the most effective implement(s) and/or machines that should be used. Justify the choice of machinery where necessary.

[20 marks]

b) Briefly describe how the major components of a mouldboard plough work to achieve its principle tillage objective.

[5 marks]

Question 2

a) State **three** functions that planter wheels may perform.

[6 marks]

b) What seed spacing is required when planting maize in rows 100 cm apart if the desired plant population is 38,000 plants per hectare and an average emergence of 95% is expected?

[4 marks]

c) Given that a 100 g sample of maize contained 80 seeds. Calculate the amount of seed (in kg) required per hectare.

[6 marks]

d) If a horizontal plate planter with 15-cell seed plate that has a diameter of 199 mm is used to plant the maize seeds, calculate the linear cell speed (in meters/minute) when plating at 7.2 km/hr?

[6 marks]

e) Given that the diameter of the planter drive wheel is 382 mm, calculate the overall gear ratio between the drive wheel and the seed plate.

[3 marks]

SECTION B

Question 3

a) Define the following terms in the context of agricultural machinery performance and management.

i) Theoretical field capacity

ii) Throughput capacity

iii) Material capacity

iv) Scheduling efficiency

[8 marks]

b) Consider the following factors that influence field efficiency of farm machinery. For each factor, suggest ways of reducing field time losses.

i) Minor field breakdowns

ii) Material handling such as filling seed hopper or fertiliser hopper during planting.

iii) Farm plots during setup of a new farm

[12 marks]

c) Briefly explain why it is important to match the tractor power to an implement, and also state the ultimate objective.

[5 marks]

Question 4

Figure Q4 shows a tractor with a fully mounted three-furrow mouldboard plough. The ploughing depth is controlled by automatic draft control with upper link sensing.

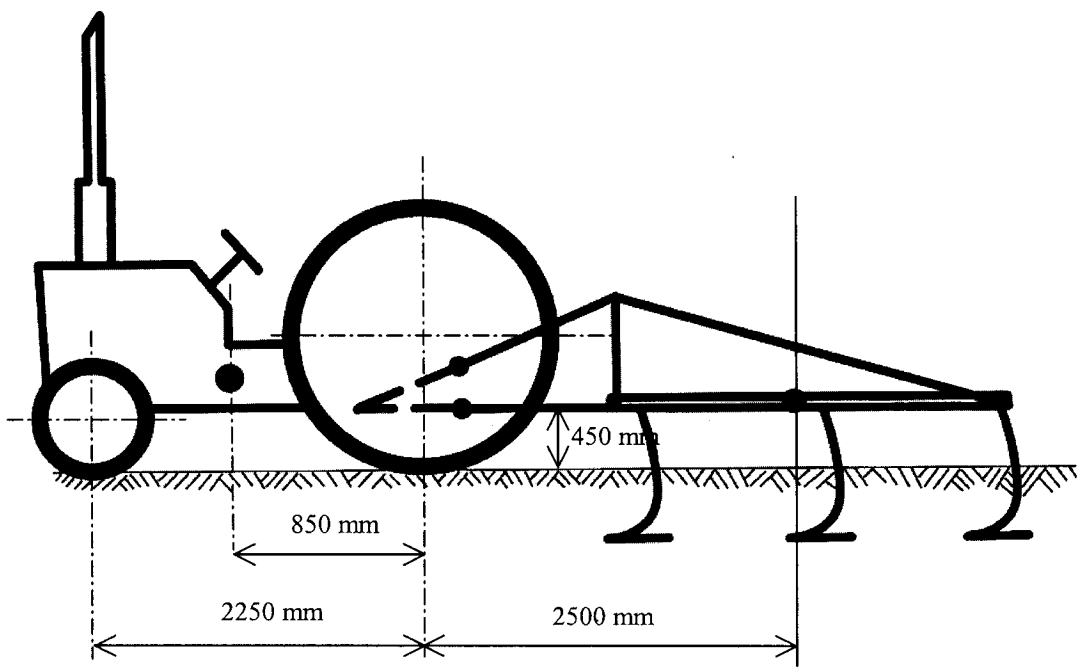


Fig Q4

Given the following information:

Weight of the tractor	25 kN
Weight of the plough	5 kN
Draft force on each plough body	2.5 kN
Side force on each plough body	500 N
Maximum tractor engine power	54 kW
Gross tractive efficiency	56%

Coefficient of rolling resistance for the tractor rear wheels, = 0.10

Coefficient of rolling resistance for the tractor front wheels, = 0.12

Coefficient of friction between the landside and the furrow wall, = 0.45

The line of action of the total horizontal soil force on the plough can be taken to act 100 mm below the soil surface level. Calculate:

i) the vertical reaction on the tractor front and rear wheels

[12 marks]

ii) the thrust required at the tractor driven wheels

[5 marks]

iii) the coefficient of thrust

[4 marks]

iv) maximum tractor operating speed on a level field

[4 marks]

SECTION C

Question 5

a) The guiding principle in machinery selection is to select "Best, least cost machinery – labour system". Explain the statement.

[4 marks]

b) Outline the procedure for calculating depreciation using the sum-of-the digits method.

[5 marks]

c) What is the rationale behind the use of the discounted cash flow method in investment appraisals?

[5 marks]

d) Briefly explain the **three** causes of obsolescence of farm machinery.

[6 marks]

e) Explain the importance of costing agricultural operations.

[5 marks]

Question 6

a) Select appropriate size of plough (m width) and Tractor (kW) for ploughing 360 hectares of sorghum field in a period with an equivalent of 30 working days, each with 12 working hours. Assume tractor forward speed of 10.8 km/h, field efficiency of 80%, and specific soil resistance of 8 kN/m-width of the plough. Allowable engine loading is 75% of maximum engine power. The tractor net tractive efficiency is 69% with transmission efficiency of 97%. Roundup the implement width to the nearest 0.1 m and the tractor engine power to the nearest 1 kW

[10 marks]

b) Calculate the total costs per hour and per hectare for using the machinery selected above. Assume that the plough is only used for the 360 hectares stated above, while the tractor is used for an extra 640 hours per year on the farm. Additional information is given below;

	Tractor	**Plough**
Purchase price (P)	K 80,000,000	K 7,200,000
Trade-in value	20% of P	10% of P
Economic, n	10 years	8 years
Shelter/Insurance/Tax	1.5% P	0.1%P
Repair and Maintenance per hour	0.008% P	0.035%P
Average fuel consumption (at 75% loading)	14.5 1/h	
Price of diesel fuel	K 3200/litre	
Cost of lubricants	15% of the cost of Fuel	
Wage for the operator	K 4,000/hour	
Bank interest rate 35%		

[15 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING
DEPARTMENT OF AGRICULTURAL ENGINEERING

POST HARVEST TECHNOLOGY
EA452

FINAL EXAMINATION **JANUARY 2004**

TIME allowed: 3 hours **answer FIVE (5) questions**

It is desirable to show the method of calculation and the steps taken to achieve the results.

QUESTION 1

A pipe heat exchanger is to be used to pre-heat a chilled liquid before vacuum evaporation. The liquid flows through the inner tube at 3.5 m^3/h. The inside surface of this tube is maintained at a temperature of 100 °C along the length of the tube by means of condensing steam. If the liquid is heated from 2 °C to 38 °C, calculate the length of the pipe heat exchanger required.

Take: Inside diameter of the inner tube =2.5 cm

Density of liquid $=1.0 * 10^3$ kg/m^3

Viscosity of liquid $=1.0 * 10^{-3}$ kg/ms

Thermal conductivity of liquid =0.6 W/m °C

Specific heat of liquid =4.2 kJ/kg °C

State any assumptions you make. The following equations may be used.

$Nu = 4$ laminar flow

$Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$ turbulent flow

[20 marks]

QUESTION 2

(a) Describe with the aid of a suitable property diagram a simple practical vapour compression refrigerator. Explain how an additional heat exchanger can improve the performance of such a system.

[10 marks]

(b) Calculate the Coefficient of Performance (C.O.P.) for a refrigerator using R12 as the refrigerant,

(i) for a simple cycle without an additional heat exchanger and no sub-cooling of the condensate,

(ii) for a cycle incorporating a heat exchanger to effect sub-cooling such that the condensate enters the expansion valve at +10 °C.

Comment briefly on the results obtained.

The operating conditions of the refrigerator are as follows:

Condenser pressure $0.745\ MN/m^2$ (7.45 Bars)

Evaporator pressure $0.1003\ MN/m^2$ (1.003 Bars)

Assume that the heat exchanger operates adiabatically and the compression process occurs isentropically.

Thermodynamic pressure-enthalpy diagram for R12 are provided.

[10 marks]

QUESTION 3

(a) Define the terms 'Incompressible' and 'Compressible' as applied to filter cakes. Discuss the role of filter aids when filtering highly compressible solids.

[10 marks]

(b) A filter press is being operated so as to maintain the flowrate of filtrate constant. The total pressure drop developed across the cake and medium in the early stages of the cycle is shown in Table 1.

Calculate the compressibility coefficient of the cake and the time required to attain a total pressure drop of $1400\ kN/m^2$ across the system.

You may assume that the pressure drop across the cake ($-\Delta p_c$) is related to time (t) by the expression:

$$(-\Delta p_c)^{1-s} = K'' t$$

where s is the compressibility coefficient of the cake and K″ is a constant.

TABLE 1

TIME, t (s)	TOTAL PRESSURE DROP, $-\Delta p$ (kN/m^2)
0	20
30	27
60	41
90	60
120	85
150	114

[10 marks]

QUESTION 4

(a) Briefly describe the more common methods used to elevate bulk particulate foods.

[5 marks]

(b) Suggest an appropriate system for discharging, daily, 20, 000 kg of mealie meal from a bulk delivery vehicle to storage silos located 20 m above ground.

Your answer should indicate:

(i) The reasons which determine your choice of handling procedure, and

(ii) What safety precautions you would apply in installing and operating the system.

[15 marks]

QUESTION 5

(a) Sugar is ground from crystals of which 80 % pass a 500 μm sieve, down to a size in which 80 % passes a 88 μm sieve and a 5 horsepower motor is found just sufficient for the required throughput. If the requirements are changed such that the grinding is only down to 80 % through a 125 μm sieve but the throughput is to be increased by 50 % would the existing motor have sufficient power to operate the grinder? Assume Bond's equation.

[10 marks]

(b) A liquid having viscosity $2.5 * 10^{-2}$ kg/ms and density 1200 kg/m^3 is agitated in a baffled tank (vortexing minimised). The impeller used has a diameter of 0.4 m and speed of rotation 360 rpm. The relationship between power number N_p, and Reynolds number N_{Re}, for the impeller used is given by

N_{Re}	10	10^2	10^3	10^4	10^5	10^6
N_p	4.0	1.0	0.4	0.27	0.22	0.22

Calculate the power requirement for this operation.

The power equation may be used

$$(P/D^5N^3\rho) = C[\ (D^2N\rho/\mu)^a\ (D.N^2/g)^b]$$

[10 marks]

QUESTION 6

(a) Discuss the factors influencing heat losses to air from hot surfaces.

[5 marks]

(b) A completely enclosed rectangular, continuous blanching tank is 7 m in length, 1.5 m wide and 1.0 m depth.

The outside surface temperature at any point on the surface of the tank is 50 °C and the surface has an emissivity of 0.9. If the blanching tank is situated in a processing hall whose walls are at a temperature of 15 °C calculate the heat loss by radiation.

To reduce heat losses it is proposed to paint the entire surface of the blancher with aluminium paint, giving a surface emissivity of 0.4. Calculate the likely reduction in heat loss.

Take Stefan-Boltzmann constant as $5.67 * 10^{-8}$ W m^{-2} K^{-4}.

Assume radiation heat transfer coefficient is given by,

$h_r = \varepsilon_1 \sigma (T_1^2 + T_2^2)(T_1 + T_2)$

where ε_1 = emissivity of radiation surface at T_1.

[15 marks]

QUESTION 7

(a) Write notes on the following:

(i) Equilibrium moisture content

(ii) Sun drying

(iii) Deterioration of fresh fruits and vegetables

(iv) Purpose of packaging

(v) Common grain pests

[10 marks]

(b) A feed material containing 45 % by weight of solute is to be extracted in a multistage, counter-current system. If the rich solution leaving is to contain 60 % and the spent solid 5 % of solute, by weight, respectively, how many real stages are required? Fresh solvent is used initially and the underflow from all the stages contains 0.5 kg of solution per kg of insoluble solids. Average stage efficiency was found to be 75 %.
You may assume that the equation to the underflow line on a right angle equilibrium diagram is:

$$X_s = (k/(k+1)) - X_a$$

Where k is the mass of solution adhering to 1 kg insoluble solids in the underflow and X_s and X_a are the mass fractions of solvent and solute respectively, in the underflow.

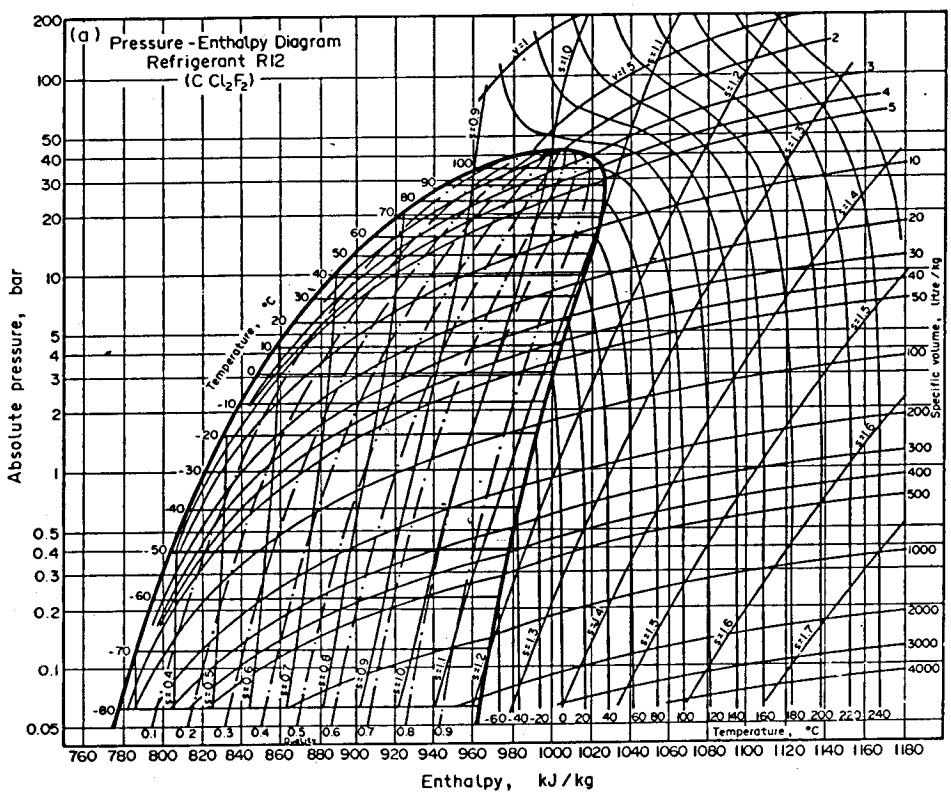
[5 marks]

(c) Describe ONE type of continuous, moving bed oil extractor.

[5 marks]

END

(a)


(a) Pressure-Enthalpy Diagram
Refrigerant R12
(C Cl2F2)
Absolute pressure, bar
Enthalpy, kJ/kg
Temperature, °C
Specific volume, litre/kg

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING
DEPARTMENT OF AGRICULTURAL ENGINEERING

October 2003 - January 2004 Semester

FINAL EXAMINATION

EA 512 FARM MACHINERY DESIGN

Date: 9th January 2004 **Time: 3 hours**

INSTRUCTIONS

1. This examination consists of sections A and B.
2. Section A consists of questions 1 to 6 carrying 15 marks each. Attempt any FIVE questions from this section.
3. Section B consists of only one question (QUESTION 7) which carries 25 marks and is COMPULSORY.
4. Use separate answer books for each section.

SECTION A

Attempt any FIVE questions from this section.

Question ONE

(a) Outline the classification of machine design.

(5 marks)

(b) Briefly explain the following mechanical properties of metals:
   (i) Elasticity
   (ii) Plasticity
   (iii) Ductility

(6 marks)

(c) With the aid of labelled diagrams show the features of the main types of lightweight concrete.

(4 marks)

Question TWO

(a) Discuss the following types of casting processes:
   (i) Permanent mould casting
   (ii) Die casting
   (iii) Centrifugal casting

(8 marks)

(b) Give TWO examples for each of the following categories of manufacturing processes:
   (i) Machining processes
   (ii) Surface finishing processes
   (iii) Processes effecting change in properties

(3 marks)

(c) Name and differentiate FOUR main types of loads which may act upon a machine Component.

(4 marks)

Question THREE

(a) Briefly explain Hooke's law.

(3 marks)

(b) A hydraulic press exerts a total load of 3.5 MN. This load is carried by two steel rods supporting the upper head of the press. If the safe stress is 85 N/mm^2 and E = 210 kN/mm^2, calculate:
   (i) The diameter of the rods
   (ii) The extension in each rod in a length of 2.5 m.

(8 marks)

(c) Outline FOUR points a design engineer should consider in the process of selecting a factor of safety.

(4 marks)

Question FOUR

(a) Derive mathematical expressions for loads carried by individual bars of a composite bar consisting of two bars in terms of total load, cross-sectional area and Young's modulus.

(6 marks)

(b) Briefly explain the term "Resilience".

(4 marks)

(c) A wrought iron bar 45 mm in diameter and 3.0 m long transmits a shock energy of 100 N-m.
Calculate:
(i) The maximum instantaneous stress
(ii) The elongation

Take E = 200 GN/m^2

(5 marks)

Question FIVE

(a) State FOUR assumptions on which the torsion equation is based.

(4 marks)

(b) A shaft is transmitting 90 kW at 180 r.p.m. If the maximum allowable shear stress is 60 N/mm^2 and the maximum torque transmitted is 7500 N-m, calculate:
(i) The mean torque
(ii) A suitable diameter for the shaft

(6 marks)

(c) State the bending moment equation (indicating what the various parameters stand for) and list THREE assumptions made in deriving the equation.

(5 marks)

Question SIX

(a) An axle is 1.5 m long and is supported in bearings at its ends. The axle carries a load of 25 kN at the centre. If the bending stress is not to exceed 50 N/mm^2, calculate the diameter of the axle.

(6 marks)

(b) Outline the classification of bearings with particular reference to direction of load to be supported and nature of contact (support your explanation with labelled diagrams).

(6 marks)

(c) Define the following terms as used in properties of bearing materials:
(i) Comformability
(ii) Embeddability
(iii) Bondability

(3 marks)

Section B: Compulsory

Question seven

As a design engineer at TDAU you are involved in the design of hammer mills to be milling lime stone. You are given the task of checking the size of the shaft, the suitability of the ball bearings selected and to determine the dimension of the key to hold the pulley to the shaft given in fig Q7.

The pull exerted by the ~~bearings~~ pulley is 1.6 kN and the maximum power provided is 15 kW with the shaft rotating at 800rpm. The shaft is machined from cold drawn steel with tensile strength Sut= 690Mpa, yield strength 580 Mpa and brinell hardness of 197.

The bearings selected are:

Bearing a: SKF ball bearing designation 6207

Bearing b: SKF ball bearing designation 61804.

In addition a key way is machined to provide for mounting of the pulley.

a) What is the torque experienced by the shaft.

(2 marks)

b) What are the radial forces experienced by bearing A and bearing B.

(3 marks)

c) Calculate the factor of safety of the shaft at the pulley area (with a key way), at the point on the left of the shaft where it steps from 30mm to 35 mm (assume the step has the same stress concentration factor as the retaining ring groove).

(10 marks)

d) Determine the life of the two bearings in millions of revolutions.

(5 marks)

e) If the key is to be made from mild steel determine its dimensions.

(5 marks)

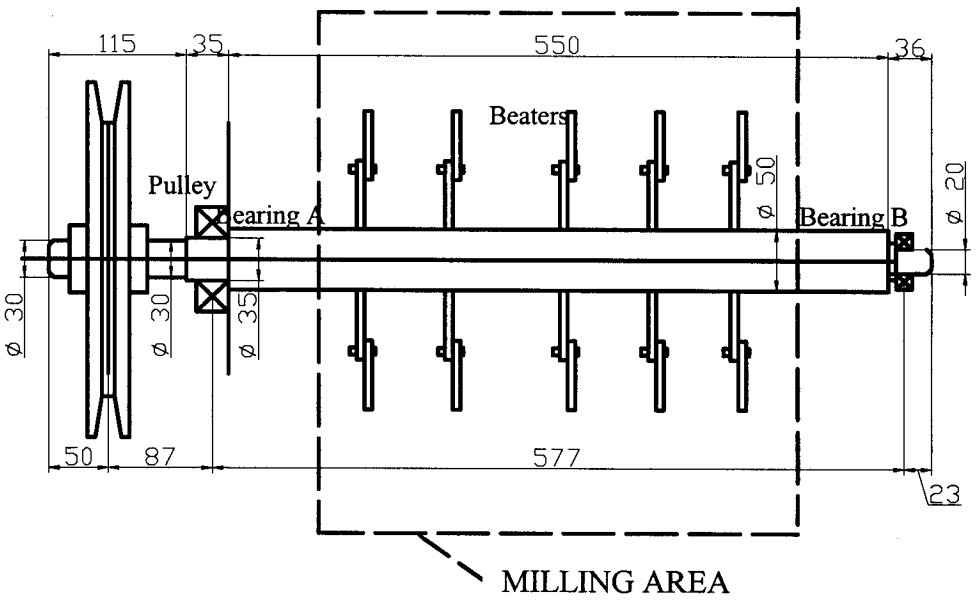


Fig Q7 Hammer mill shaft with pulley

DATA SHEET

Some values of K_f for shafts made of carbon steel.

Type of notch	Type of load p	K_f
Retaining ring groove	bending	2.5 to 3.0
Retaining ring groove	torsion	2.5 to 3.0
Key-groove (flat key)	bending	1.7 to 2.0
Key-groove (flat key)	torsion	1.6 to 1.8
Key groove (gib-head, woodruf)	bending	1.5 to 1.6
Key groove (gib-head, woodruf)	torsion	1.4 to 1.5
Hole perpendicular shaft axis	bending	1.4 to 1.7
Hole perpendicular shaft axis	torsion	1.4 to 1.7
Press or shrink fit end	bending	2
Press or shrink fit end	torsion	1.5

The **torsional deflection** is found with the equation.

$\theta = \frac{T.l}{G.I_t}$ Torsional deflection vary from 2° per meter to 4° per meter

Data on permissible **transverse deflection** are rare. For **transmission shafts** a thumb-rule of **0.001 to 0.0006 of the length between supports can be used**. For shafts **supporting gears**, more rigidity is required and values of **0.00015 of the length between supports is used.**

$$\sigma_{max} = k_f . \frac{M.f_d}{Z_b} \le \sigma_d$$

$\sigma_d = \frac{\sigma_y}{n} k_a k_b k_c k_d$ for non rotating axles

$\sigma_d = \frac{\sigma_f}{n} k_a k_b k_c k_d$ for rotating axles

where σ_y is the yield strength, σ_f is the fatigue strength calculated from the relation

$$\sigma_f = S'_e = \begin{cases} \mathbf{0.504 S_{ut}, S_{ut} \le 1400 MPa} \\ \mathbf{700 MPa, S_{ut} > 1400 MPa} \end{cases}$$

n is the factor of safety The factor of safety can be chosen between 1.3 and 1.5 . When fd is omitted in the Mc formula the factor of safety should be 2 to 4.

Surface factor $\mathbf{k_a = a.S_{ut}^b}$

where S_{ut} is the minimum tensile strength while a and b can be found in the

Size factor $\mathbf{k_b} = \left(\frac{d}{7.62}\right)^{-0.1133}$ 2.79<d<51 mm. **For larger sizes k_b varies from 0.60 to 0.75 for bending and torsion. For axial loading there is no size effect. Therefore use K_b =1**

Surface finish	Factor a (Mpa)	Exponent b
Ground	1.58	-0.085
Machined or cold-drawn	4.51	-0.265
Hot-rolled	57.7	-0.718
As forged	272	-0.995

as $Zb=0.1\ d^3$

load factor k_c=1 because the distortion energy theorem is being used and it will be assumed to have been taken care of.

For temperatures up to 250°C k_d=1 which will adequate for most uses in agricultural engineering.

$$\sigma_d \ge k_f . \frac{10M.f_d}{d^3} \Leftrightarrow d \ge \sqrt[3]{k_f . f_d \frac{10M}{\sigma_d}}$$

The maximum shear stress (direct shear stress i.e. not caused by a torque)

$$\tau_{max} = \frac{4}{3} . \frac{F}{A} = \frac{16F}{3\pi d^2} \le \tau_d$$

Load condition	α (loading coefficient)
Reversed bending and constant torsion	0.4
Reversed bending and repeat torsion	0.7
reversed bending and reversed torsion	1.0

$w\mathbf{d} = \sqrt[3]{\frac{10M_c}{\sigma_d}}$ where

$$Mc = \sqrt{(M_b . k_f . f_d)^2 + \frac{3}{4}(\alpha . T . k_{fs} . f_d)^2}$$

Mc is the comparative moment, σ_d is the fatigue design stress, f_d is the dynamic factor

The values of F_d are given in the table below.

Values for fd	bending	torsion
Steady load	1.5	1.0
Dynamic load, minor shocks	1.5 to 2.0	1.0 to 1.5
Dynamic load, heavy shocks	2.0 to 3.0	1.5 to 3.0

Table 4 Guide to values of requisite basic rating life L_{10h} for different classes of machines

Class of machine	L_{10h} operating hours
Household machines, agricultural machines, instruments, technical apparatus for medical use	300 ... 3 000
Machines used for short periods or intermittently: Electric hand tools, lifting tackle in workshops, construction machines	3 000 ... 8 000
Machines to work with high operational reliability during short periods or intermittently: Lifts (elevators), cranes for packaged goods or slings of drums, bales etc.	8 000 ... 12 000
Machines for use 8 hours per day but not always fully utilised: Gear drives for general purposes, electric motors for industrial use, rotary crushers	10 000 ... 25 000
Machines used 8 hours per day and fully utilised: Machine tools, woodworking machines, machines for the engineering industry, cranes for bulk materials, ventilator fans, conveyor belts, printing equipment, separators and centrifuges	20 000 ... 30 000
Machines for continuous use 24 hours per day: Rolling mill gear units, medium sized electrical machinery, compressors, mine hoists, pumps, textile machinery	40 000 ... 50 000
Water works machinery, rotary furnaces, cable stranding machines, propulsion machinery for ocean-going vessels	60 000 ... 100 000
Large electric machinery, power station plant, mine pumps and mine ventilator fans, tunnel shaft bearings for ocean-going vessels	≈ 100 000

Table 5 Guide to values of requisite basic rating life L_{10s} for road and rail vehicles

Type of vehicle	L_{10s} millions of km
Wheel hub bearings for road vehicles:	
Private cars	0,3
Commercial vehicles, buses	0,6
Axlebox bearings for rail vehicles:	
Goods wagons (to UIC specification based on continuously acting maximum axle load), freight cars	0,8
Suburban stock, tramcars	1,5
Main line passenger carriages	3
Main line motor units	3 ... 4
Main line diesel and electric locomotives	3 ... 5

Adjusted rating life equation

In the life equation discussed on page 28

$$L_{10} = \left(\frac{C}{P}\right)^p$$

the influence of bearing load on the life of a given bearing is considered. Where the rolling bearings listed in this catalogue are used in conventional applications, a calculation of the basic rating life L_{10} is adequate, since the recommendations regarding requisite life are based on experience and, in fact, consider factors such as lubrication.

It may, however, be desirable to consider other factors influencing bearing life in more detail. In 1977, ISO introduced a revised life equation to this end. This adjusted rating life equation is

$$L_{na} = a_1\, a_2\, a_3 \left(\frac{C}{P}\right)^p$$

or simply

$$L_{na} = a_1\, a_2\, a_3\, L_{10}$$

where

L_{na} = adjusted rating life, millions of revolutions (the index n represents the difference between the requisite reliability[1] and 100 %)

a_1 = life adjustment factor for reliability

a_2 = life adjustment factor for material

a_3 = life adjustment factor for operating conditions

A calculation of the adjusted rating life presupposes that the operating conditions are well defined and that the bearing loads can be accurately calculated, i.e. the calculations should consider the load spectrum, shaft deflection etc.

For the generally accepted reliability of 90 % and for bearing materials to which the C values correspond, and for normal operating conditions, $a_1 = a_2 = a_3 = 1$ and the equations for the basic and adjusted rating lives become identical.

[1] By reliability is meant the probability that a bearing will attain or exceed a specified life

Life adjustment factor a_1

The a_1 factor for reliability is used to determine lives other than the L_{10} life, i.e. lives which are attained or exceeded with a greater probability than 90 %. Values of a_1 are given in Table 6.

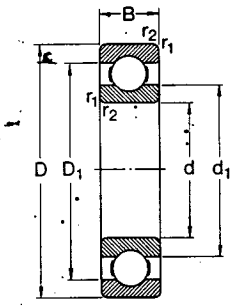
Life adjustment factor a_2

When determining SKF basic dynamic load ratings, the fact has been taken into account that the standard steels used by SKF have better life properties than the material on which the equations given in ISO 281/I-1977 are based. When using these load ratings (C values), therefore, $a_2 = 1$. Higher values of a_2 can, however, be applied to SKF bearings made of special steels; please consult SKF.

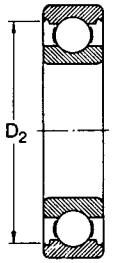
Table 6 Values of life adjustment factor a_1

Reliability %	L_{na}	a_1
90	L_{10a}	1
95	L_{5a}	0,62
96	L_{4a}	0,53
97	L_{3a}	0,44
98	L_{2a}	0,33
99	L_{1a}	0,21

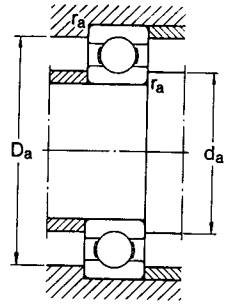
single row
d **15–30** mm



With full outer ring shoulders

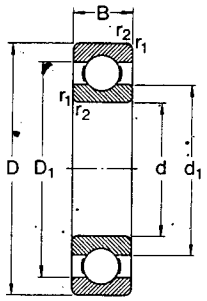


With recessed outer ring shoulders

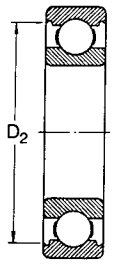


Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Lubrication grease	oil	Mass	Designation
d	D	B	C	C_0	P_u				
mm			N		N	r/min		kg	–
15	24	5	1 560	800	34	28 000	34 000	0,0074	**61802**
	28	7	4 030	2 040	85	24 000	30 000	0,016	**61902**
	32	8	5 590	2 850	120	22 000	28 000	0,025	**16002**
	32	9	5 590	2 850	120	22 000	28 000	0,030	**6002**
	35	11	7 800	3 750	160	19 000	24 000	0,045	**6202**
	42	13	11 400	5 400	228	17 000	20 000	0,082	**6302**
17	26	5	1 680	930	39	24 000	30 000	0,0082	**61803**
	30	7	4 360	2 320	98	22 000	28 000	0,018	**61903**
	35	8	6 050	3 250	137	19 000	24 000	0,032	**16003**
	35	10	6 050	3 250	137	19 000	24 000	0,039	**6003**
	40	12	9 560	4 750	200	17 000	20 000	0,065	**6203**
	47	14	13 500	6 550	275	16 000	19 000	0,12	**6303**
	62	17	22 900	10 800	455	12 000	15 000	0,27	**6403**
20	32	7	2 700	1 500	63	19 000	24 000	0,018	**61804**
	37	9	6 370	3 650	156	18 000	22 000	0,038	**61904**
	42	8	6 890	4 050	173	17 000	20 000	0,050	**16004**
	42	12	9 360	5 000	212	17 000	20 000	0,069	**6004**
	47	14	12 700	6 550	280	15 000	18 000	0,11	**6204**
	52	15	15 900	7 800	335	13 000	16 000	0,14	**6304**
	72	19	30 700	15 000	640	10 000	13 000	0,40	**6404**
25	37	7	4 360	2 600	125	17 000	20 000	0,022	**61805**
	42	9	6 630	4 000	176	16 000	19 000	0,045	**61905**
	47	8	7 610	4 750	212	14 000	17 000	0,060	**16005**
	47	12	11 200	6 550	275	15 000	18 000	0,080	**6005**
	52	15	14 000	7 800	335	12 000	15 000	0,13	**6205**
	62	17	22 500	11 600	490	11 000	14 000	0,23	**6305**
	80	21	35 800	19 300	815	9 000	11 000	0,53	**6405**
30	42	7	4 490	2 900	146	15 000	18 000	0,027	**61806**
	47	9	7 280	4 550	212	14 000	17 000	0,051	**61906**
	55	9	11 200	7 350	310	12 000	15 000	0,085	**16006**
	55	13	13 300	8 300	355	12 000	15 000	0,12	**6006**
	62	16	19 500	11 200	475	10 000	13 000	0,20	**6206**
	72	19	28 100	16 000	670	9 000	11 000	0,35	**6306**
	90	23	43 600	23 600	1 000	8 500	10 000	0,74	**6406**

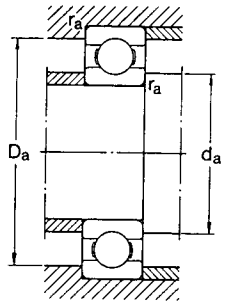
Dimensions					Abutment and fillet dimensions		
d	d_1 ≈	D_1 ≈	D_2 ≈	$r_{1,2}$ min	d_a min	D_a max	r_a max
mm					mm		
15	17,9	21,1	–	0,3	17	22	0,3
	18,4	24,7	–	0,3	17	26	0,3
	20,2	27	28,2	0,3	17	30	0,3
	20,2	27	28,2	0,3	17	30	0,3
	21,5	29,2	30,4	0,6	19	31	0,6
	23,7	33,9	36,3	1	20	37	1
17	20,2	23,2	–	0,3	19	24	0,3
	20,4	26,7	–	0,3	19	28	0,3
	22,7	29,5	31,2	0,3	19	33	0,3
	22,7	29,5	31,2	0,3	19	33	0,3
	24,2	32,9	35	0,6	21	36	0,6
	26,5	37,6	39,6	1	22	42	1
	32,4	47,4	–	1,1	23,5	55,5	1
20	24	28,3	–	0,3	22	30	0,3
	25,6	31,4	–	0,3	22	35	0,3
	27,3	34,6	–	0,3	22	40	0,3
	27,2	35,1	37,2	0,6	24	38	0,6
	28,5	38,7	40,6	1	25	42	1
	30,3	42,1	44,8	1,1	26,5	45,5	1
	37,1	55,6	–	1,1	26,5	65,5	1
25	28,5	33,3	–	0,3	27	35	0,3
	30,2	36,8	–	0,3	27	40	0,3
	33,3	40,7	–	0,3	27	45	0,3
	32	40,3	42,2	0,6	29	43	0,6
	34	44,2	46,3	1	30	47	1
	36,6	50,9	52,7	1,1	31,5	55,5	1
	45,4	63,8	–	1,5	33	72	1,5
30	33,7	38,5	–	0,3	32	40	0,3
	35,2	41,8	–	0,3	32	45	0,3
	38	47,3	–	0,3	32	53	0,3
	38,2	47,1	49	1	35	50	1
	40,3	52,1	54,1	1	35	57	1
	44,6	59,9	61,9	1,1	36,5	65,5	1
	50,3	70,7	–	1,5	38	82	1,5



With full outer ring shoulders



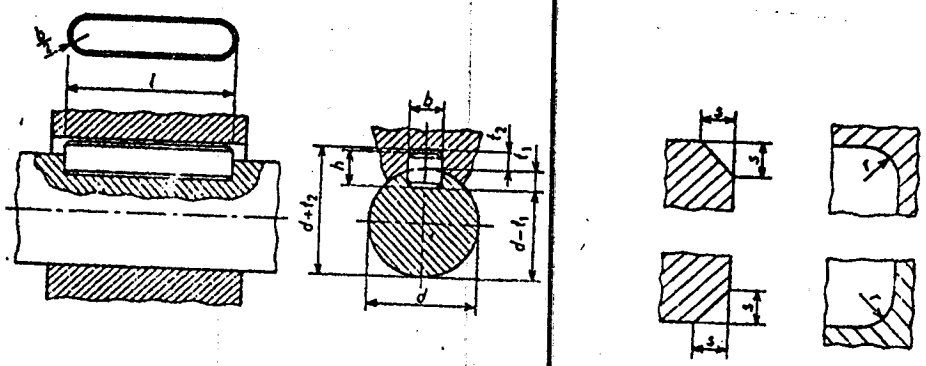
With recessed outer ring shoulders



Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Lubrication grease	oil	Mass	Designation
d	D	B	C	C_0	P_u				
mm			N		N	r/min		kg	–
35	47	7	4 750	3 200	166	13 000	16 000	0,030	**61807**
	55	10	9 560	6 200	290	11 000	14 000	0,080	**61907**
	62	9	12 400	8 150	375	10 000	13 000	0,11	**16007**
	62	14	15 900	10 200	440	10 000	13 000	0,16	**6007**
	72	17	25 500	15 300	655	9 000	11 000	0,29	**6207**
	80	21	33 200	19 000	815	8 500	10 000	0,46	**6307**
	100	25	55 300	31 000	1 290	7 000	8 500	0,95	**6407**
40	52	7	4 940	3 450	186	11 000	14 000	0,034	**61808**
	62	12	13 800	9 300	425	10 000	13 000	0,12	**61908**
	68	9	13 300	9 150	440	9 500	12 000	0,13	**16008**
	68	15	16 800	11 600	490	9 500	12 000	0,19	**6008**
	80	18	30 700	19 000	800	8 500	10 000	0,37	**6208** —
	90	23	41 000	24 000	1 020	7 500	9 000	0,63	**6308** —
	110	27	63 700	36 500	1 530	6 700	8 000	1,25	**6408**
45	58	7	6 050	4 300	228	9 500	12 000	0,040	**61809**
	68	12	10 100	6 700	285	9 000	11 000	0,14	**61909**
	75	10	15 600	10 800	520	9 000	11 000	0,17	**16009**
	75	16	20 800	14 600	640	9 000	11 000	0,25	**6009**
	85	19	33 200	21 600	915	7 500	9 000	0,41	**6209**
	100	25	52 700	31 500	1 340	6 700	8 000	0,83	**6309**
	120	29	76 100	45 000	1 900	6 000	7 000	1,55	**6409**
50	65	7	6 240	4 750	250	9 000	11 000	0,052	**61810**
	72	12	14 600	10 400	500	8 500	10 000	0,14	**61910**
	80	10	16 300	11 400	560	8 500	10 000	0,18	**16010**
	80	16	21 600	16 000	710	8 500	10 000	0,26	**6010**
	90	20	35 100	23 200	980	7 000	8 500	0,46	**6210**
	110	27	61 800	38 000	1 600	6 300	7 500	1,05	**6310**
	130	31	87 100	52 000	2 200	5 300	6 300	1,90	**6410**
55	72	9	8 320	6 200	325	8 500	10 000	0,083	**61811**
	80	13	15 900	11 400	560	8 000	9 500	0,19	**61911**
	90	11	19 500	14 000	695	7 500	9 000	0,26	**16011**
	90	18	28 100	21 200	900	7 500	9 000	0,39	**6011**
	100	21	43 600	29 000	1 250	6 300	7 500	0,61	**6211**
	120	29	71 500	45 000	1 900	5 600	6 700	1,35	**6311**
	140	33	99 500	62 000	2 600	5 000	6 000	2,30	**6411**

Dimensions					Abutment and fillet dimensions		
d	d_1 ≈	D_1 ≈	D_2 ≈	$r_{1,2}$ min	d_a min	D_a max	r_a max
mm					mm		
35	38,7	43,5	–	0,3	37	45	0,3
	41,6	48,6	–	0,6	39	51	0,6
	44	53,3	–	0,3	37	60	0,3
	43,7	53,6	55,7	1	40	57	1
	46,9	60,6	62,7	1,1	41,5	65,5	1
	49,5	66,1	69,2	1,5	43	72	1,5
	57,4	80,6	–	1,5	43	92	1,5
40	43,7	48,5	–	0,3	42	50	0,3
	47	55,2	–	0,6	44	58	0,6
	49,4	57	–	0,3	42	66	0,3
	49,2	59,1	61,1	1	45	63	1
	52,6	67,9	69,8	1,1	46,5	73,5	1
	56,1	74,7	77,7	1,5	48	82	1,5
	62,8	88	–	2	49	101	2
45	48,7	54,5	–	0,3	47	56	0,3
	52,3	60,8	–	0,6	49	64	0,6
	55	65,4	–	0,6	49	71	0,6
	54,7	65,6	67,8	1	50	70	1
	57,6	72,9	75,2	1,1	51,5	78,5	1
	62,1	83,7	86,7	1,5	53	92	1,5
	68,9	96,9	–	2	54	111	2
50	54,7	60,5	–	0,3	52	63	0,3
	56,8	65,3	–	0,6	54	68	0,6
	60	70,4	–	0,6	54	76	0,6
	59,7	70,6	72,8	1	55	75	1
	62,5	78,1	81,7	1,1	56,5	83,5	1
	68,7	92,1	95,2	2	59	101	2
	75,4	106	–	2,1	61	119	2
55	60,2	67	–	0,3	57	70	0,3
	63	72,1	–	1	60	75	1
	67	78	–	0,6	59	86	0,6
	66,3	79,1	81,5	1,1	61,5	83,5	1
	69	86,6	89,4	1,5	63	92	1,5
	75,3	101	104	2	64	111	2
	81,5	115	–	2,1	66	129	2

SQUARE AND RECTANGULAR PARALLEL KEYS AND THEIR CORRESPONDING KEYWAYS



Dimensions in mm

d above	d up to and incl.	b	h	1) t_1	1) t_2	l above	l up to and incl.	s r	tolerances on s	tolerances on r
6	8	2	2	1,2	1	6	20	0,16	+ 0,09 0	0 — 0,08
8	10	3	3	1,8	1,4	6	36			
10	12	4	4	2,5	1,8	8	45			
12	17	5	5	3	2,3	10	56	0,25	+ 0,15 0	0 — 0,09
17	22	6	6	3,5	2,8	14	70			
22	30	8	7	4	3,3	18	90			
30	38	10	8	5	3,3	22	110	0,40	+ 0,2 0	0 — 0,15
38	44	12	8	5	3,3	28	140			
44	50	14	9	5,5	3,8	36	160			
50	58	16	10	6	4,3	45	180			
58	65	18	11	7	4,4	50	200			
65	75	20	12	7,5	4,9	56	220	0,6		0 — 0,2
75	85	22	14	9	5,4	63	250			
85	95	25	14	9	5,4	70	280			
95	110	28	16	10	6,4	80	320			
110	130	32	18	11	7,4	90	360			
130	150	36	20	12	8,4	100	400	1,0		0 — 0,3
150	170	40	22	13	9,4	These values are not standardized				
170	200	45	25	15	10,4					
200	230	50	28	17	11,4					
230	260	56	32	20	12,4			1,6	+ 0,4 0	0 — 0,4
260	290	63	32	20	12,4					
290	330	70	36	22	14,4					
330	380	80	40	25	15,4			2,5	+ 0,5 0	0 — 0,5
380	440	90	45	28	17,4					
440	500	100	50	31	19,5					

d = shaftdiameter
b = width of the key and of the keyway
h = height of the key
l = length of the key and of the keyway
t1= depth of the keyway in the shaft, measured at the center
t2= depth of the keyway in the hub, measured at the center
s = chamfer of the key
r = fillet of the keyway in the shaft and the hub

normal values of l				
6	20	45	100	220
8	22	50	110	250
10	25	56	125	280
12	28	63	140	320
14	32	70	160	360
16	36	80	180	400
18	40	90	200	

1) The depth of the keyway in the shaft and in the hub can be measured directly or by measuring (d-t1) and (d+t2). The depth of the keyway may not be measured from the side of the keyway.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS
JANUARY 2004

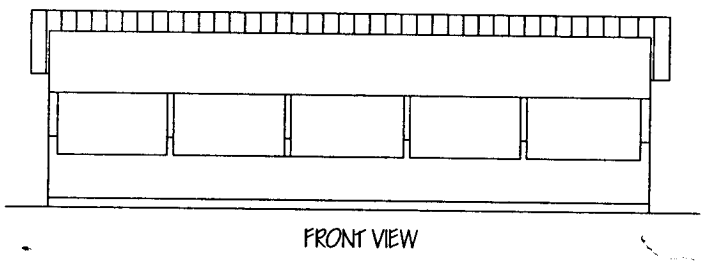
EA522: FARM STRUCTURES II

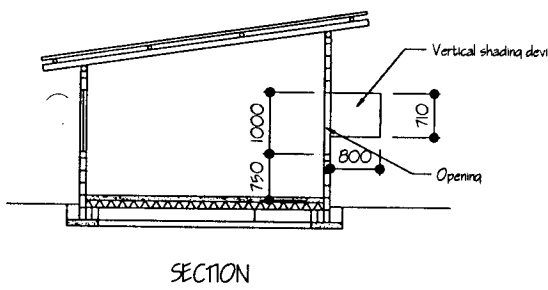
INSTRUCTIONS: Answer any FIVE questions. All questions carry 20 marks.
TIME ALLOWED: THREE HOURS

QUESTION 1

(a) Figure 1 shows the south-west facing facade of a building located in Lusaka (latitude 16°S). Use the shadow angle protractor to determine the period of shading from the vertical shading device on three days as follows: **(12 marks)**

(i) December 22
(ii) August 30
(iii) September 23





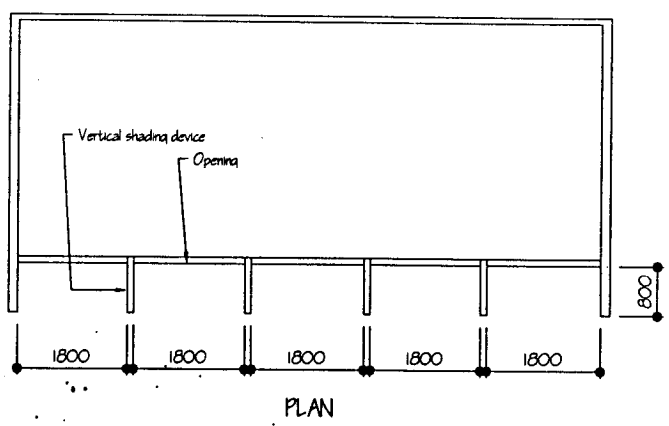


Figure 1 (all dimensions in mm)

(b) Determine the moisture transmission in 30 days across $1m^2$ of a wall of a building composed of three layers as shown in Figure 2. The pressure difference across the wall is 564 Pa. The permeance of the materials are as follows: **(8 marks)**

A: concrete 1.90×10^{-3} g/(24hr.m^2.Pa)
B: Polyethene sheet 0.4×10^{-3} g/(24hr.m^2.Pa)
C: 6mm plywood paneling 3.45×10^{-3} g/(24hr.m^2.Pa)

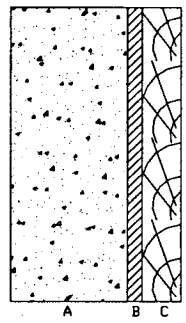


Figure 2

QUESTION 2

(a) Define the following properties of the climatic environment in agricultural buildings giving appropriate units: **(8 marks)**
(i) Specific volume
(ii) Enthalpy
(iii) Dew-point temperature
(iv) Relative humidity

(b) Discuss briefly the use of ventilation of agricultural buildings as a means to control the internal environment. **(8 marks)**

(c) Calculate the rate of ventilation in m^3/s due to thermal forces if the areas of openings are $10.2m^2$, the temperature inside is 26°C, the temperature outside is 16°C and the height difference between inlet and outlet is 1.2m. Use a reduction factor of 0.65. **(4 marks)**

QUESTION 3

(a) Define ***comfort zone*** and discuss the factors that affect it in livestock. **(12 marks)**

(b) An evaporative cooling system is installed in a poultry house. When the outside air at a dry-bulb temperature of 30°C and 20% relative humidity is passed over the wet pads, the relative humidity inside the house increases to 75%. **(8 marks)**
Use the psychrometric chart provided to determine:
(i) The dry-buld temperature in the house;
(ii) The volume of water taken up by the air every hour if the air flow rate is 1.2m/s.

Note: The density of water is 1000kg/m3
The specific volume of air should be determine at the inlet into the building.

QUESTION 4

(a) Discuss the use of building specifications in the building production process. **(6 marks)**

(b) Describe using a simple sketch the design of a milking shed suitable for a medium-scale dairy farmer with 10 to 30 cows. **(14 marks)**

QUESTION 5

(a) Discuss the following types of building life: **(9 marks)**
- (i) Physical life
- (ii) Economic life
- (iii) Write-off life

(b) A farmer wishes to expand his farm by constructing a new milking parlour for 50 cows. The proposed scheme has the following costs per cow: **(11 marks)**

Purchase of land	K 300,000.00
Building construction and equipment	K1,700,000.00
Cost of one cow	K 260,000.00

Annual interest and operating costs per cow are as follows:

Feed	K 800,000.00
Miscellaneous	K 550,000.00
Fixed costs and labour	K 610,000.00

Interest on half the investment is at a rate of 8%.

The annual cost as a percentage of original costs on buildings, equipment and cows are as follows:

Repair and maintenance of buildings and equipment	2.5%
Depreciation of building and equipment	2.5%
Insurance on building and equipment	1.0%
Insurance per cow	1.2%

The gross income is evaluated per cow from the sale of milk estimated at 3200 litres per year and sold at a wholesale price of K400 per litre.

For this investment, determine the payback period.

QUESTION 6

(a) Discuss any five (5) factors to be considered in the planning of a zoned farmstead. **(10 marks)**

(b) The water supply for a farmstead near is collected from roof catchments and stored in a single tank. The monthly rainfall is given in Table 1 and daily requirements for the maximum day in Table 2. If the farmer wishes to collect all the rainfall in the catchments, what is the required storage capacity of the tank given that the total catchment area is 760 m^2. **(10 marks)**

Table 1 Monthly rainfall (mm)

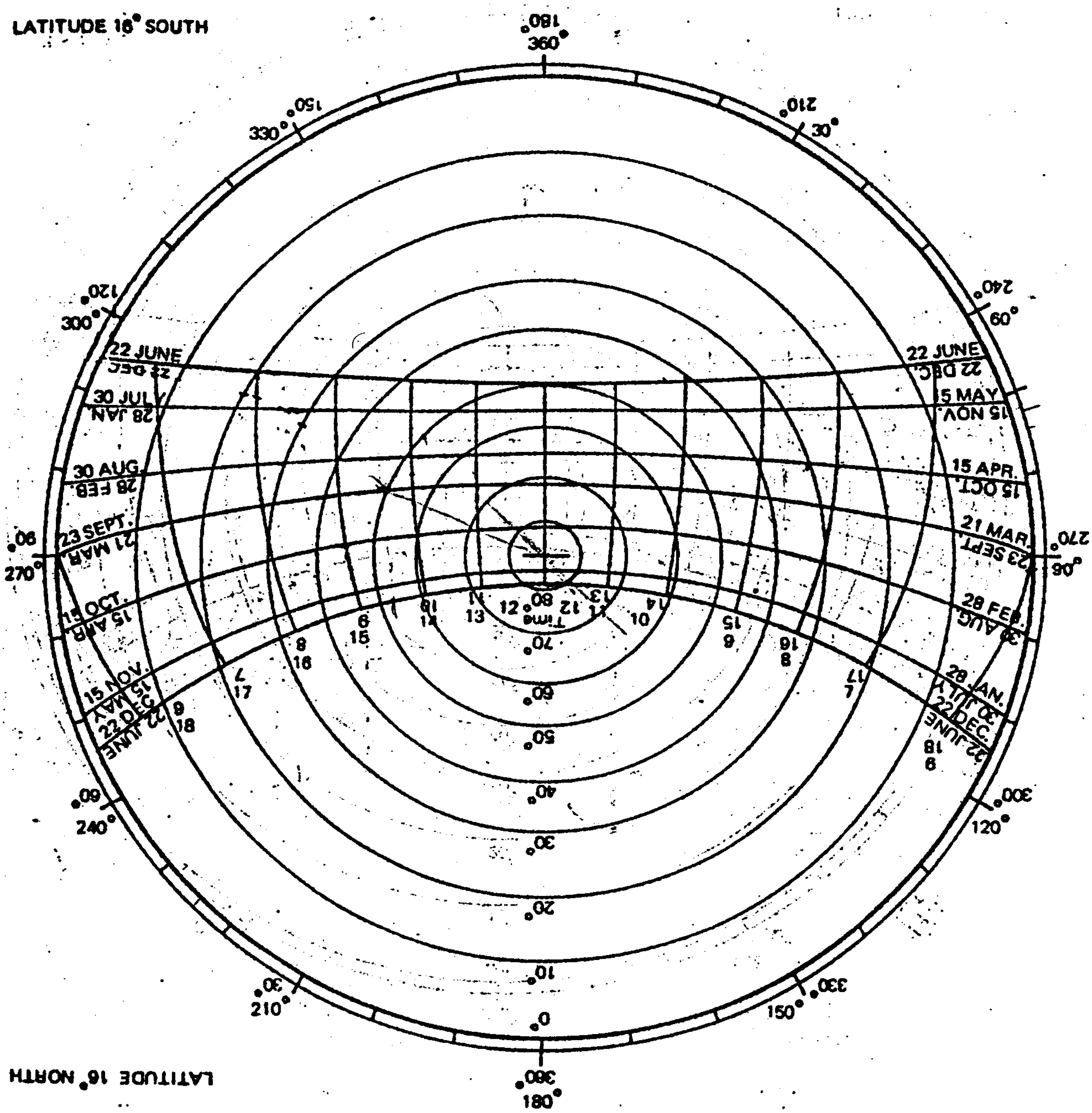
Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Ma	Apr	May	Jun
-	-	-	7.9	204.7	335.5	347.5	148.8	176.8	203.7	-	-

Table 2 Daily water requirements (litres)

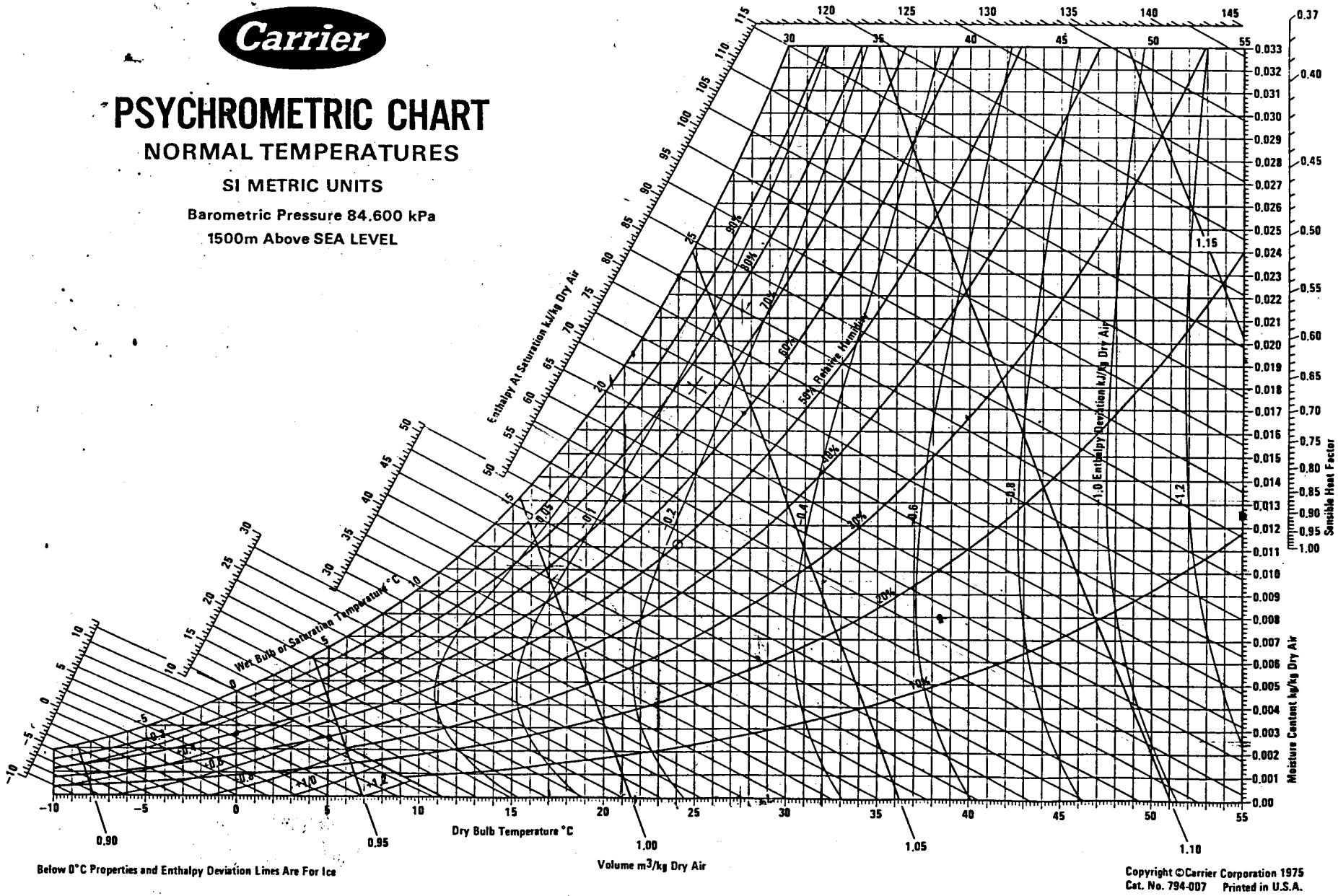
	Dairy Cows	Pigs	Layers
Number	8	32	135
Requirements	70	30	4

END OF EXAMINATION

EXAMINER: Dr. Edward Lusambo Department of Agricultural Engineering



LATITUDE 16° SOUTH
LATITUDE 16° NORTH
22 JUNE
30 JULY
30 AUG.
23 SEPT.
15 OCT.
15 NOV.
22 DEC.
15 MAY
15 APR.
21 MAR.
28 FEB.
28 JAN.
Time
80°
70°
60°
50°
40°
30°
20°
10°
0°
360°
180°
30°
60°
90°
120°
150°
210°
240°
270°
300°
330°


Carrier
PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 84.600 kPa
1500m Above SEA LEVEL
Enthalpy At Saturation kJ/kg Dry Air
Wet Bulb or Saturation Temperature °C
Dry Bulb Temperature °C
Volume m3/kg Dry Air
1.0 Enthalpy Deviation kJ/kg Dry Air
Sensible Heat Factor
Moisture Content kg/kg Dry Air
50% Relative Humidity
Below 0°C Properties and Enthalpy Deviation Lines Are For Ice
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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS 8 JANUARY 2004

EA 542: IRRIGATION ENGINEERING

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ATTEMPT (5) QUESTIONS ONLY
ALL QUESTIONS CARRY EQUAL MARKS

QUESTION 1:

(a) Write a note (about 100 words) on the nature and effect of cavitation. [4 marks]

(b) A Kafue sugar cane grower has purchased an electrically driven centrifugal pump with a design discharge capacity of 320.82 L/min. The following data is also known of the pumping plant adjacent to the Kafue River.

Suction Side
The static suction lift is 5 m (i.e., the difference in elevation between the water surface and the centre line of the pump). The head loss in the Foot Strainer Valve is 75 per cent of the suction velocity head. The suction pipe has a long 90° Sweep Bend in which the head loss is 0.45 m. The head loss due to friction in the 8 m long and 70 mm ID suction pipe is given by the manufacturer as 1.42 m.

Discharge Side
The water is to be pumped into a Storage Tank on top of a small hill from where it is to be diverted by gravity to the fields. The elevation difference between the centre line of the pump and the full reservoir level is 32 m. The discharge pipe is 120 m long and 75 mm ID of Asbestos Cement with a Hazen-Williams C_2 value of 140. The combined head loss in the Gate Valve plus a Long 90° Sweep Bend is 2.35 m. The head loss in the Check Valve (Reflux Valve) is 80 per cent of the velocity head of the discharge pipe.

(i) What is the total head, which is to be delivered by the pump? [8 marks]

(ii) What is the Brake Power required by the pump if it is 70 per cent efficient? [2 marks]

(iii) The pump will operate at an elevation of 920 m where the water temperature is 20 °C. Check for cavitation if the required net positive suction head NPSHr is 1.60 m. The drawdown is negligible in a large river. [6 marks]

QUESTION 2

Given the following data for the soil profile of an irrigated field which consists of two horizons:

	A Horizon	B Horizon
i) Mass basis moisture content (%)		
wilting point	10	25
field capacity	28	38
saturation	40	47
ii) Bulk density, (g/cm^3)	1.15	1.35
iii) Thickness of horizon (cm)	40	80
iv) Initial volumetric moisture content (%)	15	35

(a) Calculate the amounts of hygroscopic water, plant available water and gravity water for each horizon.

[3 marks]

(b) Plot the resultant moisture content of the profile if 15 cm of water is added after irrigation. Assume that the A-B horizon interface does not impede flow and that drainage from the B horizon is not impeded.

[6 marks]

(c) Assuming that a shallow rooted crop is being grown on the field (therefore consider only the A horizon as the soil moisture reservoir), how long will it take to deplete the reservoir to 25 % of capacity if the Evapotranspiration (ET) rate is 6.21 mm/day and the A horizon is initially at field capacity?

[4 marks]

(c) How much water (mm) will have to be applied at that time if the irrigation is 65% efficient?

[2 marks]

(e) If a rainfall of 15 mm occurs on the 5^{th} day, how soon thereafter will irrigation be required? Assume that 80 % of the rainfall is effective and infiltrates to the A and B horizons. Irrigation is provided when both A and B horizons are at 50 % of field capacity.

[5 marks]

QUESTION 3

a) Prove the following statements:

(i) " To double the quantity of water flowing over an overflow-type control structure, the depth must be increased only 1.6 times. "

[2 marks]

(ii) " To double the quantity of water flowing through a submerged orifice type of control structure, the effective head, h, must be four times the original head. "

[2 marks]

b) An irrigation canal is to be of trapezoidal cross section with natural lining of channel banks and bottom. To prevent scour, the average velocity is to be 0.61 ms^{-1}, the design depth of water is 0.55 m and the side slopes are 2 horizontal to 1 vertical. If a discharge of 56.634 m^3s^{-1} is to be conveyed, determine the slope and bottom width of a suitable trapezoidal channel section. Assume Manning's roughness coefficient as n = 0.020.

[8 marks]

c) A flow of 1.2 m^3s^{-1} is diverted for one full day a week to a farm storage reservoir. From this reservoir, water is continuously diverted to irrigate a 100 ha farm. The main canal from the reservoir to the farm is 1450 m long and is unlined. The daily crop water requirement during the peak demand is 8.5 mm per day. The losses in the irrigation canal are 1.5 litres per minute per metre canal. The evaporation and seepage losses of the reservoir are 7.5 m^3 per hour. Determine:

(i) the reservoir storage efficiency, er [2 marks]

(ii) the conveyance efficiency, ec [2 marks]

(iii) the application efficiency, ea [2 marks]

(iv) the overall efficiency, es [2 marks]

QUESTION 4

(a) Write short notes on the following terms:

(i) Constant-discharge nozzles

(ii) Water hammer

(iii) Recession phase

(iv) Pipe couplers

(v) Infiltration opportunity time [5 marks]

(b) Irrigation can bring wealth and prosperity to a community but it can also bring sickness and sometimes death. Discuss (i) how the development of large irrigation schemes can lead to an increase in the prevalence of diseases such as malaria and schistosomiasis and (ii) the methods available to the engineer for the control of these diseases.

[5 marks]

(c) Determine the required capacity of a sprinkler system to apply water at the rate of 1.25 cm per hour. Two 186 metres long sprinkler lines are required. Sixteen sprinklers are spaced at 12- metre intervals on each line. The spacing between the laterals is 18 m. Allowing 1 hour for moving equipment and each 186-metre sprinkler line, how many hours would be required to apply a 50 mm irrigation to a square 16-hectare field? How many days are required assuming 10-hour days?

[10 marks]

QUESTION 5

(a) A 24 ha field of potatoes is to be irrigated by the furrow method. The runs are 300 m long, the average slope is 0.75% and the rows are spaced 80 cm apart. The water application efficiency is 60%. The effective root zone is 90 cm deep. The available moisture holding capacity is 17 cm/m depth. The field is to be irrigated when 45% of the available moisture capacity is depleted.

(i) What flow rate is required if the field is to be irrigated in 13 days?

(ii) If the maximum non-erosive furrow stream is used, how many hours should you leave the water running in a 'set' in order to apply the specified depth of water?

(iii) How many furrows can be irrigated in a set?

[10 marks]

(b) A submerged orifice is used to measure the flow in the supply ditch to the furrow system above. If the head is not to exceed 17 cm and the horizontal dimensions of the rectangular opening are five times the height, what are the dimensions of the rectangular orifice? Assume C = 0.61

[6 marks]

(c) A basin 20 m wide is constructed on sloping ground and the land is not levelled. The irrigation depth required to fill the soil reservoir is 90 mm. To apply 90 mm of water at the upper end, 160 mm must be applied at the lower end. Calculate the water loss and irrigation efficiency. [4 marks]

QUESTION 6

(a) A farmer in Kabwe wants to grow maize under border strip irrigation. He has acquired a plot of land that measures 300 m long and 200 m wide. The land slopes in the length direction. The net irrigation depth of water is 78 mm and the application efficiency is 52 per cent. There is a reliable water supply to the plot of 180 m^3 per hour. The frequency of irrigation is 13 days. The elevation at the head of the border strip is 1443.8 m and the elevation at the bottom of the border strip is 1442.6 m. The unit stream size available for each border strip is 5 litres per second and the soil is loamy. Table Q6 (a) gives suggested border strip sizes for three soil conditions.

Table Q6 (a): Suggested border strip sizes

Soil Type	Irrigation Depth (mm)	Slope (%)	Width (m)	Length (m)	Unit stream (litres/s)
SAND	100	0.2 0.4 0.8	12-30 10-20 5-10	60-100 60-100 75	10-15 8-10 5-7
LOAM	150	0.2 0.4 0.8	15-30 10-20 5-10	90-300 90-180 90	4-6 3-5 2-4
CLAY	200	0.2 0.4	15-30 10-20	300+ 180-300	3-6 2-4

Determine the following parameters for this Kabwe farmer:

(i) gross depth of irrigation application [1 mark]

(ii) slope of the land [1 mark]

(iii) the width of the border strip [2 marks]

(iv) the length of the border strip [2 marks]

(v) how many border strips can be irrigated at same time? [2 marks]

(vi) sketch the field [2 marks]

b) A trapezoidal farm canal carries a maximum flow of 125 m^3 of water per hour to an irrigated maize field using furrow irrigation. For optimum irrigation, each furrow must be supplied with 2.30 litres per second. Table Q6 (b) gives the relationship between siphon tube diameter and the head (difference between water surface in the supply canal and water surface in the irrigation furrow).

Table Q6 (b): Discharge for siphon tubes (litres per second)

Diameter (mm)	Head (mm) 50	100	150	200
10	0.1	0.1	0.1	0.1
20	0.2	0.3	0.3	0.7
30	0.4	0.6	0.7	0.8
40	0.8	1.1	1.3	1.5
50	1.2	1.7	2.0	2.3
100	4.7	6.6	8.1	9.3

(i) How many furrows can be irrigated at the same time? [2 marks]

(ii) If the head available is 20 cm, what size of siphon tube is required? [2 marks]

(iii) Draw the supply canal, siphon tube and furrow arrangement showing the head that is producing the flow. [2 marks]

(iv) If only one irrigation setting is possible per day, how long will it take to irrigate a 1-hectare (100m x 100m) field with furrow spacing at 1 m intervals and a furrow width of 25 cm? [2 marks]

(v) It is said that as much as 30 % of the inflow in furrow irrigation is lost as runoff. How would you minimize this loss of water? [2 marks]

QUESTION 7

a) An auger hole is bored in the soil to a depth of 190 cm below the water table. After the hole has been pumped out several times and allowed to refill, it is pumped out again and the rate of rise of the water at an elevation of 101.6 cm below the water table is observed to be 1.91 cm in one minute. The calculation based on the above data show that the hydraulic conductivity of the soil is 0.404 metres per day. Calculate the diameter of the auger hole that was used in situ.
[6 marks]

b) For the drainage of an irrigated area, drain pipes with a radius of 0.1 m will be used. They will be placed at a depth of 1.8 m below the soil surface. A relatively impermeable soil layer was found at a depth of 6.8 m below the soil surface. From auger hole tests, the hydraulic conductivity above this layer was estimated as 0.8 m/day. Irrigation is applied approximately every 20 days. The average irrigation losses, which recharge the already high water table, amount to 40 mm.

What drain spacing must be applied when an average water table depth of 1.20 m below the soil surface is to be maintained? [Use the table provided to find the equivalent depth].
[14 marks]

USEFUL INFORMATION

$$WP = \frac{QH}{6116}$$

$$h_L = FH_L + M_L$$

$$H_L = \frac{KC_1LQ^m}{D^{2m+n}}$$

$C_1 = 277778, 591722, 610042$

$m = 2.0, 1.85, 1.90$

$n = 1.0, 1.17, 1.10$

$K = (0.285C_2)^{-1.852}$

$$K = \frac{Ks}{348}$$

$$A = \frac{60Q}{LS}$$

$$BP = \frac{WP}{Ep}$$

$$VH = \frac{Q^2}{435.7D^4}$$

$$NPSHa = B_aP_r - VP_w - H_L - M_L - VH - SL - DD$$

$$B_aP_r = 10.33 - 1.17x10^{-3}h + 5.55x10^{-8}h^2$$

$$Hs = SL + DL + DD + H_L + M_L + Ho + VH$$

$$q_m = \frac{0.6}{s}$$

$$d = \frac{qx360xt}{WxL}$$

$$\frac{h_t}{h_o} = 1.16e^{-\alpha t}$$

$$\alpha = \frac{\pi^2Kd}{\mu L^2}$$

USEFUL INFORMATION

$$L^2 = \frac{4K_aH^2}{v} + \frac{8K_bd'H}{v}$$

$$Q = CA\sqrt{2gh}$$

$$v = \frac{R^{2/3}S^{1/2}}{n}$$

$$Q = 1859bh^{2/3}$$

$$P_d = P_u - 9.81(h_L \pm \Delta Z)$$

$$\frac{P_1}{\rho g} + Z_1 + \frac{V_1^{\,2}}{2g} + H_p = \frac{P_2}{\rho g} + Z_2 + \frac{V_2^{\,2}}{2g} + H_{L_{1-2}}$$

$$Cu = 100(1.0 - \frac{\Sigma x}{mn})$$

Temperature, °C	Vapour Pressure, kN/m^2
0	0.61
10	1.23
20	2.34
30	4.24
40	7.38

Aluminium Tubing with couplers each 6.1 m, Ks = 0.43

Aluminium Tubing with couplers each 12.2 m, Ks = 0.39

Aluminium Tubing without couplers, Ks = 0.33

END OF EXAMINATION

Table 1. Values for the equivalent depth d of Hooghoudt (r_o = 0.1 m, d and S in m)

S → / d	5 m	7.5	10	15	20	25	30	35	40	45	50
0.5 m	0.47	0.48	0.49	0.49	0.49	0.50	0.50				
0.75	0.60	0.65	0.69	0.71	0.73	0.74	0.75	0.75	0.75	0.76	0.76
1.00	0.67	0.75	0.80	0.86	0.89	0.91	0.93	0.94	0.96	0.96	0.96
1.25	0.70	0.82	0.89	1.00	1.05	1.09	1.12	1.13	1.14	1.14	1.15
1.50		0.88	0.97	1.11	1.19	1.25	1.28	1.31	1.34	1.35	1.36
1.75		0.91	1.02	1.20	1.30	1.39	1.45	1.49	1.52	1.55	1.57
2.00			1.08	1.28	1.41	1.5	1.57	1.62	1.66	1.70	1.72
2.25			1.13	1.34	1.50	1.69	1.69	1.76	1.81	1.84	1.86
2.50				1.38	1.57	1.69	1.79	1.87	1.94	1.99	2.02
2.75				1.42	1.63	1.76	1.88	1.98	2.05	2.12	2.18
3.00				1.45	1.67	1.83	1.97	2.08	2.16	2.23	2.29
3.25				1.48	1.71	1.88	2.04	2.16	2.26	2.35	2.42
3.50				1.50	1.75	1.93	2.11	2.24	2.35	2.45	2.54
3.75				1.52	1.78	1.97	2.17	2.31	2.44	2.54	2.64
4.00					1.81	2.02	2.22	2.37	2.51	2.62	2.71
4.50					1.85	2.08	2.31	2.50	2.63	2.76	2.87
5.00					1.88	2.15	2.38	2.58	2.75	2.89	3.02
5.50						2.20	2.43	2.65	2.84	3.00	3.15
6.00							2.48	2.70	2.92	3.09	3.26
7.00							2.54	2.81	3.03	3.24	3.43
8.00							2.57	2.85	3.13	3.35	3.56
9.00								2.89	3.18	3.43	3.66
10.00									3.23	3.48	3.74
∞	0.71	0.93	1.14	1.53	1.89	2.24	2.58	2.91	3.24	3.56	3.88

Table 1. (cont.)

S → / d	50	75	80	85	90	100	150	200	250
0.5	0.50								
1	0.96	0.97	0.97	0.97	0.98	0.98	0.99	0.99	0.99
2	1.72	1.80	1.82	1.82	1.83	1.85	1.00	1.92	1.94
3	2.29	2.49	2.52	2.54	2.56	2.60	2.72	2.70	2.83
4	2.71	3.04	3.08	3.12	3.16	3.24	3.46	3.58	3.66
5	3.02	3.49	3.55	3.61	3.67	3.78	4.12	4.31	4.43
6	3.23	3.85	3.93	4.00	4.08	4.23	4.70	4.97	5.15
7	3.43	4.14	4.23	4.33	4.42	4.62	5.22	5.57	5.81
8	3.56	4.38	4.49	4.61	4.72	4.95	5.68	6.13	6.43
9	3.66	4.57	4.70	4.82	4.95	5.23	6.00	6.63	7.00
10	3.74	4.74	4.89	5.04	5.18	5.47	6.45	7.09	7.53
12.5		5.02	5.20	5.38	5.56	5.92	7.20	8.06	8.68
15		5.20	5.40	5.60	5.80	6.25	7.77	8.84	9.64
17.5		5.30	5.58	5.76	5.99	6.44	8.20	9.47	10.4
20			5.62	5.87	6.12	6.60	8.54	9.97	11.1
25			5.74	5.96	6.20	6.79	8.99	10.7	12.1
30							9.27	11.3	12.9
35							9.44	11.6	13.4
40								11.8	13.8
45								12.0	13.8
50								12.1	14.3
60									14.6
∞	3.88	5.38	5.76	6.00	6.26	6.82	9.55	12.2	14.7

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
ELECTRICAL AND ELECTRONICS DEPARTMENT

SEMESTER 2 FINAL EXAMINATIONS-16TH JAN, 2004

EE209-PRINCIPLES OF ELECTRICAL ENGINEERING I

ANSWER: **FIVE (5) QUESTIONS** All questions carry equal marks

Q1

(a) Determine E_{THEV} and Z_{THEV} to the left of T1T2 in FIG1 and determine the current in the 3-ohm resistor. [12 marks]

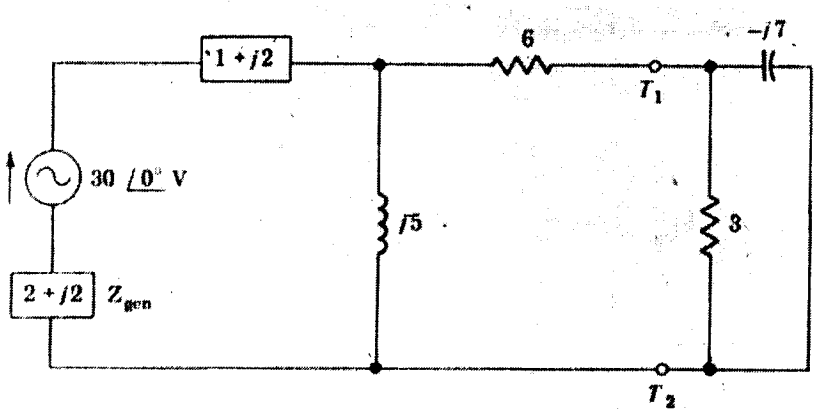


FIG 1

(b) For the same circuit replace the thevenin equivalent with the Norton equivalent and hence determine the current in the resistor. [8 marks]

Q2

(a) Differentiate between apparent power, active power and reactive power. [5 marks]

(b) A 30-ohm resistor, a 60 μF capacitor and a coil whose inductance and resistance are 40 mH and 6-ohms respectively are connected in parallel and supplied by a 240-V 50-Hz supply. Sketch the circuit and determine: [15 marks]

(i) The current to each branch.
(ii) The feeder current.
(iii) The system active power.
(iv) The system apparent power.
(v) The system power factor and power angle

Q3

(a) Define capacitance. [2 marks]

(b) A 24-V battery is connected in series with a 150-μF capacitor, a 1kΩ resistor, and a switch. Sketch the circuit and determine:

(i) i_c and v_c at t = (0+). [4 marks]
(ii) The steady state current. [2 marks]
(iii) The current at t = 1τ. [2 marks]
(iv) The IR drop at t = 1τ. [2 marks]
(v) The voltage across the capacitor and the voltage across the resistor at steady state. [4 marks]
(vi) The accumulated energy at steady state. [2 marks]
(vii) The accumulated charge at steady state. [2 marks]

Q4

(a) State Kirchoff's voltage and current laws [2 marks]

(b) Determine the slide setting required on a 4000-ohm rheostat in order to get 9-v output from a 12-v battery. Sketch the circuit. [6 marks]

(c) (i) Using the ~~voltage~~ current divider equation determine the current in the 6200-ohm resistor in FIG2. [12 marks]

(ii) Determine the voltage drop across the parallel section.
(iii) Determine the current drawn by the 564-ohm resistor.
(iv) The power drawn by the 6200-ohm resistor

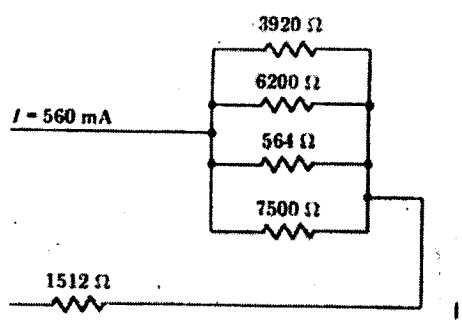


FIG 2

Q5

(a) Explain the significance of quality factor of a coil [3 marks]

(b) Determine the Q of a 200-turn coil operating at 2000-Hz, whose resistance and inductance are 10-ohm and 0.040-H respectively. [5 marks]

(c) A series resonance circuit has a resistance of 1000-ohms and a cut-off frequencies of 20000 Hz and 1000-Hz. Determine: [12 marks]

(i) The bandwidth.

(ii) The resonant frequency.

(iii) The quality factor at the resonant frequency.

(iv) The inductance

(v) The capacitance.

Q6

An 8-H, 4-Ohm coil is connected in series with a 2-ohm resistor, a 6-V battery, and a switch. Sketch the circuit and determine:

(a) The initial current when the switch is closed. [2 marks]

(b) The final current. [2 marks]

(c) The voltage drop across the coil at t = (0+). [3 marks]

(d) The current in the 2-ohm resistor at t = one time constant. [4 marks]

(e) The voltage across the 2-ohm resistor at t = one time constant. [4 marks]

(f) If the 2-ohm resistor is to be replaced by another that would cause the time constant of the circuit to be 1/3s, determine the resistance value of the new resistor. [5 marks]

Q7

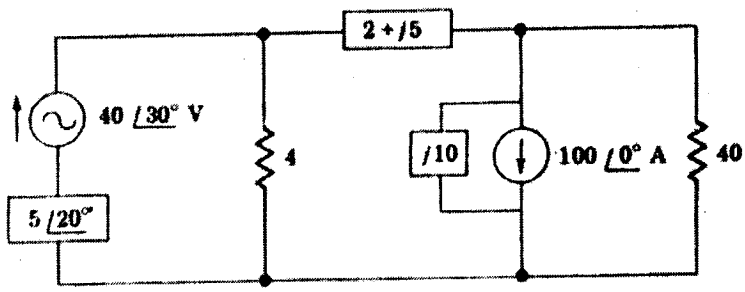


FIG 3

(a) Convert the voltage source in FIG3 to current source. [4 marks]

(b) Write the node equations. [9 marks]

(c) Solve for the voltage across the (2+j5)-ohm impedance and determine the current through it. [7 marks]

Q8

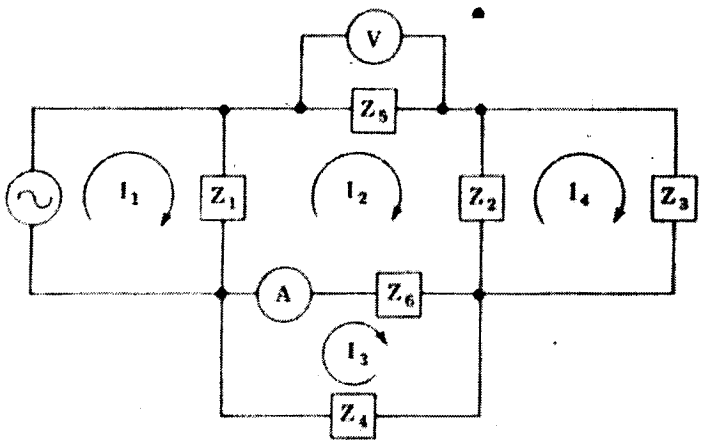


FIG 4

The loop currents and two impendances for the 60-Hz network shown in FIG4 are:

$I_1 = 20/60^0$ A
$I_2 = 50/30^0$ A
$I_3 = 10/21^0$ A
$I_4 = 70/100^o$ A
$Z_5 = 6.0/25^o$ Ω
$Z_6 = 15/40^o$ Ω

Determine:

(a) The ammeter reading. [5 marks]
(b) The voltmeter reading [5 marks]
(c) Active, reactive and apparent power drawn by Z_5 [5 marks]
(d) Series connected parameters that make up Z_5 (henrys, farads, ohms). [5 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

FINAL EXAMINATIONS – JANUARY 2004

EE 342 – ELECTRONICS ENGINEERING I

TIME: **THREE HOURS**
ANSWER: **FIVE QUESTIONS**

Boltzmann's constant	$k=1.38\times10^{-23}$ J/K
Electronic charge	$q=1.6\times10^{-19}$ C
Ambient Temperature	T=300 K

Q1 (a) Describe and discuss in details transportation of holes and electrons across a pnp bipolar junction transistor biased to operate in an active region using Elbers – Moll Model.

(b) Explain in details as to what is understood by terms such as avalanche multiplication and zener breakdown in semiconductors.

(c) Discuss the following terms as they relate to semiconductors:

(i) pn junction capacitance,
(ii) potential hill and
(iii) energy gap

Q2 (a) Draw Ebers-Moll Model for a pnp bipolar junction transistor and label clearly the directions of:

(i) current dependent generator, $\alpha_F I_E$

(ii) current dependent generator, $\alpha_R I_C$

(iii) diode current $I_{EO}\left(e^{\frac{qV_{BE}}{kT}}-1\right)$ and

(iv) diode current $I_{CO}\left(e^{\frac{qV_{BC}}{kT}}-1\right)$

(b) Derive two equations for the emitter terminal current, I_E, and collector terminal current, I_C, in terms of base emitter and base collector junction voltages using Elbers-Moll Model for a pnp bipolar junction transistor.

(c) (i) Solve, using Ebers-Moll equations for pnp bipolar junction transistor, explicitly for emitter terminal current, I_E, and collector terminal current, I_C, in terms of pn junction voltages V_{BE} and V_{BC}

(ii) with the help of Ebers-Moll equations, solve explicitly for the base-emitter junction voltage, V_{BE}, and base-collector junction voltage, V_{BC}.

Q3 (a) (i) Draw a bipolar junction transistor equivalent circuit which gives a fairly good visualization of the performance of the transistor at high frequency.

(ii) Explain the meaning of the following symbols and what they stand for: r_b, r_π, c_π, c_μ, r_μ, v, and $g_m v$

(iii) Explain the feedback between output and input of a transistor. Which of the symbols in (ii) is involved in the feedback between output and input.

(b) Draw a hybrid-π high frequency model equivalent circuit and show equations for:

(i) base current i_b
(ii) collector current i_c, and
(iii) voltage, v, across r_π.

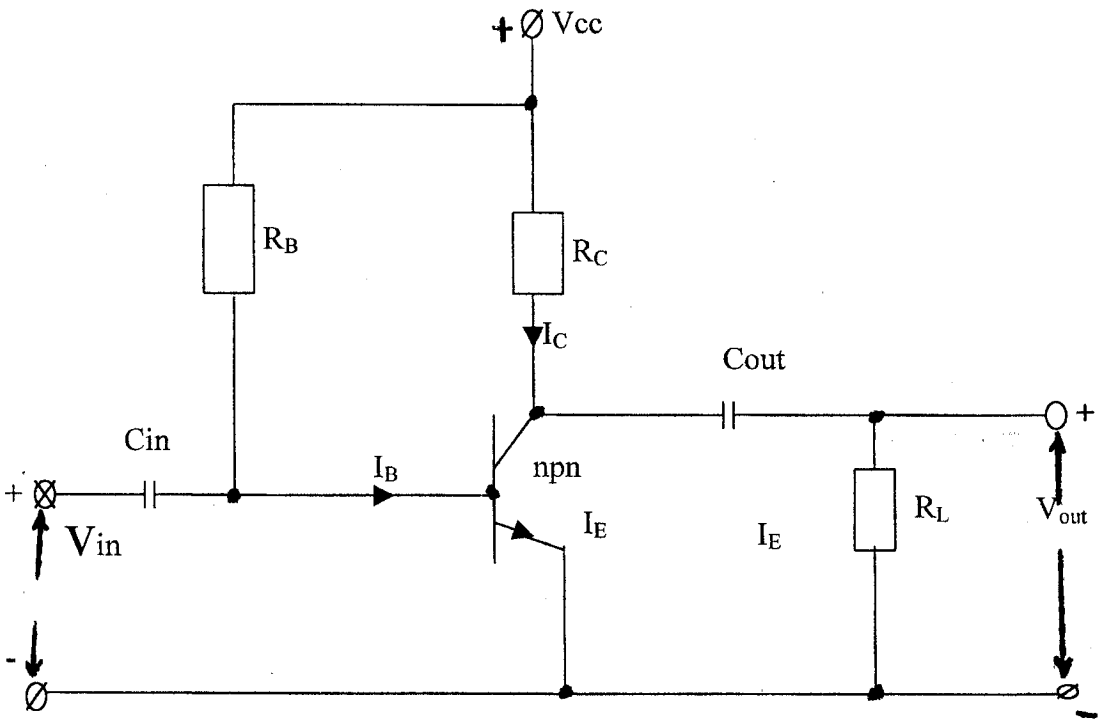
(c) Show the approximate relationship between h and hybrid – π parameters for a common emitter bipolar junction transistor configuration.

Q4. It is a well known fact in electronics that a bipolar junction transistor of any configuration cannot work properly unless it (transistor) is biased and given a working or quiescent point in the active region. The biasing of the transistor gives a dc-load line in turn.

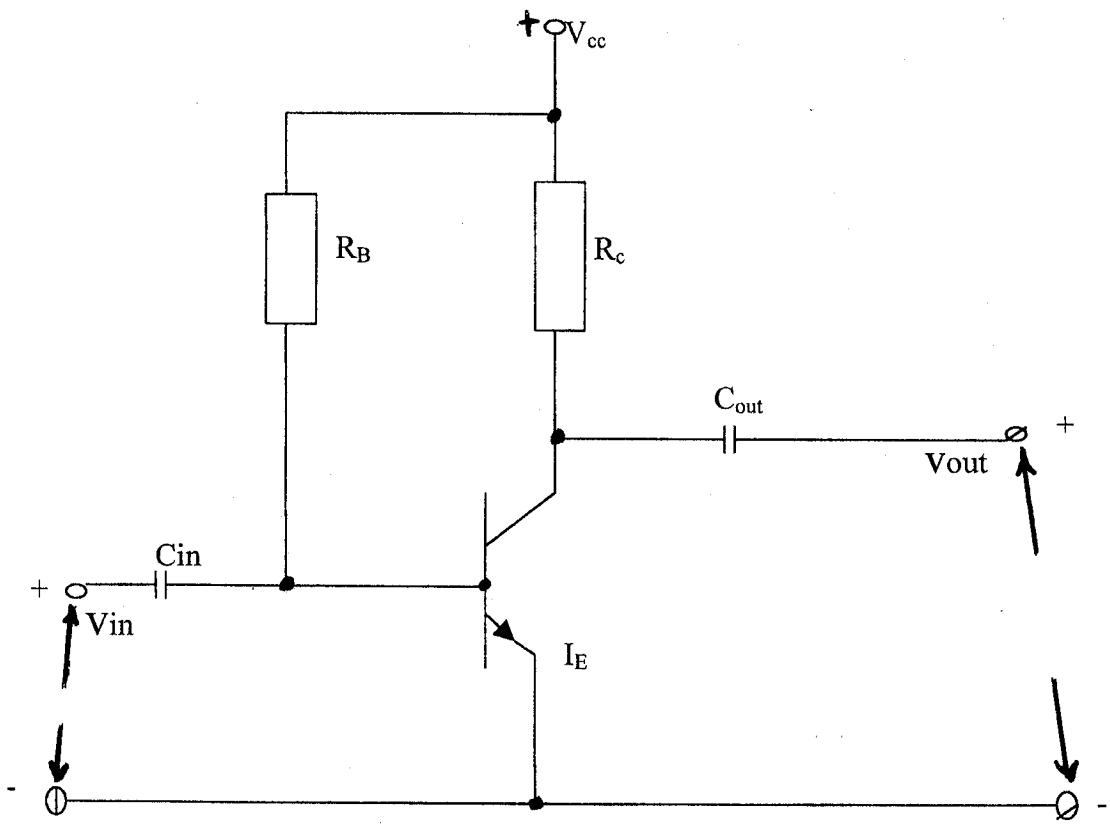
(a) Explain in details the biasing of the transistor shown below.

(b) Discuss and explain how the dc load line, using perhaps Kirchoffs' Law, is drawn.

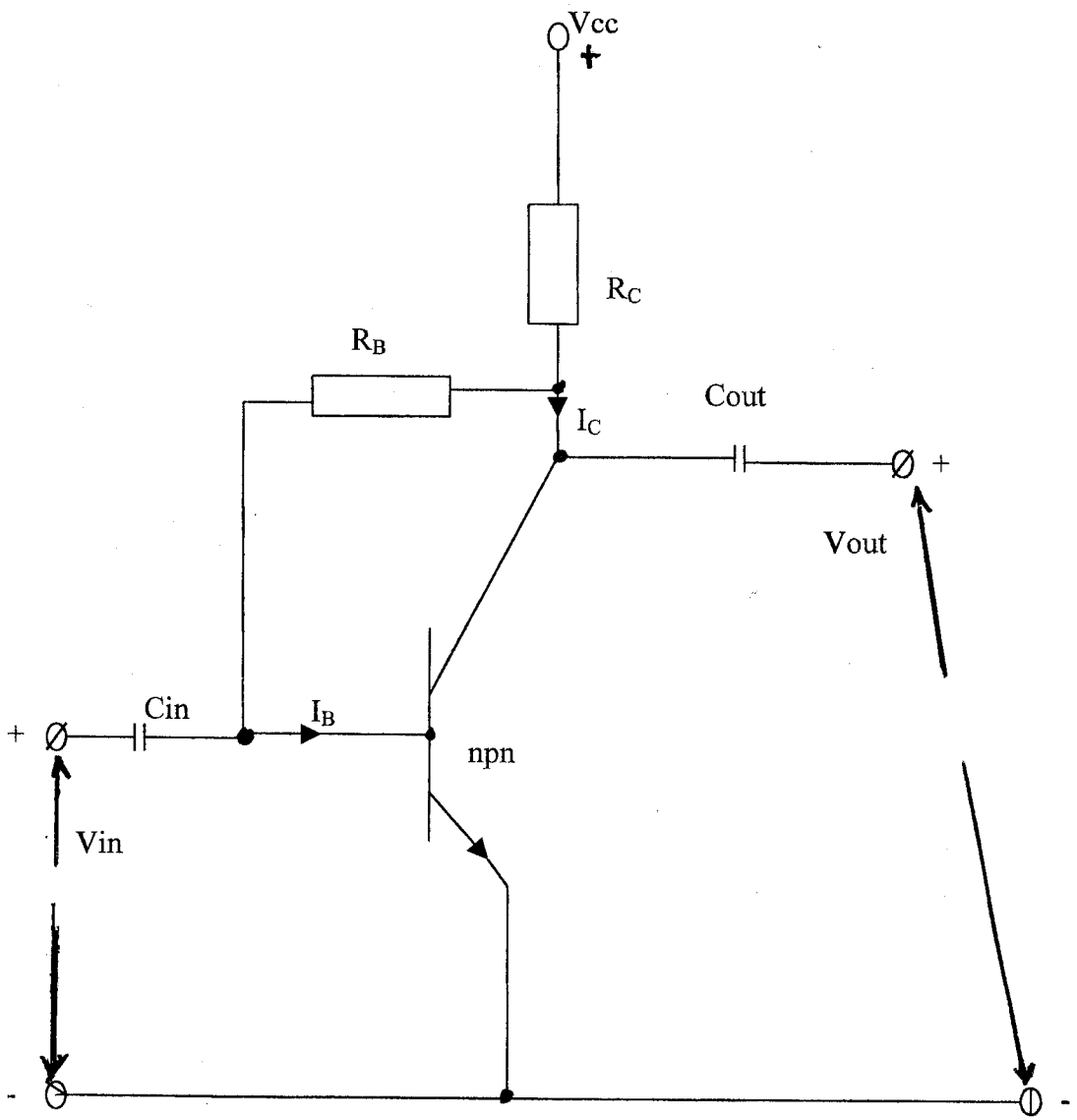
(c) The working point of a transistor must be placed in the middle of the dc loadline. However, we do not have to choose a bias circuit which stabilizes the working point only but it must also prevent thermal runaway which leads to destruction of the transistor. Explain and discuss what is understood by thermal runaway and how biasing of a transistor is done to prevent it.



Q5. (a) Explain why the circuit shown below needs a supply voltage, Vcc, two resistors R_B and R_C and two capacitors, one at the input and another at the output.

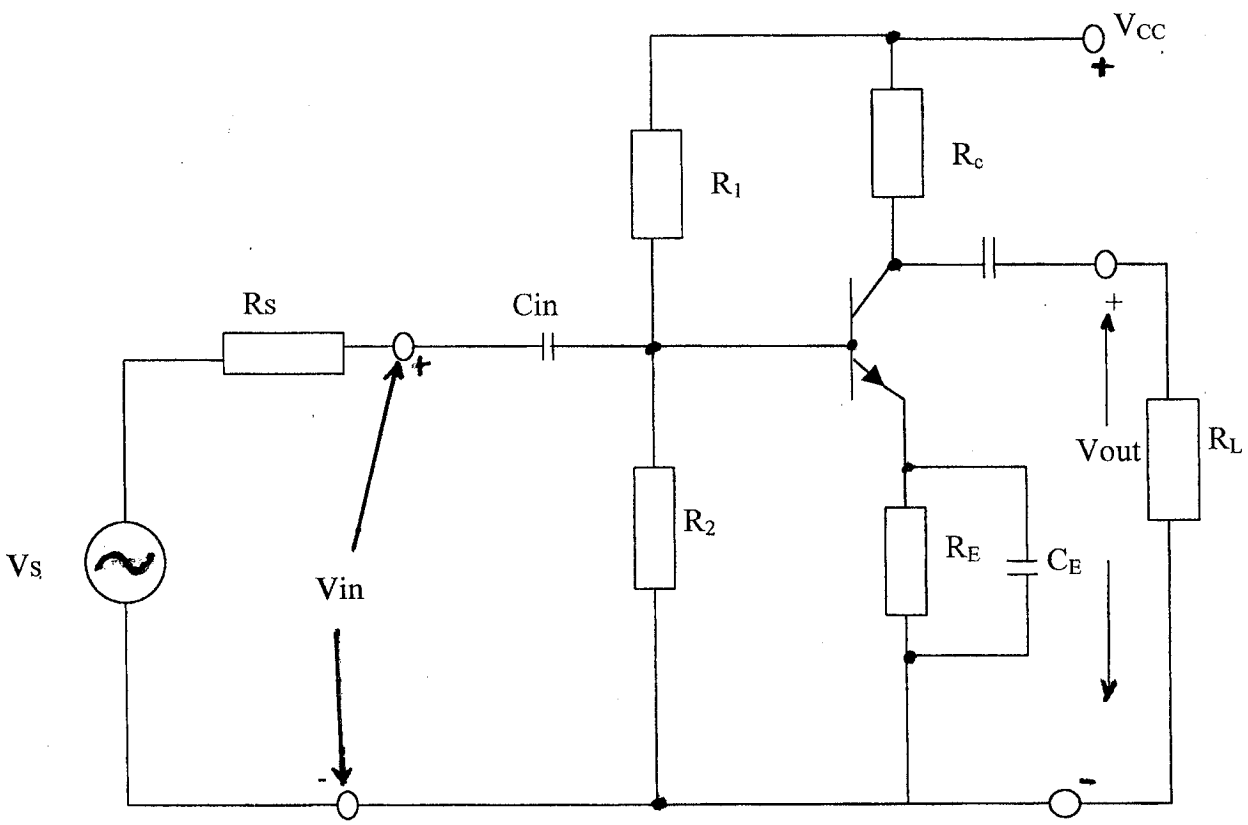


(b) The circuit shown below is said to give thermal stability because if the collector current tends to increase, the base current falls tending to bring the collector current back to its original value. Explain and discuss in details how this comes about.



(c) The circuit shown below is the most used one. The necessary steady voltage at the base is provided by a potential divider network consisting of resistors R_1 and R_2. A resistor R_E connected in the emitter lead biases the transistor and is therefore ac short-circuited by a capacitance, C_E. Compute the expressions for:-

(i) Current passing across resistor R_1 if base current, I_B, is negligible,
(ii) Collector current, I_C, using Kirchoff's Voltage Law ('KVL') and
(iii) The voltage, V_{CE}, between the collector and emitter terminals.



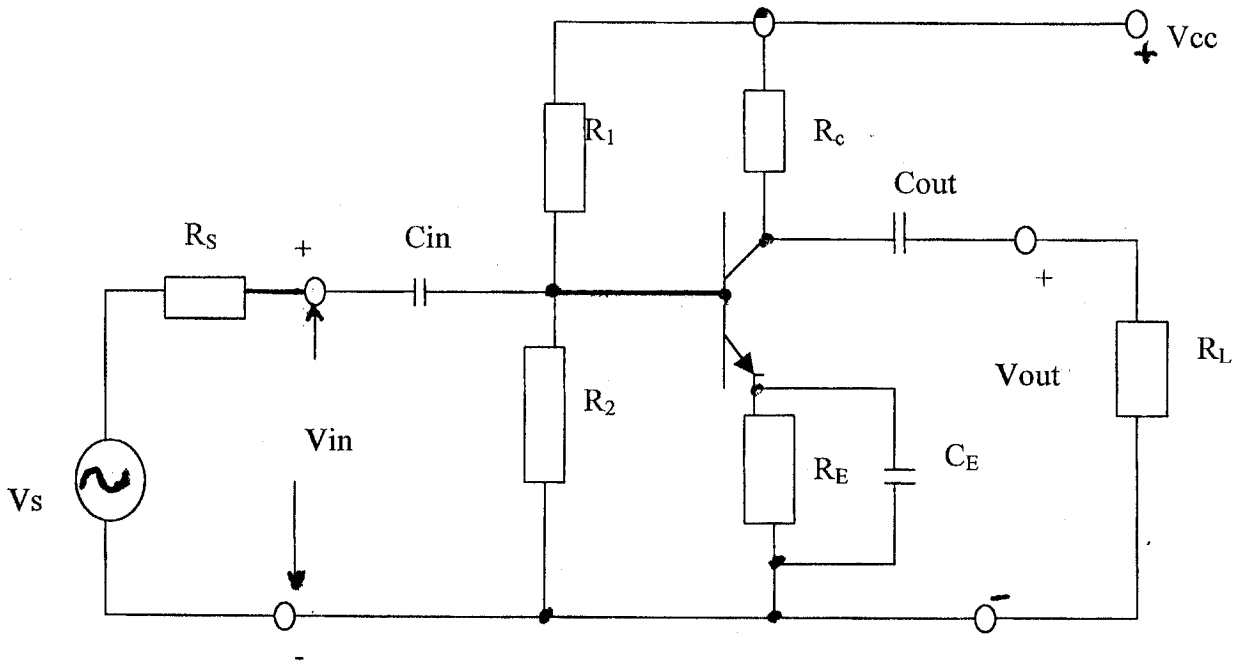
Q6. In electronics we are told the following rules should be applied when creating the equivalent incremental circuit.

(i) Internal resistance in power supply (Vcc) is zero.
(ii) Power supply Vcc is ground
(iii) By pass and coupling capacitors are ac short circuited
(iv) Transistor capacitors are ac open circuited.

(a) Draw the equivalent incremental circuit of the circuit shown below.

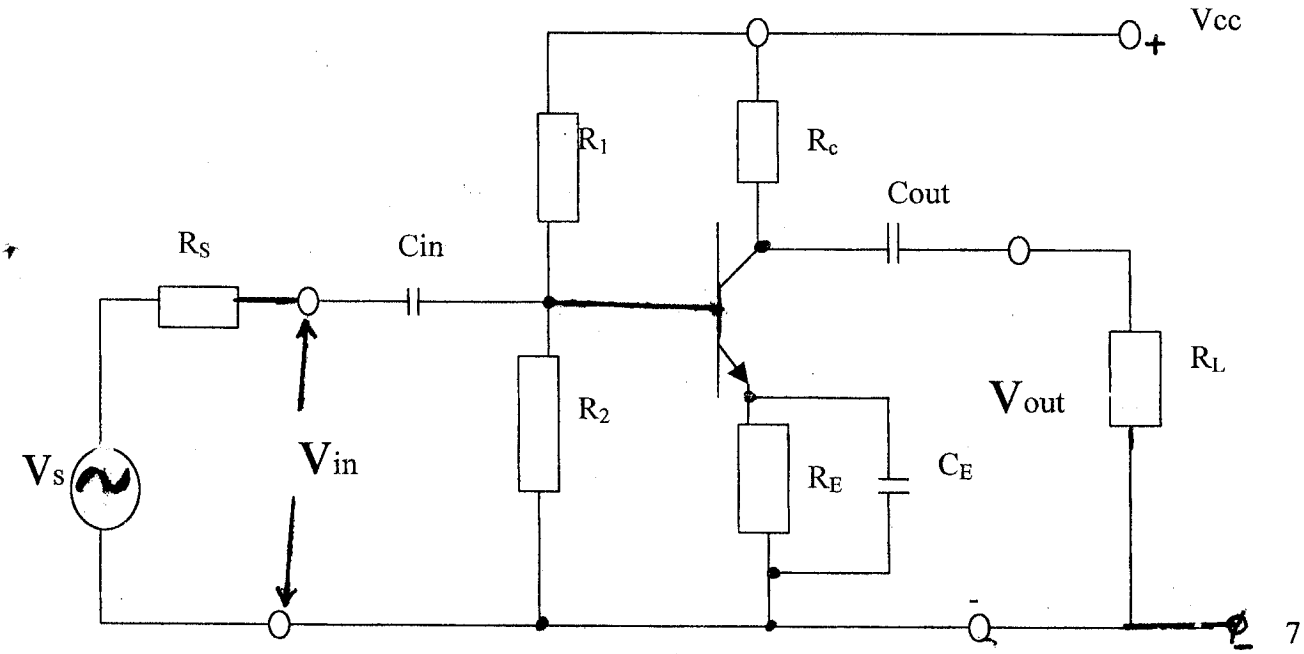
(b) Derive an expression for the voltage gain, A_v, of the circuit shown below

(c) Derive an expression for the current gain, A_i, of the circuit shown below



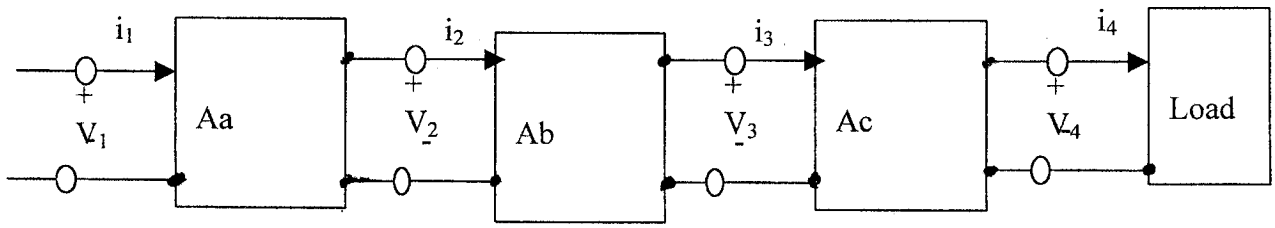
Q7. Derive an expression for the output resistance of the circuit shown below. To achieve this you have to take the following into consideration:

(a) create an equivalent incremental circuit by:
(i) considering that the supply voltage is zero or short circuited,
(ii) internal resistance in the supply voltage is zero,
(iii) bypass and coupling capacitors are ac short circuited,
(iv) transistor capacitors are ac open circuited,
(v) apply a current source, i_1 having a voltage V_i over itself in place of the load, R_L,
(vi) let the current go into the circuit and
(vii) short circuit the signal voltage source, vs

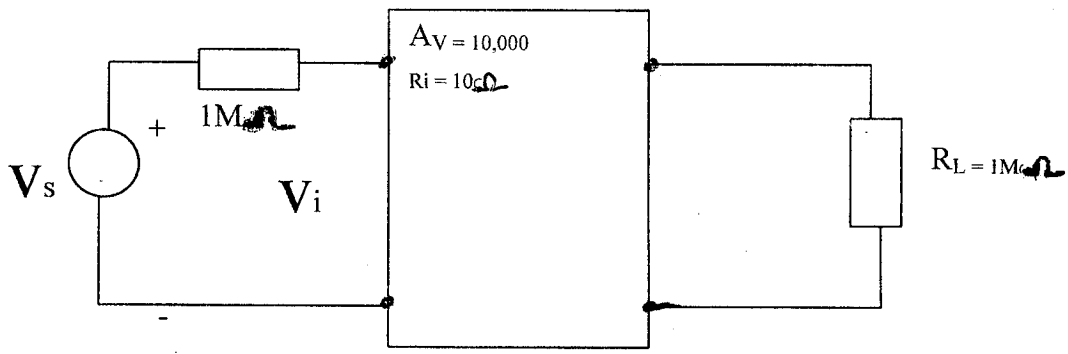


Q8 To achieve a desired voltage or current gain and frequency response, several stages of amplification may be required. When the stages are connected in cascade, the output of one stage is connected to the input of the next.

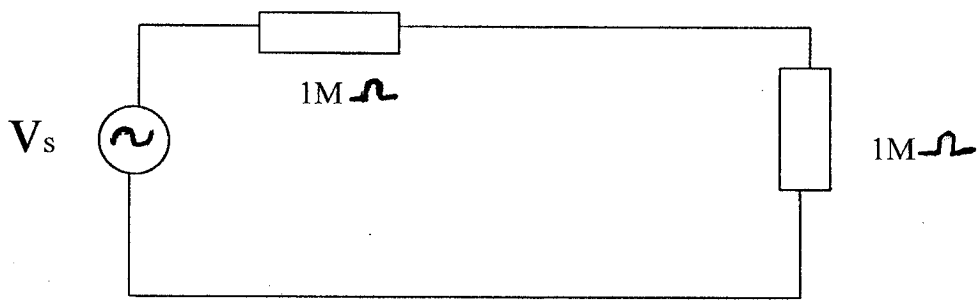
(a) Calculate the overall voltage gain of the amplifiers connected in cascade shown below.



(b) Calculate the power gain of the circuit shown below



(c) Calculate the power gain of the circuit shown below



(d) Compare the power gain of the circuit in (c) with the power circuit shown in (b) and draw a conclusion as to the role the amplifier plays in power gains.

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
SECOND SEMESTER EXAMINATIONS 2003-JANUARY 2004

EE 392 ELECTRICAL ENGINEERING PRACTICE

TIME: THREE HOURS

SECTIONS A AND B-ELECTRICAL ENGINEERING COMPONENTS
SECTION C-MECHANICAL ENGINEERING COMPONENT
ATTEMPT ANY TWO QUESTIONS FROM EACH SECTION.USE SEPARATE ANSWER BOOKLET FOR SECTION C
TWENTY MARKS PER QUESTION
THE RELEVANT FIGURES (DIAGRAMS) COME AFTER SECTION C

SECTION A-ELECTRICAL DESIGN AND DRAWING

1. A 3-phase Induction Motor drives a Centrifugal Pump.The pump, delivers water to a pump box (tank). A level control, using a rod operated float switch, is installed in the pump box with a high level setting (MS1) to stop the motor.The low level setting starts the motor .The float moves.up with the rising level of water.The panel is to be situated near the pump motor installation. 'Start'and'Stop'push buttons are to be installed on the panel. A green light to indicate 'Motor Run' condition is to be mounted on the panel.

   The other components are as follows:-

   I. A 3-pole Main Motor Contactor C with two pairs of Auxiliary contacts mounted on the block. The coil operates on single phase 220 VAC.
   II. A 3-pole thermal overload relay operating a microswitch MS3
   III A 3-pole combined fuse switch.

   a) Sketch the Motor Control Circuit showing:

   i) the power circuit as a single line diagram
   ii) all the control devices in the control circuit.

   (16 Marks)

   b) The name plate ratings of an Induction Motor are 4-pole, 3.3 kV, 50 Hz, 3-Phase 150 kW, full load efficiency of 90 % at a power factor of 0.88.. If the motor is to be connected to a 3.3 kV, 3-Phase, 50 Hz Supply, calculate the current transformer ratio to operate a 5 A Ammeter.

   (4 Marks)

2.

a) Sketch a block diagram for a split mode regulated power supply with AC mains input to give ± 15 VDC output . ***(5 Mark)***

b) The following components are available to build the above power supply unit.

i) A 240V/32V, 50 VA, centre-tapped transformer.
Note the secondary voltage rating is line-to-line.

ii) An SPST switch, 0.5A

iii) A 500 mA fuse

iv) Four Diodes PIV 100 V, 1A.

v) Two filter capacitors 10,000 μF, 40V

vi) Two voltage regulators ± 1.2 V, 1A.

vii) Two resistors, 220 Ω, 125 mW.

viii) Two resistors, R_v, to be calculated.

Design and sketch a circuit diagram showing how the above components may be connected to realise the split mode regulated power supply of part (a).

(10 Marks)

c) For part (b) above:

i) Calculate the value of the Resistor, $R_{v,}$ to give the required output voltages of ± 15 VDC. Assume the I_{ADJ} of the voltage regulators to be about 50 μA. If the minimum wattage for the Resistor is 125 mW, specify the power rating of $R_{v.}$ The 220 Ω Resistor is connected across the output and Adj terminals of the voltage regulator.

ii) For the specifications given, calculate the maximum voltage across the filter capacitor. For this designed output voltage of ± 15 V. What is maximum power dissipation of the voltage regulators.

(5 Marks)

3.

a) Figure Q3 shows the Schematic Diagram for the Diesel Electric Traction System used on the Haul and Dump Trucks at Nchanga Open Pits, Chingola.These trucks are also referred to as the Rubber Tyred Vehicles (RTV). For the following sketches, show only the components, which play a part in the respective modes of operation. The closed contactors may be represented as conductor. For the input power supply to the motor circuits show only the GA1 and GA2 busbars.

(a) Sketch the circuit diagram for the following modes of operation;

(I) Forward propulsion ***(5 Marks)***

(II) Reverse propulsion ***(5 Marks)***

(III) Dynamic braking ***(5 Marks)***

(b) What is dynamic braking? Explain with the aid of a block diagram the energy flow during dynamic braking. ***(5 Marks)***

SECTION B-ELECRICAL MEASUREMENTS AND FAULT FINDING

4. a) Explain the loading effect of a Voltmeter.
Two Voltmeters having sensitivities of 2000 Ω/V and 20 000 Ω/V respectively are used to measure the Voltage across terminals 1 and 2 of Fig. Q4 A. If $R_1 = 20\ k\Omega$ and $R_2 = 10\ K\Omega$. Calculate the respective errors in the measurements of V_{12}. What do you deduce from these results? ***(5 Marks)***

b) Briefly explain the operating principle of Bridge circuit of Fig.Q4 B. Determine the expression for measuring the resistance R.

$P = 750\ \Omega$ $Q = 250\ \Omega$

The tolerances of resistors P and Q are each 0.02%. S is a decade box with steps 100 Ω to 0.1 Ω. If S is set to 147.3 Ω at balance, determine:-

i) the unknown resistance
ii) the percentage error that exists in the calculated value of i).
(10 Marks)

c) Briefly explain how the circuit of Fig. Q4C may be used as an ohmeter. Deduce an expression for determining R_X.
(5 Marks)

5 Figure Q5 shows a circuit diagram for a Regulated Power Supply.used in the. Fault Finding Experiment.

(a) Show that the output voltage will vary as follows:
$V_R((R8+P+R7)/R7) \geq E_O \geq V_R(R8+P+R7)/(R7+P)$
Where V_R is the voltage at test point 13 ***(8 Marks)***

(b) The Power Supply unit is now loaded to 0.7 A.The voltage at test point 4 significantly drops to about 0.4 A, while the a.c.voltages are as expected. What could be the fault? ***(3 Marks)***

(c) The Thyristor (Thy) requires a gate voltage of 0.6 V to turn-on and conduct anode to cathode current. What does the turn-on action do to the regulator function? ***(3 Marks)***

(d) Calculate the corresponding load current for this condition. ***(1 Mark)***

(e) Explain the resetting action of switch SW2. ***(3 Marks)***

(f) If the voltage between test points 11 and 13 is zero. What could be the fault? ***(2 Marks)***

6.

a) Fig Q6 shows an Ammeter circuit using a D"Arsonal meter movement with an fsd of 100μA and R_m of 2700 Ω. Calculate values R_1 to R_4 ***(6 Marks)***

b) State three types of error, which may contribute to the total or overall measurement error. Give two examples of one of these error types. ***(4 Marks)***

c) The determination of an electrical quantity may, in general, be represented mathematically by the following expression;

Show that the maximum possible error occurs when; ***(5 Marks)***

$$\frac{\partial X}{X} = \pm \frac{(\partial A + \partial B + \partial C + \partial D + \partial E)}{X}$$

A resistance box has the following components and tolerances;

100 kΩ	± 0.05 %
10 kΩ	± 0.05 %
1 kΩ	± 0.05 %
100 Ω	± 0.1 %
10 Ω	± 0.5 %

Determine in ohms the error limit in a setting of 372.54 kΩ ***(5 Marks)***

SECTION C-MECHANICAL ENGINEERING COMPONENT

Question 7

You are designing the suspension for a new pick up. The net weight of the pick up is 900kg, distributed 35% on the rear axle and 65% on the front axle. When fully loaded an additional 1000kg is added to the pickup, distributed 70% on the rear axle and 30% on the front axle. You are using, on the front axle 2 identical helical close coiled springs in parallel, and on the rear axle 2 identical leaf springs in parallel. Your design constraint is, completely unloaded to fully loaded, the maximum static deflection on either axle should not exceed 8 cm. given for:

Helical spring:

Mean coiled diameter	=	15cm
Modulus of rigidity	=	82.5 GN/m^2
Wire diameter	=	20mm

Leaf spring:

Length	=	60cm
Number of leaves	=	3
Width to thickness ratio	=	12:1
Elastic modulus	=	120 GN/m^2

Find:

(a) the number of coils required in the helical springs ***(5 marks)***

(b) the width of the leaf springs ***(5 marks)***

(c) the deflection at both axles when acted upon the net weight of the pickup only. ***(4 marks)***

(d) If the distance between the rear and front axle is 2.4m what is the magnitude and direction of the shift in the centre gravity of the pickup when loaded with the additional 1000kg. ***(6 marks)***

Question 8

A solid 1m shaft of radius 30 mm and density 6 g/cm^3 carries 4 unbalanced masses spaced as follows:

Masses A, B, C, and D are 7, 8, 9, and 12kg respectively, rotating at radii 11, 9, 10, 12cm respectively, and spaced from one end of the shaft at 25, 40, 55, and 75 cm respectively. the angular spacing from A to B, C, and D are 70, 170, and 300° respectively.

(a) Balance the shaft using two 10 kg masses at either end ***(9 marks)***

(b) If before balancing, the shaft rotated at 300 rpm what will be its rotation after balancing. ***(5 marks)***

(c) If all masses are removed from the shaft and the power transmitted is 10 kW, determine the maximum shear stress on the shaft. ***(6 marks)***

Note: Uniform disc or cylinder, radius r. I about the central axis is $\frac{mr^2}{2}$ and

$k = \frac{r}{\sqrt{2}}$

Question 9

You are designing the spring damper system for a 850 kg motor rally vehicle. The test road is sinusodially undulated with a maximum displacement of 30cm. If the maximum allowable displacement of the vehicle relative to the road is 36cm, determine:

(a) the damping ratio and state whether it is over, critically or under damped ***(5 marks)***

If the length of one undulation is 4m, and the damping coefficient is 8000kg/s, determine:

(b) the stiffness of the suspension ***(4 marks)***

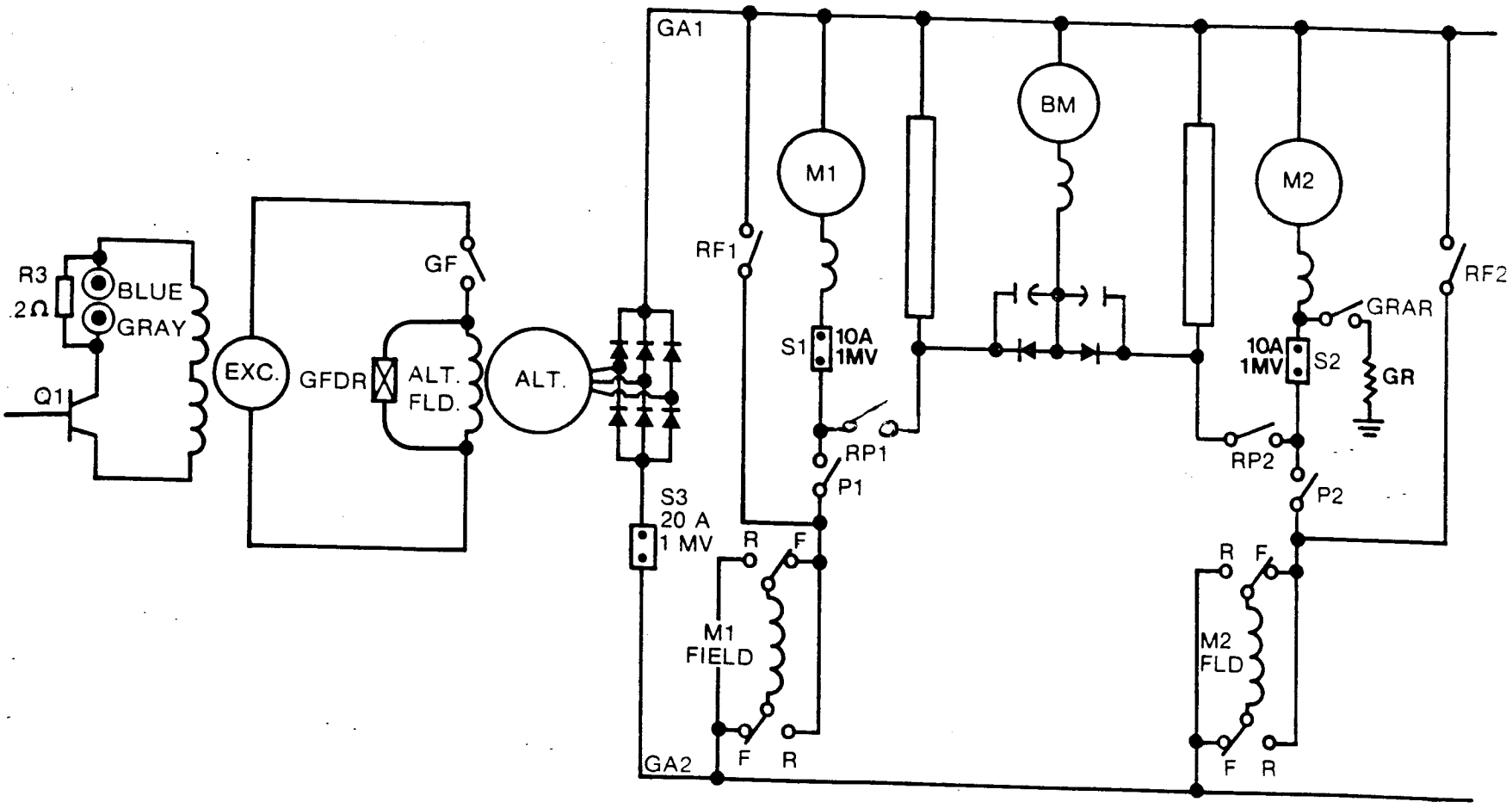
(c) the speed in km/h of the vehicle at maximum displacement ***(5 marks)***

(d) the maximum displacement of the vehicle if the and the vehicle is moving a 170km/h ***(6 marks)***

THE RELEVANT DIAGRAMS FIG Q3,FIG 4A,B & C,FIG 5 & 6 ARE ATTACHED

END OF EE392 EXAMINATION

FIG.Q3 ROTATING CIRCUITRY



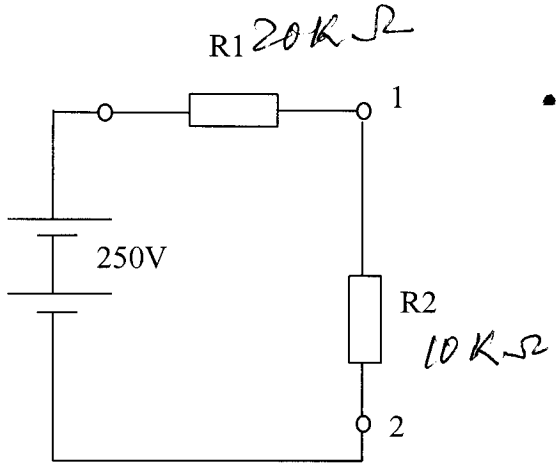


Fig Q 4 A

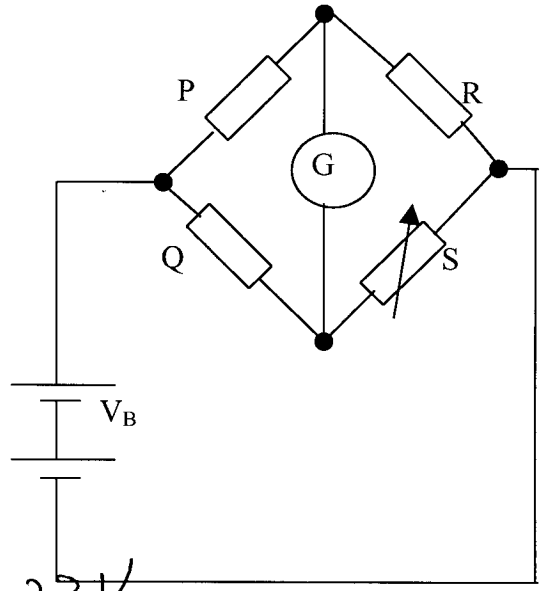


Fig Q 4 B

$V_{12} = \frac{10 \times 250}{30} = 83.33V$

50V Scale ?

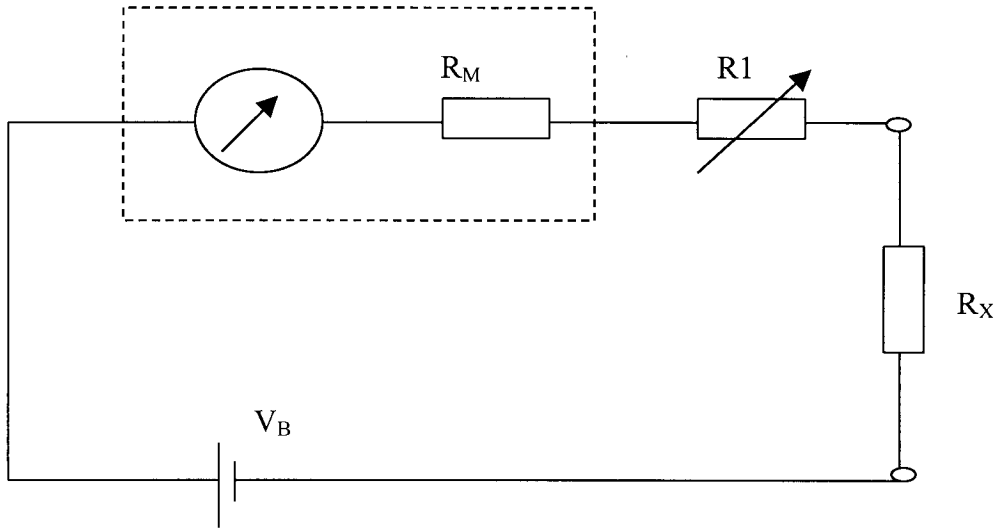


Fig Q 4 C

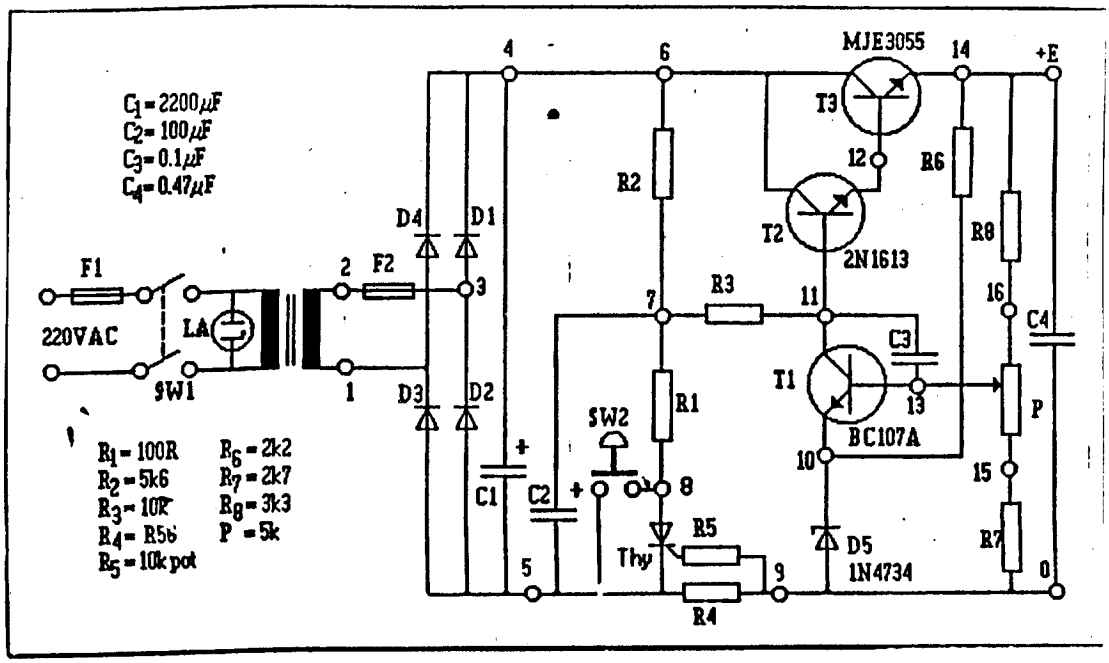


Fig.Q5 Regulated Power Supply

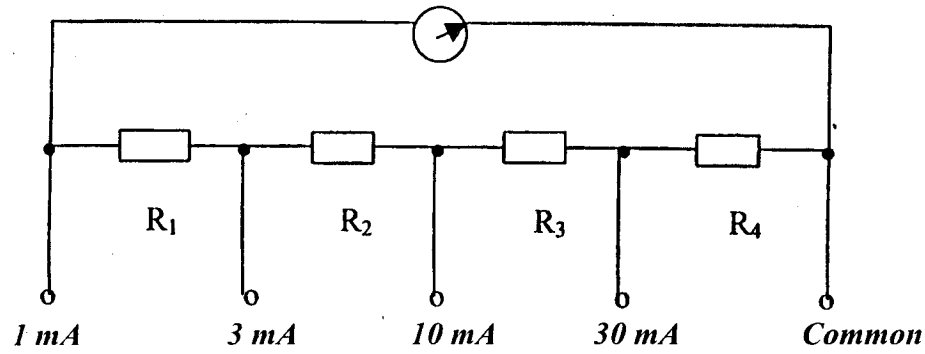


Fig. Q6.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS 2002/2003

SEMESTER II, JANUARY 2004

EE 422 : ELECTRICAL MACHINES I

ANSWER : *Any FIVE (5) Questions*

TIME : *Three (3) hours*

QUESTION 1

a) Beginning with application of Faraday's Law of Electromagnetic Induction, derive the expression for induced r.m.s voltage in a transformer winding having N turns, sinusoidal excitation and supply frequency f. ***(7 marks)***

b) i) Sketch the equivalent circuit, on a per phase basis, of a three phase transformer stating clearly what each element represents. ***(7 marks)***

ii) Draw the voltage/current phasor diagrams for the primary and secondary of the transformer in b(i). ***(6 marks)***

QUESTION 2

a) Describe, with aid of sketches, the short circuit and open circuit tests in a transformer. ***(10 marks)***

b) A 200-kVA single-phase transformer with a voltage ratio 6350/660 has the following winding resistances and reactances:

$R_1 = 1.56\Omega$, $R_2 = 0.016\Omega$
$X_1 = 4.67\Omega$ $X_2 = 0.048\Omega$

On no-load the transformer takes a current of 0.96A at a power factor of 0.263 lagging. Calculate the equivalent circuit parameters referred to the high voltage winding. ***(10 marks)***

QUESTION 3

a) i) What is meant by the term "armature reaction" in a d.c. machine? ***(4 marks)***

ii) Compare and contrast armature reaction in d.c. machine and in a synchronous machine. ***(4 marks)***

b) i) Show that e.m.f. generated in the armature winding of a d.c. machine is given by:

$$E = 2 \cdot Z/c \cdot pN_r/60 \cdot \phi$$ ***(8 marks)***

ii) A four-pole wave-connected armature of a d.c. machine has 51 slots with 12 conductors per slot and is driven at 900 r/min. If the useful flux per pole is 25mWb, calculate the value of the generated e.m.f. ***(4 marks)***

QUESTION 4

a) An eight-pole lap-connected armature of a d.c. machine, driven at 350 r/min, is required to generate 260V. The useful flux per pole is about 0.05Wb. If the armature has 120 slots, calculate a suitable number of conductors per slot. ***(10 marks)***

b) Describe, with the aid of sketches, the power split in:

i) d.c. generator ***(5 marks)***
ii) d.c. motor ***(5 marks)***

QUESTION 5

a) i) Starting with the expression

$$E = 2 \cdot Z/c \cdot pN_r/60 \cdot \phi$$

Show that the speed of a d.c. motor is approximately proportional to the voltage applied to the armature and inversely proportional to the flux. ***(8 marks)***

ii) A d.c. motor runs at 900 r/min off a 460-V supply. Calculate the approximate speed when the machine is connected across a 200-V supply. Assume the new flux to be 0.7 of the original flux. ***(6 marks)***

b) Show that the torque of a d.c. motor is given by:

$$T = 0.318\ I_a/c\ Zp\Phi$$

defining all terms. ***(6 marks)***

QUESTION 6

a) Derive the equivalent circuit of an induction machine beginning with the basic power split in the air gap i.e.

electrical power/mechanical power = s/(1-s) ***(10 marks)***

b) Show that the torque of an induction motor is given by the expression below and sketch the speed-torque curves.

$$T = \frac{3V_s^2}{2\pi n_s} \cdot \frac{R_2'/s}{(R_1 + R_2'/s)^2 + X^2}$$ ***(10 marks)***

QUESTION 7

a) Show that maximum torque of an induction motor occurs when the value of slip is

$$s = \frac{R_2'}{\sqrt{(R_1^2 + X^2)}}$$

and obtain the expression for maximum torque. ***(12 marks)***

b) Show that the droop of speed with torque over working range in an induction motor is given by :

$$\frac{-dn}{dT} = \frac{2\pi n_s^2}{3V_s^2} \cdot R_2'$$

(8 marks)

QUESTION 8

a) Describe the principle of operation of a synchronous machine. ***(4 marks)***

b) Show that armature reaction in a synchronous machine may be represented by a reactance and hence sketch the equivalent circuit. ***(6 marks)***

c) Derive the expression for torque in a cylindrical rotor (non-salient) synchronous machine and hence show that for small values of load angle (δ), the torque is proportional to the load angle (δ). ***(10 marks)***

END OF EXAMINATION EE 422

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
END OF YEAR EXAMINATIONS
EE442 ELECTRONIC ENGINEERING II

JANUARY 2004

TOTAL MARKS: 100
ANSWER ANY FIVE QUESTIONS

Q1. Analyze the two circuits given in figure 2.and in each case determine the cut off frequency f_o. State the merits of the circuits.

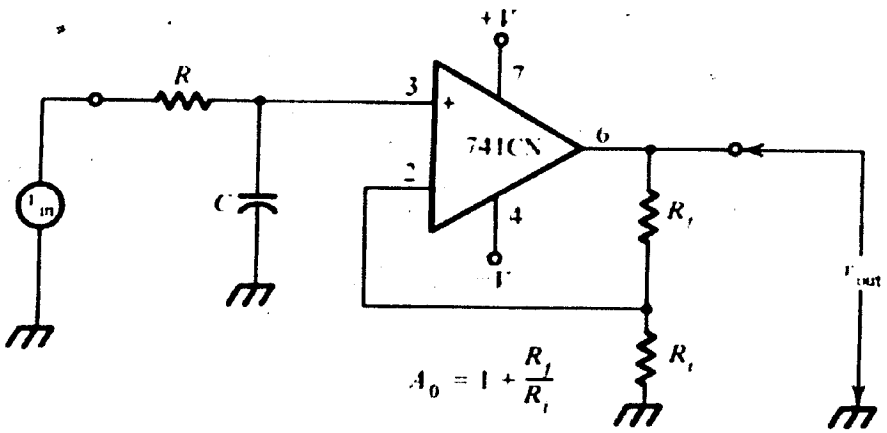


Fig2. a

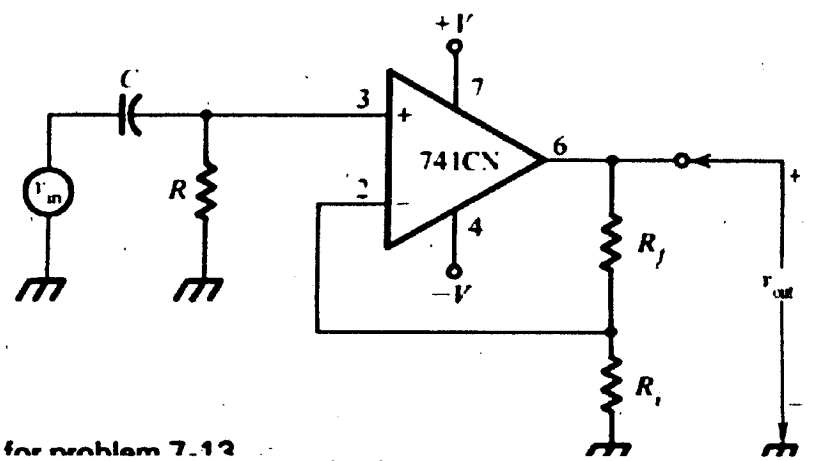


Fig2 b.

Q2. a. Draw the inside components that make up the 555 Timer and explain its working.

b. Using a 555 Timer design a monostable multivibrator with trigger pulse shaping which will drive a LED on for 0.5s each time it is pulsed.

Q3.a. State the four elements necessary for a circuit to produce a low distortion sine wave

b. Using the above, derive the function of the wien bridge oscillator.

c. Explain one method of implementing the adaptive negative feedback.

Q4. For the given basic difference amplifier in fig.4, carry out small signal analysis to determine

i_{e1}, i_{e2}, v_{o1}, v_{o2}, and $(v_{o1}-v_{o2})$.

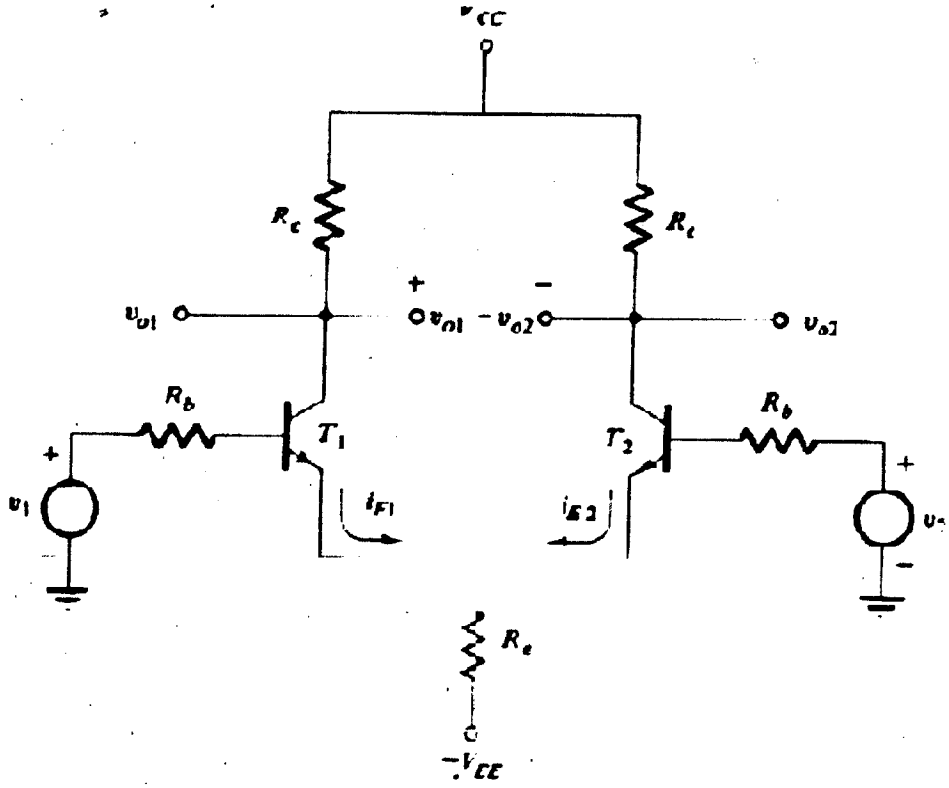


fig4.

Q5. The Darlington differential amplifier shown in fig5. is available as a self contained integrated circuit . Determine the quiescent operating conditions. assume h_{fe} =100 for all transistors.

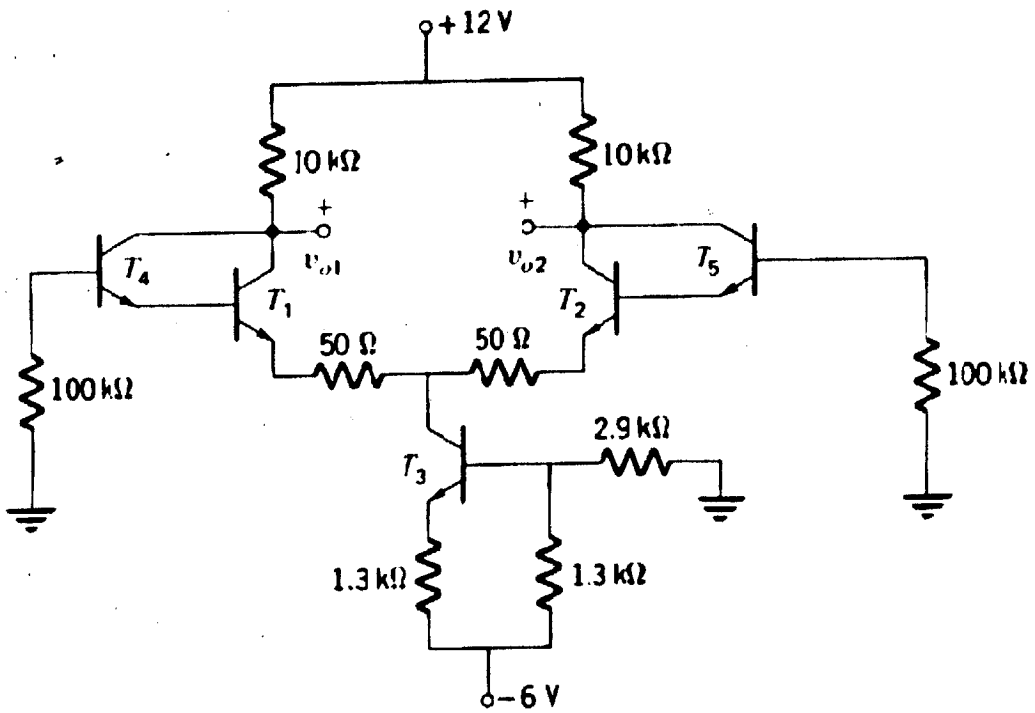


fig5.

Q6. a. Draw a small-signal h-parameter equivalent circuit for the common emitter amplifier of figure6, if hoe and h_{re} are negligible.

b. Find the expression for the voltage gain ratio $Av = v_o/v_i$

c. Find the expression for the current gain $A_i = i_L/i_b$.

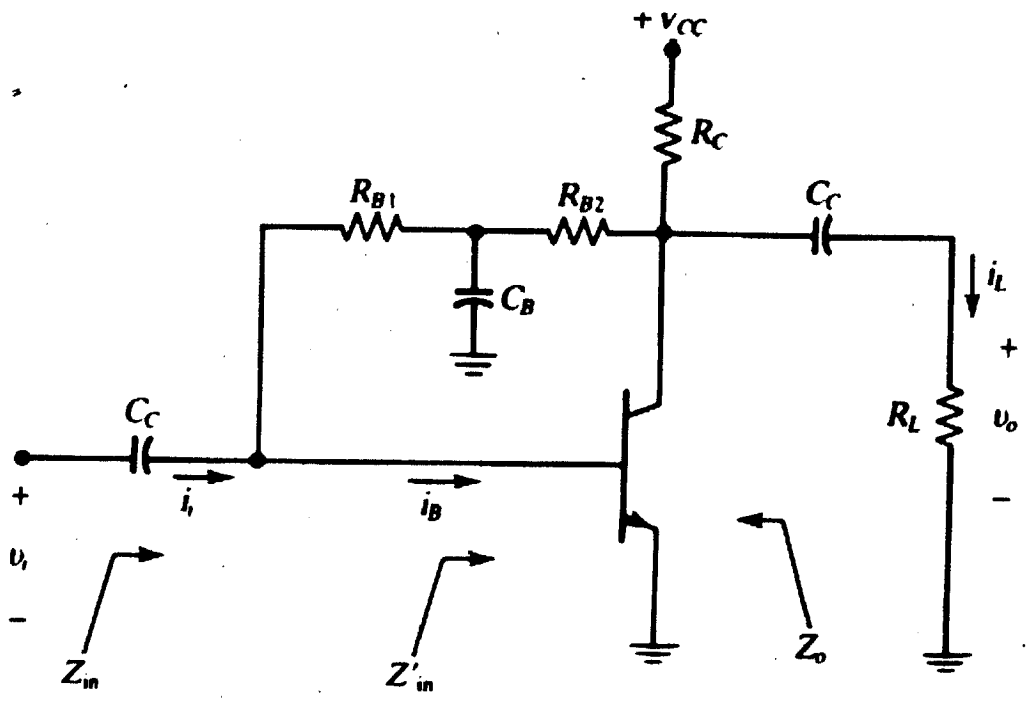


fig6.

Q7. Based on the current source FET model of fig.7,

a. **Draw a small signal equivalent circuit suitable for analysis of the common source amplifier.**

b. **Derive an expression for the voltage-gain ratio Av =v_L/v_i**

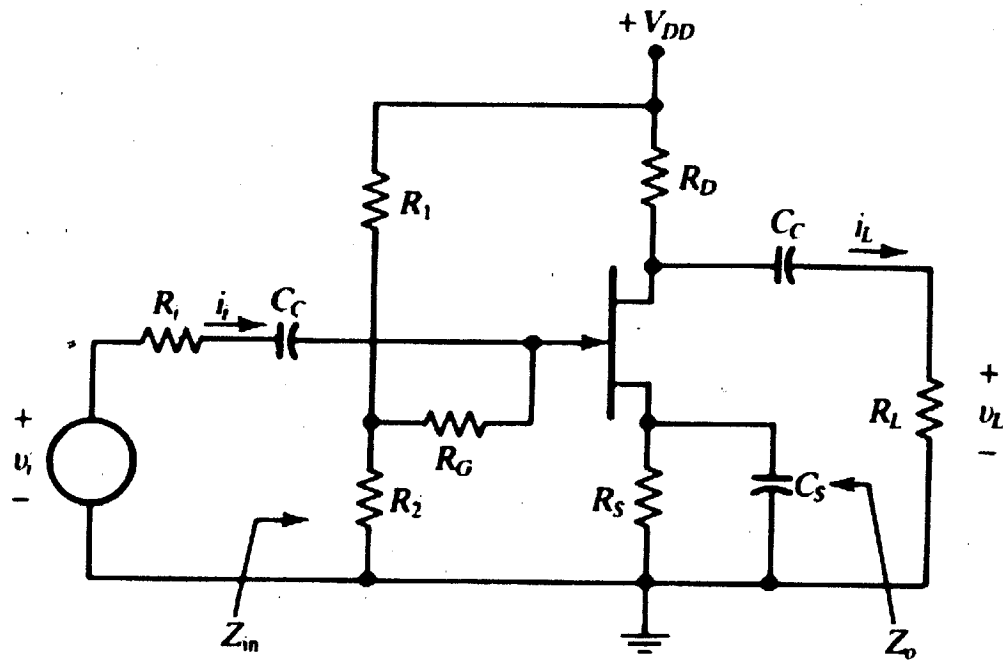


fig7.

Q8. Design an adjustable voltage regulator (3 volt to 28 volts)with a short circuit current of 60 mA. Use a 723 regulator for the design.

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UNIVERSITY EXAMINATIONS
SEMESTER II 2003 JANUARY 2004
EE462: INSTRUMENTATION

This exam consists out of two parts a compulsory part (part A) and an elective part where you select 4 out of 6 questions (part B).
Each question carries 20 marks divided over the various parts.
Good luck!

Section A. Compulsory part: answer the questions below.

a) Devise a program that could be used to operate the task shown in figure 1 for the automatic drilling of workpieces. After pressing S5 the drill motor and the pump for the air pressure for the pneumatic valves have to be started. The workpiece has to be clamped. The drill has then to be lowered and drilling started to the required depth. Then the drill has to be retracted, the workpiece unclamped and the drill motor and pump stopped (8 marks).

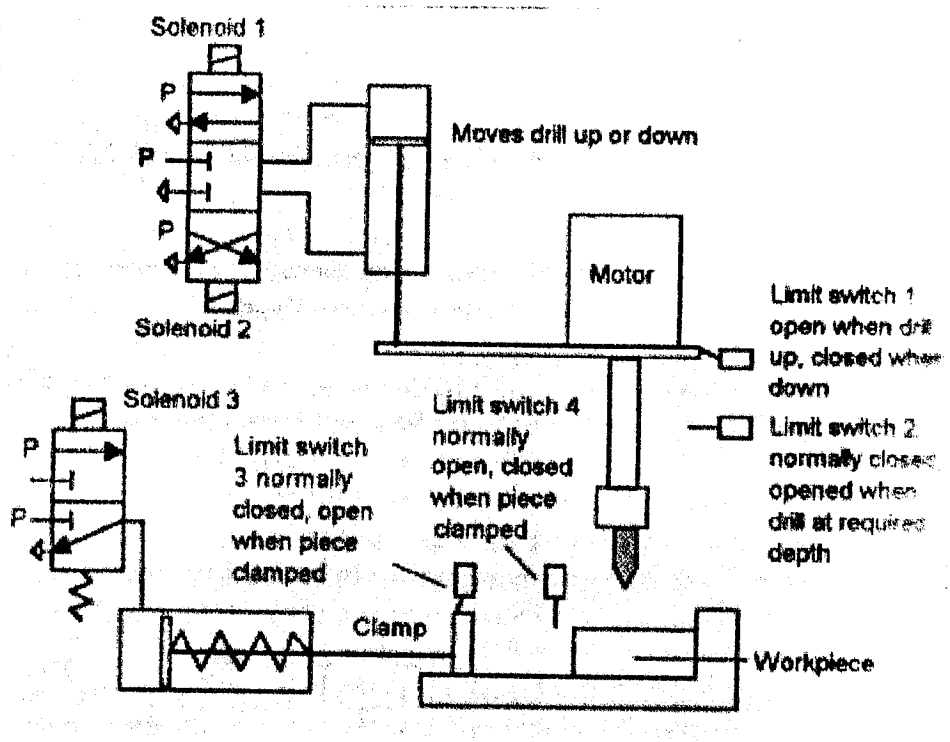


figure 1: drilling

b) For the above question complete the figure below (figure 2) by drawing the necessary connections: (5 marks)

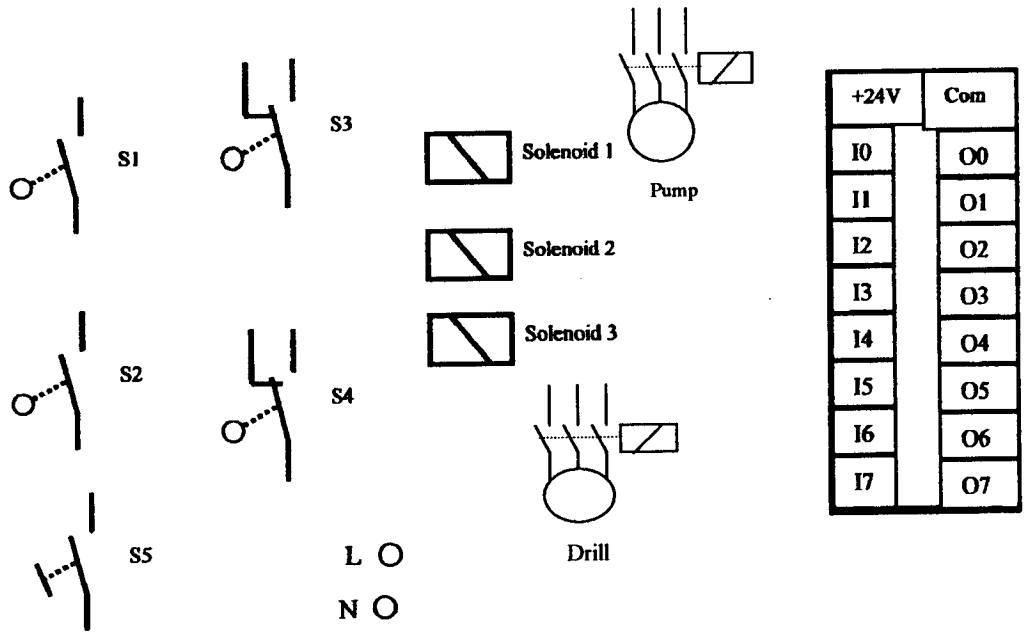


figure 2: physical connection of inputs/outputs

c) Replace the control circuit (used for a running light) as depicted in fig 3 using a PLC. Draw the ladder program needed to accomplish this. (7 marks)

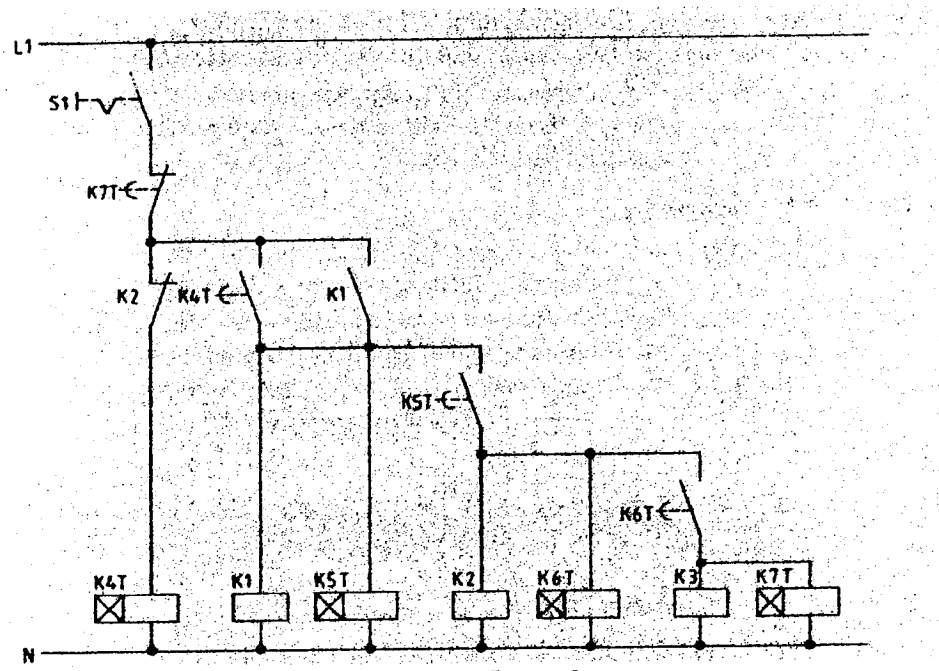


figure 3

B. Answer 4 out of 6 questions

Q1. ***PLC***

Design a setup that has the objective to detect and reject bottles emerging from a filling and capping machine that have not been capped (figure 4).
Bottle caps can be detected by using two photoelectric detectors. One detects the presence of a bottle (i.e. S1) and the other detects the presence of a cap (i.e. S2). The photoelectric detector S1 is mechanically mounted so that it is triggered just before the cap photoelectric detector (S2). If a cap signal is not detected within 500ms once the bottle detector detected a bottle than the reject solenoid is held energized for 1 sec.

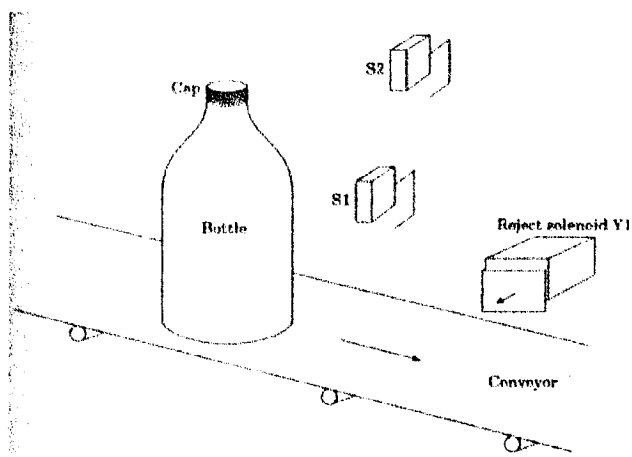


figure 4: capping machine

Assign S1 to input I1, S2 to input I2. Output Q1 activates solenoid Y1.

a) Design the Ladder diagram, function block or List program to accomplish this. (15 marks)
b) The output unit of the PLC can be a relay, transistor or triac type. Which type should you select here and why? (5 marks)

Q2. ***Bridges and transducers***

a) Figure 5 illustrates the arrangement for a Schering capacitance bridge.
Derive the following balance conditions: (12 marks)

$$R_x = R_4 \frac{C_3}{C_1},$$

$$C_x = C_1 \frac{R_3}{R_4}.$$

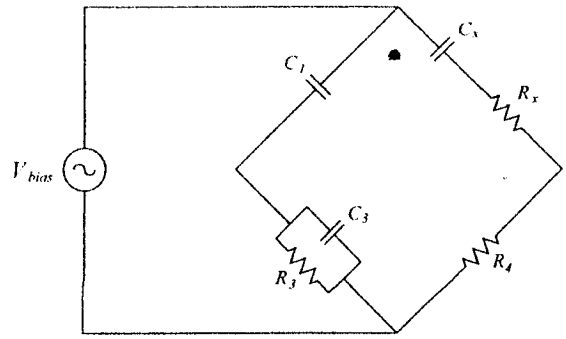


fig 5. Schering capacitance bridge

b) Calculate the value of the capacitance of the transducer depicted in figure 6 when the inner rod is fully inserted (8 marks)

$\varepsilon_0 = 8{,}85 pF/m$

$\varepsilon_r = 1$

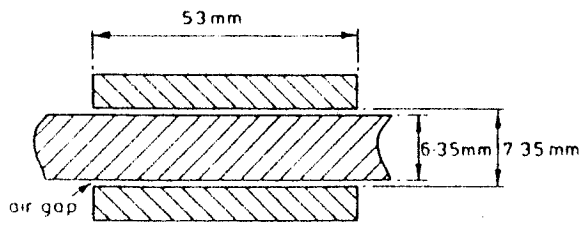


figure 6: transducer

Q3. ***Op-amps***

a) Derive for an **inverting amplifier** the formula used to calculate the input resistance and the output resistance.(14 marks)

b) Complete the table below based on fig. 7: (6 marks)

A	B	C	D	Vout [Volt]
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

REMARK: a "0" means BUTTON NOT pressed, a "1" means BUTTON PRESSED..

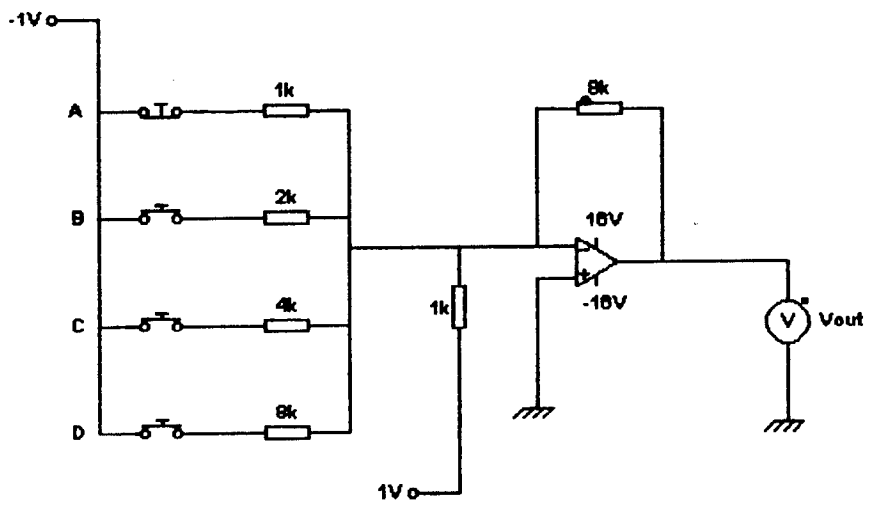


figure 7.

Q4. Analog to digital converters

a) For the dual slope converter: explain (using a schematic diagram) & prove: $V_{in} = (n/N)V_{ref}$ (14 marks)

b) Which is the largest possible change in V_{in} that could go undetected? (6 marks)

Q5. True & non-true RMS meter

a) One cycle of a periodic waveform is described by $V_{(t)}=Ae^{(t/T-1)}$ over the interval $0<t<T$. This repeats in $T<t<2T$, $2T<t<3T$, and so on.

1. What is the average rectified value? (3 marks)
2. What is the rms value? (3 marks)
3. What is the crest factor? (2 marks)
4. What is the form factor? (2 marks)
5. If a non-true-rms meter gave a reading of 2,00 volt, what would be the correct RMS value? (4 marks)

b) Draw the circuit used for determining the true rms value of an input voltage using the thermal balance principle and explain its operation. (6 marks)

Q6. Explain briefly:

a) Aliasing (2 marks)
b) slew rate (2 marks)
c) common mode rejection ratio (2 marks)
d) gage factor (2 marks)
e) crest factor (2 marks)
f) GPIB (2marks)
g) 12 bit resolution (2 marks)
h) Sample rate (2 marks)
i) Harmonics (2 marks)
j) Cold junction (2 marks)

END OF EE462 EXAMINATION JANUARY 2004, PREPARED BY F. DOBBELAERE

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SECOND SEMESTER EXAMINATIONS 2003-JANUARY 2004

EE 532 POWER ELECTRONICS

TIME: THREE HOURS
ATTEMPT FIVE QUESTIONS
TWENTY MARKS PER QUESTION
THE RELEVANT FIGURES ARE ATTACHED

1.

a) Using a transistor as a switch,sketch the basic inverter circuit for 'a half bridge' (or a centre-tapped source) inverter with an inductive load. Sketch the output voltage waveform (across the R-L combination) ***(5 +5 Marks)***

b) With the aid of output voltage waveforms ,briefly describe the operation of the series inverter shown in Fig 1QB for the case when L =0.Indicate the voltages across the Resistor and Capacitor. ***(5 +5 Marks)***

2. The Converter circuit of Figure Q2 is used to control power from a fixed 240 V a.c. source into an Oven -a resistive heater of 9.6 Ω.

a) Sketch the load voltage and current waveforms for the thyristor, T, and, diode D_1 at $\alpha = 60^0$. ***(5 Marks)***

b) Determine an expression for the output voltage,$V_O(\alpha)$ in terms of the phase delay angle α. ***(5 Marks)***

c) Draw the graph of the normalised output voltage, $V_O(\alpha)/V_S$, for α between 0 and Π radians for every Π/12 radians. ***(8 Marks)***

d) The power is to be controlled from 1.5 kW to 4.86 kW, determine the range of control for the phase delay angle α. ***(2 Marks)***

3. The DC Chopper circuit of Fig Q3.

a) Assume the chopper circuit components to have no losses and that the inductor L_L maintains the load current perfectly smooth. Briefly explain the operation of the chopper circuit. ***(8 Marks)***

b) The basic D.C. chopper circuit shown in Figure Q3 is supplied at 240 V and has a load resistance, RL, of 20 Ω. The value of the load inductor, L_L, is sufficiently high for the load current to be assumed constant and the inductor, L, has Q-factor of 15. The main Thyristor,TI, is rated at 10 A, and has a turn off time of 25 μs appropriate to its operating conditions in the chopper. The chopper operates with a mark/space ratio of 7:3 at 5 kHz.

(1) If TI is to operate at its minimum turn-off time, calculate the load voltage. (*3 Marks*)

(11) Hence, or, otherwise, calculate the minimum value of C to ensure minimum turn-off time of TI. (*2 Marks*)

(111) If the peak value of current through TI is not to exceed twice its maximum rating, calculate the minimum value of inductance, L. (*3 Marks*)

(IV) If the conduction period of TI is reduced to the acceptable minimum to what value must the operating frequency be raised in order that the same output voltage is applied to the load. (*4 Marks*)

4. A fully controlled three-phase bridge Rectifier is operated in the inversion mode at $\alpha=135^0$ and with a completely smoothed dc line current of 120 A. This rectifier is supplied by a 3300 V/ 550 V D Y 1 Transformer.

(a) Sketch the circuit diagram. (*4 Marks*)

(b) Using the template for three-phase waveforms, sketch the waveforms of the secondary phase voltage and current, making clear magnitudes and relative displacements. (*4 Marks*)

(c) Derive an expression for the D.C. output voltage in terms of the phase delay angle α and hence determine the D.C. output voltage and the power, at $\alpha=135^0$ (*5 Marks*)

(d) With the aid of a diagram illustrate the converter power relationships in terms of the displacement angle ϕ,and the distortion factor cos δ. Hence or otherwise, determine the fundamental reactive power on the a.c. side of the converter. (*5 Marks*)

(e) Calculate the transformer secondary winding utilization factor. (*2 Marks*)

5. Fig Q5 shows a Three Phase Double Star Rectifier Circuit.

a) Derive an expression for the D.C. out put voltage of an m- pulse diode rectifier (*3 Marks*)

b) What is the function of the interphase reactor. (*3 Marks*)

c) What is the pulse number of the output voltage (*2 Marks*)

d) In terms of the secondary line voltages,V_{L1} and V_{L2} determine an expression for the D.C. output voltage across R_L. (*3 Marks*)

e) Sketch a circuit using a three winding transformer to obtain a 12 pulse dc out put (*9 Marks*)

6. The silicon controlled rectifier is used as building block to realise the AC/DC Converter

a) Give a one statement definition of an AC/DC Converter. (*1 Mark*)

b) With the aid of a diagram, show the possible quadrants of operation of a fully controlled AC/DC Converter as viewed from the D.C. terminals. (*4 Marks*)

c) Sketch a circuit of a two-pulse AC/DC Converter configuration for a DC Motor Drive capable of both forward and reverse motion. (*5 Marks*)

d) In terms of output voltage ,V_d ($\propto$),continuous DC current, I_d ,the DC motor back e.m.f ,E, and the motor electric torque ,T_E ,and the mechanical load torque ,T_M ,briefly describe the operation of the above converter when applied to a hoisting and lowering application of a small Hoist.

(10 Marks)

7. A controlled semi-conductor module consists of two common cathode diodes in series with a thyristor.This module is used in conjunction with a centre-tapped secondary single -phase transformer to charge a bank of four 12-Volt Batteries connected in series. The charger is connected to a 220 V,50 Hz Supply.An inductor ,L, and a resistor R are connected in series with the Battery.The diode and thyristor conduction voltage drops are respectively 1.0 and 1.6 Volts.The circuit parameters are :

Total series resistance in the charging circuit $R_S = 5\ \Omega$, $N_P : N_S = 1.83 : 1$

a) Sketch the circuit diagram. ***(4 Marks)***

b) What is the effect of the inductor in this circuit ? (2 ***Marks)***

c) Determine an expression for the charging current, I_d, in terms of the phase delay angle $\propto$.. ***(4 Marks***

d) Calculate the charging current ,I_d, at the start of a charging cycle assuming each battery is evenly discharged to 11.0 V.,with the phase angle delay angle $\propto$..set such that the semiconductor devices conduct for 60 % of the maximum conduction angle and L is set to zero.

(6 Marks)

e) For the above condition if L is set such that there is continuous charging current,what would be the value of the charging current.

(4 Marks)

8. Attempt any two of the following :

a) With the aid of suitable diagrams briefly describe how AC switches may be used as Static Var compensators. ***(10 Marks)***

b) Sketch a diagram for a Brushless Exciter for a large Alternator. ***(10 Marks)***

c) With the aid of suitable diagrams show how the star -zigzag connection eliminates DC ampere-turns unbalance in a three limb transformer core.

(10 Marks

THE RELEVANT DIAGRAMS ARE ATTACHEDM AFTER THIS PAGE.

END OF EXAMINATION

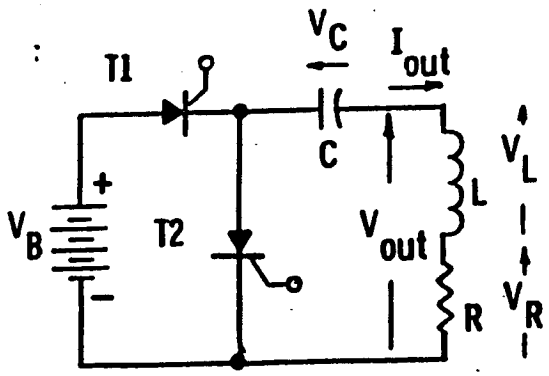


Fig Q 1 B

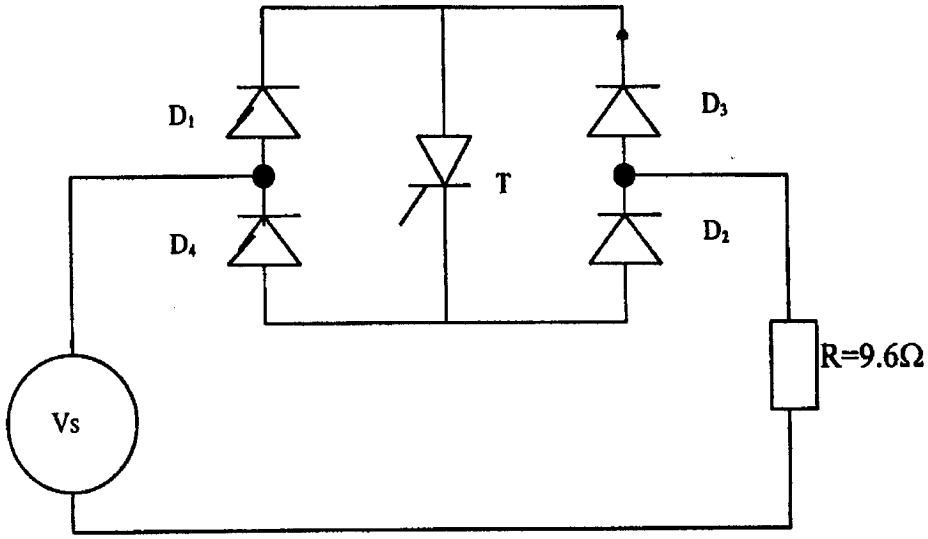


Fig. Q 2

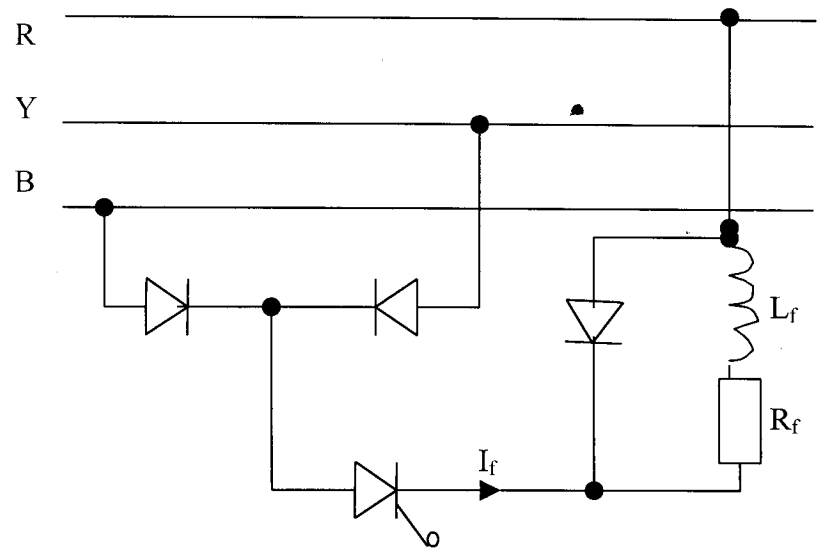


DIAGRAM NOT REQUIRED IN THIS EXAMINATION

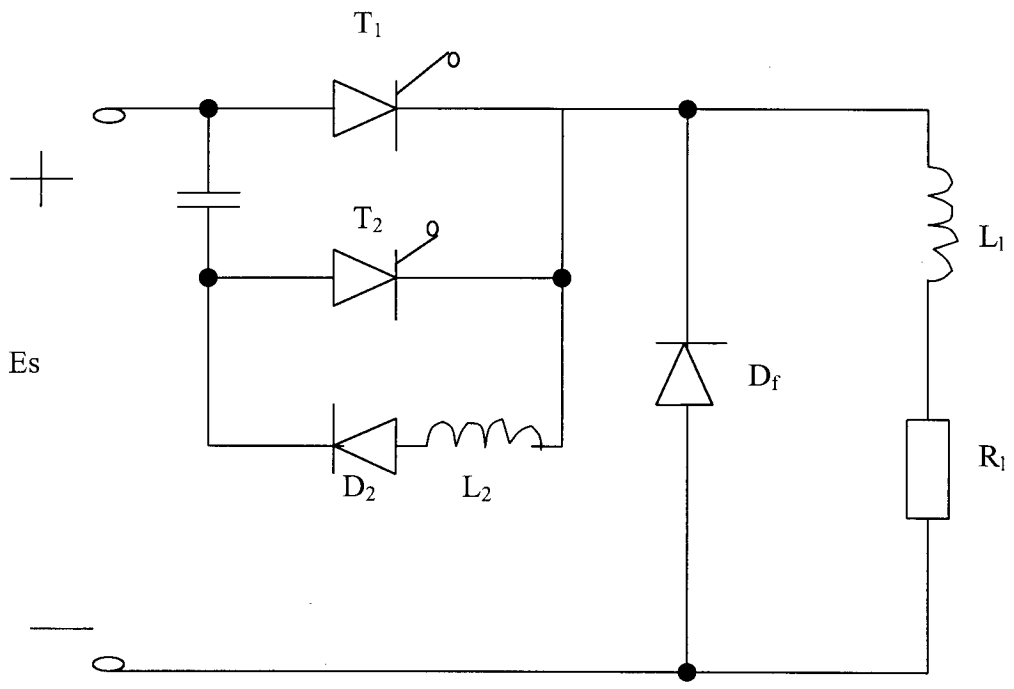


Fig 3 THYRISTOR CHOPPER CIRCUIT

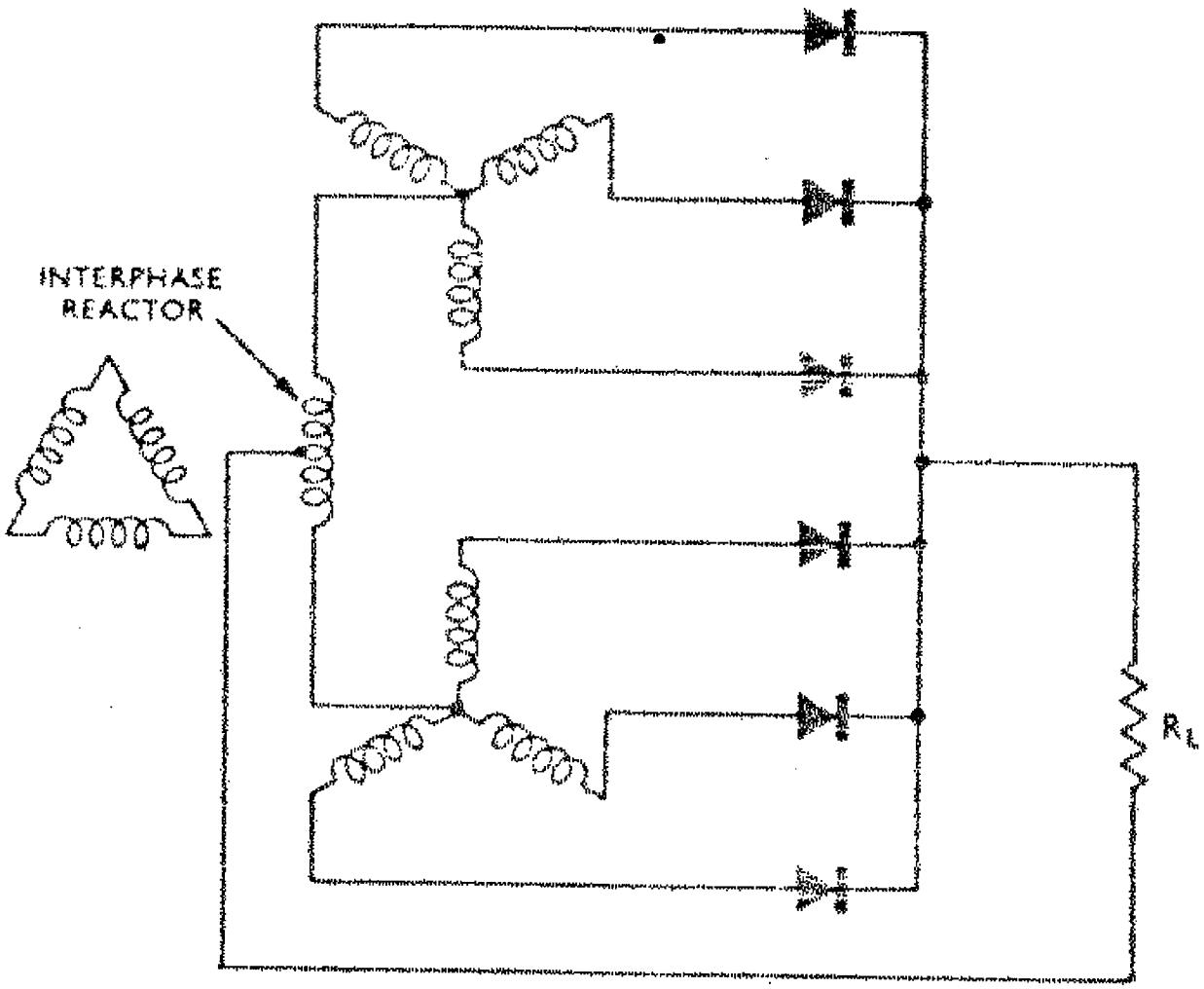
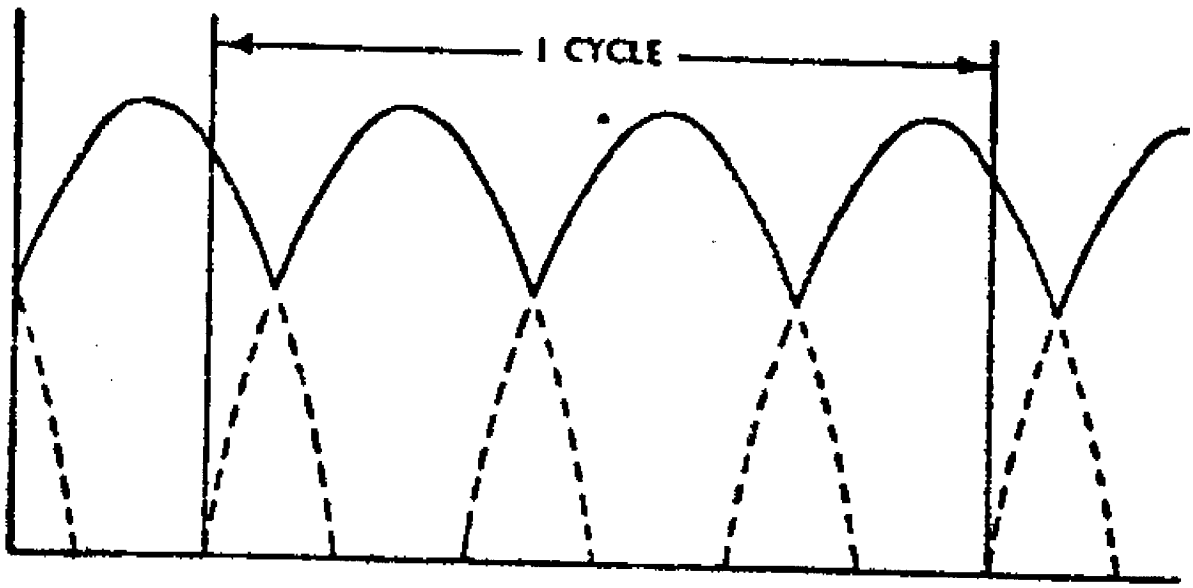


Figure Q5. Three Phase Double Star Circuit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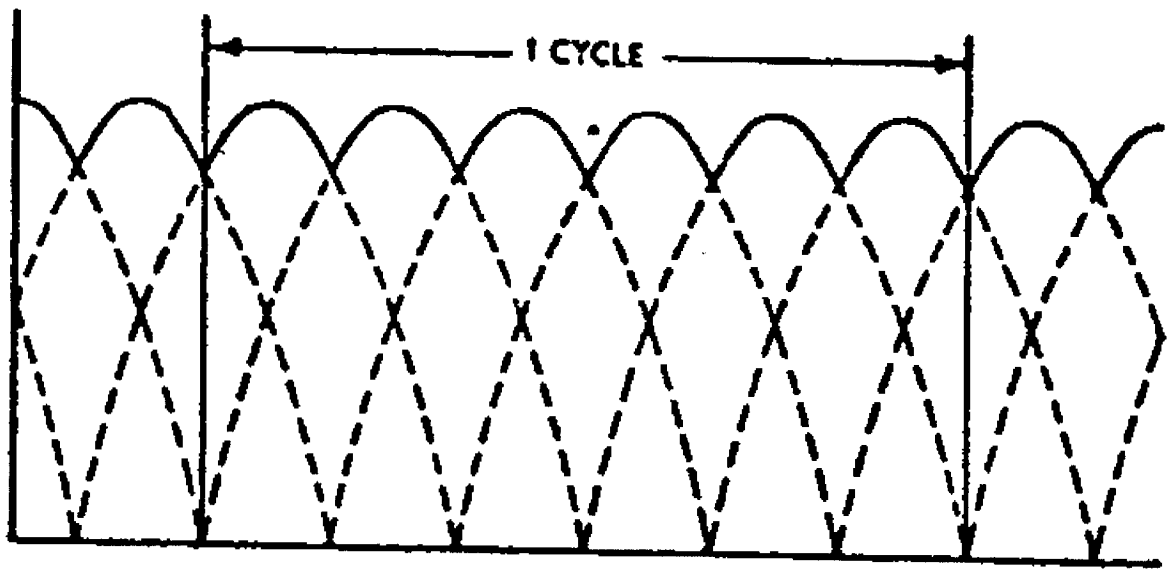
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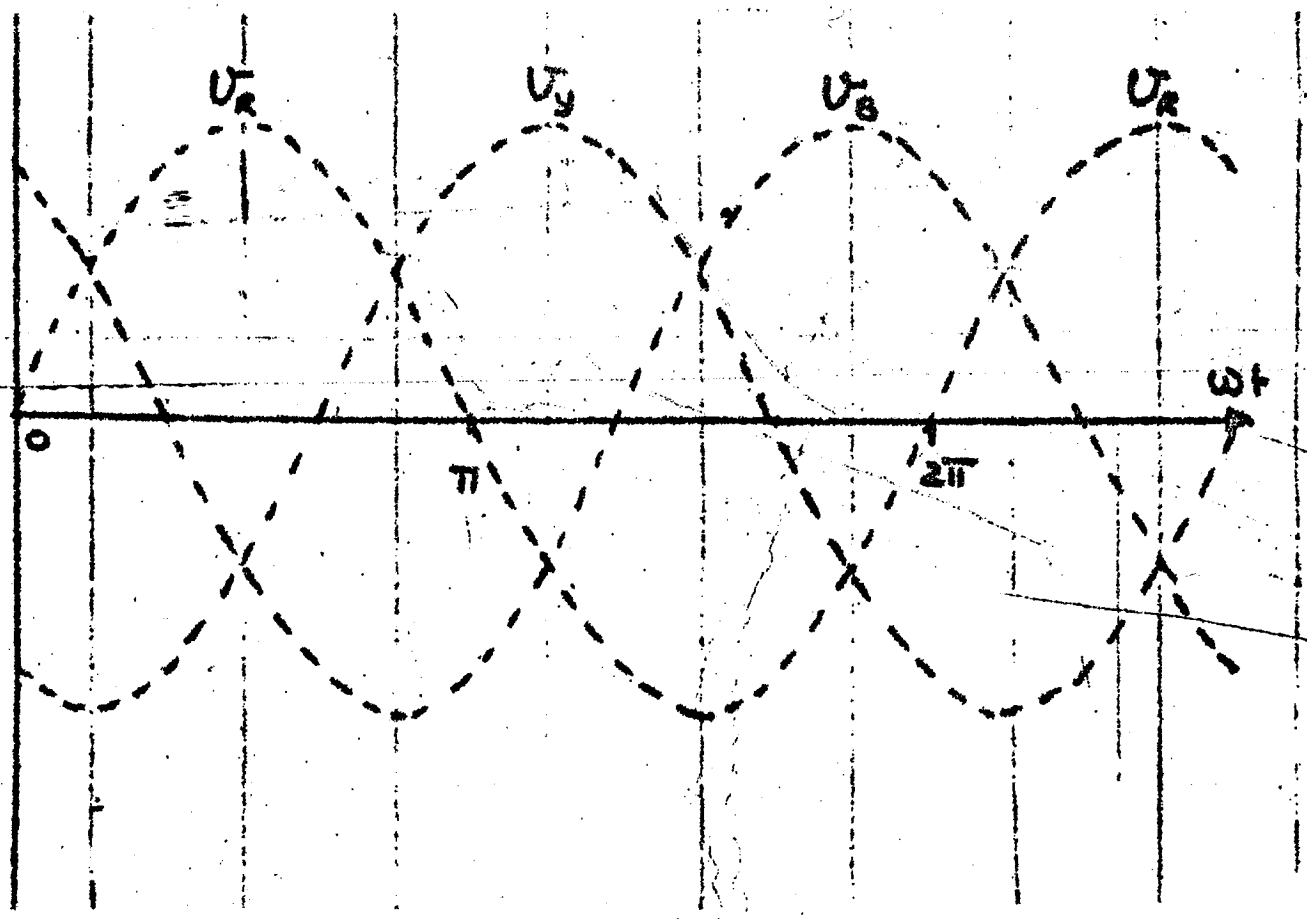
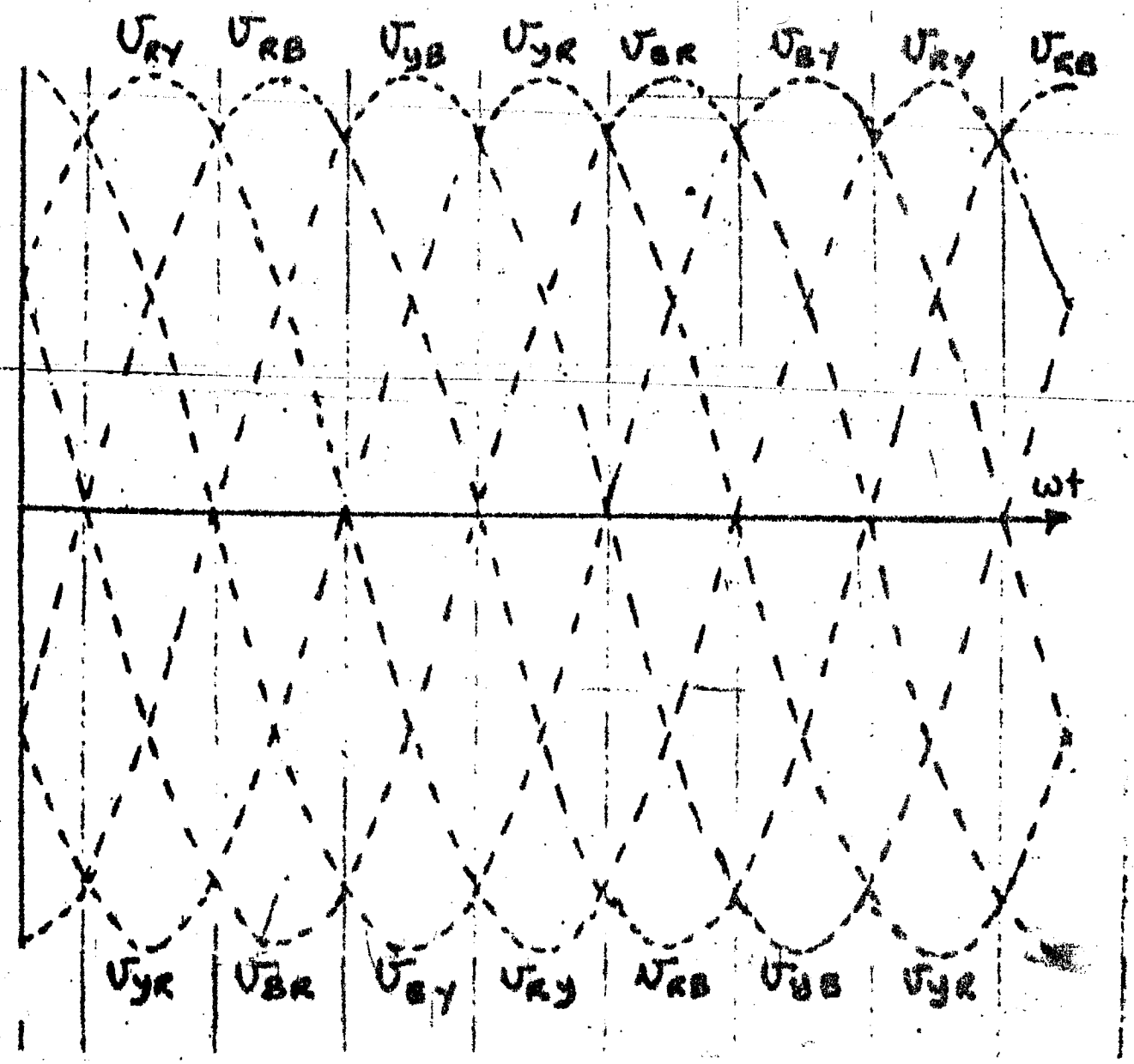

U_R
U_Y
U_B
U_R
ωt
0
π
2π


U_{RY}
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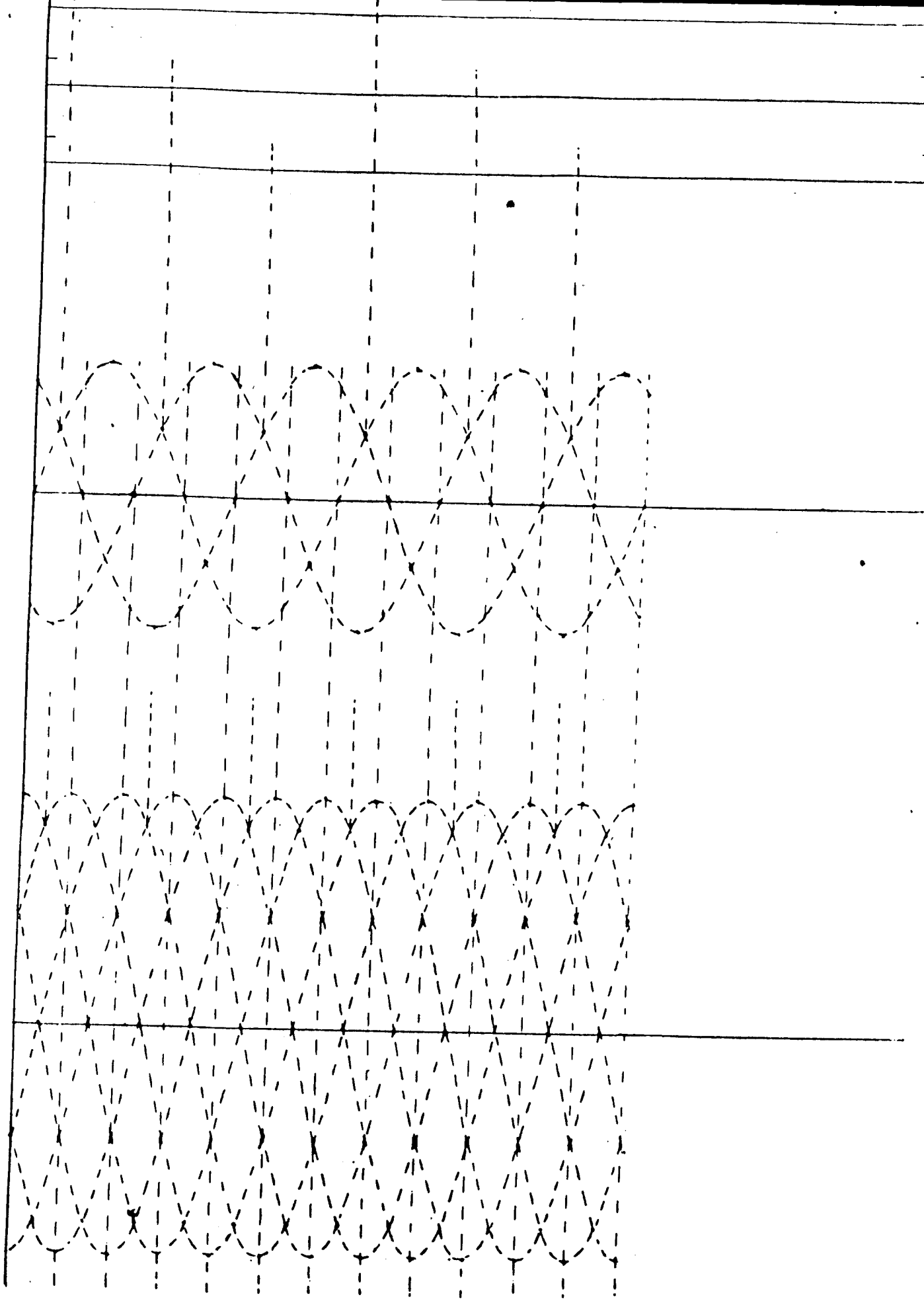

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS OCTOBER 2002
SEMESTER II

EE 552 ELECTRICAL POWER SYSTEMS II

TIME: THREE HOURS
ANSWER: QUESTION 1 AND 5 and ~~TWO~~ 3 OTHERS.
EACH QUESTION CARRIES 20 MARKS

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1. (i) Briefly describe four renewable energy technologies that are available in Zambia. To what extent can renewable energy sources help in increasing accessibility to electricity for households in peri-urban and rural areas of Zambia? Suggest ways of how this programme would be aided by the Ministry of Education and Ministry of Health rural solar power programs on a sustainable basis, given that the present ZESCO rural electrification programme has not been very successful for the past 30 years. What social and economic benefits would such an electrification programme bring to the rural communities if rural telecommunications and ICT centres are created at schools and hospitals throughout Zambia? (10 Marks)

   (ii) Briefly describe three power system analyses that are carried out to ensure adequacy, security and safety requirements are satisfied during steady state operation. (10 Marks)

2. (i) What is the optimal number of voltage swing buses and automatic generation control areas which are required in wheeling power from Congo DR to South Africa via Zambia in order to satisfy the load-frequency control objectives? State the two basic LFC objectives for an interconnected power system? (10 Marks)

   (ii) How does the voltage stability problem differ from the power stability problem ? What tools are used to solve them? Verify that when there is a surplus of 5MW in a system the time rate of change of frequency will be 0.1 Hz/sec for normal system frequency of 60 Hz. (10 Marks)

3. (i) What are the three major sources of voltage transients? What is an isokeraunic map? What type of equipment is affected by spikes, impulses and surges? What equipment can provide effective protection against spikes, impulses and surges? What are the three basic requirements that should be specified on a surge suppressor rating plate? (10 marks)

   (ii) What is insulation coordination and demonstrate your answer with a sketch showing the protection margin between the equipment insulation withstand curve and the protective device ceiling voltage. Define the basic insulation level (BIL) in terms of the standard IEEE impulse voltage wave. Sketch a generic standard impulse wave as a function of time. Under what system earthling conditions can reduced BILs be used in Extra High

Voltage systems of greater than 115kV norminal system voltage. What is the effect of equipment grounding on the equipment BIL? (10 Marks)

4. (i) Draw the star-equivalent per unit sequence networks of a three-phase three-winding (Primary **Y** solidly grounded, **d11**Tertiary, Secondary **Y** solidly grounded) transformer. Express the star-equivalent impedances in terms of the pair-wise short-circuit test leakage impedances. (5 Marks)

(ii) Given a three-winding single phase transformer the following ratings and per unit impedances:
Winding 1: 300 MVA, $X_{12} = 0.10$ pu on 300 MVA, 13.8 kV;
Winding 2: 300MVA, 199.2 kV, $X_{13} = 0.16$ pu on 50 MVA , 13.8 kV;
Winding 3: 50MVA, $X_{13} = 0.14$ pu on 50 MVA , 13.8 kV.
Winding resistances and exciting current are neglected. Calculate the impedances of the per-unit equivalent circuit using a base of 300 MVA and 13.8 kV for terminal 1. Draw the the pu equivalent circuit showing all impedances. (15 Marks)

5. (i) Derive the interconnected sequence relations from the phase domain conditions of a double line to ground fault, through fault impedance Z_F to ground . Then determine the configuration of the interconnected positive, negative and zero sequence networks. (10 Marks)

(ii) Given a Thevenin equivalent at fault point in a power system having : Z_o= j0.250 pu, Z_1= j0.13893 pu, V_F=1.05$\angle 0^\circ$ pu and Z_2= j0.14562 pu. on 100 MVA and 13.8kV line to line voltage level. Consider a double Line to ground fault from phases B to C through a bolted fault impedance Z_F = j0.0. Calculate the subtransient fault current in each phase, and neutral fault current. (10 Marks)

6. (i) State at least five Energy Management System functions in a central contol centre for an interconnected power power system? Compare with what is in practice in ZESCO or Copperbelt Energy Company. (10 Marks)

(ii) Draw the operating states transition diagram of a power system as a function of the equality and inequality constraints including the disaster , rebuild and recovery states. How can the component Extremis Islanding state contribute to power system topological reliability and prolonged component economic life if it is designed based on the transition diagram? (10 Marks)

END OF EE 552 EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

EE 562 – SYSTEMS & CONTROL ENGINEERING (II)
DEFERRED END OF SEMSESTER EXAM. 2004

TIME: THREE HOURS

INSTRUCTIONS

1. ATTEMPT: ANY TWO QUESTIONS FROM SECTION A AND ANY THREE FROM SECTION B

2. SEPARATE ANSWER BOOKLETS SHOULD BE USED FOR EACH SECTION

3 ALL QUESTIONS CARRY EQUAL MARKS

4 A table of Z-transforms is provided

5..DO NOT TURNOVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO

EE562, PLC component

Solve following two questions:

Question 1 **(15 marks)**

a) Given:

A number of inputs and outputs are connected to a given PLC (see fig 1)

A Ladder Program is loaded into this PLC and executed (see fig 2).

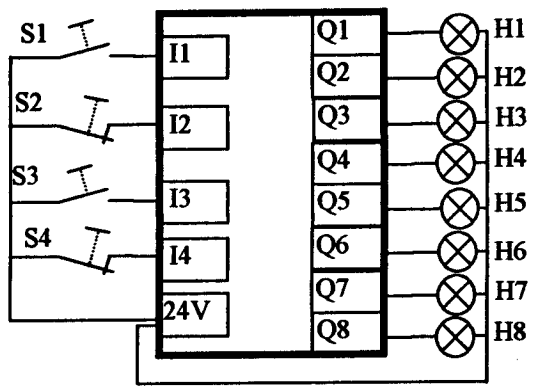
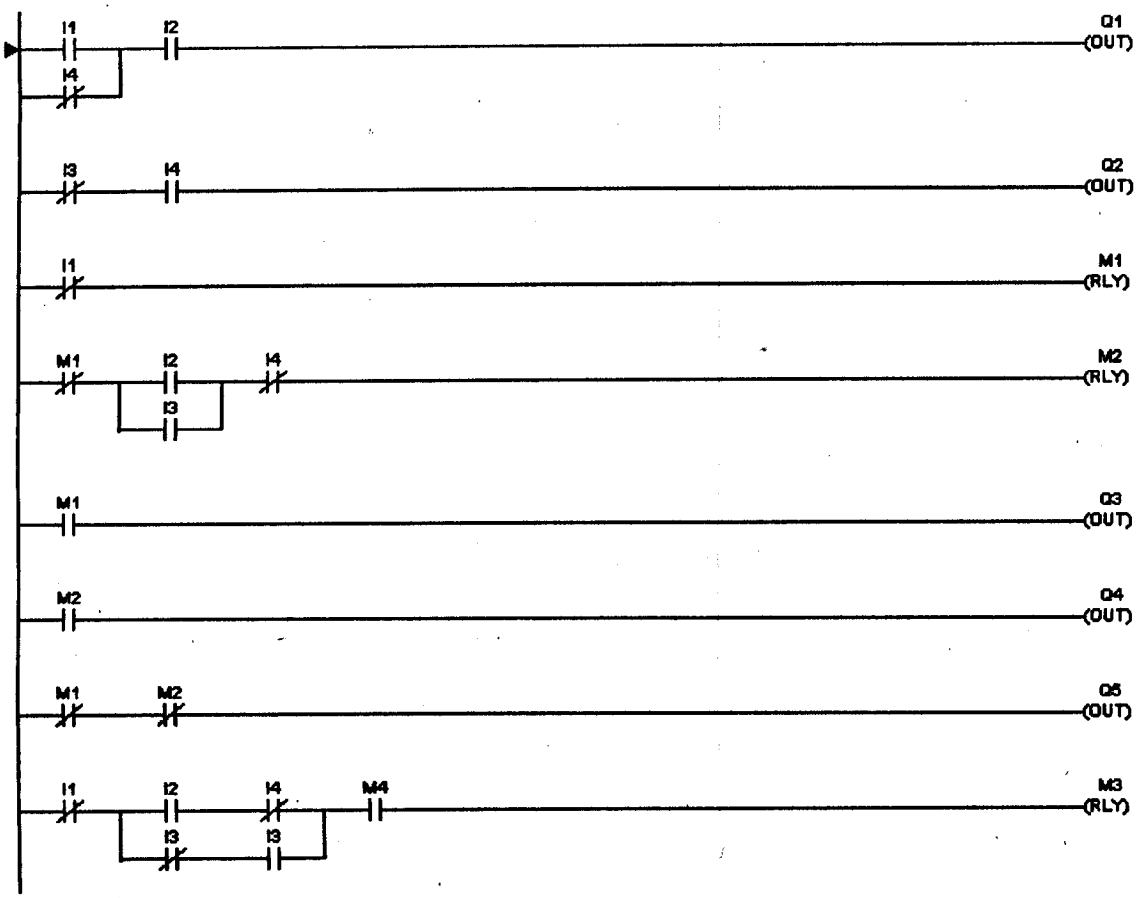


fig 1: PLC wiring

The Ladder diagram:



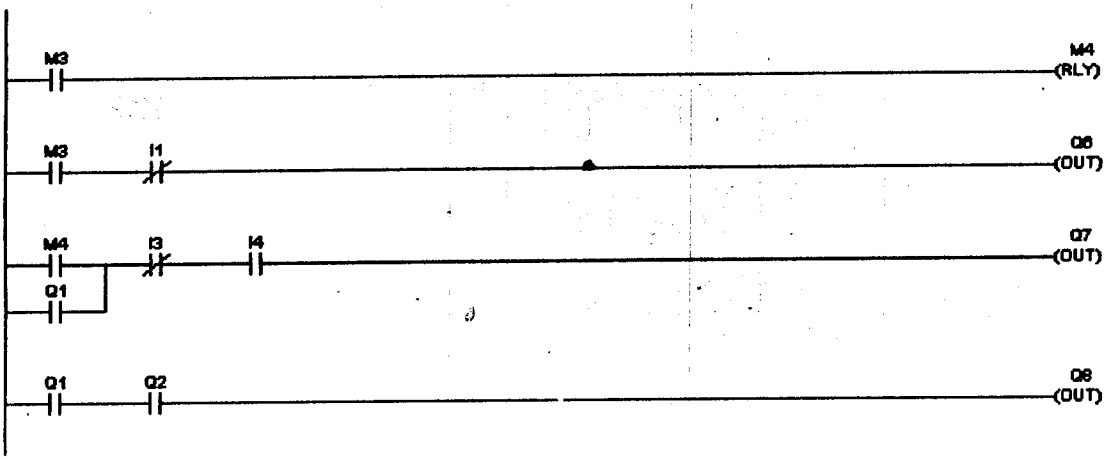


fig 2: Ladder program

b) Question:
With the given information complete the table below.

Status of the # OUTPUT's	**none of the buttons is activated (pressed)**	**Only S1 is activated (pressed)**	**Only S2 is activated (pressed)**	**S1, S2 and S4 are activated**
H1	Off	ON	Off	Off
H2				
H3				
H4				
H5				
H6				
H7				
H8				
M1				
M2				

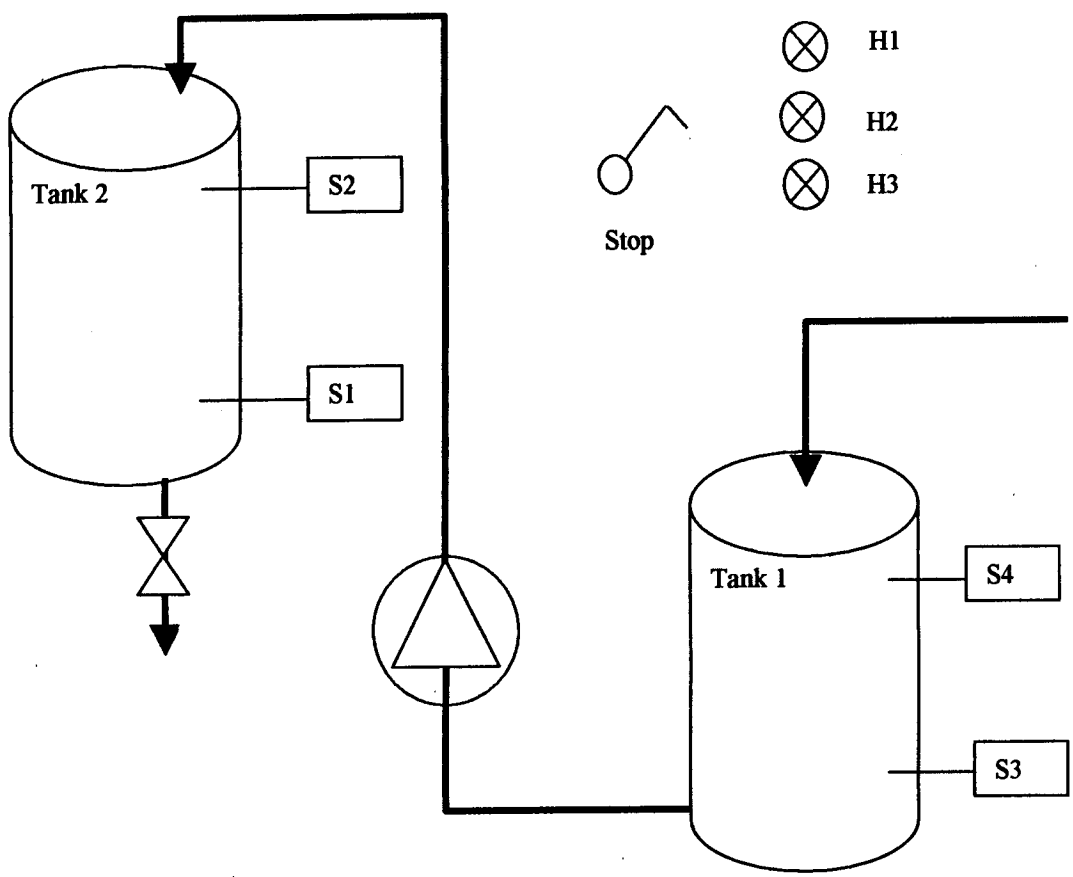
Table1

Question 2: **(15 marks)**

Design a solution based on a PLC to solve following problem:
a) Given:

* Two tanks are connected via a pump.
* Tank 1 is filled at irregular times
* The liquid is pumped from tank 1 to tank 2 when:
the level in the second tank falls below the minimum level (indicated by S1) AND the level in the first tank is above its minimum (indicated by S3) then the pump should start pumping until either the level in the second tank reaches the full mark (indicated by S2) or the level in the first tank falls below the minimum level (indicated by S3).

- The pump should start automatically although it must be possible to stop it at all times.
- When both tank 1 and tank 2 are empty it must be indicated by H1
- When tank 1 is full it must be indicated by H2
- When tank 2 is empty it must be indicated by H3



b) Question:

1) Draw the physical connections of needed inputs and outputs to the PLC
2) Design the Ladder Program needed here.

SECTION B

QUESTION 1

(a) With the aid of suitable or relevant sketches explain what is meant by the following terms.

(i) Sampling **(2 marks)**

(ii) Quantization **(2 marks)**

(iii) Data interpolation **(2 marks)**

(b) What are the resolution and dynamic range of a 12-bit DAC? **(2 marks)**

(c) (i) Write down the z-transform of the decaying exponential $x(t) = e^{-t}$ sampled at a frequency of 10 Hz. **(2 marks)**

(ii) A unit step function is sampled every T seconds. Work out the z-transform of the resulting sample sequence, assuming that the value of the unit step at a time t = 0 is 1. What would be the sampled step delayed by T seconds? **(7.5 marks)**

(c) Determine the sampled step response of the system whose Transfer function is 1/(1+2s), sampled at 3 Hz. **(7.5 marks)**

QUESTION 2

Determine the inverse z-transform of

$$C(z) = \frac{z(z+0.4)}{(z-1)(z-0.3)(z-0.8)}$$

using

(a) long division **(12.5 marks)**

(b) partial fractions **(12.5 marks)**

QUESTION 3

Sketch the root loci for a system with an open – loop transfer function of

$$Go(s) = \frac{K(s+1)}{(s+2+j3)(s+2-j)}$$

and unity feedback. **(25 marks)**

QUESTION 4

(a)

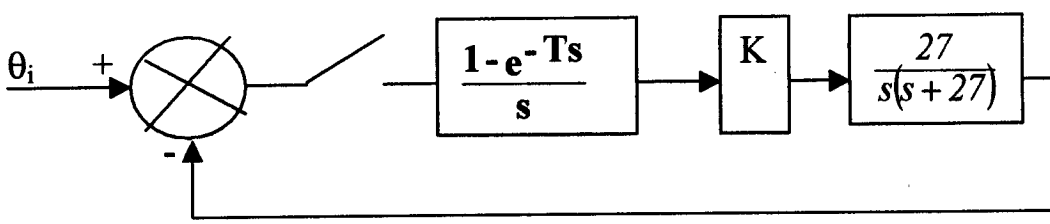


Fig 1

Find the closed-loop digital (z) transfer function for the system shown in fig1 and determine if the system is stable for K = 20 and K = 100. **(12.5 marks)**

(b)

For a system with an open-loop transfer function of

K/(s(s+1)

(i) sketch the root locus diagram **(5.5 marks)**
(ii) calculate the gain K for critical damping. **(3.5 marks)**

(iii) calculate the gain K for a damping ratio of 0.6. **(3.5 marks)**

QUESTION 5

(a)

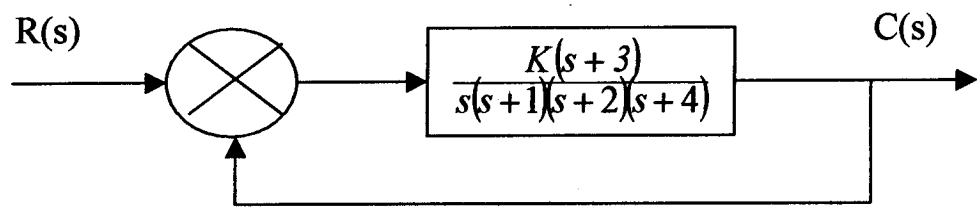


Fig 2

For the system of fig 2, find the frequency and gain, K, for which the root locus crosses the imaginary axis. For what range of K is the system stable? **(12.5 marks)**

(b)

Determine whether the sampled –data systems with the following transfer functions are stable or unstable.

(i) $G(z) = 4/(z + 06)$ **(1 mark)**

(ii) $G(z) = (0.2z- 0.6)/(z^2 + 0.1z + 0.5)$ **(3.5 marks)**

(iii) $G(z) = (0.1z + 0.7)/(z^2 + 0.2z - 0.1)$ **(3.5 marks)**

(iv) $G(Z) = 1/(2z^3 + 1.6z^2 + 0.5z + 0.2)$ **(4.5 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
Department of Electrical and Electronic Engineering
UNIVERSITY EXAMINATIONS - January, 2004
EE572: TELECOMMUNICATION SYSTEMS

TIME: THREE HOURS
ANSWER: ANY FIVE QUESTIONS
TOTAL MARKS: 100

$\mu_o = 4\pi \times 10^{-7}$ henry per metre is the permeablity of vacuum or free space, $\epsilon_o = 8.854 \times 10^{-12} \simeq \frac{1}{36\pi} \times 10^{-9}$ farad per metre is the dielectric permittivity of vacuum or free space,

$c = 3 \times 10^{8}$ metres/sec is the velocity of light in vacuum or free space.

Q1. (a) Define a complex Poynting vector. Derive the equation for the complex Poynting theorem. State the theorem.

(b) What is an electromagnetic plane wave ? What are uniform and non-uniform plane waves ? State their properties.

(c) Derive the electric wave equation

$$\nabla^2 E = \gamma^2 E$$

Where E is the electric field intensity and γ is the intrinsic propagation constant of a medium.

(d) Consider the reflection of a uniform plane wave when it is normally incident on a plane boundary between two media. Show the schematic diagram and write down the field equations. Write the condition for the continuity of the wave impedance at the boundary. Write down the expressions for the reflection and transmission coefficients, standing wave ratio and power densities. Make any necessary assumptions.

(e) Consider a uniform plane wave propagating in a lossless dielectric. Calculate the phase constant β, the intrinsic impedance of the medium η and the phase velocity v_p . The impressed frequency is100 MHz and the relative permittivity of the medium is 1.23.

[5+3+3+5+4]

Q2. (a) Write down the Helmholtz's equation for the TM_{mn} mode in a rectangular waveguide. Derive the field equations for this mode in the partial differential equation form showing the different steps. Discuss the solution of these equations to derive TM_{mn} field equations in rectangular waveguides. Consider a lossless dielectric.

(b) Derive the expressions for the average power transmitted through a rectangular waveguide for both TE_{mn} and TM_{mn} modes.

(c) An air-filled rectangular waveguide of inside dimensions 1.5x3 cm operates at 12 GHz. Find the cutoff frequencies for TE_{01} , TE_{10} ,TM_{11} and TE_{11} modes.

[10+6+4]

Q3. (a) Show by means of a suitable diagram the propagation of light rays in a step index optical fiber. Define the numerical aperture. What is the significance of numerical aperture ? Derive an expression for the multipath time dispersion of the fiber.

(b) Show the different types of optical fiber by means of a suitable diagram.

(c) Calculate the multipath time dispersion for an unclad glass fiber of refractive index 1.45. Calculate also the multipath time dispersion when the fiber is cladded with glass having the refractive index 1.41. Calculate the light gathering powers of these two fibers, one unclad and the other cladded as mentioned earlier. Compare these two fibers.

[8+7+5]

(CONTINUED IN PAGE 2)

Q4. (a) Distinguish between (I) Directive gain and directivity (ii) Radiation resistance and loss resistance .

(b) If the radiation resistance is 3.5 times the total loss resistance then calculate the antenna effeciency . Assume the antenna to be a resonant one.

(c) TE mode in cylindrical waveguide. A TE_{11} mode is propagating through a circular waveguide. The radius of the guide is 4.5cm, and the guide contains an air dielectric.

(i) Determine the cutoff frequency

(ii) Determine the wavelength λ_g in the guide for an operating frequency of 4 GHz.

(iii) Determine the wave impedance Z_g in the guide.

Given $k_c a = 1.841$

Where k_c and a are the cutoff wave number and the radius of the guide. The direction of propagation is the positive z direction.

(d) Explain the Cassegrain feed for the paraboloid reflector of a microwave antenna. Calculate the beamwidth between the nulls of a 3m paraboloid reflector used at 10 GHz. Find the effective radiated power of the antenna if the actual power fed to the primary antenna is 1.2 watts.

[4+2+6+8]

Q5. (a) Draw the detailed block diagram of a pulsed radar set and explain the diagram.

(b) Calculate the maximum range of a radar system which operates at 2cm (wavelength) with a peak pulse power of 500kW, if its minimum receivable power is 10^{-13} W, the capture area of its antenna is $5m^2$, and the radar cross-sectional area of the target is $20m^2$.

(c) What is a parasitic element in an antenna ? Describe the Yagi-Uda antenna.

(d) Calculate the input impedance of a half- wave folded dipole with equal diameter arms. The input impedance of a straight half-wave dipole is 72 ohms. The same power is applied to both the dipoles.

[7+5+6+2]

Q6. (a) Explain Manchester encoding and differential Manchester encoding. Show them in a diagram for the bit stream 0001110100. Assume the line is initially in the low state. Mention the advantages and the disadvantages of each encoding.

(b) Show the IEEE standard 802.3 frame format and explain the 802.3 MAC sublayer protocol.

(c) What is the baud rate of the standard 10-Mbps 802.3 LAN ?

(d) Explain the binary exponential back off algorithm in an 802.3 LAN.

[6+7+3+4]

Q7. (a) Explain the IEEE standard 802.4 token bus MAC sublayer protocol. Show the frame format.

(b) Compare IEEE 802.3,802.4 and 802.5 standards in brief. What are the factors other than the performance that are important when making a choice between 802.3 and 802.4 ?

(c) Explain the token ring MAC sublayer protocol. Show the token format and the data frame format.

(d) A 4-Mbps token ring has a token-holding timer value of 10msec. What is the largest frame that can be sent on this ring ?

[6+5+6+3]

Q8. Write short notes on any four:

(a) DQDB (b) Superheterodyne receiver (c) TCP/IP (d) Satellite communication and its applications (e) Two-cavity Klystron (f) Transmission line and its parameters (g) FM stereo transmitters and receivers (h) End -fire array antenna.

[20]

END OF QUESTION PAPER

The University of Zambia
School of Engineering

Semester 2 Final Examinations – January 200[illegible]

EG269: Information Technology

Instructions:
Time: Three hours

Answer five questions in total: Three questions from Section A and two questions from Section B

SECTION A

Answer THREE (3) ONLY questions ONLY from this section

Question 1
Distinguish between
a) MICR and OMR
b) Joystick and a touch screen
c) Dot matrix and Laser printer
d) ROM and EPROM
(Total: 20 Marks)

Question 2
a) Briefly describe the purpose of each of the following software.
   i) Network operating System
   ii) Compiler
   iii) E-Mail
   iv) Spreadsheet
   Give an example for each of the above types of software (16 Marks)
c) A memory location contains the hexadecimal value 35. Express this value as:
   i) a decimal number
   ii) Binary Coded Decimal (BCD)
   (4 Marks)
(Total: 20 Marks)

Use C++ to answer Question 3 and 4

Question 3

a) With regard to programming, distinguish between the following concepts

i) Simple and Complex data types

ii) Array and Record

iii) Deterministic and non-deterministic loop (12 Marks)

b) Use a deterministic loop to display even numbers between 0 and 100 (8 Marks)

(Total Marks 20)

Question 4

a) Distinguish between

i) Class and an object

ii) Protected and Public data items

iii) Constructor and destructor member function

iv) Black box and White box testing

(12 Marks)

b) If a, b and c are integers, what is the value of the following expressions given a=3, b=11 and c=9

i) b%3

ii)(a>b) || (c!=a) (4 Marks)

c) What will the following code fragment print out?

```
var1=20;
cout << var1--;
cout << '\n'<<++var1;
```

(4 Marks)

(Total Marks 20)

SECTION B

Answer THREE (3) ONLY questions ONLY from this section

Question 5

The company database keeps track of a company's employees, departments and projects

1. The company is organized into departments. Each department has a name, a number and an employee who manages the department. We keep track of the start date when that employee started managing the department. A department may have several locations .

2. A department controls a number of projects, each of which has a name, number and a single location.

3. We store each employee's name, Social Security Number, address, sex, salary and birthdate. An employee is assigned to one department, but may work on several projects which are not necessarily controlled by the same department. We keep track of the number of hours per week that an employee works on each project. We also keep track of the direct supervisor of each employee.

4. We want to keep track of the dependants of each employee for insurance purposes. We keep each dependants,s name, sex, birthdate and relationship to the employee

Required
a) Identify the entities and the corresponding attributes in this database (8 Marks)
b)List the relationships and the associated attributes if any (4 Marks)
c) Draw an entity relationship diagram based on the information above (8 Marks)
(Total Marks 20)

Question 6
Simple data types used to represent attributes of entities include character, integer, float, Boolean and date among many others.
a) Briefly explain the use of each of the data types identified above.
(5 Marks)
b) What data type would be appropriate to represent the following attributes of a car:
Owner name Char
Manufacturer
Model Int
Year of manufacture
Maximum speed
Fuel Consumption
Seats Int
(7 Marks)
c) Explain at least four limitations of file based systems (8 Marks)

(Total: 20 Marks)

Question 7
a) Distinguish between
i) Data Manipulation Language and Data Definition Language (4 Marks)
ii) Database and Database Management System (4 Marks)
b) Write down the various stages involved in database development (12 Marks)
(Total Marks 20)

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
UNIVERSITY SEMESTER II EXAMINATIONS 2003
(JANUARY 2004)

EG 475 - ENGINEERING MANAGEMENT AND SOCIETY I

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. 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 FOUR QUESTIONS.

Question 1

a) The shares in national income of the Zambian agricultural, industrial and services sectors are respectively 18%, 34%, and 48%. The share of the Zambian manufacturing sector in national income equals 12%. In total, 18.5% of the formal sector labour force is employed in industry. Would Sutcliffe consider Zambia as an industrialised country? Explain your answer. (10 Marks)

b) List the items that a country must consider in order to arrive at an optimum mix of elements of an industrial strategy. (5 marks)

c) In the 20th century, a number of developing countries adopted an *import substitution industrialisation trade strategy*. However, this did not yield desired results. Give 4 reasons that led to the failure of this strategy, giving a brief explanation for each. (5 marks)

Question 2

a) Which options does a developing country have to accumulate capital? (6 marks)

b) Explain the following:
i) Savings gap
ii) Foreign exchange gap

(4 marks)

c) In an intensely competitive environment, the introduction of a continuous stream of a new product is essential to a firm's profitability. With the aid of sketches, give 3 ways in which you could either maintain or increase sales. (10 marks)

Question 3

a) In the period after Independence the government embarked on a programme of industrialisation based on policy of import substitution. In promoting self-reliance,

domestic industries were encouraged to produce manufactured goods. This support operated through putting tariff barriers on imports, keeping close government control over foreign exchange and restricting access to many multinational enterprises.
In the 1990s the newly elected government of President Frederick Chiluba, with the assistance of the IMF and World Bank and the conditions laid down in their Structural Adjustment Programmes and stabilisation policies, adopted an alternative strategy for industrialisation.

i) What were the aims of this strategy? (5 marks)

ii) Outline the policies that were introduced. (5 marks)

b) What is Appropriate Technology? (3 marks)

c) What factors would you consider when determining the appropriateness of a particular technology (7 marks)

Question 4

a) Describe the criteria used by R.B Sutcliffe to define an industrialised country. (10marks)

b) Explain why he used these criteria. (5 marks)

c) Give your criticism with regard to the approach by Sutcliffe. (5 marks)

Question 5

Technological innovation is one of the most important contributory factors underlying internationalisation and globalisation of economic activities.
Briefly outline the major innovations that have influenced today's global economy.
(20 marks)

SECTION B: ATTEMPT ANY ONE QUESTION

Question 6

Each of the sub-questions numbered 6.1 to 6.6 inclusive has only one right answer. On the answer booklet provided, write a letter (A, B, C, or D) of your chosen correct answer to each sub-question.

6.1 Which ONE of the following best describes the opportunity cost to society of building a new school?
A) The increased taxation to pay for the school.
B) The money that was spent on building the school.
C) The other goods that could have been produced with the resources used to build the school.
D) The running cost of the school when it is opened.

(3 marks)

6.2 The term "mixed economy" implies all of the following conditions EXCEPT which ONE?

A) The allocation of resources is mainly through the price system.
B) Producers have an incentive to advertise their products.
C) There is some government planning of the use of resources.
D) All industries have a mix of small and large companies.

(3 marks)

6.3 In a market economy the price system provides all of the following EXCEPT which ONE?

A) An estimation of the value placed on goods by consumers.
B) A distribution of income according to needs.
C) Incentive to producers.
D) A means of allocating resources between different uses.

(3 marks)

6.4 The demand curve for a good will shift to the right

A) If there is an increase in the supply of the good.
B) If the price of the good falls.
C) If consumer incomes rise.
D) When the price of a substitute good falls.

(3 marks)

6.5 If the demand for a good is price inelastic, which ONE of the following statement is correct?

A) If the price of the good rises, the total revenue earned by the producer increases.
B) If the price of the good rises, the total revenue earned by the producer falls.
C) If the price of the good falls, the total revenue earned by the producer increases.
D) If the price of the good falls, the total revenue earned by the producer is unaffected.

(4 marks)

6.6 Which ONE of the following will tend to make the supply of labour to a particular occupation more elastic?

A) Low skill requirements.
B) The need to pass professional examinations.
C) High wage rates.
D) A legal minimum wage.

(4 marks)

Question 7

Why is "Scarcity" such an important concept in economics? (20 marks)

END OF EXAMINATION

The University of Zambia
School of Engineering
EG 575-Engineering, Management and Society 2003
Semester II Final Examination, January 2004

TIME: THREE (3) HOURS **Closed Book**

Instructions

Answer **Five** (5) questions, **One** (1) Question from **Section A**, and **ALL** Questions in **Sections B and C**. Use separate answer scripts for each section. All questions carry equal marks (20 marks).

SECTION A

Question 1

The term appropriate human resources refers to individuals in the organization who make a valuable contribution to management goal attainment. Briefly discuss the four major steps followed by management when filling both managerial and non managerial openings.

Question 2

Discuss in detail how leadership affects motivation.

Question 3

(A) Management training makes much use of role-playing. What are the benefits that can be achieved from this training technique rather than study.

(B) What are the advantages for:

(i) The company, and

(ii) The employee

using a graded payment rather than a free position scheme

SECTION B

Question 4

Outline the essential elements for a valid contract to legally subsist.

Question 5

Describe in detail the classification of Law in Zambia.

SECTION C

Question 6 (10 + 10)

(A) In feasibility studies, a feasibility analysis is often carried out. Discuss the following terms
- (i) Need analysis
- (ii) Financial analysis
- (iii) Project impact
- (iv) Process work

(B) Define or explain the following terms
- (i) Full network analysis
- (ii) Milestones
- (iii) Direct costs
- (iv) Overhead recovery
- (v) Absorption by product

Question 7 (12 + 8)

(A) The following are multiple choice questions or simply True/False statements.

(i) The affirmative purpose of planning is to increase the degree of organizational success. (T/F)

(ii) Which of the following is not one of the purposes of planning:
(a) systematic; (b) protective; (c) affirmative; (d) coordination; (e) fundamental.

(iii) The following is a potential disadvantage of planning:
(a) too much time may be spent on planning; (b) an inappropriate balance between planning and other managerial functions may occur; (c) some important activities may be neglected; (d) incorrect use of the planning function could work to the detriment of the organisation; (e) all of the above.

(iv) The first major step in the planning process, is:
(a) developing premises; (b) listing alternative ways of reaching organisational objectives; (c) stating organisational objectives; (d) developing plans to pursue chosen alternatives; (e) putting plans into action.

(v) A subsystem is a system created as part of the process of the overall management system. (T/F)

(vi) The purpose of the planning subsystem is to increase the effectiveness of the overall management system through which of the following:
(a) systematizing the planning function; (b) more effective planning; (c) formalizing the planning process; (d) integrating the planning process; (e) none of the above.

(B) Discuss and illustrate the three managerial skills.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS

January 2004

ENGINEERING MATHEMATICS II - EM 312

TIME ALLOWED: THREE (3) HOUR

INSTRCTUIONS: (i) Answer Question 7 and any other **four**.
(ii) All questions carry equal marks
(iii) Show all necessary working

---

1. Given two points P(4 , -2 , 12) and Q (6 , 2, -4)

find the (i) The equation of a vector
(ii) Parametric form of the equation of the vector
(iii) Symmetric equations of a line joining two points

(b) If a point $(\alpha,10,\Gamma)$ lies on the line in (ii), find α and Γ.

(c) Identify the Given surface $x^2 + 8x - 2y^2 + 8y + z^2 = 0$

How would this surface look like in the following planes:
(i) xy plane
(ii) xz plane
(iii) yz plane.

(d) Find the limits of the integral on the RHS

$$\int_0^2\int_0^6\int_0^{4-x^2} f(x,y,z)dzdydx = \iiint f(x,y,z)dxdzdy$$

2. (a) Find the directional derivative of f (x,y) = xy^2 in the direction of $2i + 3j$ at a point (4,-1)

(b)
(i) Find the center of mass of a region bounded by $y = x^2$ and the line $y = 1$, $\rho(x,y) = y + 1$
(ii) Sketch the region cut from the first quadrant by the curve $x^2 + y^2 = 1$ and evaluate its area

(c)
(i) Show that the line of intersection of the planes $x + 2y - 2z = 5$ and $5x - 2y - z = 0$ is parallel to the line

$x = -3 + 2t$, $y = 3t$, and $z = 1 + 4t$

(ii) The vectors $2i + 3j$, $4i + j$, and $5i + yj$ have their initial points at the origin. Find the value of 'y' that will make the vectors terminate on a common straight line.

3. a)

(i) Show that if the necessary partial derivatives of the components of

$F = Mi + Nj + Pk$

are continuous, then the div(CurlF) = 0

(ii) Use the result in (i) to show that

$$\iint_S \nabla \times F.nds = 0$$

For any surface to which the Divergence theorem applies.

b) Suppose R is a region in the xy-plane, C is its boundary, and the area of R is given by

$$A(R) = \oint_C \frac{1}{2}(xdy - ydx)$$

Suppose the equations $x = f(u,v)$, $y = g(u,v)$ map R and C in a continuous and one-to-one manner onto a region R' and curve C', respectively, in the uv-plane. Use Green's formula to show that

$$\iint_R dxdy = \iint_{R'} \begin{vmatrix} f_u & f_v \\ g_u & g_v \end{vmatrix} dudv = \iint_{R'} \left(\frac{\partial f}{\partial u} \frac{\partial g}{\partial v} - \frac{\partial f}{\partial v} \frac{\partial g}{\partial u} \right) dudv$$

c)

(i) Find the centriod of the region between the parabola $x + y^2 - 2y = 0$ and the line $x + 2y = 0$.

(ii) Change the following double integral to an equivalents double integral in polar coordinates and sketch the region of integration.

$$\int_{-a}^{a} \int_{0}^{\sqrt{a^2 - y^2}} xdxdy$$

4.

a) Describe the characteristic of a Normal distribution.

b) Telecel uses a call center to handle reservations made by telephone. The calls received in any week have been found to be normally distributed with a mean of 20000 and a standard deviation of 4000. What is the probability that in a week, the company receives:

i) More than 15,000 calls?

ii) Less than 12,000 calls?

iii) Between 12,500 and 17,300 calls?

iv) In how many weeks of the year would it be expected to receive more than 18,200 calls?

c) A Graduate from the University of London, department of Mechanical and Robotics Engineering is looking for a job. He is called for interviews as Production Engineer, Fabrication Engineer and Automobile Engineer. He considers that the probability for post of Production Engineer is 0.6, the corresponding probabilities for the posts of Fabrication Engineer and Automobile Engineer are 0.4 and 0.8 respectively. You may assume that the probability of getting one post is independent of the probability that he will be offered the other posts. Calculate the probability that he will be offered

(i) All the three posts

(ii) At least one post

(iii) Exactly one post

d) It is known that 10% of calculators manufactured by a certain firm are defective. Random samples of five calculators are selected from a large lot. Calculate the probability that at most two calculators are defective.

5. (a) Calculate the work done when a force field $F(x,y) = xyi + 2(x^3 - y)j$ moves a particle around the unit circle in the counterclockwise direction.

(b) Evaluate

$$\int_0^1 \int_0^{\sqrt{1-x^2}} \int_{\sqrt{x^2+y^2}}^{\sqrt{2-x^2-y^2}} z^3 \, dz dy dx$$

© Find the centroid of "ice cream- cone shaped" region below the sphere $x^2 + y^2 + z^2 = z$ and above the cone $z^2 = x^2 + y^2$.

(d) Change the order of integration after evaluating

$$\int_0^1 \int_0^y \int_0^x x^2 \, dz dx dy$$

For the following

i) $\iiint x^2 \, dx dy dz$

ii) $\iiint x^2 \, dy dz dx$

6.

a) Show that the vector field is exact

$$F(x,y,z) = \left(\frac{1}{x+2y+3z}\right)i + \left(\frac{2}{x+2y+3z} + y^2\right)j + \left(\frac{3}{x+2y+3z}\right)k \quad \text{is exact}$$

And use the theorem to show that $\int_C F(x)dx$ is independent of the path taken.

b) Let W be the solid enclosed by the ellipsoid

$$\left(\frac{x^2}{a^2}\right) + \left(\frac{y^2}{b^2}\right) + \left(\frac{z^2}{c^2}\right) = 1$$

then the volume of $V_w = \iiint_W dxdydz$

Compute the volume by making the transformation x = au, y = bv, z = cw (Hint: in the uvw coordinate system you get a sphere)

c) Using stokes theorem evaluate the line integral

$\oint_C F.dx$ Where $F(x,y,z) = (x+2y)i + (y-3)j + (z-2)k$

Where C is the unit circle in the plane z = 2.

7.(a) The overall production output of Dell computer macro chips (which is assumed to follow a Poisson distribution) is known to record 1% defects. In a random sample of 1200 components, determine the probability of including

i) 4 or less defects

ii) 10 or more defects

(b) A large stock of resistors has 80% within tolerance values. If 7 resistors are drawn at random, and follow a Binomial distribution, determine the probability that

i) At least 5 are acceptable

ii) All 7 are acceptable

(c) A company produces an engine component for an aircraft industry. The average weight of this component is 12 kg with a standard deviation of 2 kg. The **specification weight limits relating to this component are 10 kg to 13.5 kg**. If the components weigh less than 10 kg, they are scrapped. If they weigh more than 13.5 kg but less than 14 kg they are re-machined down to size at an extra cost of $ 600. Any component weighing over 14 kg are also scrapped. Components are produced in batches of 200. (You may assume that the weights of components follow a normal distribution).

You are required to:

(i) Find the probability that a component will weigh between specification limits.

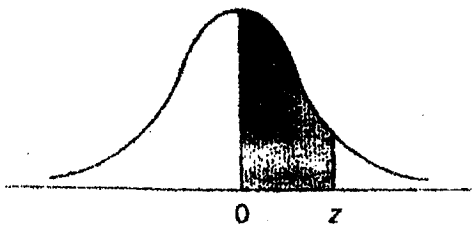
(ii) Find the probability that a component will need re-machining.

(iii) Calculate the number of components that could be scrapped per batch.

(iv) Calculate the extra cost of machining per batch.

END OF EM 312 ENGINEERING MATHEMATICS II

CURVE AREAS



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Source: Abridged from Table I of A. Hald, *Statistical Tables and Formulas* (New York: John Wiley & Sons, Inc.) 1952. Reproduced by permission of A. Hald and the publisher.

The University of Zambia
School of Engineering
Department of Geomatic Engineering

GE212 Final exam – 5th January 2004

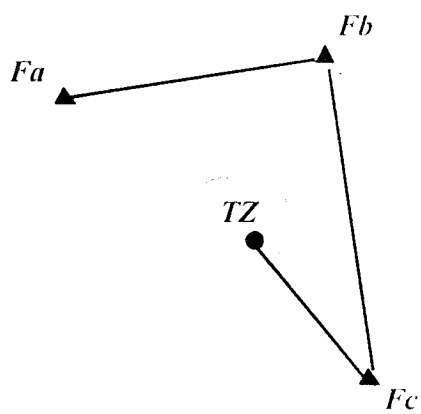
Instructions: *This paper is divided into three sections.*
Answer all questions except Section B, Answer 3 or 4.
Remember to answer each section in a ***separate answer booklet.***
Time allowed: 3 hours

Section A: Introduction to Geomatics

Question 1

During a survey to effect a subdivision of a property in Kabulonga. a minute theodolite was correctly mounted above point *Fc* in order to determine the plane coordinates of point *TZ*. The distance *Fc-TZ* was measured thrice along the slope with a tape as 64.467m, 64.466m and 64.465m. The known coordinates of *Fa* and *Fb* are:

Fa	3749.497m	987.879m
Fb	3699.464m	976.657m



The horizontal angles from point *Fc* are observed in two rounds and for the vertical angle only one FL and FR reading are taken.

Horizontal angles (Degrees)

Pnt	Readings		Simple Mean	Reduced Mean	Remarks
	FL	FR			
Fb	00°00'10"	180°00'14"			
TZ	07°44'38"	187°44'39"			
Fb	60°00'05"	240°00'07"			
TZ	67°44'33"	247°44'35"			

Vertical angles

Pnt	Readings		Reduced FL	Reduced FR	Mean
	FL	FR			
TZ	84°47'57"	275°11'59"			

i) Complete the booking forms.

[5 Marks]

ii) Calculate the co-ordinates of point *TZ*, given that the bearing and horizontal distance of *Fc* from *Fb* are 347°21'40" and 82.909m respectively

[10 Marks]

iii) With the aid of diagrams explain the concept of transitting the theodolite. Why is it necessary to transit the telescope when measuring angles?

[10 Marks]

Question 2

(a) A nominal distance of 30m was set out with a steel tape from point *A* to point *B*. The tape was in catenary (with sag) under a pull of 200N and at a mean temperature of 17 °C. Point *A* was 0.68m below point *B*, which was 250.00m above mean sea level. Determine the horizontal distance between the points, reduced to mean sea level. The tape was standardised in catenary, with a pull of 178N and a temperature of 20 °C. It further had a mass of 0.026Kg/m and a cross sectional area of 3.25mm^2. You are given that the coefficient of linear expansion is 0.0000009 per °C, Young's modulus is 155KN/mm^2 and the radius of the earth is 6367km.

[15 Marks]

(b) A level survey is carried out around a particular area for vertical control works. Points 1, 2, 3, 4 and 5 are pegs for which the Reduced levels are determined. Point 4 is a centreline point on a road at which a cross-section has to be made. This is done in the same survey. The cross-section points are 4, 4a, 4b, 4c and 4d. Their distances from the centreline are indicated in the column for remarks in table 1.

Name: Instrument:
Date: Weather:

LEVELLING

POINT	READINGS			DISTANCE		HEIGHT DIFF		REDUCED LEVEL	REMARKS
	BS	IS	FS	BS	FS	RISE	FALL		
1	1.576			49.6				1165.613	BM
2	2.010		0.894	46.8	49.1	0.682		1166.295	CP
3	1.097		1.131	38.3	47.4	0.879		1167.174	CP
4	1.045		1.786	30.1	38.2		0.034	1167.140	CP
4a		2.168					1.123	1166.017	-6 m
4b		1.087				1.051		1167.068	-3 m
4c		1.140					0.053	1167.045	+3 m
4d		2.239					1.099	1165.946	+6 m
5	0.962		1.179	65.6	39.5	1.060		1167.026	CP
1			1.712		56.1		0.750	1166.256	BM
Σ	6.610		6.702	230.4	230.3	3.702	3.059		

i) Complete the booking form.
ii) Calculate the misclosure in the loop and state whether or not it is acceptable (assuming σ = 20mm).
iii) Give a list of the adjusted RL's of the five pegs.

[10 Marks]

Section B – Photogrammetry-Answer only one question from this section

Question 3 (5+12+8)

a. Define the following terms: (2+2+1)

i. Vertical photograph
ii. Low oblique photograph
iii. High oblique photograph

b. Points A and B are at elevations 223 m and 162 m above datum respectively. The photographic coordinates of their images on a vertical photograph are

	X (mm)	Y (mm)
A	-52.35	-48.27
B	40.64	43.88

What is the horizontal length of the line AB if the photo was taken from a height of 1510m above datum with a 152.4mm focal length camera?

c. Mention and describe any four products of aerial photogrammetry.

Question 4 (3+5+4+5+3+5)

a. Name three major components of an aerial camera. (3)

b. Aerial photos of a project area were taken at scale 1:24,000 with a 153mm focal length camera. The end lap was 65% while the side lap was 30%.

Calculate:

(i) The flying height of the place was 1584m above mean sea level,

(ii) Ground dimensions covered by a 230mm by 230 mm picturdformat.

(iii) The ground spacing between exposure stations,

(iv) The ground spacing between the flight lines,

(v) The total ground area expressed in hectares covered by a pair of overlapping photographs.

Section C - Cartography

Question 4

a) A map projection is a system that gives a relation between a position of a point on the earth's surface and its position on the map.

i. Explain the differencebetween an orthogonal and a central perspective projection. Give an example of each.

[4 Marks]

ii. Why must distortions be kept to a minimum in a projection?

[4 Marks]

b) The whole Zambian territory is mapped on topographic maps at various scales.

i. What are topographic maps?

[3 Marks]

ii. What are derived topographic maps? Give one Zambian example.

[4 Marks]

c) A GIS involves data manipulation and analysis. List and briefly explain any two spatial operations?

[10 Marks]

End of Exam

Instructions: *Use the tables below to answer question 1.However, remember to attach the completed tables to your answer booklet for section A.*

Horizontal angles (Degrees)

Pnt	Readings		Simple Mean	Reduced Mean	Remarks
	FL	FR			
Fb	00°00′10″	180°00′14″			
TZ	07°44′38″	187°44′39″			
Fb	60°00′05″	240°00′07″			
TZ	67°44′33″	247°44′35″			

Vertical angles

Pnt	Readings		Reduced FL	Reduced FR	Mean
	FL	FR			
TZ	84°47′57″	275°11′59″			

Instructions: *Use the table below to answer question 2 (b). However, remember to attach the completed table to your answer booklet for section A.*

Name:
Date:

Instrument:
Weather:

LEVELLING

POINT	READINGS			DISTANCE		HEIGHT DIFF		REDUCED LEVEL	REMARKS
	BS	IS	FS	BS	FS	RISE	FALL		
1	1.576			49.6				1165.613	BM
2	2.010		0.894	46.8	49.1				CP
3	1.097		1.131	38.3	47.4				CP
4	1.045		1.786	30.1	38.2				CP
4a		2.168							-6 m
4b		1.087							-3 m
4c		1.140							+3 m
4d		2.239							+6 m
5	0.962		1.179	65.6	39.5				CP
1			1.712		56.1				BM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF GEOMATIC ENGINEERING

2nd SEMESTER FINAL EXAMINATIONS 2002/2003 - JANUARY 2004

GE 215 - INTRODUCTION TO COMPUTING FOR GEOMATICS

Instructions: **Answer all the questions. Use separate answer booklet(s) for each section.**

Total: 100 points **Duration: Three Hours**

SECTION A

Question 1 (2+4+4+4+3+3)

a) List two features that a Personal Computer needs to have for it to be used as a server.
b) What is computer topology? Sketch the three common ones namely: Bus, Star and Ring.
c) List four resources that networked computers can share.
d) List four reasons why computers are networked.
e) Mention three bounded media commonly used in networking of computers.
f) List three advantages a peer-to-peer network has over a server-client network.

Question 2 (6+8+6)

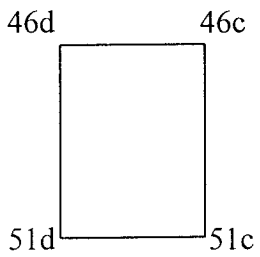
a) What is meant by the following terms:
   i) Relative frequency of occurrence of an event?
   ii) Random event?
   iii) Error propagation?
b) The position of a point B is determined by the radial distance r=200 m with σ_r=0.5 m, and the azimuth angle β=60°, with σ_1=0°30′. Compute rectangular co-ordinates E, N and the associated covariance matrix for point B. (Assume r and β to be uncorrelated.)
c) Describe the three commonly used measures of reliability of survey measurements.

SECTION B

Question 3 (8+12)

(a) Reproduce the following Microsoft Word document (attached). **Font:** Tahoma, **Font style regular/italics/bold**, as given. **Font size 12**. Save the document under your surname, i.e. file name is "your surname", "Tutu".

(b) Use Microsoft Excel to compute (i) the area, (ii) the distances and bearings between subsequent beacons, i.e. 46d-46c; 46c-51c; 51c-51d; and 51d-46d. The sketch below can be of use.



		Plot 51				
beacon		**Y**	**X**	**distance**	**Bearing (degrees)**	
46d		4217.79	5552.03			
46c		4225.85	5565.13			
51c		4235.22	5559.37			
51d		4227.16	5546.27			
46d		4217.79	5552.03			
			Area =		**Square Metres**	

NB: Formulae for area, distance and bearing is given as:

Area from coordinates = $\frac{1}{2}\{\sum_{i=1}^{n} X_i(Y_{i+1} - Y_{i-1})\}$, where n is number of beacons in this case four (4).

Distance = $\sqrt{(X_{i+1} - X_i)^2 + (Y_{i+1} - Y_i)^2}$; and Bearing = $tan^{-1}(\Delta Y/\Delta X)$

Title: Deformation Monitoring Using Satellite (GPS) and Conventional Surveying

1. Introduction

Open cast mines often suffer from slope failures due to instability. Thus monitoring of ground movements is of prime importance. Reliable and accurate geodetic networks are required for deformation monitoring.

Deformation monitoring consists of four stages: specification, design, implementation and analysis.

Specification of the requirements of the monitoring scheme can be problematic. Questions such as "to what confidence level is the movement to be detected?" "Are all points to be monitored to the same accuracy?" " Is the direction of the movement required?" " Is absolute or relative movement required?" Only after these questions are answered can the design commence.

Monitoring networks may be classified thus:

i. *Absolute network:* in which one or more points may be considered stable, i.e. outside the deforming zone or structure, thus providing a reference datum against which changes in coordinate values can be assessed.
ii. *Relative network*: in which all the points are assumed to be subject to deformation, thus having no stable reference datum.

2. Problem Definition

To study and if possible, improve on, the existing monitoring networks at one of the active open cast mines –specifically Nchanga Open Pit in Chingola.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF GEOMATIC ENGINEERING

Second Semester Examinations – January 2004
GE 352 - Land Law and Land Resource Management

Part I Land Law Component

Instructions: *Answer Question one (1) and any other two (2) questions*
Answer in a separate booklet

Question 1
Outline and define the two tests applied when determining whether a chattel has become a fixture

Question 2
Outline the classification of property.

Question 3
What is meant by the doctrine of tenures and estates?

Question 4
Define a profit and outline its essential requirements.

Question 5
Discuss the purpose of the following pieces of Legislation:
(i) The Lands Act
(ii) The Lands and Deeds Registry Act
(iii) The Lands Acquisition Act
(iv) Town and Country Planning Act
(v) Common Leasehold Act
(vi) Land Survey Act

GE 352 QUESTIONS

Part II: Planning component

ANSWER ALL QUESTIONS. ANSWER ALL QUESTIONS IN YOUR OFFICIAL ANSWER BOOKLET

QUESTION 1 (10 points)

(a) In physical planning of settlements several levels of layout plans can be distinguished. Assign the scales given in table 2 to the plans given in the table 1:

Table 1: Plan types

Structure plans
Principal layouts
Layout of individual villages/towns
Detailed layout of central service areas and residential areas
Detailed layout of house plots and houses

Table 2: Scales

1:50 - 1:100
1:10,000 – 1:25,000
1:50,000 – 1:100,000
1:500 – 1:2,000
1:5,000 – 1:10,000

(b) State whether the following statements are true or false:

1. Major inputs to pysical planning of layout of settlements are basic data, development principles, and planning standards.
2. Design criteria are easier to apply for new settlements than in case of existing ones where compromises are inevitable.
3. Physical planning of service centres involves a search for the optimum balance between high land use rates and sufficient reserves for expansion.
4. Detailed layout of residential areas shows the arrangement of house plots, adjoining farm plots (if any), parking places, roads and footpaths, and location of houses.
5. Settlement units are parts of development schemes and consist of several villages grouped around a service centre.

QUESTION 2 (5+4+3+3 points)

(a) State whether the following statements alluded to regional/physical planning are true or false:

1. Physical planning is not necessary, it interferes with the free market, and in general the freedom to do things the way we want.
2. Planning of a bridge is not different from the planning to upgrade a township e.g. Kalingalinga.
3. Regional planning focusses on reducing inter- and intra-regional economic imbalances.
4. Regional/physical planning in Zambia is guided by the Town and Country Planning Act.
5. Physical planning focusses on the optimum arrangement of space with respect to market efficiency, equity and conservation principles.

(b) Complete the following sentences (*write in your answer book*):

1. In Zambia, the Town and Country Planning Act provides for
   (i).....

   (ii) .....

2. In Zambia, the Building regulations are intended to
   .....

(c) Rearrange the following words to describe what planning is in general:
preparing, decisions for action, a process of, directed at achieving goals, a set of, by optimal means, in the future

(d) Apply the following sets of words to how uncertainty in planning can be resolved/minimised:

(i) consultation/coordination
(ii) popular partcipation/consultation
(iii) data collection/re

1. resolving uncerntainty in knowledge
2. resolving uncertainties as to the future intentions of other planning agencies/organisations
3. resolving uncertainities as to the appropriate value judgement

University of Zambia
School of Engineering
Department of Geomatic Engineering
Box 32379
Great East Road Campus

GE 431 – Photogrammetry II Semester Exam, January 2004

Instructions:

Answer all questions in section A
Answer ONLY two (2) questions from section B
Time allowed: Three (3) hours only

SECTION A:

Question A1:

I. List five (5) major differences between Aerial and Close Range Photogrammetry **(5)**

II. A computerisation project in the Lusaka City Council focused on mapping the utility (water, road, electric and telephone) network of the city in order to create a GIS System capable of supporting strategic, management and operational activities of the council chose to use Photogrammetric (aerial mapping) instead of field survey method to successfully accomplish the task;

a) Explain the motivation for the choice of the above method with respect to the following project parameters: Scope, Time, Money and Quality **(10)**

b) Given a desirable photography scale of 1:5000 for the above project of which Lusaka City lies about 1260m above mean sea level, what is the most appropriate camera focal length (give reasons for your choice) to be used and the resulting flying height above datum of the aircraft **(5).**

Question A2:

I. The Spatial Similarity Transformation equation used for absolute orientation of a model is defined as follows;

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} Xo \\ Yo \\ Zo \end{bmatrix} + k\, R_{\Omega\Phi K} \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix}$$

What is the meaning of all the parameters in the equation above **(7).**

II. The following parameters are given for the above equation: k = 0.99999776677,

$\Omega = 0.009999^{\circ}$ $\Phi = 25.0007877^{\circ}$ $K = 90.0095656^{\circ}$;

x' = 178.909999m y' = 209.000445m z' = 900.000112m

Xo = 8230307.090m Yo = 533456.213m Zo = 1280.009m

a) Calculate the ground coordinates of the model point represented above based on the $\Omega\Phi K$ sequence of rotations **(10).**

b) How many control points are needed to solve the absolute orientation problem in theory and practice. Give reasons for your answer **(3).**

Question A3:

I. Explain the principles of the two methods used for calculating the corrections for lens distortions during photogrammetric mapping. Use appropriate diagrams where applicable **(10)**.

II. Describe the main parts of a mechanical projection stereoplotter and explain their functions in the photogrammetric process **(10)**

SECTION B:

Question B1:

Given the Rotation Design Matrix A whose elements are as follows;

A_{11} = 0.9996388 A_{12} = -5.853594E-03 A_{13}= -2.623424E-02
A_{21} = 5.768582E-03 A_{22} = 0.9999779 A_{23}= -3.31498E-03
A_{31} = 2.625307E-02 A_{32} = 3.162455E-03 A_{33} = 0.9996504

And the following observation equation AX = L + V representing the photogrammetric process;

I. Calculate the normalised matrix of A derived from the observation equation above given that equal weights are applied to all observations **(15)**

II. Explain the principle and significance of the Coplanarity condition with the help of a clear diagram **(5)**

Question B2:

I. What are the major differences between the following? **(10)**
   i. Model and Photo Coordinates
   ii. Optical and Mechanical projection stereoplotters
   iii. Orthophoto and Line map
   iv. Monocomparator and Stereocomparator
   v. Relative Orientation and Absolute Orientation

II. Classify the main approaches for aerial triangulation and explain the major differences in the approaches **(10)**

Question B3:

I. Using well-labelled diagrams show the two cases of relative orientation using the single projector and independent model methods? **(10)**

II. (a) What are the main principles of Online and Offline orthophoto production systems **(6)**
(b) What are the major advantages of Online and the Offline orthophoto production system? **(4)**

University of Zambia
School of Engineering
Geomatic Engineering Department
GE472-Principles of Surveying II
University Examinations-January 2004

Instructions:

Section A: 1 compulsory Question	25 marks
Section B: Attempt 1 out of 2 Questions	25 marks
Section C: Attempt 2 out of 3 Questions	50 marks

Time: 3 hours

Section A: Compulsory

Question 1

a. Explain how the atmosphere affects distances measured with the electromagnetic distance-measuring device (EDM). (8) [Details of Barrel and Sears or Cauchy equations not required]

b. To check the accuracy of your EDM, it was used on a baseline known to be 100.000m and it gave 100.028m. On a separate baseline that was known to be 2402.023 it gave 2402.696m. If you are told that your instrument is likely to suffer from only one type of error:
   i. What error would you suspect? (1)
   ii. What is the likely cause of this error? (3)
   iii. If a reading of 789.012 m is taken with the same instrument what would be the corrected value? (3)

c. Give a brief cost/benefit analysis of electronic versus analogue survey equipment. (6)

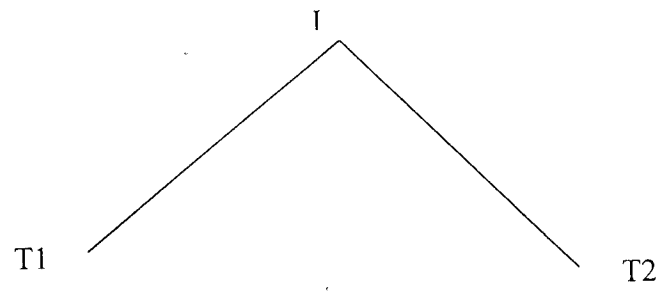
d. Explain the use of a ***scale factor*** in coordinate computation (give examples) (4)

Section B: Attempt One Question Only

Question 2

The following angle readings were taken at a point to be used as the intersection point of a composite highway curve. T2 and T1 are the end and start points of the curve respectively.

	FL (gons)	FR (gons)
T1	124.9876	324.9996
T2	377.9877	177.9875



The through chainage of I is 2970m. The design speed of the highway is 110km/h, the centrifugal ratio is 0.23 while the rate of change of radial acceleration is 0.36 m/s*3.

a. Compute
   i. the length of transition (5)
   ii. length of the circular part of the curve (5)

b. Compute and tabulate setting out data for the first two points on each of the three sections (i.e. the entry transition, the circular part and the exit transition) (12)

c. What checks can be applied in the field to ensure that the right curve has been set out. (5)

Question 3

Two underground drivages AO and BO on bearings of 117°32′30″ and 57°06′00″, respectively, are to be connected by a curve of radius 350m by means of nine chords.

a. Compute:
   i. The common chord length (5)
   ii. The bearing of the first 5 chords (8)
   iii. The tangent length (4)

b. If the coordinates of A are 56.9m W , 1120.2mN and the distance AO=2230.5m, compute the coordinates of the center of the curve. (8)

Section C: Attempt any Two Questions

Question 4 [15+10]

Two corners A and B of a proposed building ABCD are to be set out from two traverse stations P and Q. The corners are to be set out initially by angle and distance from the station P and checked by intersection from station Q. The design coordinates A and B and the traverse coordinates of P and Q are based on the same coordinate system and are given in table 4. The vertical angles along the directions to A and B are P to A = +03°24'32" and P to B = -02°14'03".

Calculate

i. The clockwise horizontal angles that must be set out from P relative to the line *PQ* and from *Q* relative to the line *QP* to establish the directions *A* and *B*.

ii. The surface distances that must be set out from *P* to establish the positions of *A* and *B* assuming that the gradients are constant along directions *PA* and *PB*.

Table 4

Point	m E	m N
A	591.37	606.22
B	621.37	606.22
P	637.83	621.18
Q	583.15	619.23

Question 5

a. You are the engineer in charge of a construction site for a large sports complex. Your superior does not understand the meaning of some process called ***setting out*** mentioned in the contract documents.

You are required to write a memo explaining the meaning of setting out, its aims, and other important matters that must be considered. (15)

b. Three points P, Q, and R have the following coordinates:

P	950	1200
Q	983	1340
R	1027	1240

Locate point S on PQ from which a perpendicular SR can be set out to establish R. What is the length of that perpendicular? (10)

Question 6

a. Mention two types of designs of electronic tachometers. Explain the major differences between the two. (4)

b. The following is an extract from the database of national survey control points

			E	N	h
ZS88	Hillside	UTM27	620701.100	8266201.400	1130.210
ZT547	Karenga	UTM27	623938.109	8260715.624	1083.360

i. What is the meaning of UTM27 in the table? (5)

ii. Compute the ground slope distance between these two points. (11)

c. A slope distance 2650m was measured from ZS88 to point A at bearing 198°. If A has a height of 1232m, find its coordinates. (***Use the Scale factor in (b)).*** (5)

THE UNIVERISTY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS

SEMESTER II EXAMINATIONS – 2003
JANUARY 2004

ME 209 – ENGINEERING DRAWING I

TIME ALLOWED: Four (4) Hours
CLOSED BOOK

INSTRUCTIONS

1. Answer question One (Q1) and any three (3) questions from the rest, of which two (2) should come from **SECTION A** and one (1) from **SECTION B**.

2. Question One (Q1) should be **ANSWERED SEPERATELY** on the face bearing the title block

3. Just above the title block indicate your **COMPUTER NUMBER**

4. Construction lines should **NOT** be erased and should be clearly visible

5. Do not give any dimensions unless asked otherwise

6. Marks will be awarded for correct solution, accuracy, neatness and good linework

7. All dimensions are in millimeters

SECTION A – MECHANICAL SECTION

Q1. Fig.Q1. shows the front and end elevation of a Bracket Casting. Draw scale 1:1

i. The given Front view
ii. Its Plan view
iii. A Sectional view on plane A-B

[40 Marks]

Q2. Fig.Q2 shows a front elevation of an Oil Can. Draw, scale 1/1,

i. A Plan
ii. The End elevation
iii. A Development of the surface of part B with the seam being at the shortest end.

[15 Marks]

Q3. An isometric view of a Rag Bolt is represented in Fig.Q3. Omitting the 70mm section consisting of a square block and a bolt and nut assembly, draw, scale 1/1,

i. A Front Elevation viewed in direction F with its base consisting of the 100mm diameter
ii. An End view
iii. A Plan

[15 Marks]

Q4. Outlines of two (2) rubber wheels are shown in Fig.Q4. The radius of the larger wheel is twice the radius of the smaller one. The wheels rotate, about their respective centers P and Q, without slipping at the point of contact. Two (2) links AC and BC are hinged at circumferential points A and B respectively, meeting at a hinged joint C. For one complete clock-wise revolution of the larger wheel, trace the locus of hinge C from its current given initial position.

[15 Marks]

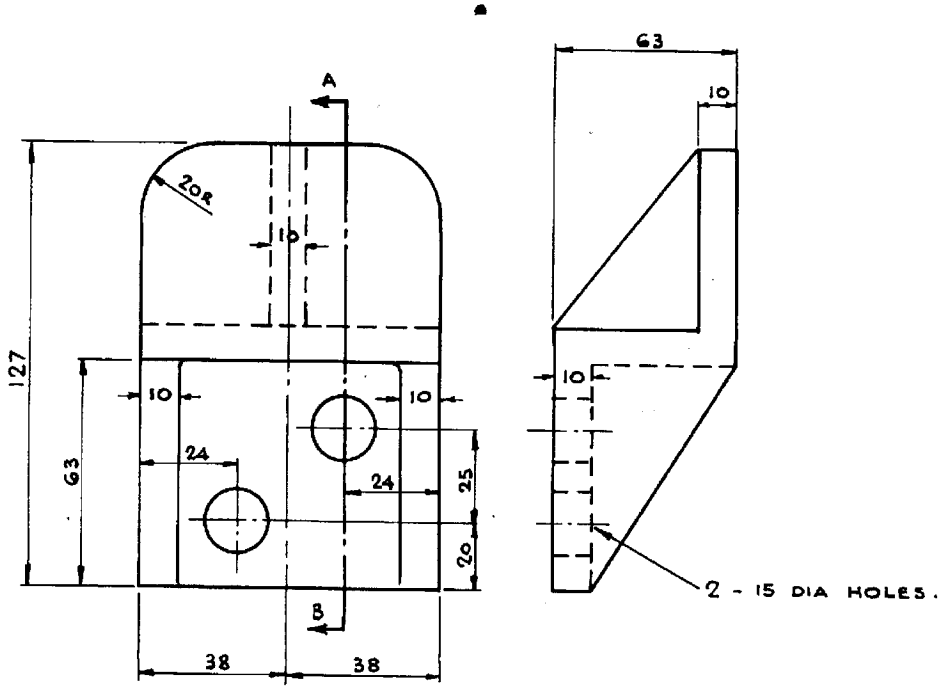

63
10
A
20R
10
127
10
10
63
24
24
25
20
B
38
38
2 - 15 DIA HOLES.

Fig.Q1

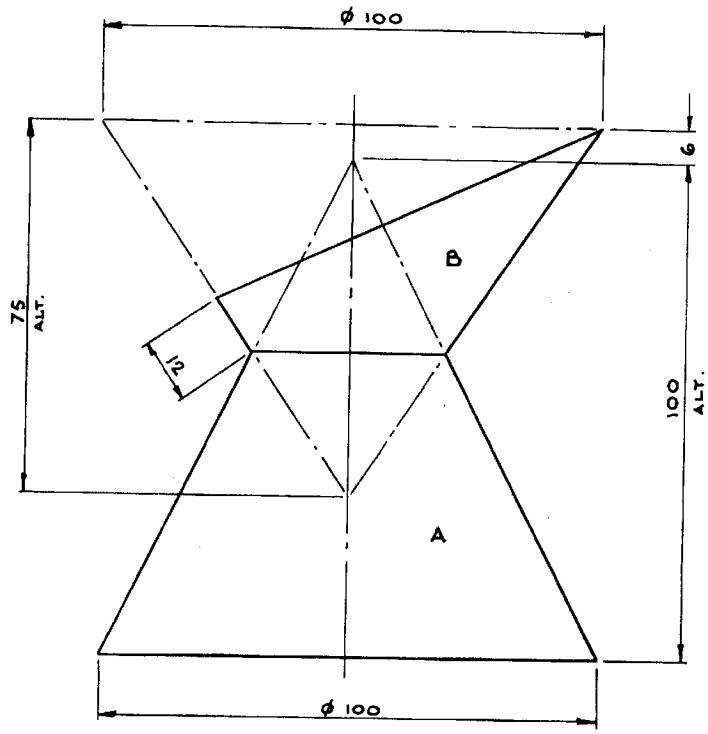

ϕ 100
6
B
75
ALT.
12
100
ALT.
A
ϕ 100

Fig.Q2

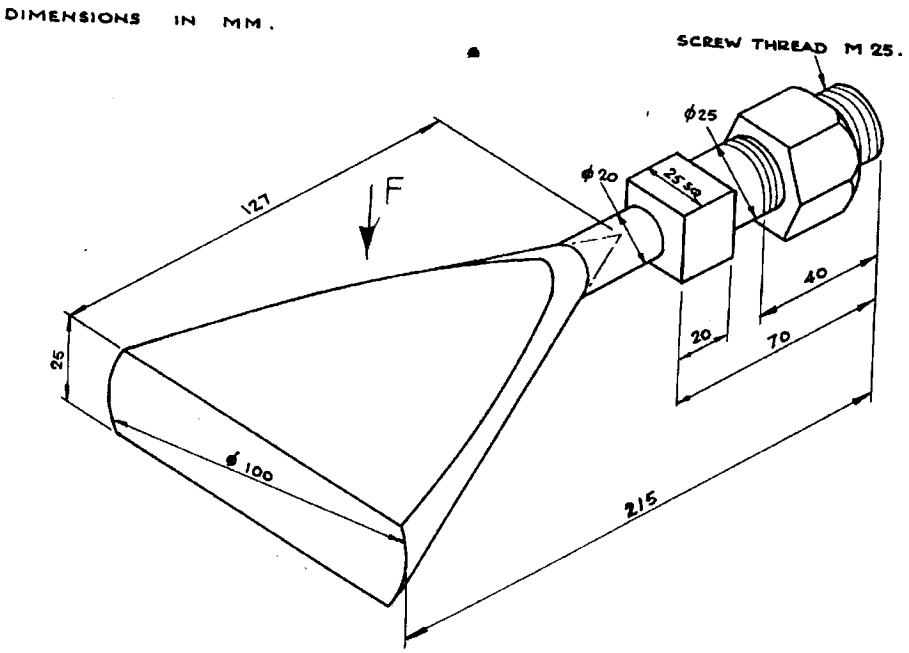


Fig.Q3

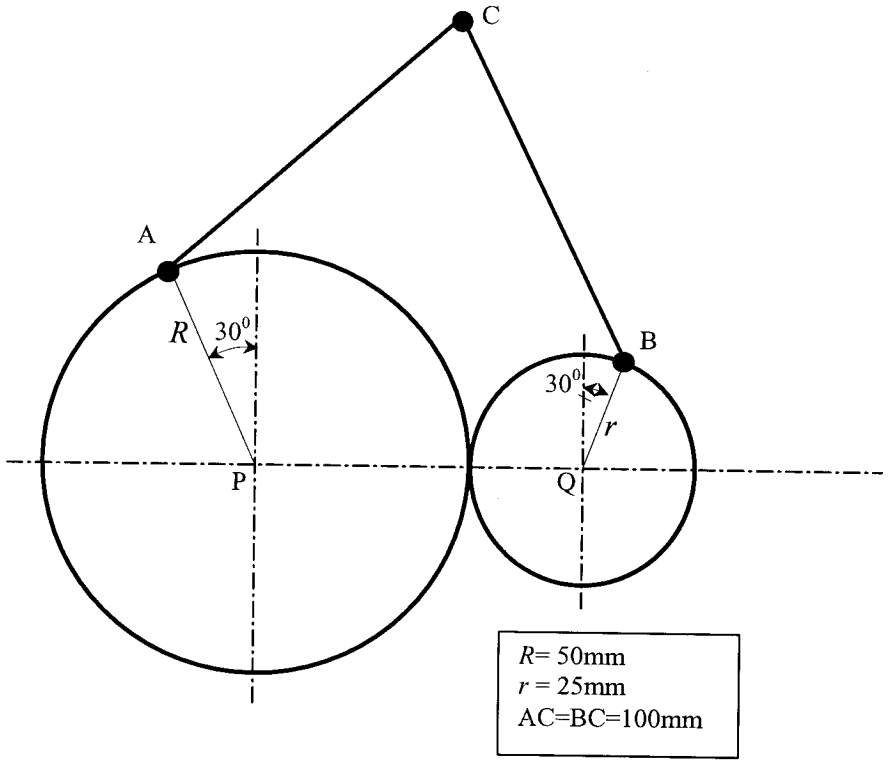


Fig.Q4

END OF SECTION A

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS

SEMESTER II EXAMINATION 2003

JANUARY 2004

ME 232 - PROPERTIES OF ENGINEERING MATERIALS I

TIME ALLOWED: THREE HOURS **ALL QUESTIONS CARRY EQUAL MARKS**

ANSWER: FIVE QUESTIONS (Two from Section A and Three from Section B)

ANSWER SECTIONS A AND B IN SEPARATE ANSWER BOOKS

SECTION A: ANSWER QUESTIONS 1 and ONE OTHER FROM THIS SECTION.

Question 1 (This Question is Compulsory)

Thermal analysis of a number of alloys of copper and silver give the following results.

Per cent copper	5	20	28	50	65	90	95
Per cent silver	95	80	72	50	35	10	5
1st arrest	945	860	780	900	950	1045	1050
2nd arrest	860	780	-	780	780	780	820
3rd arrest	570	-	-	-	-	-	635

The melting temperature of pure copper is 1083°C and that of pure silver is 960°C.

(a) If the maximum solubility of each metal into the other at room temperature can be assumed to be about 2%, plot the phase diagram for the Cu-Ag alloy system as accurately as possible, using the data given. [04 marks]

(b) Describe the changes, which would occur when the following alloy compositions are allowed to cool slowly from the liquid state to room temperature. [04 marks]
   (i) 5 per cent Cu / 95% Ag.
   (ii) 50% Cu / 50% Ag.

(c) For 50% Cu / 50% Ag, give the compositions of the phases present and their relative proportions at the following temperatures: [12 marks]
   (i) 850°C
   (ii) 780°C

Question 2

(a) Define coordination number and packing fraction as they relate to atomic lattices. [02 marks]

(b) Calculate the coordination numbers and the packing fractions of the following systems.
   (i) Face centred cubic [05 marks]
   (ii) Body centred cubic [05 marks]
   (iii) Hexagonal close packed. [05 marks]
   (iv) From your answers in (a), (b) and (c) or otherwise, show which of the three systems above is the most close packed. [03 marks]

Question 3

(a) What is electrochemical corrosion? [04 marks]

(b) Explain each of the following forms of metallic corrosion with illustrations: [12 marks]

(i) Pitting

(ii) Corrosion fatigue

(iii) Stress corrosion

(iv) Fretting corrosion

(c) Explain briefly how *pH* control may be used as a method of corrosion control, citing one specific example where this method is widely used. [04 marks]

SECTION B: ANSWER QUESTIONS 4 and TWO OTHERS FROM THIS SECTION.

Question 4 (This Question is Compulsory)

(a) Define resilience. [02 marks]

(b) Determine the minimum yield strength for a steel to be used in an assembly if it has a modulus of resilience of 0.75 MPa and a modulus of elasticity is 207 GPa. [06 marks]

(c) You are the Chief Engineer of a Materials Testing Laboratory in Lusaka and have been requested to conduct a tensile test on a specimen. The cylindrical specimen is initially 30 cm long and 10 mm in diameter and the material is isotropic. The initial load is 4000 N. The measured uni-axial strain is 0.015 and Poisson's ratio is 0.3.

(i) What are the elastic and shear moduli of the cylinder [03 marks]

(ii) What is the final length and diameter of the rod under the 4000 N load [03 marks]

(iii) What would be the lateral and axis strains on the cylinder if a load of 7000 N is applied. [03 marks]

(v) What is the final length and diameter of the rod under 7000 N load? [03 marks]

Question 5

(a) You are heading the Heat Treatment Laboratory, and you have been given a task to develop a Technological Process of heat treating a large screwdriver, an external source of heat being used only once, to develop a fine pearlitic structure in the shank and tempered martensitic structure at the tip. How would this screwdriver be heat-treated? [05 marks]

(b) List THREE requirements for martensite to form in plain-carbon steel. [03 marks]

(c) Briefly explain what retained austenite is. [07 marks]

(d) Why is it sometimes important to know how much of retained austenite is produced in steels? [05 marks]

Question 6

(a) Define Pig iron. [03 marks]

(b) In Pig iron production name three functions, which Coke serves. [03 marks]

(c) Name the basic reactions in integrated steel mills. [06 marks]

(d) Define drying and calcination in iron and steel production. [08 marks]

Question 7

(a) Define Polymerisation. Name and describe two polymerisation processes. [04 marks]

(b) Cross-linking (curing) of thermosetting polymers occurs in one of three ways. Describe each. [08 marks]

(c) Elastomers and thermosetting polymers are both cross-linked. Why are they different in behaviour? [08 marks]

END OF ME 232 FINAL EXAMINATION
G M Munakaampe / Dr J Phiri

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY EXAMINATIONS
SEMESTER II FINAL EXAMINATIONS, JANUARY 2004
ME 312 MACHINE TOOLS AND PRINCIPLES OF ELECTRICITY II

TIME: THREE HOURS **CLOSED BOOK**

ANSWER : FIVE QUESTIONS only as follows:

ANSWER at least **TWO questions from each section**, with questions **Q1** and **Q5** as compulsory questions.

QUESTIONS for **SECTION A** and **SECTION B** to be answered in separate Answer Books.

MARKS: ALL questions carry EQUAL MARKS (20).

SECTION A

Q1. a) What assumptions should be made with respect to Merchant's cutting theory? Give clearly labeled diagrams for force, velocity and work piece geometry associated with Merchant's cutting theory. **(6 marks)**

b) Orthogonal single point cutting data from a lathe dynamometer test is given as follows:

Tangential cutting force F_c	=	1.08 kN
Axial force F_a	=	1.0 kN
Cutting velocity v_c	=	165 m/min
Rake angle α	=	10 deg.
Shear plane angle θ	=	19 deg.

Calculate the following:

i) Velocity of sliding at the chip/tool interface, v_{chip}. **(4 marks)**

ii) Work done per minute in overcoming friction. **(4 marks)**

iii) Show that the work input is equal to the sum of the work done in shearing and overcoming friction. **(6 marks)**

Q2. a) Discuss the mechanism of metal removal associated with face milling of a flat surface. What are the likely force distributions in face milling with respect to chip length? Give a clearly labeled sketch of the work piece and tooling arrangement to illustrate your answer. **(8 marks)**

b) Show that the power required to drive a milling cutter depends upon the mean chip thickness, mean specific cutting pressure for the material being cut, angle of engagement between the cutter and the work piece, width of cut and the work piece feed.

If the cutting speed only is increased, what are the likely effects upon the forces and power required for cutting?

(12 marks)

Q3. a) Give an outline of the essential elements of a metal removal machine tool. What factors must be incorporated in machine tool configurations to guarantee high precision and accurate machined products? **(10 marks)**

b) What are acceptance tests for machine tools?

With the help of clearly labeled sketches, discuss the method of performing an acceptance test for the following:

i) Correct rotation of the main tool spindle on a CNC vertical milling centre. **(5 marks)**

ii) Parallelism of the Y-axis movement of the coordinate table of a CNC vertical milling center. **(5 marks)**

Q4. a) Define surface texture in the context of machined surfaces.
How is surface texture measured? **(8 marks)**

b) With the help of labeled sketches, give outlines of the following chip forms arising from single point cutting. Clearly indicate conditions that give raise to such chip forms.

i) discontinuous chip **(3 marks)**
ii) built up edge **(3 marks)**
iii) serrated chip **(3 marks)**
iv) continuous chip **(3 marks)**

SECTION B

Q5. (a) Explain how armature reaction occurs in a dc generator and the effect it has on the flux distribution of the Machine. **[4 marks]**

(b) Explain the function of commutation in a dc generator. **[4 marks]**

(c) A six-pole dc generator has a lap-connected armature with 480 conductors. The resistance of the armature circuit is 0.02 ohms. With an output current of 500 A from the armature, the terminal voltage is 230 V when the machine is driven at 900 rpm. Calculate the useful flux. **[6 marks]**

(d) Calculate the emf developed in the armature of a two-pole dc generator, whose armature has 280 conductors, is wave wound and is revolving at 1000 rpm. The flux per pole is 0.03 Wb. **[6 marks]**

Q6. A 100 KVA, 3300/240 V transformer has $R_1 = 3.49$ ohms, $R_2 = 0.012$ ohms. The values of reactance are $X_1 = 5.3$ ohms and $X_2 = 0.016$ ohms. Calculate for the transformer:

(a) Equivalent resistance as referred to both primary and secondary. **[4 marks]**

(b) Equivalent reactance as referred to both primary and secondary. **[4 marks]**

(c) Equivalent impedance as referred to both primary and secondary. **[4 marks]**

(d) Total copper loss, first using individual resistances of two windings and Secondly using equivalent resistance referred to each side. **[4 marks]**

(e) Given that iron losses are 2500 watts, calculate the efficiency of the Transformer. **[4 marks]**

Q7. Three identical coils, each having reactance of 20 ohms and a resistance of 20 ohms are connected in (a) star (b) delta across a 440 V, 3 phase line. Calculate:

(a) For the star connection:
(i) Line current; **[4 marks]**
(ii) Reading on each of the two wattmeters connected to measure power. **[6 marks]**

(b) For the delta connection:
(i) Line current; **[4 marks]**
(ii) Reading on each of the two wattmeters connected to measure power. **[6 marks]**

Q8. (a) Three inputs A, B and C are applied to the inputs of AND, OR, NAND and NOR gates. Give in each case the algebraic expression for the output. **[4 marks]**

(b) Assuming that AND, OR, NAND, NOR and NOT gates are available, sketch the combination that will realise the following:

(i) $\mathbf{A \bullet B \bullet \overline{C} + \overline{A \bullet (\overline{B + C})} + \overline{A + B + C}}$ **[8 marks]**

(ii) $\mathbf{B + (A + \overline{\overline{B} + \overline{C}}) + \overline{A + B \bullet C} + \overline{A \bullet B \bullet C}}$ **[8 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS

SEMESTER II EXAMINATIONS – 2003
JANUARY 2004

ME 332 – STRENGTH OF MATERIALS I

1. ANSWER A TOTAL OF **FIVE (5)** QUESTIONS, AT LEAST **TWO (2)** FROM EACH SECTION.
2. EACH SECTION TO BE ANSWERED IN **SEPAERATE BOOKLETS**
3. YOU ARE REMINDED TO USE **NEAT HANDWRITTING** & USE **CLEARLY LABELED DIAGRAMS** IN YOUR ANSWERS

SECTION A - ***Answer at least two (2) questions from this section***

Q1. A Bracket in form of a plate is fitted to a column by means of two (2) rivets A and B in the same vertical line, as shown in fig.Q1. Distance AB= 60mm and C is the mid-point. A load of 100kN is applied to the bracket at a bearing point D, which is at a horizontal distance of 150mm from C. The load acts at an angle of 30^0 to the horizontal. Determine the diameter of the rivets, which are made of steel with a yield stress in shear of 240MPa. Take factor of Safety of 1.5.

[20 Marks]

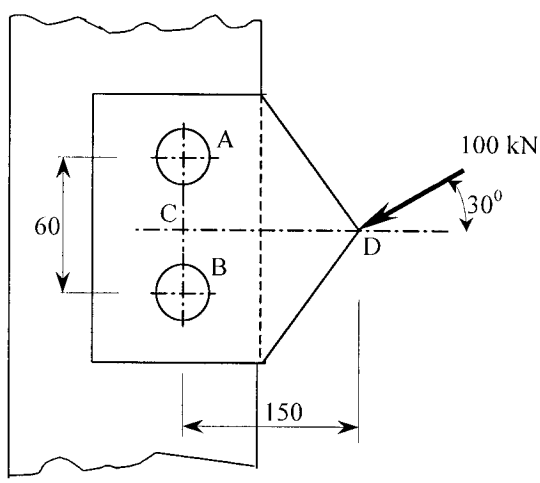


Fig.Q1

Q2. Fig.2 shows the shear force diagram of a loaded beam.

a) Determine the loading on the beam
b) Draw its corresponding bending moment diagram
c) Determine the maximum bending moment between points marked *B* and *C* on the shear force diagram
d) Determine the location of points of zero bending moment between points marked *B* and *C* measured from *B* on the shear force diagram.

[20 Marks]

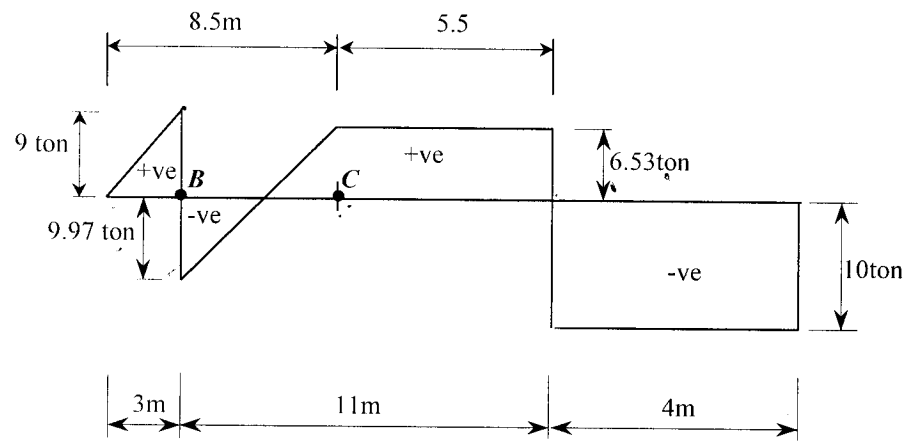


Fig.Q2

Q3. A uniformly tapered cantilever of circular solid cross-section is fixed at one end and carries a concentrated load *P* at the free end. The diameter at the free end is 20 cm and increases uniformly to 40 cm at the fixed end over a length of 2 meters. At what distance from the free end will the bending stresses in the cantilever be maximum? Also calculate the value of the maximum bending stress if the concentrated load *P*=2970 kg

[20 Marks]

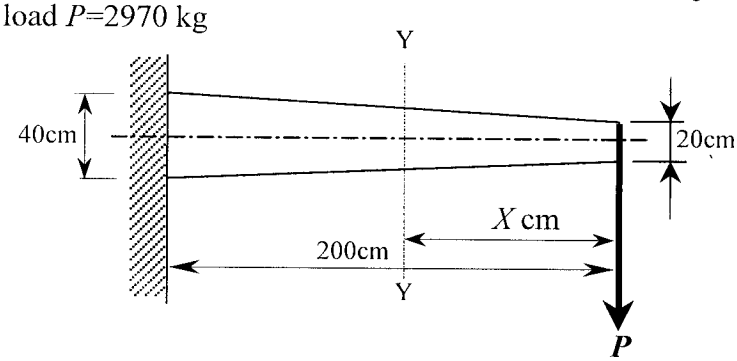


Fig.Q3

Q4. A channel-section beam is 50mm wide and 50mm deep with a 5mm wall thickness. It is simply supported over a length of 1m and carries a uniformly distributed load of 50 kN/m over its entire length. It also has a point load of 50kN at mid-span. Sketch the shear stress distribution across the beam section 0.25m from one of the supports and indicate the important values.

[20 Marks]

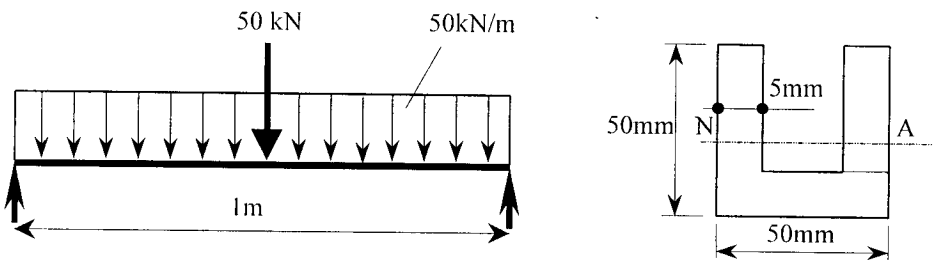


Fig.Q4

END OF SECTION A

SECTION B - *Answer at least two (2) questions from this section*

Q5 **(a)** Draw neat illustrative sketches to bring about the difference between a helical coil tension spring and helical coil compression spring.

(b) As part of a design team for manufacturing tractor-trailers, you are required to design a carriage spring, which is to carry a load of 7.2kN and bear a maximum stress of 240MN/m^2. Using a 10mm thick spring steel plate with E=210GN/m^2, space requirements allow the spring to be 800mm long, 60mm broad. Determine the following:

(i) Number of plates required to carry the load
(ii) Central deflection
(iii) Initial radius of curvature, if plates straighten under the load
(iv) Sketch the spring showing clearly the determined parameters

[5+15 = 20 Marks]

Q6 **(a)** Distinguish between hoop stress and longitudinal stress.

(b) Suppose water freezes in a pipe, along which axis will rapture take place? Give technical reasons for your answer.

(c) A built up cylindrical gasoline storage tank made of 8mm thick steel plate is 5m long and 500mm diameter. Given that the efficiencies of the longitudinal and circumferential joints are 85% and 55% respectively, calculate the following when the tank is subjected to an internal pressure of 2.5MN/m^2:

(i) Circumferential and longitudinal stresses induced
(ii) Change in length, diameter and volume of the cylinder

Take E = 200GN/m^2 and m = 3.5 **[4+4+12 = 20 Marks]**

Q7 **(a)** Distinguish between a strut and a column.

(b) Explain briefly the phenomenon of buckling.

(c) An 80cm long piston rod in a steam engine is subjected to a maximum load of 60kN. Determine the diameter of the rod using Rankine's formula given the following information:

Permissible compressive stress	= 100MN/mm^2
Constant in Rankine's formula	= 1/7500 (for hinged ends)
Length coefficient of rod for partially fixed ends	= 0.6

[4+4+12 = 20Marks]

Q8 **(a)** Define the following:

(i) Resilience
(ii) Proof resilience
(iii) Modulus of resilience

(b) Figure Q8 shows a bar of length l and X-sectional area A, which is rigidly fixed at the top and free at the other end. A load W is allowed to fall from height h onto a collar fitted at the lower end of the bar. Assuming that the bar does not break due to the impact of the weight, but instead causes a maximum elongation of δl, derive the expression for the equivalent static or gradually applied load P, which could produce the same elongation δl.

(c) A bar 3m long and 5cm diameter hangs vertically and has a collar securely attached to the lower end. Find the maximum stress induced and the corresponding elongations when

(i) A weight of 250N falls 1cm on the collar
(ii) A weight of 2500N falls 1cm on the collar

Take E = 200GN/m^2

[3+10+7 = 20 marks]

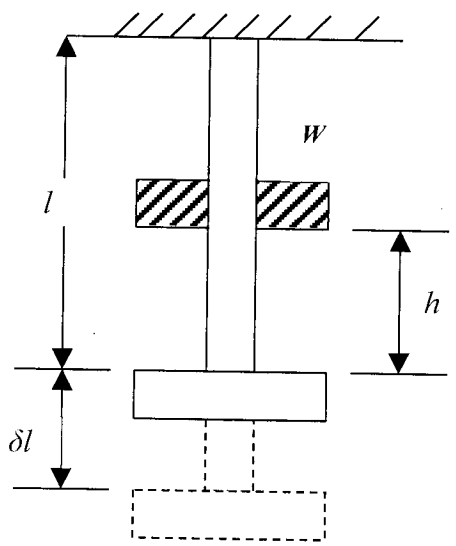


Fig.Q8

End of ME 332 – Strength of Materials I Semester II Examination
Mr. C.G. Chizyuka & Mr. S.S. Virdy

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS

SEMESTER II EXAMINATIONS 2003
JANUARY 2004

ME 405 - MACHINE DESIGN I

PAPER II

TIME ALLOWED: THREE HOURS **OPEN BOOK**

ANSWER: ALL QUESTIONS

In rural areas construction of houses using concrete blocks is limited due to the fact that most block making machines use either electrical motors or a small engines operating at between 1500 and 2000 rpm to induce the vibrations that are required to compact the blocks during manufacturing. This can be avoided by using other means to effect the compaction of the sand-cement aggregate.

The Ministry of Local Government and Housing requires 200 block making machines that are NOT powered by either electric motors or heat engines. Each machine is required to produce between 400 and 800 blocks in an 8-hour day shift depending on block size and operators. There should not be more than two operators per machine. Each machine should be able to produce blocks in the three standard sizes, namely 100mm, 150mm and 200mm wide. A sketch of a typical block is shown Fig 1.

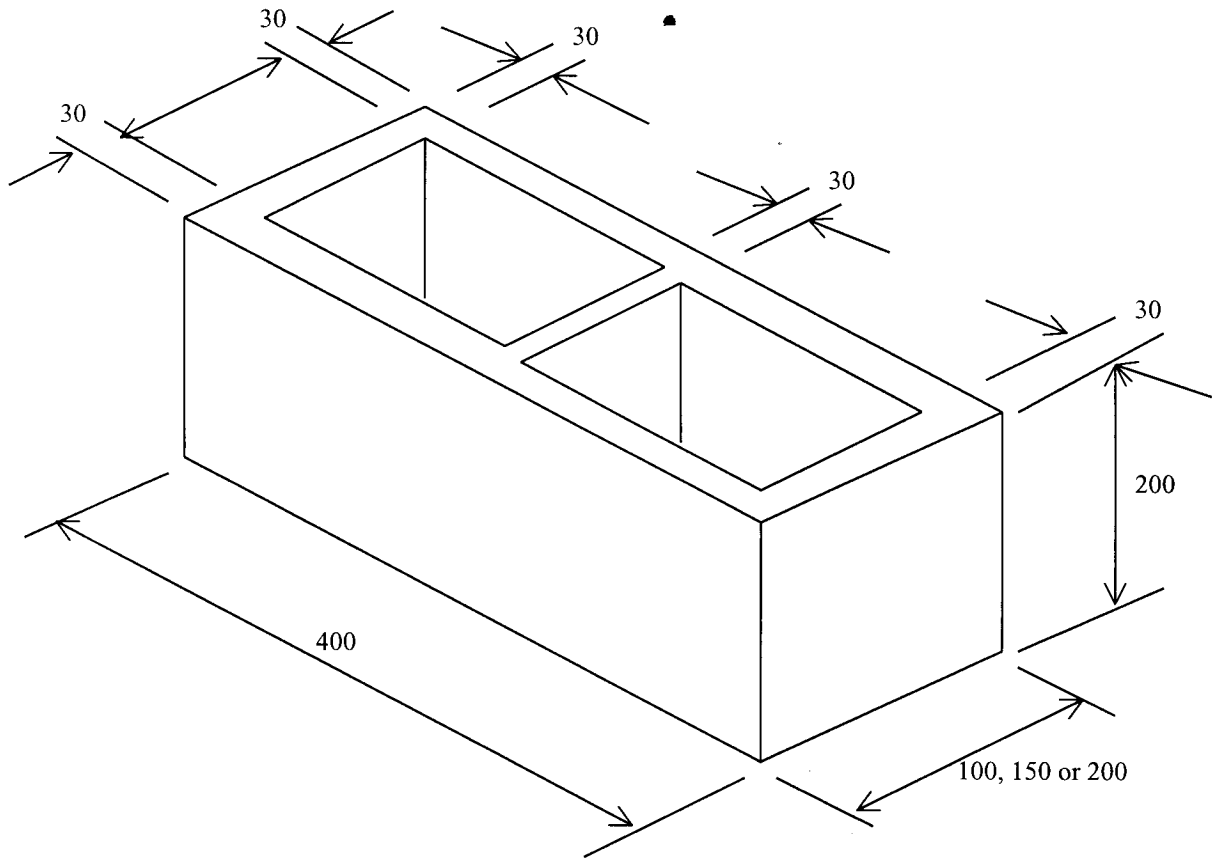
A concrete mix of three wheel burrows of river sand to one bag of 50kg cement would normally be used for making the blocks.

(a) Write a detailed product design specification (PDS) for the machine. [20 marks]

(b) Produce TWO (2) different functional designs for the above machine. [50 marks]

(c) Select the better of the two designs using the two stage (matrix) method and four (4) relevant design factors. [20 marks]

(d) Select the material for 5 major components of the best design. [10 marks]



The holes are 170 deep

All dimensions are in millimetres

Figure 1: **Sketch of a Concrete Block**

END OF EXAMINATION ME 405 PAPER II
Prof. S B Kanyanga /G M Munakaampe

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY SEMESTER II EXAMINATIONS - JANUARY 2004

ME 472 – VIBRATIONS AND CONTROL ENGINEERING I

TIME: THREE (3) HOURS CLOSED BOOK

INSTRUCTIONS:
- ANSWER **FIVE (5) QUESTIONS ONLY**
- ALL QUESTIONS CARRY EQUAL MARKS
- USE SEPARATE ANSWER BOOKS FOR EACH SECTION

SECTION A – VIBRATIONS

ANSWER **ONLY TWO (2)** QUESTIONS FROM THIS SECTION:

QA-1. (a) State three ways by which damping can be achieved, differentiating them. *[6 marks]*

(a) It has been recommended that a structure operating under cryogenic conditions should employ hysteretic damping. As the Vibrations Engineer, you are tasked to determine the following:

i) Solid damping constant
ii) Hysteresis damping constant
iii) Equivalent viscous damping constant
iv) Energy absorbed per cycle for a critical amplitude of 12.7mm

Justify the use of such a damping method as opposed to the traditional one that uses a fluid.

Initially, static tests showed that the spring modulus was 0.3N/mm, while the effective mass is 900g. On the other hand, vibration tests revealed that the ratio between successive amplitudes is 1.064.

[14 marks]

QA-2. (a) Explain the source of imbalance in a rotary machine assembly. *[2 marks]*

(b) Is such imbalance desirable or not? Explain. *[6 marks]*

(c) Results from an examination of a compressor assemble yielded the following:

Effective compressor mass	100kg
Spring support, total stiffness	700N/mm
Damping ratio	0.20
Resultant imbalance force	350N at an operating speed of 3000rpm

The compressor is supposed to be mounted on a structure within an existing plant. Limitations would be imposed by space availability and strength of the mounting. You are therefore required to determine the following parameters for subsequent evaluation of the feasibility of mounting the compressor:

i) Amplitude of motion
ii) Transmissibility, and hence transmitted force

[12 marks]

QA-3. (a) Discuss how the following basic vibration equation could be applied in the design of the Following instruments: vibrometers, velometers and accelerometers.

$$z(t) = \frac{\left(\frac{\omega}{\omega_n}\right)^2}{\sqrt{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]^2 + \left(2\zeta\frac{\omega}{\omega_n}\right)^2}} Y\sin(\omega t - \phi)$$

[9 marks]

(b) You are the Design Engineer for Semmy Vibrations Instruments. Analysis of a spring-mass-damper system used as an accelerometer revealed the following:

Undamped natural frequency	100cps
Damping coefficient	0.020Ns/mm

The device is designed to measure vibrations of equipment operating up to 3000rpm. A calibration procedure revealed that the device records an acceleration of $9m/s^2$ when the actual is $10m/s^2$. Determine the effective mass and spring constant of the accelerometer.

[11 marks]

SECTION B – CONTROL ENGINEERING

ANSWER ONLY THREE (3) QUESTIONS FROM THIS SECTION:
Answer QB-1 and Any Other Two (2) Questions

QB-1. Figure QB-1 shows a simplified diagram of a process furnace. The temperature of the process fluid is measured at the outlet of the furnace by a temperature transmitter which sends a signal to the temperature controller. The controller has a dial so that the desired value of the process outlet temperature (the reference temperature) can be set. The controller compares the measured temperature with the reference temperature and the fuel flow is increased or decreased accordingly. The exact relationship between the error in temperature and the fuel valve movement is determined by the control law.

a) Identify the type of control system and draw its block diagram. *[15 marks]*
b) What is the main source of disturbances to this system and what would be the effect of the disturbances on the output? *[5 marks]*

QB-2. Given the system shown in Figure QB-2:

a) Determine the differential equation of operation for this system. *[7 marks]*

b) The system is in a state of equilibrium at t = 0 s, with r(0) = 2 and d(0) = 0. Show that c(0) = 6. *[3 marks]*

c) A step function disturbance d(t) = 3 is then initiated at t = 0 s. Determine the system response for t > 0 s, using Laplace Transforms. *[10 marks]*

QB-3. The block diagram of a feedback control system is shown in Figure QB-3. Find the system transfer function (in its simplest form) given that:

$$G_1(s) = \frac{5}{s(s+1)};\quad G_2(s) = \frac{2}{s};\quad G_3(s) = 2;\quad H_1(s) = \frac{s}{s+4};\quad H_2(s) = \frac{5s}{s+2}$$

[20 marks]

QB-4.

ANSWER EITHER

QB-4A. The feed forward transfer ratio given by:

$$G(D) = \frac{1}{D^2 + 6D + 5}$$

is proportionally controlled (gain factor K) in a negative feedback loop which contains a proportional feedback element $K_F = 0.4$.

a) Calculate a number of the poles of the controlled system and draw the root locus. *[7 marks]*

b) Determine the values of K for which the controlled system is stable. *[3 marks]*

c) If the proportional controller K is replaced by a controller

$$K^* = \frac{K}{D+2},$$

sketch the root locus of the new system. *[5 marks]*

d) Determine the values of K for which the controlled system is stable. *[5 marks]*

OR

QB-4B. Find the range of the controller gains K and K_I so that the feedback system in Figure QB-4 is asymptotically stable. *[15 marks]*

Plot the allowable region for stability (i.e. K_I against K). *[5 marks]*

END OF EXAMINATION – ME 472

Dr A N Ng'andu and Mr E Matsika

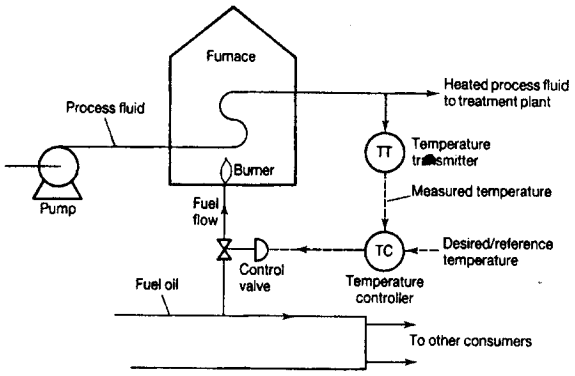


Figure QB-1

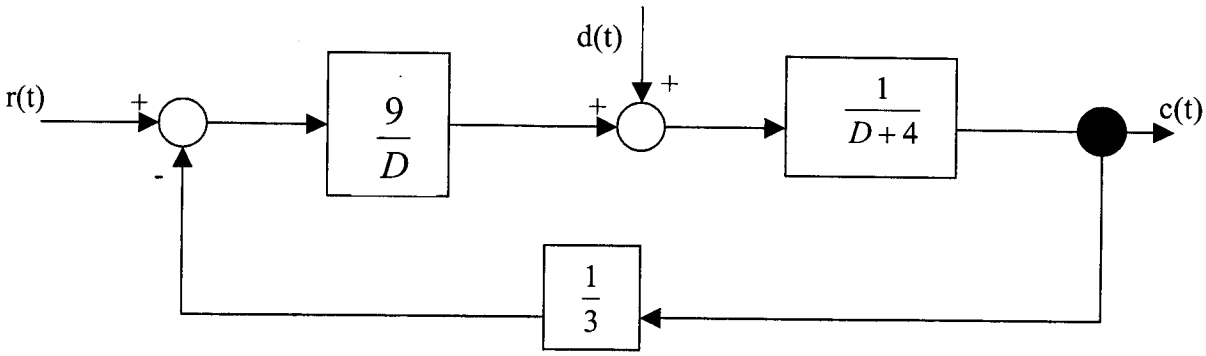


Figure QB-2

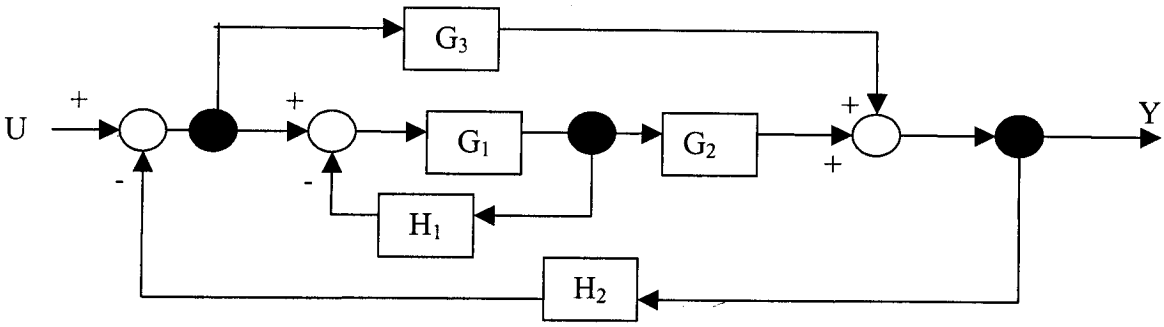


Figure QB-3

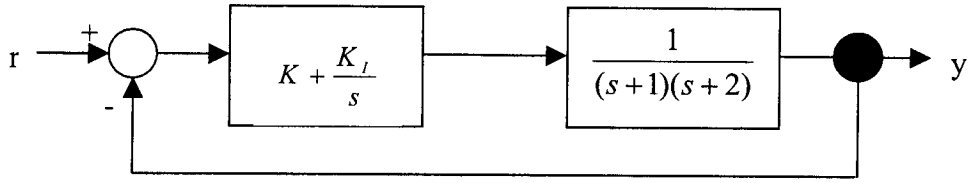


Figure QB-4

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

ME 585 - AUTOMOBILE ENGINEERING
SEMESTER II FINAL EXAMINATION - JANUARY 2004

INSTRUCTIONS:

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

The paper contains two sections:

Section A - Answer Two Questions only
Section B - Answer Three Questions only
All questions carry equal marks
Answer Sections A and B in separate booklets

Draw Sketches, graphs, and state all assumptions where necessary

SECTION A
ANSWER ~~THREE~~ TWO QUESTIONS ONLY

Q1. With the aid of diagrams, describe in detail the principle of operation of a mechanism embodied in the design of the motor vehicle that would provide comfort to passengers by reducing shocks and vibrations as much as possible whilst moving on uneven surfaces.
[20 marks]

Q2. The engines are the most vulnerable component of the motor vehicle structure. Discuss the type and cause of wear related to the reciprocating and rotary mechanism, and valve timing mechanism of the engine. What defects would you monitor during maintenance of the second order of the two mechanisms, and what measures would you put in place to rectify them?
[20 marks]

Q3. Describe in detail the design features and purpose of various types of modern automobile workshops. What tools and equipment would you recommend for the workshops you have described above?

[20 marks]

SECTION B
ANSWER THREE QUESTIONS ONLY

Q4. (a) Describe what coasting is and state why it is important. [6 marks]

(b) From a coasting test conducted on a BMW, the following data was obtained:

Run in one direction:
Initial speed = 4m/s
Running out time = 5s

Run in opposite direction:
Initial speed =4m/s
Running out time =12s

Determine:
(i) Deceleration in both directions [2 marks]
(ii) The run out distance in each direction [2 marks]
(iii) Rolling resistance coefficient and the angle of inclination of the road [6 marks]

(c) The same vehicle is subjected to an overtaking test from which the following was obtained:

Speed of overtaking vehicle = 30m/s
Speed of overtaken vehicle = 25m/s

Determine:

(i) The distance and time required for the BMW to overtake at 30m/s [2 marks]
(ii) The safe intervals between the overtaking and overtaken vehicles at the beginning and end of overtaking [2 marks]

Q5. The table below gives the relationship between vehicle speed, power required to overcome resistance to motion and power developed by the engine on the level for a saloon car.

Speed (km/h)	40	60	80	100	120
Power required to overcome resistance to motion (kW)	1.87	7.46	17.5	29.8	44
Power developed by the engine (kW)	21	31.8	38.8	38	29

(a) Determine:

(i) Plot graphs of power against speed [4 marks]
(ii) The maximum speed of the car on the level [2 marks]
(iii) The maximum power available for acceleration, the speed at which this occurs and the maximum acceleration which can be achieved if the vehicle has a mass of 1750kg. [5 marks]

(b) Discuss the factors that would affect the fuel consumption of the car. [4 marks]
(c) Determine the running fuel consumption at the maximum speed if the effective fuel consumption, the transmission efficiency and the fuel density are given as 350g/kWh, 0.9 and 0.76kg/litre, respectively. [5 marks]

Q6. The following data is give for an internal combustion engine driven saloon vehicle:

Coefficient of rolling resistance	= 0.018
Mass	= 1.3t
Frontal area	= 1.8 m^2
Drag coefficient	= 0.45
Air density	= 1.3 kg/m^3

(a) Calculate the end speed of the vehicle in free motion down (i.e. engine disconnected from the transmission) a gradient of 7°. Ignore the influence of the wind. [7 marks]

(b) If the vehicle now moves down the same hill with a tractive force of 700 N, determine the end speed. Comment on the results with respect to (a). [4 marks]

(c) With the condition given in (b), can the vehicle reach a maximum speed of 50 m/s? Discuss your answer, assuming the vehicle is in top gear. [3 marks]

(d) If the vehicle is driven on a flat road at a constant speed of 100 km/h, determine the tractive power required to keep the vehicle moving at this speed with a head wind of 50 km/h at an angle of 20° to the longitudinal of the vehicle. [6 marks]

Q7. (a) Describe the three ways by which braking can be achieved. [6 marks]

(b) A vehicle of mass 1250kg is moving in direct drive along a road of grip coefficient 0.75. During this period, the engine develops a maximum power of 80kW at 3500rpm. The following additional data is available:

Differential gear ratio	4.1
Road resistance coefficients	0.081
Distance of CG from front axle	1.52m
Distance of CG from rear axle	1.41m
Wheel radius	0.35m
Height of CG	0.6m
Transmission Efficiency	0.9
Coefficient accounting for rotating masses during braking	1.00

If the driver decides to use emergency braking, using the brake system only, determine:

(i) The maximum braking forces [1 mark]

(ii) The maximum deceleration [1.5 marks]

(iii) The braking time [2.5 marks]

(iv) The average deceleration during the increase of deceleration from zero to the maximum value and hence the speed of the vehicle at the end of this period and the braking distance. The driver's reaction time, the time for brake operation and the time during which deceleration increases from zero to the maximum value are 0.53s, 0.33s and 0.5s, respectively. [3 marks]

(v) The optimum distribution of the braking force. [1.5 marks]

(vi) The reaction change coefficients. Comment on your answers. [4.5 marks]

END OF SEMESTER II FINAL EXAMINATION - ME 585

HAPPY NEW YEAR!!!