

THE UNIVERSITY OF ZAMBIA
 UNIVERSITY EXAMINATIONS – 2000/2001
 FIRST SEMESTER & SECOND SEMESTER
 SCHOOL OF ENGINEERING

1.	CE 219	Statistics and introduction to strength of materials
2.	CE 381	Civil engineering materials and practices
3.	CE 531	Reinforced concrete Design
4.	CE 582	Construction techniques and management
5.	EA 311	(Farm Power And Machinery)
6.	EA 401	Energy sources and Utilisation in Agriculture I
7.	EE 209	Principles of Electricity
8.	EE 309	Principles of Electricity II
9.	EE 311	Electric Circuits
10.	EE 321	Electromechanics and Electrical Machines
11.	EE 342	Electronic Engineering I
12.	EE 422	Electrical Machines I
13.	EE 431	Electronics And Engineering II ee 4-1
14.	EE 452	Electric power Systems
15.	EE 471	Telecommunications
16.	EE 532	Power Electronics
17.	EE 541	Electronic Engineering III
18.	EE 562	Systems and Control Engineering II
19.	EE 572	Telecommunication Systems
20.	EG 112	Workshop Technology
21.	EG 269	Information Technology
22.	EG 475	Engineering, management and society 1998-2000
23.	EM 212	Engineering mathematics II
24.	EM 312	Engineering mathematics III
25.	ME 252	Properties of Engineering materials I
26.	ME 375	Dynamics
27.	ME 431	Strength of materials II
28.	ME 515	Production Technology II paper I
29.	SE 332	Photogrammetry I
30.	SE 352	Land Law cadastre and survey Regulations

29.	C	445	Bio-Inorganic Chemistry
30.	C	451	Advanced Organic Chemistry
31.	C	481	Inorganic Industrial Chemistry
32.	C	491	Organic Industrial Chemistry
33.	CAV	251	Analytical/Physical/Organic Chemistry
34.	CST	2021	Introduction to Computer Systems
35.	EM	211	Engineering Mathematics I
36.	EM	311	Engineering Mathematics III
37.	EM	431	Engineering Mathematics V
38.	GEO	111	Introduction to Human Geography I
39.	GEO	175	Introduction to Mapping Techniques in Geography paper II
40.	GEO	211	The Geography of Africa
41.	GEO	271	Quantitative Techniques in Geography I
42.	GEO	381	Environment and Development
43.	GEO	451	Land Resources Survey
44.	GEO	481	Environment and Development II
45.	GEO	911	Population Geography
46.	GEO	931	Rural Geography
47.	GEO	955	Geomorphology
48.	GEO	961	Soils Geography
49.	GEO	971	Aerial Photographs and Interpretation paper II
50.	M	111	Mathematical Methods I
51.	M	161	Introduction to Mathematics, Probability Methods III
52.	M	211	Mathematics Methods III
53.	M	221	Linear Algebra I
54.	M	225	Introduction to Mathematical Logic
55.	M	261	Introduction to Statistics
56.	M	331	Real Analysis III
57.	M	335	Point set Topology
58.	M	361	Mathematical statistics
59.	M	411	Theory of Functions of a Complex Variable I
60.	M	461	Multivariate Analysis
61.	M	911	Mathematical Methods V
62.	M	941	Structured Computer Organisation
63.	M	981	Numerical Analysis I

31. SE 412 Numerical methods and programming for surveyors
32. SE 472 Principles of surveying II
33. SE 481 Introduction to surveying II
34. SE 542 Geodesy II
35. SE 561 Principles of Land/Geographic information systems
36. SE 562 Land Resources planning
37. SE 571 Engineering surveying

THE UNIVERSITY OF ZAMBIA.

UNIVERSITY FIRST SEMESTER EXAMINATION – JANUARY 2001.

CE 219 : STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS.

TIME: Three Hours.

ANSWER: Any THREE from Section A, and Any TWO from Section B.

Section – A.

1. Find the magnitude of the pin reaction at B for the loaded frame shown in Fig: 1.
2. The vertical position of the 100 kg block shown in Fig:2 is adjusted by the screw activated wedge. Calculate the torque M which must be applied to the handle of the screw to raise the block. The single threaded screw has square threads with a mean diameter of 30 mm and advances 10 mm for each complete turn. The coefficient of friction for the screw threads is 0.25 and that for all mating surfaces of the block and wedge is 0.4.
3. Locate the centroid of the shaded area above the parabola shown in Fig:3.
4. (a) Derive the expression for the product of inertia of the right triangular area about the X-Y axes by *direct integration* (Fig: 4).
(b) Using the results of (a) and the parallel axis theorem , derive the product of inertia of this area about the centroidal \bar{X} - \bar{Y} axes.

SECTION – B.

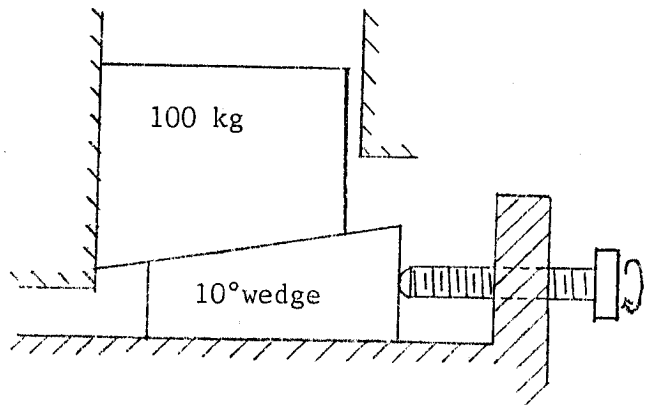
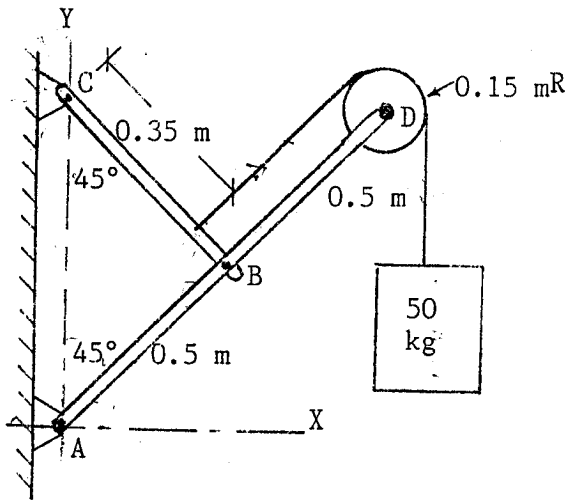
5. A steel bar of circular cross-sections is acted upon by forces as shown in Fig: 5. Determine:
 - (a) the axial stresses in each section of the bar,
 - (b) total change in length,
 - (c) change in external diameter at each section,
 - (d) total strain energy stored in the bar.

Given : $E = 210 \text{ kN/mm}^2$, Poisson's Ratio = 0.3

6. A rigid body of weight 20 kN hangs from three vertical wires, symmetrically situated with respect to the centre of mass of the body as shown in Fig: 6. The outer wires are of copper while the inner wire is of steel. All wires are equal in length and of diameter 10 mm. Determine:
- the stresses in each wire, and
 - the magnitude of these stresses if the temperature of this assembly rises by 10°C .

Given: $E_c = 102\text{ kN/mm}^2$, $\alpha_c = 18 \times 10^{-6} / ^\circ\text{C}$
 $E_s = 205\text{ kN/mm}^2$, $\alpha_s = 11 \times 10^{-6} / ^\circ\text{C}$

7. One of the principal stresses in a two-dimensional stress system is 139 N/mm^2 tensile acting on a plane A. On another plane B, the normal and shearing stresses are 108 N/mm^2 (tensile) and 62 N/mm^2 respectively. Determine:
- the angle between planes A and B,
 - the other principal stress,
 - the direct stress on the plane perpendicular to B.



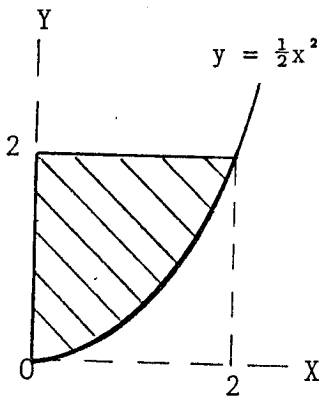


FIG: 3.

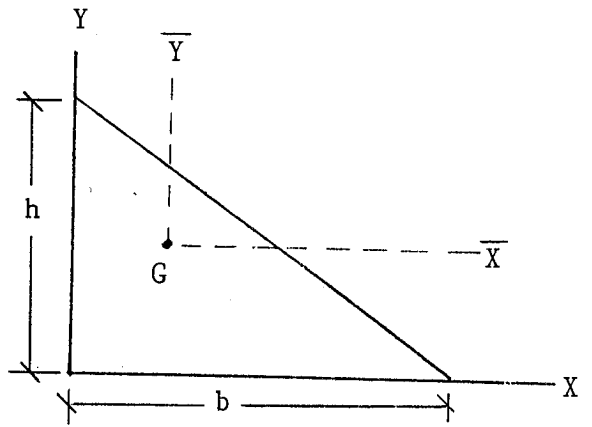


FIG: 4.

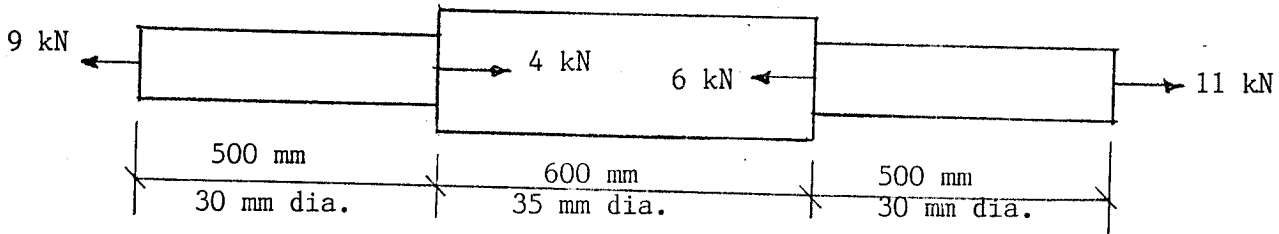


FIG: 5.

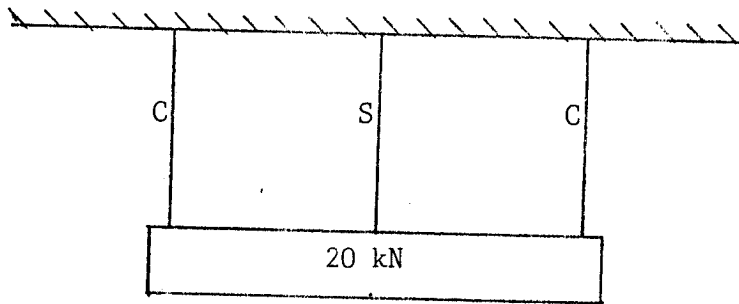


FIG: 6.

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END OF EXAMINATION.
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UNIVERSITY OF ZAMBIA
UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS – March 2001
CE 381
CIVIL ENGINEERING MATERIALS AND PRACTICES

TIME: THREE HOURS(3) HOURS

INSTRUCTIONS:

ANSWER: FIVE (5) QUESTIONS IN ALL ENSURING THAT. ALL QUESTIONS CARRY EQUAL MARKS

ATTEMPT: AT LEAST TWO (2) QUESTIONS FROM EACH SECTION.
USE A SEPARATE ANSWER BOOK FOR EACH SECTION.

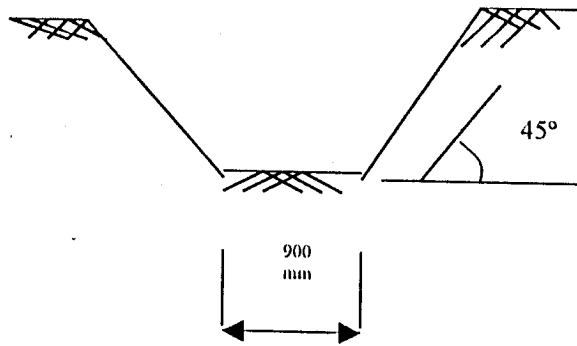
- Q1** (a) Discuss in detail the factors that determine the choice of civil engineering materials in a construction project.
- (b) What are some of the common civil engineering materials? Discuss their uses.
- (c) Discuss the advantages and disadvantages of zoning with specific reference to the City of Lusaka
- (7 + 7 +6)
- Q2** (a) Explain the following terms:
- (i) Masonry
- (ii) Specifications
- (iii) Defects in timber
- (iv) Preservation of timber
- (b) Describe in detail the steps involved in concrete mix design
- (10+10)
- Q3** (a) Metals are used extensively in construction. List some of their uses and describe the properties that set them apart from other materials in certain applications.
- (b) Bituminous materials find extensive application in modern construction. With the aid of examples, explain in detail some of their uses.

SECTION B

- Q4** Using examples, describe the four types of specifications commonly used in construction.
- (Marks: 4x5)
- Q5** Identify five types of parties that may generally be involved in a building type of project and identify their various roles.
- (Marks: 5x4)

Q6

A drainage ditch is required to solve flooding problems experienced every rain season in Kanyama. After data collection and analysis, it is decided that a V-ditch will be able to collect flood waters in the most adversely affected section of the township to a primary drainage ditch serving the city. The proposed new drainage will have to be excavated parallel to the existing road system. On a 17 m length, the drainage ditch has a 7° uniform longitudinal slope. The shape of the ditch is as shown in Fig. 1. The depth of the 17 m section at its downstream end is 3.3 m.



Assuming horizontal terrain in Kanyama, take off the total volume of earth to be excavated over the 17 m section in the construction of the proposed ditch.

(20)

Q7

Outline and explain all the steps involved in the preparation of a Bill of Quantities (BoQ).

(20)

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THE UNIVERSITY OF ZAMBIA

**UNIVERSITY DEFERRED/SUPPLEMENTARY EXAMINATIONS
MARCH 2001**

CE 582 - CONSTRUCTION MANAGEMENT AND TECHNIQUES

TIME: THREE HOURS

ATTEMPT: FIVE QUESTIONS OUT OF THE GIVEN SEVEN

NO CREDIT WILL BE GIVEN FOR ANSWERS WHERE

INTERMEDIATE STEPS IN CALCULATIONS ARE NOT SHOWN

Q1. A contractor has a K47.7m contract for which the contract budget is shown in Table Q2.1. Against each item of work is shown the value of that work subdivided among the various cost headings such as labour, plant etc.

Included in the cost heading 'Site overheads' are salaries of supervisors. At the end of month 7 a progress check shows the following percentage completion: A, B, C, D, E, F, G, all 100%; H, 80%; I, 50%; J, 30%; K, 30%; L, 10%.

Table Q2.1

Code	Item	Cost headings									Total value (Kx1000)
		Labour Category (Kx1000)	Labour (Kx1000)	Plant (Kx1000)	Materials (Kx1000)	Subcontractors (Kx1000)	Site O/H (Kx1000)	Head office O/H (Kx1000)	Profit (Kx1000)		
A	Strip soil	1	200	600	-	-	200	200	400	1 600	
B	Excavate	1	600	1 000	-	-	400	400	500	2 900	
C	Conc. founds	1	600	400	600	-	200	200	500	2 500	
D	G. F. slabs	1	1 000	600	600	-	300	300	400	3 200	
E	Cols. 1 st to roof	1	400	400	400	-	200	200	300	1 900	
F	1st slab	1	1 200	800	800	-	300	300	400	3 800	
G	Cols. 1st to roof	1	500	600	400	-	300	300	300	2 400	
H	Roof structure	2	400	300	900	-	200	200	300	2 300	
I	Roof cladding	3	300	300	500	-	200	200	300	1 800	
J	Glazing & cladding	4	200	600	1 000	1 000	400	400	400	4 000	
K	Services	1	200	-	-	10 000	1 000	1 000	100	12 300	
L	Internal finishes	5	3 000	200	4 000	-	800	800	200	9 000	
			8 600	5 800	9 200	11 000	4 500	4 500	4 100	47 700	

The cost allocations at the end of month 7 are shown in Table Q2.2.

Table Q2.2

Labour categories										Total Site Costs (Kx1000)
1 (Kx1000)	2 (Kx1000)	3 (Kx1000)	4 (Kx1000)	5 (Kx1000)	Plant (Kx1000)	Materials (Kx1000)	Sub-contractor S (Kx1000)	Site O/H (Kx1000)		
4 800	370	200	100	600	5 000	4 200	3 300	2 300	20 870	

Draw up a table of variances, calculate the percentage variance of the value completed and forecast the profit for the complete project, if present trends continue. If you were the contracts manager, what advice would you give the site agent?

(Marks 10 + 5 + 5)

- Q2.** Table Q5 below gives all the information necessary for the construction of a Precedence Diagram. Construct the diagram and indicate on it:
- earliest start times;
 - earliest finish times;
 - latest start times; and
 - latest finish times.

Table Q5 Information necessary for construction of Precedence Diagram		
Activity	Duration (weeks)	Dependence
1	2	start
2	6	1
3	6	2
4	1	2
5	3	1
6	3	4 & 5
7	2	3 & 6

(Marks: 8 + 3+ 3 + 3 + 3)

- Q3.**
- Differentiate between Specifications and General Conditions of Contract.
 - With respect to construction equipment, differentiate between ownership and operating costs.
 - State and explain the different costs in which ownership and operating costs of equipment can be classified into.
- (8 +4 +8)
- Q4.** Identify the various groups of people who use specifications and for what purpose.
- (20)
- Q5.**
- Give the names and explain the four types of specifications using examples wherever possible.
 - Explain the following terms as they pertain to the construction Industry:
 - surety bonds; and
 - warranty.
- (12 + 4 + 4)
- Q6.** Figure Q5 presents an arrow network without event numbers but showing durations for each activity in days.
- Number the events (Marks 3)
 - Calculate the earliest and latest event times (Marks 7)
 - Identify the activities that are critical (Marks 3)
 - Calculate the total float and free float of the non-critical activities (Marks 7)

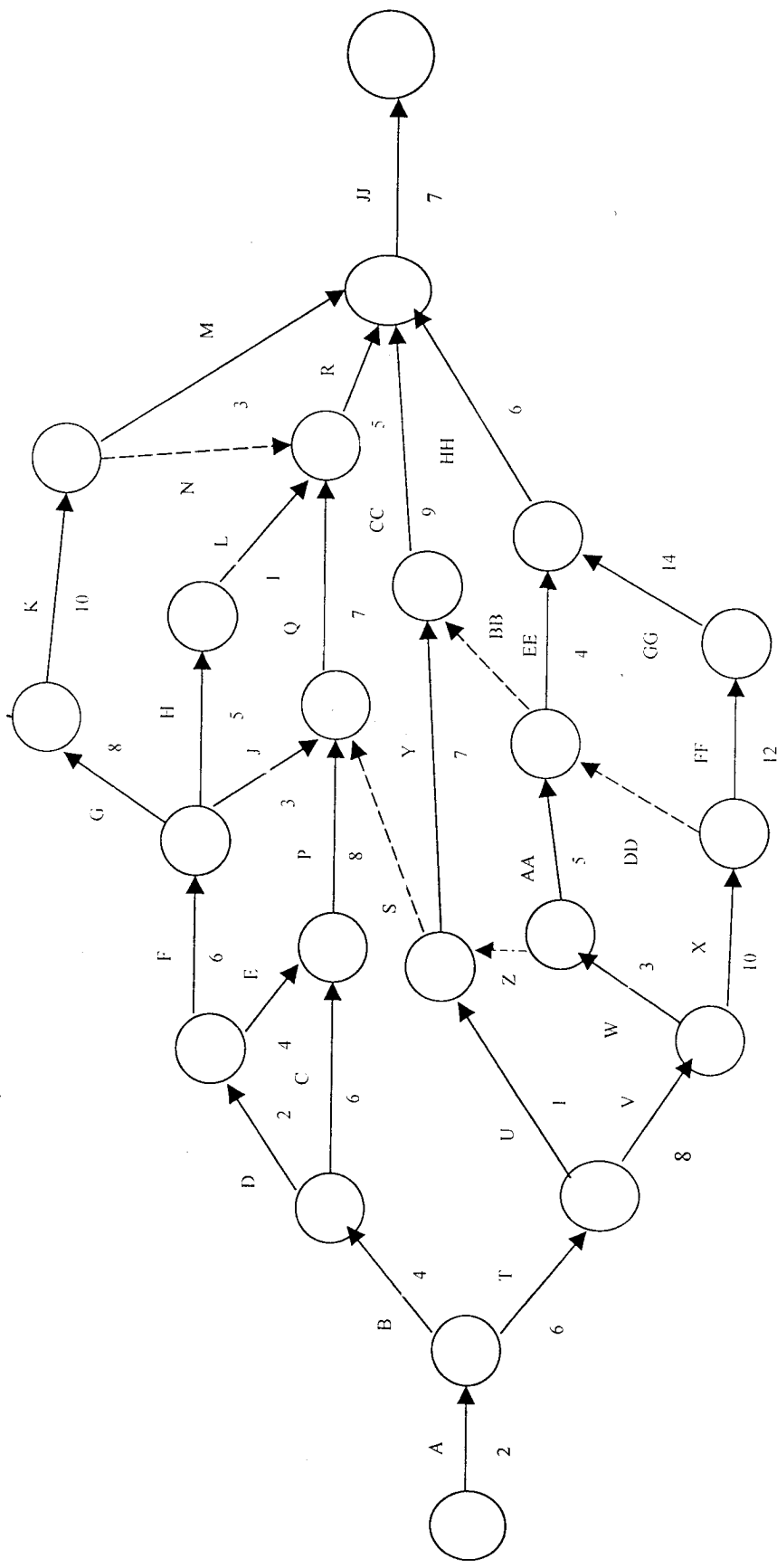


Figure Q5: Arrow network showing duration in days.

- Q7. (a) Illustrate, by way of a flow chart the essential factors to be considered in any decision situation that may be applicable to equipment selection.
- (b) What are the two principles the A-B-C material control policy is based on?
- (c) Step-by-step show how an overall material variance can be generated when instituting cost control on a construction site.

(8 + 4 + 8)

END

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
AGRICULTURAL ENGINEERING
FIRST SEMESTER EXAMINATIONS / JANUARY 2001
EA 311 (FARM POWER AND MACHINERY)

INSTRUCTIONS

TIME ALLOWED: **THREE HOURS**

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

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

ALL QUESTIONS CARRY EQUAL MARKS, (20 MARKS EACH).

THIS QUESTION PAPER COMPRISES EIGHT QUESTIONS.

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

1.
 - a) What is the role of a harness and what factors influence its choice?
[4 marks]
 - b) State **eight** characteristics of a good harness.
[8 marks]
 - c) Define Maintenance Ration and Appetite Limit.
[2 marks]
 - d) Determine the total maintenance ration and appetite limit for four animals with the following weights 600 kg, 500 kg, 450 kg and 350 kg.
[6 marks]

2.
 - a) What is the energy conversion efficiency of a human being?
[1 marks]
 - b) Define Basal metabolism.
[2 marks]
 - c) Give three functions of metabolism.
[3 marks]
 - d) A young energetic person is required to cut trees and hoe and these activities will require a power output of 150 W and 300 W respectively. Given that the Gross Power Consumption for the cutting of trees and hoeing are 600 W and 400 W respectively, determine both the total duration and rest time needed to accomplish these operations.
[14 marks]

SECTION B: ANSWER TWO QUESTIONS FROM THIS SECTION.

3. a) Make a sketch of the gasoline fuel system and label the 3 basic component of this system and describe the primary function of these parts. [6 marks]
- b) On which of these basic components are the following parts, the choke, the throttle valve and the acceleration pump found? [3 marks]
- c) Describe the function of the choke and the acceleration pump. [5 marks]
- d) Name 3 systems for hydraulic controls of hitches on tractors and explain what they do. [6 marks]
4. a) List the functions of a governor. [2 marks]
- b) What does a mechanical governor control in:
i) a petrol engine? [1 mark]
ii) a diesel engine? [2 marks]
- c) Describe the operations of the mechanism in injector pumps used to meter the amount of fuel delivered to injectors on a diesel engine [8 marks]
- d) Describe the oil mist lubrication system. [4 marks]
- e) Briefly explain why an electric powered tractor would be preferred to a diesel-powered tractor for use in a green house. [3 marks]
5. A four cylinder four stroke cycle engine with a firing order 1-3-4-2 is given in **Table Q5a** on page 3.
- a) Make a similar table for a six cylinder two stroke cycle engine with a firing order 1-4-2-6-3-5 by first determining the angle between any two power strokes that immediately follow each other. Use **Table Q5b** on the last page of this examination paper to answer this question. [10 marks]
- b) For this engine what is the ratio of the crank shaft gear to the cam shaft gear. [2 marks]
- c) **True or False?** "For an engine operated at variable speeds a lighter flywheel is needed." [2 marks]
- d) Name **three** functions of a lubrication system. [6 marks]

Table Q5a

Crank travel	Cylinder number			
	1	2	3	4
180°	Power			
360°			Power	
540°				Power
720°		Power		

SECTION C: ANSWER TWO QUESTIONS FROM THIS SECTION .

6. Outline essential field operations required in the production of a crop of wheat in their correct sequence of execution. The crop is to be grown in a field where soya beans has just been harvested. The field has a medium strength hardpan that has developed just below the normal ploughing depth from repeated use of a disk plough over the years and the soils are prone to wind erosion. For each field operation;
- i) state the objective for carrying out the operation.
 - ii) recommend the most appropriate machinery to be used.
- [20 marks]**
7. a) State and briefly explain **two** ways of changing fertiliser application rate (kg/ha) when applying the fertiliser with a tractor mounted broadcaster, operated by the power take off shaft.
- [4 marks]**
- b) State **two** advantages of using liquid pesticide formulation.
- [3 marks]**
- c) List **five** essential components of a sprayer and state the function that each part performs.
- [5 marks]**
- d) State how the following combine losses may be identified and briefly explain how they can be minimised.
- i) Shatter losses
 - ii) Threshing losses
 - iii) Separation losses
 - iv) Cleaning losses
- [8 marks]**

8. a) Briefly discuss the importance of calibrating a seed drill prior to its use. **[5 marks]**
- b) State **two** problems associated with static or workshop calibration of a seed drill **[5 marks]**
- c) A farmer would like to plant 80 kg/ha of wheat seed using a 10 x 250 mm seed drill (10 rows spaced 250 mm apart). The amount of seed collected during calibration is shown in Table Q8. If the diameter of the drive wheel is 637 mm and the drive wheel was turned 50 revolutions. Determine whether the seed drill is planting the correct amount of seed (kg/ha).

Table Q8 Amount of seed collected from each seed metering unit

<i>Unit</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>
<i>kg</i>	<i>0.20</i>	<i>0.19</i>	<i>0.21</i>	<i>0.20</i>	<i>0.20</i>	<i>0.20</i>	<i>0.21</i>	<i>0.19</i>	<i>0.20</i>	<i>0.20</i>

[10 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
AGRICULTURAL ENGINEERING DEPARTMENT
FIRST SEMESTER EXAMINATIONS, JANUARY 2001
EA 401 (ENERGY SOURCES AND UTILISATION IN AGRICULTURE I)

TIME: THREE HOURS.

ATTEMPT: ANY FIVE QUESTIONS.

ALL QUESTIONS CARRY EQUAL MARKS, (20 MARKS EACH).

THIS QUESTION PAPER COMPRISES SIX QUESTIONS

- Q1.** a) Outline any three roles man plays in providing power for agricultural production and for each role, state the relative power input and technical skills required. **[6 marks]**
- b) Continuous physical power output of a 60 kg human varies with time according to the following equation:
$$P = (68 + 932e^{-0.908t^{0.16}})$$
where: P = power output [W]
t = time [s]
- i) Calculate the time period (in hours) over which the sustainable power output of 75 W is possible. **[7 marks]**
- ii) If a field activity requires a continuous physical power input that can be sustained for 1 hour only, what rest periods would be required if the activity has to be performed for an extended period of time while maintaining the same level of power input? **[7 marks]**
- Q2.** a) Discuss the most important factor that influences the amount of energy contained in a feed that is ultimately available to an animal to meet its energy requirement for fieldwork and basal metabolism. **[4 marks]**
- b) Explain what happens in the short term as well as in the long term if the feed given to draught animals is not able to meet their total daily energy requirements. **[5 marks]**
- c) Briefly describe three distinct steps involved in training cattle for draught work. **[6 marks]**
- d) List five visible signs of healthy draught cattle. **[5 marks]**

- Q3.**
- a) Outline how crude petroleum is separated into its respective constituents. **[5 marks]**
- b) State two characteristics of catalytic cracked fuels. **[4 marks]**
- c) Define the following terms:
- i) excess air factor
 - ii) stoichiometric air to fuel ratio
 - iii) gross heat value of a fuel
 - iv) octane rating
- [4 marks]**
- d) State the relationship between:
- i) excess air factor and a lean air-fuel mixture
 - ii) excess air factor and a rich air-fuel mixture
 - iii) excess air factor and stoichiometric air to fuel ratio
- [3 marks]**
- e) Determine the stoichiometric air to fuel ratio for kerosene ($C_{12}H_{26}$) when used as a fuel in an engine. **[4 marks]**
- Q4.**
- a) Give two reasons why a two-stroke-cycle petrol engine is the preferred choice for use in a chain saw primarily used for felling trees. **[4 marks]**
- b) A four-cylinder tractor diesel engine is designed to run at 2000 rpm and develops 50 kW at rated load. Given:
 Temperature drop through the radiator, $\Delta\theta = 7^{\circ}C$
 Specific heat capacity of the coolant, $C = 3.94 \text{ kJ/kg}^{\circ}K$
 Calculate:
- i) the rate of heat dissipation to the coolant? **[2 marks]**
 - ii) the total rate of coolant circulation required to sufficiently cool the engine to the optimum engine operating temperature? **[2 marks]**
 - iii) the rate of coolant circulation per kilowatt of heat to be rejected to the coolant? **[2 marks]**
- c) State and briefly explain two consequences of operating an engine at a higher than optimum temperature. **[5 marks]**
- d) A spark ignition engine is running at 3000 rpm. If the petrol fuel takes about $\frac{1}{300}$ seconds to completely burn in the combustion chamber. How much spark advance is needed if the fuel has to completely be consumed by the time the crankshaft reaches 10° after top dead centre (TDC). **[5 marks]**

- Q5.**
- a) List the three distinct stages of lubrication in the operation of journal bearings and outline important characteristics of each stage. **[5 marks]**
 - b) An automotive lubricant container has the following words imprinted on it; "SAE **10W-30, meets API SF**". What does this mean? **[5 marks]**
 - c) State two important differences between the by-pass filtration and full-flow filtration systems. **[5 marks]**
 - d) Outline five causes of low lubrication oil pressure. **[5 marks]**
- Q6.**
- a) State five advantages of using an electric motor to power a grinding mill over a diesel engine. **[5 marks]**
 - b) Given the following specifications of the electric motor:
Power supply: 240 volts 50 Hz
Power factor: 0.75
Current drawn: 10.6 A
 - i) What parallel connected capacitor size is require to improve the power factor to 0.95 **[10 marks]**
 - ii) Why are capacitor banks used in power factor improvement of electrical installations (such as a motor) often connected in parallel? **[5 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
SECOND SEMESTER FINAL EXAMINATIONS MAY – 2000

EE 209: Principles of Electricity

TIME ALLOWED: THREE (3) HOURS

ANSWER ANY FIVE QUESTIONS: ALL QUESTIONS CARRY EQUAL MARKS

Note: ALL FIGURES ARE ON PAGE 2

- Q1.** Use the Δ - to - Y transformation to find $I_0, I_1, I_2, I_3, I_4, I_5, V_1$ and V_2 in the circuit in **Fig. 1**.
- Q2** Referring to the circuit in **Fig 2**,
- (a) Use the mesh – current method to determine the power delivered to the network by each voltage source.
- (b) Calculate the voltage V_o across the 8Ω resistor.
- Q3.** For the series resonant circuit of **Fig. 3**, determine
- (a) Z_{Total} at resonance, (b) I at resonance, (c) V_R, V_L and V_C at resonance, (d) Q factor, (e) BW if the resonance freq. $f_s = 5.0$ kHz and (f) Half power freq. P_{HPF}
- Q4.(a).** What do **FM** and **AM** stand for?
- (b). What are the two advantages and two disadvantages of **FM** system.
- (c). Draw labeled block diagrams of **AM** transmitter and **AM** receiver.
- Q5.(a)** i) What is a transducer ?
- ii) The transduction of a Photocell is from light to current. What is the transduction of each of the following transducers
- Piezoelectric crystal ,
 - LVDT,
 - Hall effect device,
 - Resistive hygrometer and
 - Strain gauge
- (b) i) What is a control system?
- ii) Derive the transfer function of the control system in **Fig 5**.
- Q6.(a).** What is the phase relationship between voltage and current in i) pure resistive load, ii) pure capacitive load and iii) pure inductive load
- (b). Find the total number of watts, volt-amperes reactive, volt-amperes and the power factor **pf** for the network of **Fig 6**.
- Q7.(a)** Draw the symbol for i) a resistor, ii) capacitor, iii) inductor, iv) independent and dependent voltage sources and v) independent and dependent current sources
- (b). State **KVL** and **KCL**
- (c). Show that the equivalent resistance R_{eq} of three resistances R_1, R_2 and R_3 connected in parallel is given by
- $$R_{eq} = (R_2 R_3 + R_1 R_3 + R_1 R_2) / (R_1 R_2 R_3)$$
- Q8. (a).** Draw a labeled circuit diagrams of **NPN** and **PNP** bipolar transistors showing their correct biasing for them to operate.
- (b). What are **MOSFET, JFET, UJT** stand for ?
- (c). Draw the N-channel and P-channel symbols of each of the components in **Q8. (b)** above.

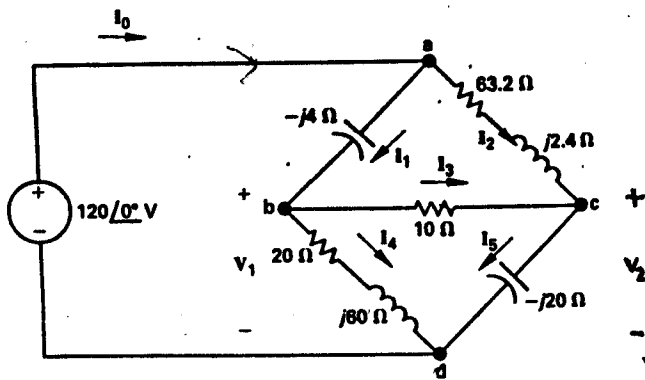


FIG 1

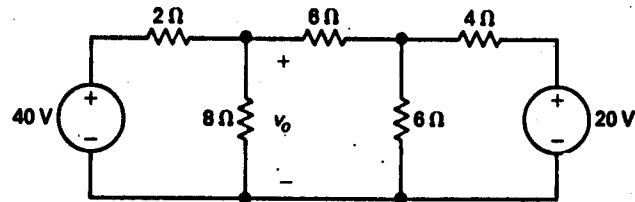


FIG 2

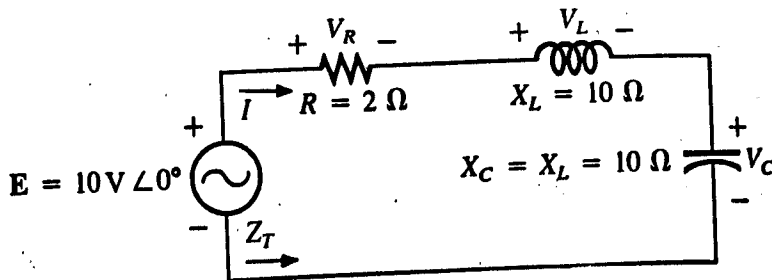


FIG 3

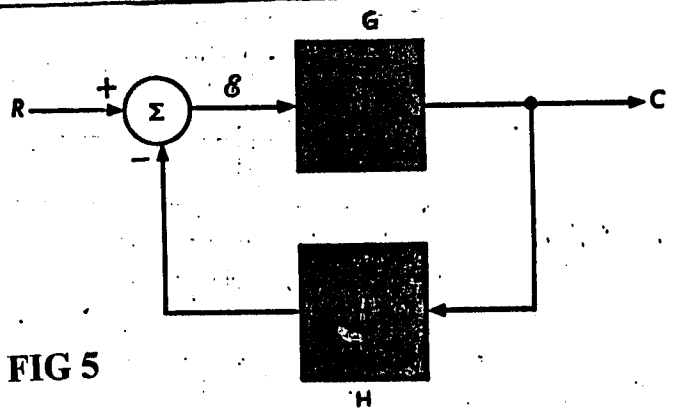


FIG 5

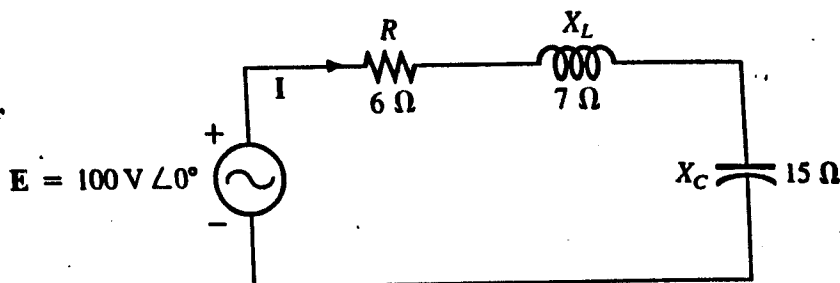


FIG 6

Time : Three hours

Answer: Five questions. All questions carry equal marks

$\mu_0 = 4 \pi \times 10^{-7} \text{ H/m}$; $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$; $e = 2.718$.

Question 1.

- (i) The electron is projected with initial velocity $v_0 = 10^7 \text{ m/s}$ into the uniform field between the parallel plates of Fig.1. It enters the field at the the midway between the plates . If the electron just misses the upper plate as it emerges from the field : (a) find the electric field intensity ;(b) calculate its velocity as it emerges from the field . Assume that $Q/m (\text{ e/m}) = 1.76 \times 10^{11} \text{ C/kg}$ (10 marks)
- (ii) A single -core line concentric cable is to be manufactured for a 60 kV , 50 Hz , Zesco transmission system. The dielectric used is paper which has a maximum permissible safe dielectric stress of 10 MV/m rms and a relative permittivity of 3.5 . calculate (a) the core and inner sheath radii for the most economical cable; (b) the capacitance per metre length; and (c) the charging current per kilometre run (10 marks)

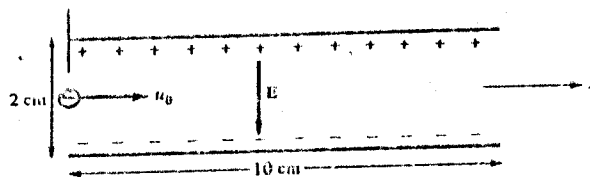
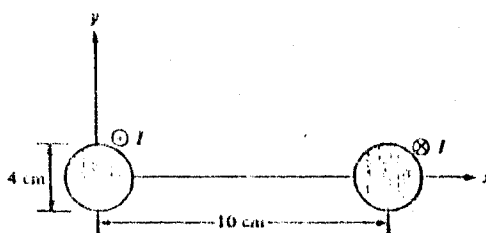


Fig.1

Question 2

- (i) An aeroplane having a wing span of 50 m is flying horizontally at a speed of 600 km/h. Calculate the e.m.f. generated between the wing tips, assuming the vertical component of the earth's magnetic field to be $40 \mu\text{T}$. Is it possible to measure this e.m.f. ? (7 marks)
- (ii) A stroke of lightning may be regarded as filamentary line current . If a lightning stroke with current 50 kA occurs 100 m away from your house , calculate the magnetic flux density at your house due to the lightning stroke . What can what can happen to the person walking around the house area and explain (7 marks)
- (iii) Consider the two-wire infinitely long line whose cross section is illustrated in Fig.2. each wire is of radius 2 cm and the wire are separated 10 cm. The wire centered at (0, 0) carries current 5 A while the other centered at (10, 0) cm carries the return current . Find H at : (5, 0) cm. (6 marks)

Fig.2



Question 3.

(i) A section of an electromagnet with a plate below it carrying a load is shown in Fig.3-a. The electromagnet has a contact area of 200 cm^2 per pole with the middle pole having a winding of 1,000 turns with $I = 3 \text{ A}$. calculate the maximum mass which can be lifted. Assume that the reluctance of the electromagnetic and the plate is negligible. **(10 marks)**

(ii) In the magnetic circuit of Fig.3-b, (a) give the electric circuit analog of the magnetic circuit ; (b) calculate the current in the coil that will produce a magnetic flux density of 1.5 Wb/m^2 in the air gap assuming that $\mu = 50\mu_0$ and that all the branches have the same cross-sectional area of 10 cm^2 **(10 marks)**

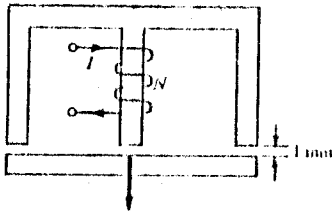


Fig.3-a

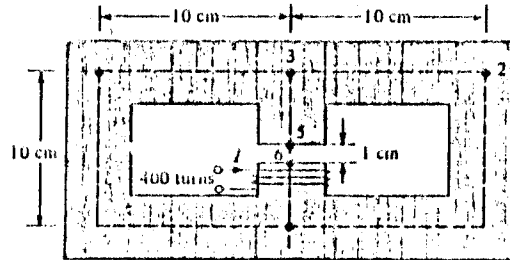


Fig.3-b

Question 4.

(i) Tests are performed on a single phase transformer , 10 kVA, 2200/220 V, 60 Hz and the following results are obtained :

	Open - Circuit Test (high - voltage side open)	Short - Circuit Test (low - voltage side shorted)
Voltmeter	220 V	150 V
Ammeter	2.5 A	4.55 A
Wattmeter	100 W	215 W

- (a) Derive the parameters for the approximate equivalent circuits referred to l.v. side and the h.v. side;
- (b) Determine the excitation current as a percentage of the rated current;
- (c) Determine the power factor for the no - load and the short circuit tests

(12 marks)

(ii) Considering the same transformer, determine the voltage regulation in percent for the following load conditions : (a) 75 % full load , 0.6 power factor lagging; (b) 75% full load , 0.6 Power factor leading ;and (c) draw the phasor diagram for conditions (a) and (b). **(8 marks)**

Question 5.

- (i) (a) Three $20 \mu\text{F}$ capacitors are star-connected across a 415 V , 50 Hz, three - phase , three - wire supply . Calculate the current in each line ;
- (b) If one of the capacitors is short - circuited , calculate the line current ;
- (c) If one of the capacitors is open - circuited , calculate the line currents and the p.d. across each of the other two capacitors .

(9 marks)

- (ii) A 415 - V, 50 Hz, three - phase distribution systems supplies a 20 - kVA, three- phase induction motor load at a power factor of 0.8 lagging , and a star - connected set of impedances, each having a resistance of 10Ω and an inductive reactance of 8Ω . Calculate the capacitance of the delta - connected capacitors required to improve the overall power factor to 0.95 lagging. **(7 marks)**
- (iii) Two such meters read 120 W and 50 W when connected to measure the active power taken by a balanced three - phase load. Find the power factor of the load. If one wattmeter tends to read in reverse direction, explain what changes may have occurred in the circuit. **(4 marks)**.

Question 6

- (i) A four -pole armature is wound with 564 conductors and driven at 800 r/min, the flux per pole being 20 mWb. The current in each conductor is 60 A. Calculate the total current, the e.m.f. and the electrical power generated in the armature if the conductors are connected (a) wave, (b) lap. **(6 marks)**
- (ii) Explain clearly the effect of the back e.m.f. of a shunt motor. What precautions must be taken when starting a shunt motor
A four -pole d.c. motor is connected to 500 V d.c. supply and takes an armature current of 80 A. The resistance of the armature circuit is 0.4Ω . The armature is wave wound with 522 conductors and the useful flux per pole is 0.025 . Calculate : (a) the back e.m.f of the motor; (b) the speed of the motor; (c) the torque in newton metres developed by the armature. **(8 marks)**
- (iv) A d.c shunt motor has an out put of 8 kW when running at 750r/min off a 480 V supply. The resistance of the armature circuit is 1.2Ω and that of the shunt circuit is 800Ω . The efficiency at that load is 83 % . determine: (a) the no load current armature ; (b) the speed when the motor takes 12 A; (c) the armature current when the gross torque is 60 N.m. Assume the flux remains constant. **(6 marks)**

Question 7.

- (i) Use only NAND gates to implement the the following logic functions:

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

$$F = (\bar{A} + \bar{B} + \bar{C}) \cdot (A + B + C)$$

(8 marks)

- (ii) Give the truth table in the table 7

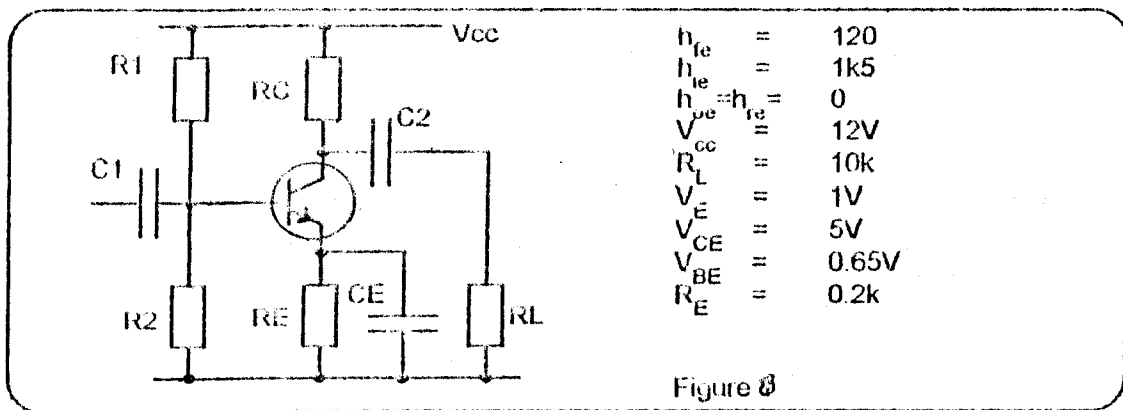
(12 marks)

- a) Find a logic for F;
b) Simplify your expression using a Karnaugh map;
c) Draw a logic circuit that implements the simplified expression for F.

A	B	C	F
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Question 8

- (i) Give the three ways of connecting signal in and out of a transistor (2 marks)
- (ii) Give the three methods used to bias the B.J.T circuit and discuss their performances (6 marks)
- (iii) For the following diagram :



Calculate:(a) R_1 , R_2 and R_C , when the current in R_1 , $I_{R1} = 10 \times I_B$; (b) Draw the mid-frequency equivalent circuit and calculate voltage gain A_v , current gain A_i , and input impedance Z_{in} ; (c) Explain the function of C_1 , C_2 , and C_E . Make an approximate calculation of the gain A_v and the input impedance Z_{in} if we remove C_E .

(12 marks)

End of EE 309 Exam.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

UNIVERSITY EXAMINATIONS JANUARY 2001

EE 311 ELECTRIC CIRCUITS

TIME: Three Hours

ANSWER: Five Questions

Laplace transform table will be distributed by the lecturer

Q1. Consider the network in figure 1

- Find the transfer function $H(s) = \frac{V_2(s)}{V_1(s)}$
- Find the step response from the network, in the time domain.
- Find the impulse response of the network, in the time domain.

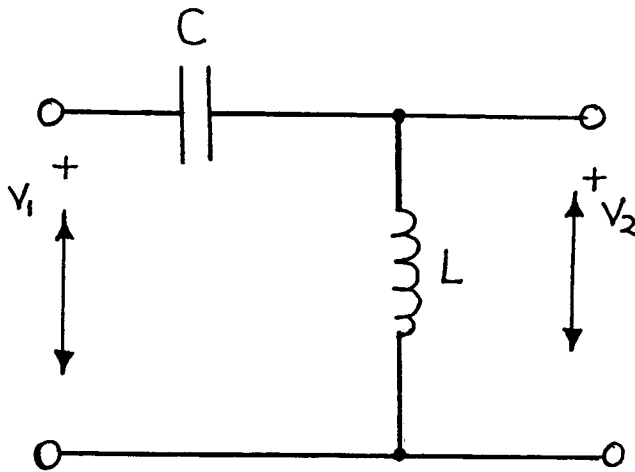


fig. 1

Q2. Consider the S-plane in figure 2

- Find the laplace equation $F(s)$ of the pole-zero plot.
- Retransform $F(s)$, i.e. Find $f(t)$
- Use initial and/or final value theorem to verify that your answer in (b) is correct.

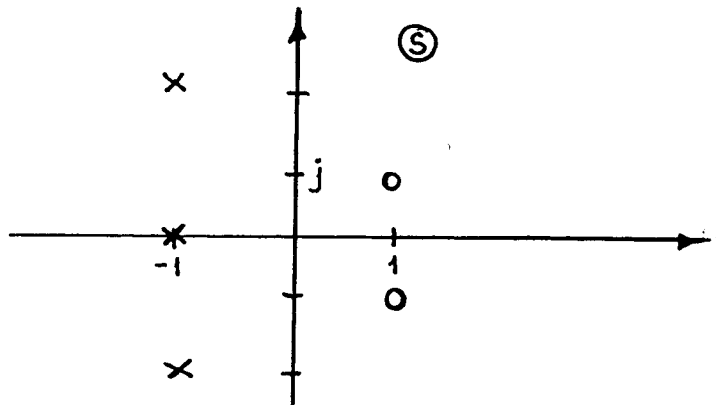


fig. 2

Q3. In this Question plot the equation model in each case.

- Give the voltage-current relation for a resistor
- Give the equation that describes the current in an ideal capacitor $i_C(t)=$
Give the equation that describes the voltage in an ideal capacitor $u_C(t)=$
- Give the equation that describes the current in an ideal inductor, $i_L(t)=$
Give the equation that describes the voltage in an ideal inductor, $u_L(t)=$

Q4. Consider the 3 different pole-zero plots in the s-planes in figure 4

- Find the transfer function $H(i)$, $H(ii)$ and $H(iii)$
- If these systems are driven by steps, what responses, will we get for (i), (ii) and (iii)
- Which transfer function (i, ii or iii) perform an integration.

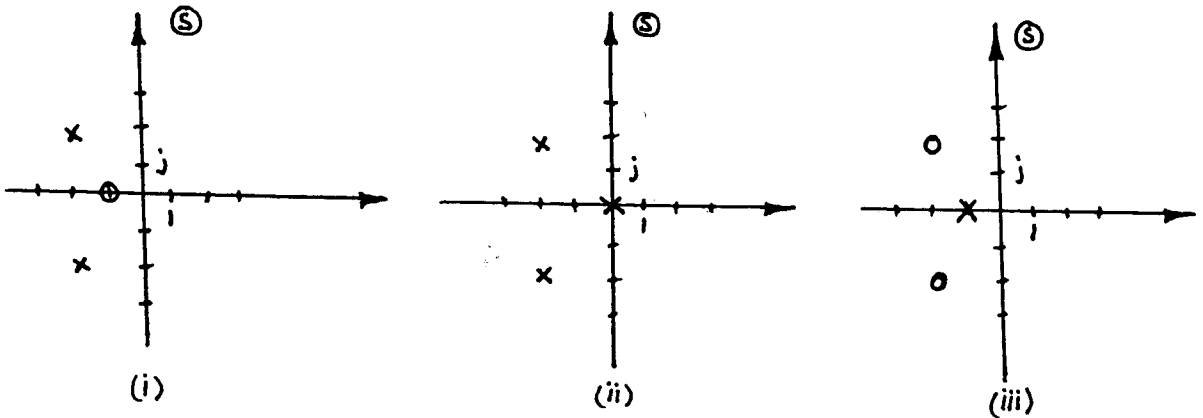


Fig 4

Q5. For the figures below, a single tuned circuit, the poles of $H(s)$ are

$$P_{1,2} = \frac{R}{2L} \pm \frac{j}{2} \left(\frac{4}{LC} - \frac{R^2}{L^2} \right)^{\frac{1}{2}} = -\alpha \pm j\beta$$

Or

$$H(s) = \frac{\alpha^2 + \beta^2}{(S + \alpha + j\beta)(S + \alpha - j\beta)}$$

- Using graphical and peaking circle methods determine ω_{\max} , ω_0 , ω_c
- Derive an expression for ω_{\max} to exist given that

$$\frac{d|H(j\omega)|^2}{d\omega^2} = -\frac{(\alpha^2 + \beta^2)^2 [2\omega^2 + 2(\alpha^2 - \beta^2)]}{[\omega^4 + 2\omega^2(\alpha^2 - \beta^2) + (\alpha^2 + \beta^2)^2]^2}$$

- From the peaking circles show the effects of the relative position of the poles in the s-plane.

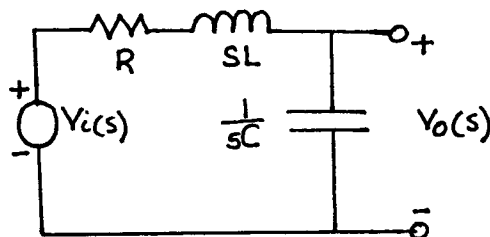
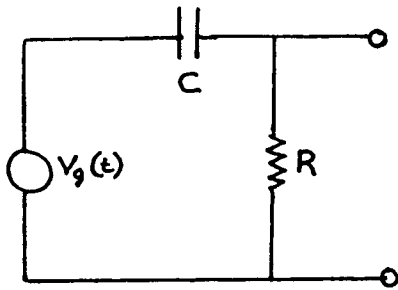
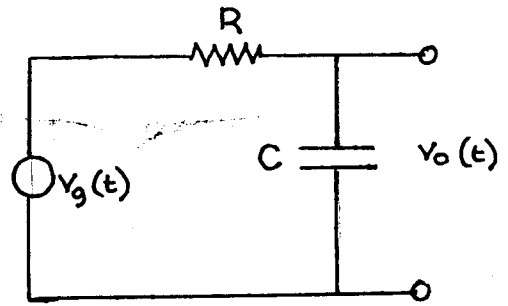


Fig 5.

Q6. Given figures 6(a) and (b) below



(a)



(b)

fig 6.

- Obtain system function ($H(j\omega)$) and determine the integrator and the differentiator.
- Find the impulse response of figure 6(a)
- Derive expressions for, step and unit ramp responses given

$$R(s) = E(s) H(s)$$

Q7.

For the R-C network in figure 7 with the excitation given as $i_g(t) = (I_0 \sin \omega_0 t) U(t)$. Find the voltage $V(t)$ across the capacitor.

It is given that $v(0^-) = v_c(0^-) = 0$ and complementary solution

$$V_p(t) = - \frac{I_0}{(G^2 + \omega_0^2 C^2)^{\frac{1}{2}}} \sin\left(\omega_0 t - \tan^{-1} \frac{\omega_0 C}{G}\right)$$

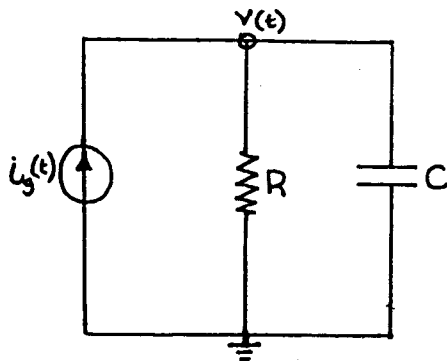


Fig. 7

Q8. In this problem you shall answer “true” or “false”. You should attach the reasoning behind your answers. Wrong answers will be penalised.

		True	False
a	All stable system shave the their zeros in the left hand side of the s-plane		
b	The voltage over an ideal inductor cannot change instantaneously unless the driving function is an impulse		
c	The Integral of the δ -function is the step function		
d	The function $x(t) = U(t) - 1/2$, is an odd function of time		

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS JANUARY 2001

EE321
ELECTROMECHANICS & ELECTRICAL MACHINES

Time: **Three hours.**

Answer **five questions.**

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$
 Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

1.

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

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

[10 marks]

A capacitor consists of two parallel conducting plates. The plates are 0.1 mm apart and the space between them is partially filled with polythene sheet of thickness 0.09 mm, relative permittivity 2.25 and breakdown strength 300 kV/cm. Assuming the breakdown strength of air is 30 kV/cm, find the maximum voltage which can be applied to the capacitor without causing breakdown. What difference does it make to the maximum voltage if the polythene sheet completely fills the space between the plates?

[10 marks]

2.

Develop the equivalent circuit of a copper-wire wound, iron-cored inductor, accounting for all power losses.

[8 marks]

A cylindrical steel plunger of diameter 3.9 cm is surrounded by a 1000-turn coil in a cylindrical steel body as shown in figure 1. The coil is energised with a current of 0.5 A. Assuming the steel has infinite permeability and neglecting leakage and fringing fluxes, calculate the total stored energy in the air-gaps.

[12 marks]

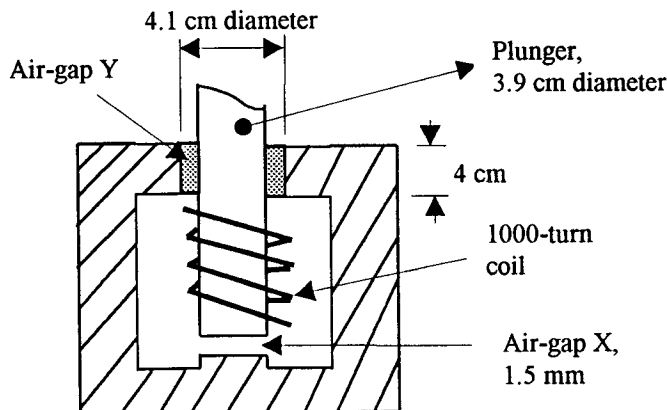


Figure 1.

3.

Describe the experimental methods used to determine the parameters of the equivalent circuit of a transformer.

[8 marks]

A 10-kVA, 200/400-V, single-phase transformer gave the following test results.

Open-circuit test (Low Voltage winding supplied): 200 V, 3.2 A, 450 W.

Short-circuit test (High Voltage winding supplied): 38 V, 25 A, 600 W.

(a) Determine the parameters of the equivalent circuit of the transformer referred to the low voltage side.

[6 marks]

(b) Find the efficiency of the transformer when the transformer delivers half its rated kVA at 0.85 power factor lagging at rated output voltage.

[6 marks]

4.

(a) Describe, with suitable circuit diagrams, how reactive power is measured in three phase circuits, giving proof that such an arrangement measures reactive power. What conditions are required to make this method valid?

[8 marks]

(b) A 3-phase, 50-Hz, 500-V motor operating at a power factor of 0.4 lagging takes 30 kW.

(i) What is the reading on the instrument face, when a wattmeter is connected to read reactive power?

[3 marks]

(ii) What is the reading on each of the two wattmeters correctly connected to measure the input power?

[5 marks]

(iii) What is the value of each of the capacitor in star connection needed to improve the power factor at the input to 0.71 lagging?

[4 marks]

5.

For a dc machine derive, from first principles, an expression for the terminal voltage V , and the electromagnetic torque, T , in terms of the machine's constants, flux per pole, ϕ , armature current, I , and speed of rotation, n .

[10 marks]

A separately excited dc generator develops 90 Nm of torque and 18 kW of power. What is the generator speed? If the armature resistance is 0.3Ω and the product of the machine constants and the flux per pole, $k\phi$, is 15 Wb, what is the terminal voltage? If the generator is then operated as a shunt-excited generator, find the value of the field resistance, if the required field current is 3 A.

[10 marks]

6.

With the help of equivalent circuits, predict the torque-speed characteristics of the DC Shunt motor and the DC series motor.

[12 marks]

A 37.3-kW, 440-V, 4-pole, DC-series motor has 31 armature slots with 18 conductors per slot. The armature is wave-wound. When the motor current is 57 A, the flux per pole is 0.035 Wb. Ignoring all power losses, determine the

electromagnetic torque of the motor when the input current is 45 A. What is the input power to the motor and the mechanical power developed?

[8 marks]

7.

(a) Use phasor diagrams of magnetomotive forces, voltages and currents to describe the modes of operation of the synchronous machine as a generator, motor and compensator. In all cases, distinguish between leading and lagging reactive power handling.

[10 marks]

(b) Three phase ac machines operate on the principle of a “rotating” magnetic flux. Describe the principal features which establish the ac machine as a induction machine and as a synchronous machine.

[4 marks]

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

(i) What is the slip?

[2 marks]

(ii) What is the speed of the rotor?

[2 marks]

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

[2 marks]

8.

Answer any two.

(a) Given that the expression of the torque T for an ac reluctance motor with unexcited rotor is $T = \frac{i^2}{2} \frac{dL}{d\theta}$, where i is the stator sinusoidal ac current given as $i = I_m \cos \omega t$, L is the inductance of the ac winding, and θ is the angular position defined by the rotor speed as $\theta = \theta_o + \omega_r t$, derive the expression for the average torque developed. The rotor is of simple form such that the inductance L varies sinusoidally with respect to θ , with peak value L_m and is superimposed on a constant value L_o , such that $L = L_o + L_m \cos 2\theta$. Indicate the practical conditions for which the average torque is finite and hence find its expression.

[10 marks]

(b) From basic concepts and defining all terms, derive an expression giving the relationship between the illuminance at a general point C and a reference point B , where B is a distance d from C on a horizontal plane surface. B is also a depth h from A , a point of a light source with luminous intensity I .

[10 marks]

(c) Knowing the expressions for the stored energy in electromagnetic fields, derive from basic principles, expressions for the mechanical forces exerted in (i) an electric field of strength E and relative permittivity ϵ_r , and (ii) a magnetic field of density B and relative permeability μ_r .

[10 marks]



THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
SECOND SEMESTER UNIVERSITY EXAMINATIONS - MAY 2000

EE 422: ELECTRICAL MACHINES I

INSTRUCTIONS...

- ◆ **TIME ALLOWED: THREE (3) HOURS**
- ◆ **ANSWER FOUR QUESTIONS: ONE QUESTION FROM EACH SECTION**
- ◆ **ALL QUESTIONS CARRY EQUAL MARKS**

SECTION A: TRANSFORMER

Q1. (a) List the losses that occur in a single-phase transformer when supplying a load. What are the measures taken to minimize each loss?

(b) State

- i. The main advantage of using an autotransformer.
- ii. The essential difference between a double wound transformer and autotransformer.
- iii. Suitable application for an autotransformer.

(c) A 10-KVA 440/110 two-winding transformer is reconnected as a step-down 550/440-V autotransformer. Compare the volt-ampere rating of the autotransformer with that of the original two-winding transformer, and calculate the conductively transferred power P_c and inductively transferred power P_i

Q2. A 150 KVA 2400/240-V transformer has the following parameters

R_1 - primary winding resistance	=	0.2 Ω
R_2 - secondary winding resistance	=	0.002 Ω
X_1 - primary leakage reactance	=	0.45 Ω
X_2 - secondary leakage reactance	=	0.0045 Ω
R_c - core resistance	=	10,000 Ω
X_m - magnetizing reactance	=	1550 Ω

(a) Refer the circuit to the primary, calculate the voltage regulation of the transformer at rated load with 0.8 lagging power factor.

(b) Determine the efficiency of the transformer operating on rated load and 0.8 lagging power factor.

(c) The transformer operates on full load 0.8 lagging power factor for 12 hours, on no load for 4 hours and on half full load unity power factor for 8 hours. Calculate the all day efficiency.

SECTION B: SYNCHRONOUS MACHINES

- Q3.** (a) State the conditions that must be fulfilled in order for a synchronous generator may be connected in parallel with a system (or bus).
- (b) Explain with the aid of labeled diagram how two synchronous generators can be synchronized using lamps.
- (c) Two identical three phase wye-connected synchronous generators share equally a load of 10 MW at 33kV and 0.8 lagging power factor. The synchronous reactance of each machine is 6Ω per phase and the armature resistance is negligible. If the power factor of the first machine is 0.9 lagging and the two machines share the load equally, what are the power factor and current of the second machine?
- Q4.** (a) Explain with the aid of a sketch, the reason why a three-phase synchronous motor is not self-starting and describe two methods of overcoming this problem.
- (b) State, giving reasons, the type of rotor construction normally used for each of the following synchronous machines: -
- i. low speed
 - ii. high speed.
- (c) State two main advantages and two main disadvantages of synchronous machines.

SECTION C: INDUCTION MACHINES

- Q5.** (a) Discuss, stating advantages and disadvantages, three methods of starting a three-phase induction motor.
- (b) Sketch the characteristic curves of an induction motor showing how the input current, power factor, efficiency, and torque vary when the slip, s , changes between 1.0 and 0 (zero). Indicate on your sketch the starting torque and maximum torque.
- Q6.** (a) Briefly describe how can an induction motor be operated as a self-excited induction generator.
- (b) Determine the parameters of the approximate equivalent circuit of a three phase induction motor from the following data:-

No load test:

Line to line voltage	=	400 V
Input power	=	1770 W
Input current	=	18.5 A
Friction & windage-loss	=	600 W

Blocked rotor test:

Line to line voltage	=	45 V
Input power	=	2700 W
Input current	=	63 A

SECTION D: DC MACHINES

- Q7.** (a) State four main causes of voltage drop in dc generators.
(b) Explain, with the aid of labeled circuit diagram, the Ward - Leonard system of speed control of dc motors.
(c) A 230 V shunt motor has an armature resistance of 0.05Ω and a field resistance of 75Ω . The motor draws 7 A of line current while running at 1120 r/min. The line current at certain load is 46 A.
- What is the motor speed at this load?
 - The no load conditions remain unchanged. On no load, the line current remains at 46 A, but a 0.1Ω resistance is inserted in the armature. Determine the speed of the motor and the power dissipated in the 0.1Ω resistance.
- Q8.** (a) Explain how the torque developed by a dc motor varies with each of the following:-
- armature current
 - field excitation
- (b) Describe how the effects of armature reaction on commutation may be overcome in a dc motor.
- (c) A 10 hp 230-V shunt motor takes a full load line current of 40 A. The armature and field resistances are 0.25Ω and 230Ω , respectively. The total brush-contact drop is 2 V and the core and friction losses are 380 W. Calculate the efficiency of the motor. Assume that stray-load loss is 1 percent of rated output. (1 hp = 0.746 kW)

End of EXAMINATION....God Bless

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

UNIVERSITY EXAMINATIONS (FIRST SEMESTER)

FRIDAY (PM) - 12 JANUARY 2001

ELECTRONICS (EE 431) & ELECTRONIC ENGINEERING II (EE441) PAPER

TIME ALLOWED: THREE (03) HOURS

ANSWER: THIS PAPER HAS EIGHT QUESTIONS. ANSWER ANY FIVE (05) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. USEFUL CONSTANTS/VARIABLES ARE GIVEN AT THE END OF THE QUESTION PAPER.

Q1. A. When is the Ebers-Moll transistor model used?

- (i) Sketch the general form of the Ebers-Moll n-p-n transistor model labeling it appropriately.**
- (ii) Using your labeled model in (i) and by inspection, derive expressions for emitter, collector and base currents when the transistor is operating in both the active and saturated regions (ignore leakage currents).**

B. Figure 1 shows the basic operation of an n-p-n transistor in common emitter configuration. V_{CC} is a fixed direct voltage, V_{BB} a varying base-input controlling voltage, R_B and R_L are resistors.

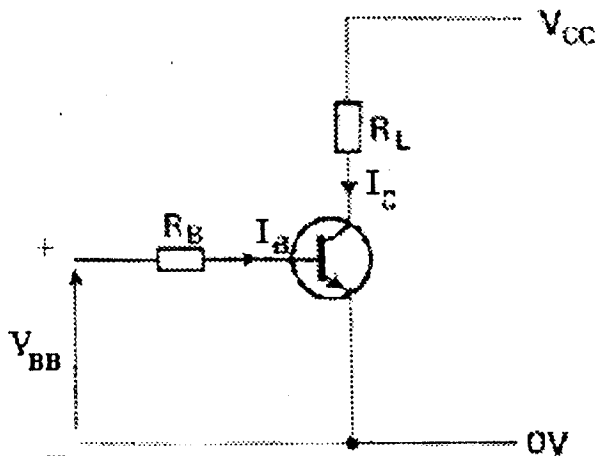


Figure 1. Basic operation of a transistor

- (i). Derive expressions for base, collector and emitter currents in terms of appropriate voltages and resistors.
- (ii). If collector current and collector-emitter voltage are measured along the y- and x- axis respectively, sketch the output characteristic of this transistor with increasing base current.
- (iii). On your sketch in (ii) superimpose a load line. Explain how a suitable operating value of collector current and collector-emitter voltage is chosen.

Q2. Silicon is the main raw material used in fabricating most of present day electronic devices. For pure silicon:

- A.**
 - (i). Briefly explain the four quantum number of its atom.
 - (ii). Using these quantum number determine the electronic configuration of this atom.
 - (iii). Explain formation of energy bands in a silicon crystal.
 - (iv). Based on your explanation in (iii), describe a metallic conductor semiconductor and insulator.
- B.**
 - (i). Using a suitably labeled diagram distinguish between electrons obeying Fermi-Dirac and Maxwell-Boltzmann statistics in a silicon crystal in relation to temperature changes.
 - (ii). Calculate the chances of a hole appearing at the top of the valence band at absolute temperature and at room temperature.

Q3. **A.** Operation of optoelectronic devices is based on the interaction of light energy with electrons.

- (i) Explain the operation of a photovoltaic cell and a photodiode. Give their symbols and two practical applications for each one.
- (ii) Detail the construction of a basic p-n junction solar cell and describe its operation. How does a p-n solar cell differ from a p-i-n solar cell.
- (iii) Detail the construction and operation of an optocoupler. Why is an optocoupler sometimes referred to as an optoisolator.

B.

- (i) Besides illumination, give another practical method of creating charge carrier pairs in silicon.
- (ii) Cadmium sulphide is often used in constructing light dependent resistors. Calculate its corresponding threshold wavelength.

Q4. A. Fabrication of modern bipolar junction transistors (BJT's) employs the planar process in which the device is formed only on one side of the silicon wafer as shown in figure 2:

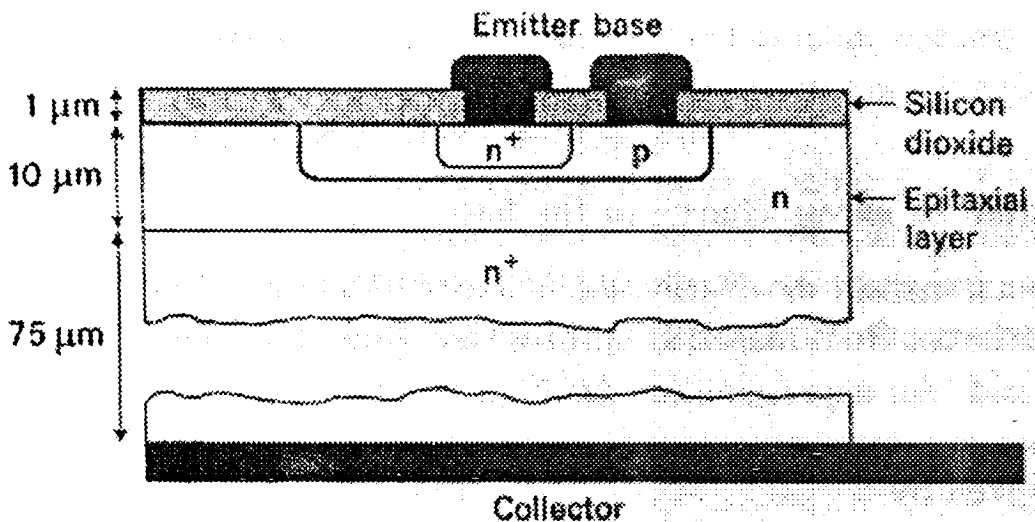


Figure 2. Section through a planar process n-p-n bipolar junction transistor (not to scale)

- (i) What are the roles of the n+ regions (both on the emitter-side and the collector-side)?
 - (ii) Why is an aluminium sheet used as the collector?
 - (iii) What is the role of the silicon dioxide layer?
 - (iv) Distinguish between a metal and a degenerate semiconductor
- B. An n-p-n common emitter transistor is operated at a collector current of 1mA, base current 20 μ A and collector base leakage current of 1nA. The recombination time of carriers in the base is 0.2 μ s. Assuming an ideal transistor, Find:
- (i) The large signal current gain h_{FE}
 - (ii) Leakage current I_{CEO}
 - (iii) Transit time of electrons when crossing the base τ_C

(iv) Excess charge in the base q_b

Q5. A. (i) Name two main types of noise in electronic devices and discuss their origins.

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

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

B. An electronic device of effective resistance $4\text{ k}\Omega$ operates at room temperature and current of 2 mA over a bandwidth of 8 MHz . Find the:

(i) Mean square shot noise current

(ii) Mean square thermal noise current

Q6. A. There are three normal modes of operating a transistor and these depend on the polarities of the junction biasing voltages V_{BE} and V_{BC} for common-emitter configuration. Name these modes and detail how V_{BE} and V_{BC} voltages are biased in each of these modes.

B. Explain the terms emitter efficiency and base transport factor and relate them to the large signal current gain of a common emitter n-p-n transistor. An n-p-n transistor has the following parameters: emitter efficiency of 0.996, base transport factor of 0.986 and collector current of 2 mA . The electrons flowing across the base occupy an effective volume of 10^{-14} m^3 and their average transit time is 1 ns . Calculate:

(i) The number density of minority carriers in the base

(ii) Recombination time of minority carriers while they are in the base.

Q7. A. Multilayer devices include thyristors, diacs and programmable unijunction transistors among others.

- (i) Why are they called multilayer devices?**
- (ii) Using suitable diagrams detail the arrangement of p-n junctions in each one of these devices. Also give their symbols.**
- (iii) Briefly describe the operation of a thyristor and sketch its voltage-current output characteristics.**

B. Sketch the plots of carrier concentration versus distance for an abrupt p-n silicon junction at room temperature if the concentration of donor atoms is 5×10^{14} atoms/cm³ and acceptor atoms are 5×10^{16} atoms/cm³. Give approximate numerical values on the axes and clearly label the p-, n- and depletion regions on your plot.

- Q8. A.**
- (i). Differentiate crystal binding types of elemental aluminium and silicon**
 - (ii). Explain how pure gallium arsenide is converted into n-type and p-type.**
 - (iii). Comment on any three commonly used semiconducting materials in respect of their production and suitability.**
 - (iv). Briefly discuss the origin of lattice scattering in a semiconductor.**
 - (v). Comment on the concept of effective mass of charge carriers. Discuss the suitability of using gallium-arsenide in high frequency devices.**

B. Holes are injected into one end of a piece of n-type silicon. The initial concentration is 10^{22} m^{-3} . If the minority carrier mobility is $0.04 \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$ and the lifetime is 10ms, calculate the distance required for the minority carrier concentration to drop to within ten percent of its equilibrium value at room temperature.

END

LIST OF USEFUL CONSTANTS AND VARIABLES

1. Boltzmann constant = $1.38 \times 10^{-23} \text{ JK}^{-1}$
2. Electronic charge = $1.602 \times 10^{-19} \text{ C}$
3. 1 electron volt = $1.602 \times 10^{-19} \text{ J}$
4. Room temperature = 27° C
5. Silicon intrinsic carrier concentration at room temperature = $1.38 \times 10^{16} \text{ m}^{-3}$
6. Cadmium sulphide energy gap = 2.42 eV
7. Energy gap for silicon = 1.08 eV at room temperature and 1.16 eV at 0 K
8. Absolute Temperature = -273° C
9. Planck's constant = $6.63 \times 10^{-34} \text{ Js}$
10. Speed of light = $3.0 \times 10^8 \text{ m/s}$
11. Assume room temperature if not specified

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

UNIVERSITY EXAMINATIONS MAY 2000

EE452

ELECTRIC POWER SYSTEMS

Time: Three hours

Answer four questions

Take $\mu_0 = 4\pi \times 10^{-7}$ H/m and $\epsilon_0 = 8.85 \times 10^{-12}$ F/m

1.

Given that the potential difference between two conductors 1 and 2 of a group of n parallel conductors charged to q is given by

$$V_{12} = \frac{1}{2\pi\epsilon_0} \left[q_1 \ln \frac{D_{12}}{r_1} + q_2 \ln \frac{r_2}{D_{21}} + q_3 \ln \frac{D_{32}}{D_{31}} + \dots + q_n \ln \frac{D_{n2}}{D_{n1}} \right]$$

where D is the distance of separation between conductors and r is the radius of the conductor, derive the expression for the capacitance of a three phase transmission line with unsymmetrical spacing.

[10 marks]

A 120-km, 50-Hz, regularly transposed 3-phase line has two conductors per phase of diameter 25.6 mm diameter each. The phases and conductors are in a horizontal arrangement with effective spacings of 10 m, 10 m, and 20 m between phases and spacings of 10 cm between centres of composite conductors in a phase. The effective resistivity of the material is $0.025 \mu\Omega\text{m}$. Using an appropriate circuit model, find the *ABCD* constants of the line.

[15 marks]

2.

Discuss insulators for overhead lines on the basis of materials and applications.

[6 marks]

Develop the expression for the sag of an overhead line conductor suspended between two supports at equal heights, assuming the curve taken by the conductor to be a parabola. Explain how the wind and ice loading is taken into account in determining the tension in the conductor.

[7 marks]

A transmission line at a river crossing is supported from two towers at heights of 30 m and 80 m above water level. The horizontal distance between the towers is 300 m. If the tension in the conductor is 30000 N and the conductor weighs 10 N/m, find the clearance between the conductor and the water at a point midway between the towers.

[12 marks]

3.

Discuss the advantages and disadvantages of interconnection of power systems.

[5 marks]

Derive the expression for the power transmitted in an inter-connector whose properties are expressed by the *ABCD* parameters.

[8 marks]

A 132-kV line has a series impedance of $0.2 + j0.4 \Omega/\text{km}/\text{phase}$ and a route length of 40 km. For a voltage drop of 10% of rated voltage, calculate the receiving-end power if its power factor is 0.8 lagging. If the voltages at both ends are both equal to the rated voltage, what is the power limit of the line?

[12 marks]

4.

Describe, with the aid of sketched waveforms, how the reactance of a synchronous generator varies with time upon the occurrence of a short-circuit at its terminals and how it affects the short-circuit current. With suitable derivations, explain how a d.c. transient component can arise at the instant of short circuit.

[8 marks]

Equipment rating for a four-bus power system shown in Figure 1 are as follows:

Generator G1: 150 MVA, 13.8 kV, $X'' = 0.2 \text{ p.u.}$;

Generator G2: 180 MVA, 18 kV, $X'' = 0.18 \text{ p.u.}$;

Generator G3: 200 MVA, 20 kV, $X'' = 0.15 \text{ p.u.}$;

Transformer T1: 150 MVA, 13.8- Δ /330-Y kV, $X = 0.12 \text{ p.u.}$;

Transformer T2: 180 MVA, 18- Δ /330-Y kV, $X = 0.10 \text{ p.u.}$;

Transformer T3: 200 MVA, 20- Δ /330-Y kV, $X = 0.10 \text{ p.u.}$;

Each 330 kV line is $X = j50 \Omega$.

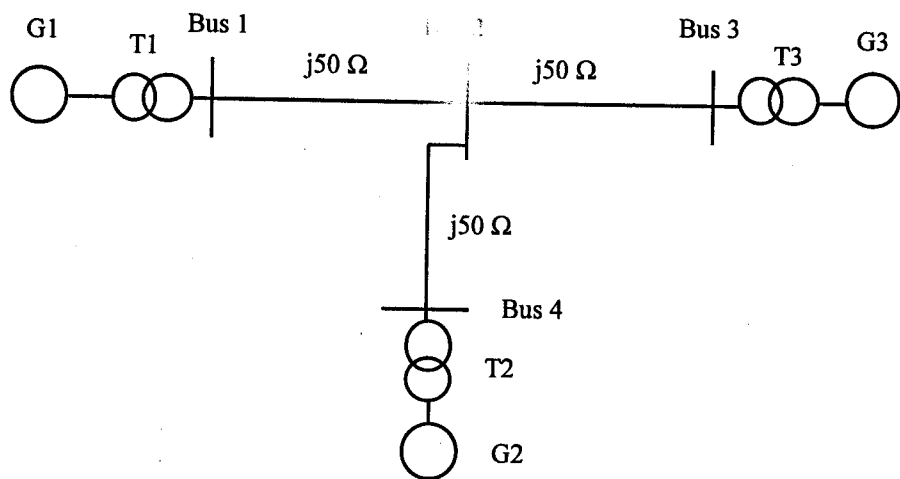


Figure 1.

A three-phase fault occurs at bus 1 where the pre-fault voltage is 330 kV and pre-fault current can be neglected. Find the fault current and the contribution to the fault current of generator G1.

[17 marks]

5.

Describe how time and current grading is achieved by application of the IDMT over-current relay.

[10 marks]

A 3-phase, 11-kV cable ABC, fed at A, has 3-phase fault levels, during maximum load conditions, of 250, 225 and 200 MVA at A, B and C, respectively. The 11-kV circuit breaker at C, controlling the 11kV/415-V, 1000-kVA transformer at C, is of the direct acting type with time limit fuses which can be assumed to blow in 0.1 s for a 200 MVA fault on the high voltage side of the transformer. At B in the section BC and at A in the section AB, are

fitted 400/5 current transformers and IDMTL relays. Assuming a discrimination time margin of 0.5 s and relay plug settings such that for a 3-phase fault immediately on the remote side of the relay, the relay plug setting has to be less than 20 by as small a margin as possible, calculate the plug settings and time setting multipliers of the relays at B and at A. If the maximum loads in sections AB and BC are respectively 2 and 1 MVA, check that the protection will not operate during maximum load conditions. The relay characteristic is given by

$$t = \frac{0.14}{PSM^{0.02} - 1}$$

[15 marks]

6.

(a) Describe the amplitude comparator circuit which can be used to realise the off-set mho distance protection relay. By referring to this circuit diagram, derive the marginal operating characteristic equation for this type of relay.

[10 marks]

(b) Drive the expression for the most economical power factor to which a lagging consumer load may be improved to by a power factor improvement apparatus. Given that the annual cost of the power factor improvement apparatus is one third the annual maximum demand charge, calculate the most economical power factor. A consumer's load is 500 kW at 0.8 power factor lagging. Determine the kVA rating of the power-factor-improvement-apparatus required for the minimum annual costs.

[15 marks]

END OF EE452 EXAMINATION



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

UNIVERSITY EXAMINATION - JANUARY 2001
EE 471 - TELECOMMUNICATIONS

TIME: 3 HOURS

ANSWER: ANY FIVE QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

- 1.
- a)
- i. For a multi-tone signal $m(t) = A\cos\omega_1t + 2A\cos\omega_2t$ determine the maximum percentage of the total sideband power to the total signal power in AM-FC modulation. (8 marks)
- ii. If the $2A\cos\omega_2t$ term of $m(t)$ is now sent alone as a single tone signal using the same carrier used to send the multi-tone signal in i) above, would it have the same sideband power as it had in i) above? (2 marks)
- What general conclusions can you draw from the answers you obtained in i) and ii) above? (2 marks)

b)

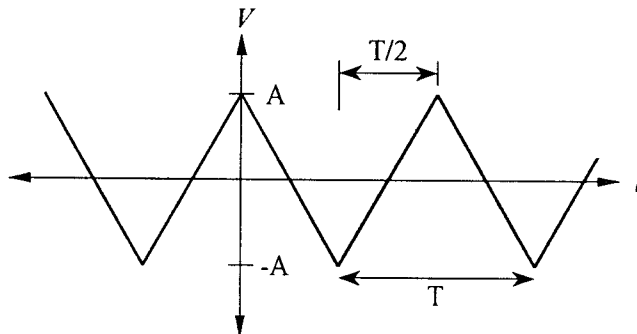


Figure 1.

The triangular waveform shown in Figure 1 is amplitude modulated with full carrier. This signal is then demodulated using an envelope detector. Derive a general expression for the maximum RC product the detector should have in order to demodulate without distortion for a given m . (6 marks)

If $m = 0.8$, $R = 1 \text{ k}\Omega$ and $C = 62.5 \text{ pF}$, determine the maximum frequency of modulating signal that would be demodulated without distortion. (2 marks)

2.

- a) It is possible to demodulate an AM suppressed carrier systems with no pilot carrier. Describe one PLL system that can be used for such demodulation, clearly deriving and indicating the different signals in the system. (10 marks)
- b)
- i. Show that the use of a square law detector on a DSB-FC signal will result in a distorted recovered signal. Let the desired recovered signal be $m(t)$. (4 marks)
- ii. Under what conditions is the recovered signal found acceptable? (2 marks)
- iii. If the second order distortion that results in i) above should be less than 10% of the total demodulated signal power and $m(t) = A\cos(2\pi 10^3 t)$, determine the maximum value of A in $m(t)$.
Take the power of the signal $A^2 \cos^2 \omega t$ to be equal to $\frac{3}{8} A^4$. (4 marks)

3.

- i. Explain what IF is and how it is achieved. Explain in detail why it is used. What criteria is used to arrive at an IF for a given application? (8 marks)
- ii. What is image frequency? Clearly explain how interference from image frequencies can be avoided. (7 marks)
- iii. What is high side and low side injection to a mixer? (2 marks)
- iv. A receiver has an IF of 455 kHz and is tuned to receive a 560 kHz signal. Determine the image frequency that would interfere with reception for the cases where high side injection and low side injection are used. (3 marks)

4.

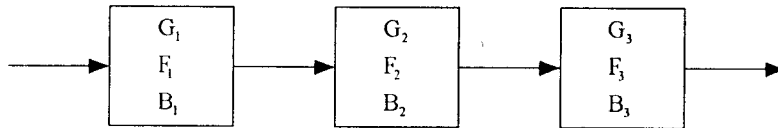


Figure 2.

- a) For the cascaded system shown in Figure 2 derive an equation for the system noise Figure F , and thence the system effective noise temperature T_e , if $B_1 \neq B_2 \neq B_3$.

(10 marks)

- b) The ground receiver of a satellite-to-ground super high frequency (SHF) communication link is shown in block diagram form in Figure 3. The various stages may be considered matched for maximum power transfer.

Calculate the equivalent noise temperature and thence the signal to noise power ratio at the input to the demodulator, when the available signal power from the aerial is 7 mW and the equivalent noise bandwidth of the receiver is 10 MHz.

$$k = 1.38 \times 10^{-23} \text{ J/K.}$$

(10 marks)

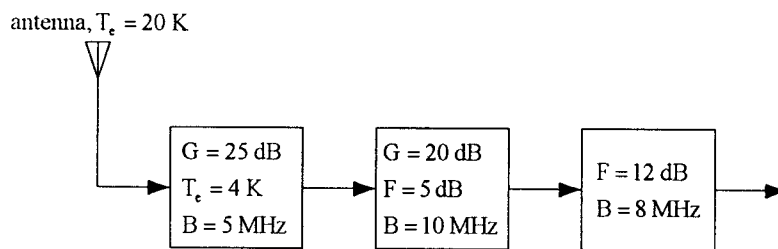


Figure 3.

5.

a) A PCM based system similar to the T1 system has the following specifications

- 8 bit signal coding
- signal bandwidth = 5 kHz
- uses nyquist sampling rate
- transmission channel bit rate of 1.61 Mbps
- maximum synchronisation correction time of 2 ms
- 1 correction bit per frame
- signalling frequency of 1 kHz

- i) Determine the number of channels transmitted. *(3 marks)*
- ii) Determine the frame rate. *(1 mark)*
- iii) Determine the number of bits in each frame. *(1 mark)*
- iv) Determine the number of bits in the synchronising code. *(1 mark)*
- v) Determine the number of bits in each signalling code. *(1 mark)*
- vi) Determine the average bits used for signal encoding. *(1 mark)*
- vii) Draw a clearly marked frame used in this transmission. *(2 marks)*
- viii) What is channel associated signalling? *(1 mark)*
- ix) Which bit is used in bit sharing and explain why it is used? *(1 mark)*

b)

- i. What is companding? *(2 marks)*
- ii. Give two advantages and two disadvantages of companding. *(4 marks)*
- iii. Name two companding systems and the countries in which they are used. *(2 marks)*

6.

- a) A system has a load impedance of $3Z_0$ and a source impedance of zero. The system is fed with a step voltage of amplitude E . Plot a graph of voltage against time, of the load voltage. (4 marks)
- b) Determine the value of C and R in the Figure 4 below, under the following conditions:
 The VSWR on line L_1 is equal to 1; all lines have a characteristic impedance of 50Ω ; $e(t) = A \sin(10^8 t)$ V and the 0.216λ line has an attenuation constant $\alpha = 1.066$ Neper per wavelength, while all other lines are lossless. (16 marks)

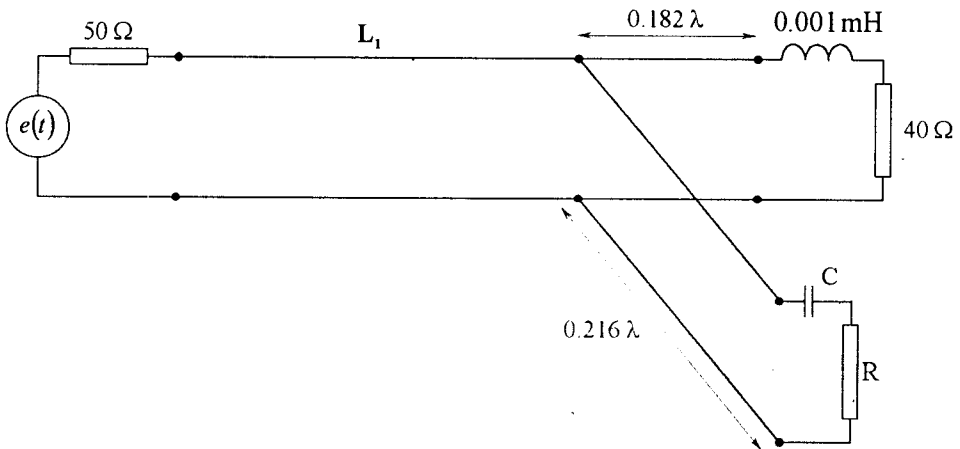


Figure 4.

7.

- a) Write the expression for PPM modulation clearly showing that the original modulating signal is imbedded in the modulated signal.
 The pulse train is given by,

$$s(t) = \frac{\tau}{T_s} + \frac{2\tau}{T_s} \sum_{n=1}^{\infty} \left[\frac{\sin\left(\frac{n\omega_s \tau}{2}\right)}{\left(\frac{n\omega_s \tau}{2}\right)} \cdot \cos(n\omega_s \tau) \right]$$

(12 marks)

- b) 8000 telephone channels are to be sent using Frequency Division Multiplexing (FDM) with three addition stages. Determine the minimum number of different frequency carrier oscillators that can be used. (2 marks)
- c) Three signals from three channels with maximum frequencies 5, 10 and 20 kHz respectively, are to be sent down a transmission line using TDM. If the samples are to be sent using frames consisting of 8 pulses(samples) each, determine the minimum possible pulse rate and corresponding sequence of samples in a frame. (6 marks)

8.

- a) Show that in the first kilometre the average change of refractive index is -40 N units. What is this change of -40 units known as? (3 marks)
For a straight ray model at standard change of refractive index determine the relationship between *effective radius* and *earth's radius*. (2 marks)
Show that ducting occurs when $\frac{dN}{dh} < -160$ N units. (4 marks)

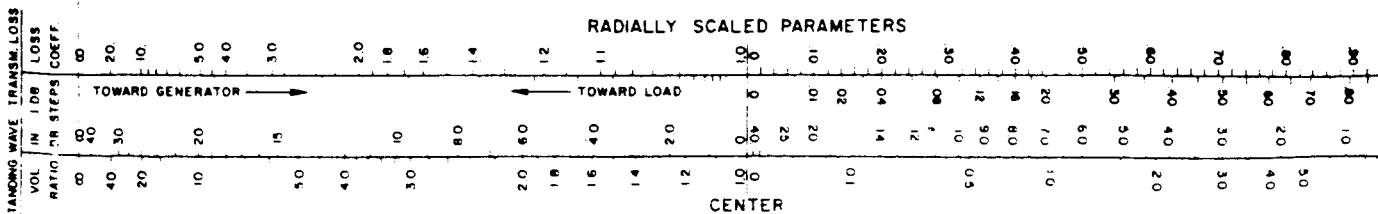
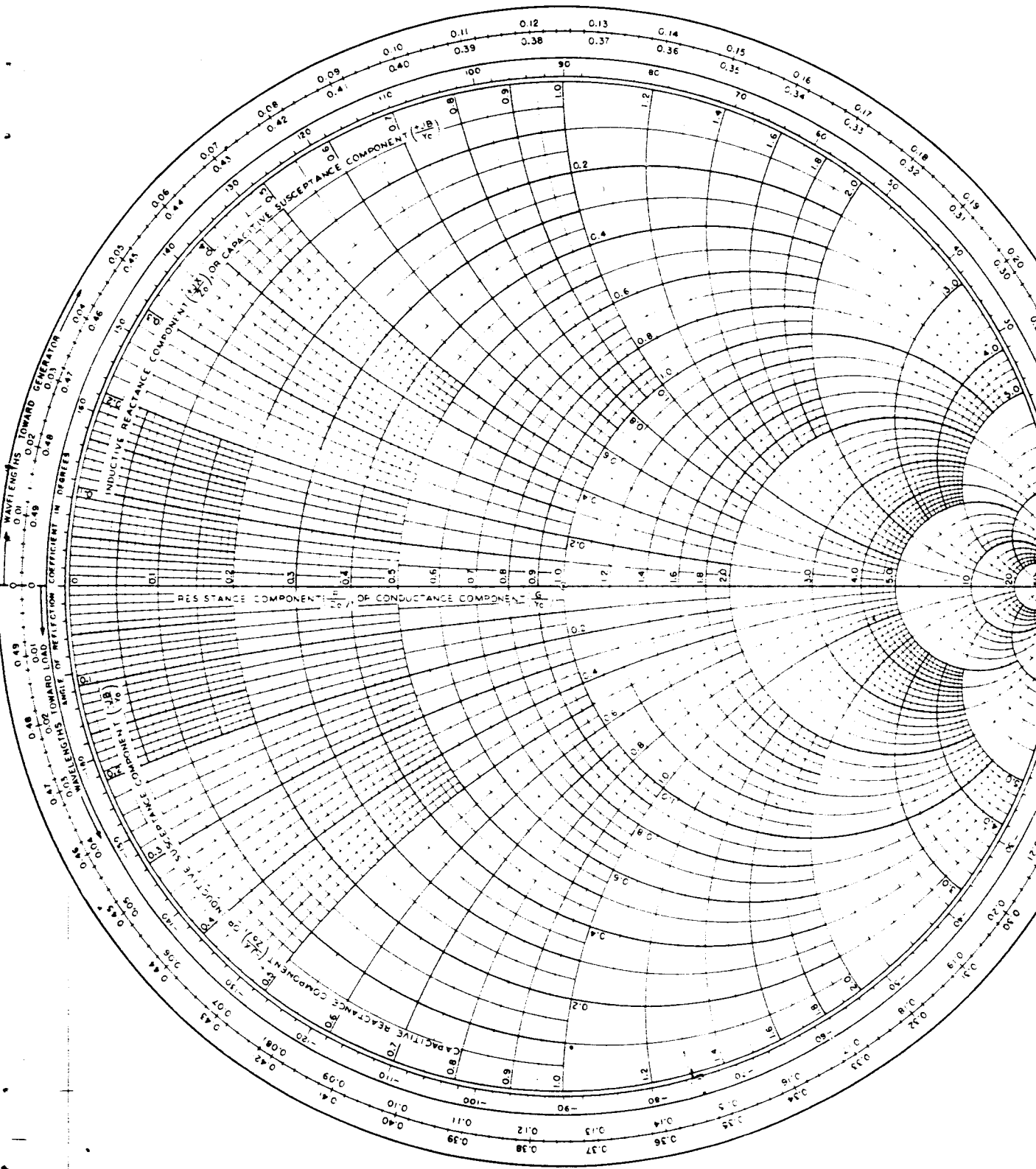
Use, $N(h) = 315e^{-\frac{h}{7.36}}$ and the earth's radius as 6,250 km.

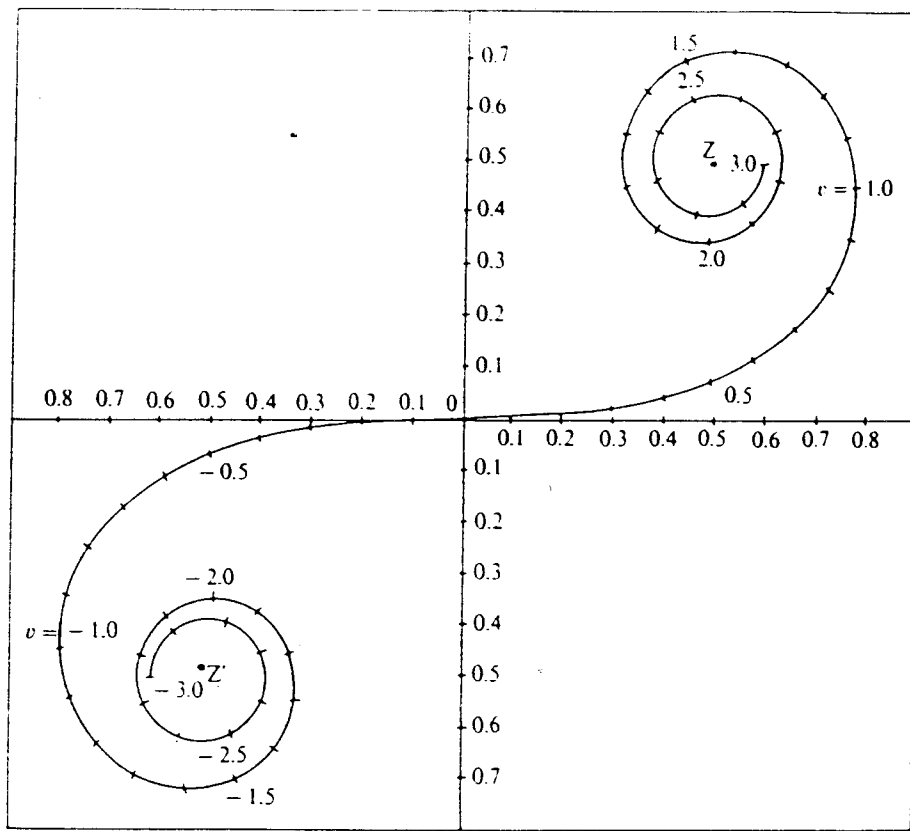
- b) A short wave broadcasting service covering a distance of 6000 km in three skips is to be established, each skip being 2000 km. If reflection takes place at a height of 250 km and that the electron density is $5 \times 10^{11} \text{ m}^{-3}$, what frequency and angle of incidence should be used? What is the maximum usable frequency? (3 marks)
- c) A 60 MHz link is made of two antennas 70 m high and 1.8 km apart. A building is to be erected in-between the antennae, such that it will be 1 km from one antenna.
- Determine what the height of the building should be for the received signal strength to be its maximum. Is this signal larger than that which could be obtained in free space? (3 marks)
 - It is required that the signal strength received at each end be 0.98 dB below that of free space. Determine the minimum height that the building should be to achieve this. (5 marks)

END OF EE 471 EXAMINATION

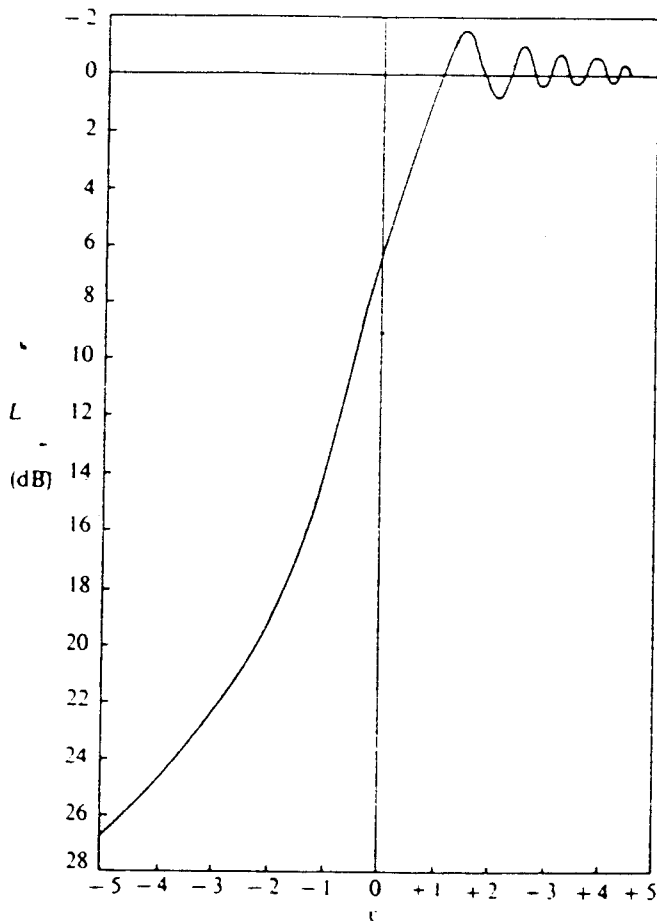
NAME	TITLE	DWG. NO.
SMITH CHART Form 5301-7560-N	GENERAL RADIO COMPANY, WEST CONCORD, MASSACHUSETTS	DATE

IMPEDANCE OR ADMITTANCE COORDINATES





Cornu spiral for diffraction over a knife-edge obstacle.



The variation of knife-edge loss L with Fresnel's parameter v .

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
SECOND SEMESTER EXAMINATIONS 1998/1999-MAY 2000
EE 532 POWER ELECTRONICS

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

1. (a) Derive an expression for the D.C. out put voltage of an m- pulse diode rectifier. (3 Marks)
- (b) Figure Q1 shows a Diode Rectifier installation for a metallurgical electrolysis process. The transformer primary winding is connected to an 11-k V supply. The rectifier supplies 1000 A D.C.
- (I) What is the function of the interphase reactor? (3 Marks)
- (II) In terms of the secondary line voltages, determine the D.C. output voltages of the separately wound secondary windings. (3 Marks)
- (III) What is the pulse number of the output voltage? (2 Marks)
- (IV) It is desired that the two rectifiers (the Y & ∇ windings) share the load current equally. If the no load D.C. voltage is 115 V, determine the turns ratio of the two secondary windings. (4 Marks)
- (V) Calculate the average and rms values of the diode currents. (5 Marks)
2. The Converter circuit of Figure Q2 is used to control power from a fixed 240 V a.c. source into a resistive heater of 9.6 Ω .
- (a) Sketch the load voltage and current waveforms, and the thyristor, T, and diode D₁, current waveforms at $\alpha=90^\circ$. (8 Marks)
- (b) The power is to be controlled from 1.2 kW to 3.6 kW, determine the range of the firing control angle α . (10 Marks)
- (c) For a design based on a maximum power output from the a.c. source, calculate the maximum rms current of the thyristor. State any assumptions made. (2 Marks)
3. (a) Briefly explain how the L-C resonant circuit principle is used to turn off a conducting thyristor in a chopper circuit. (3 Marks) + 1 = 4
- (b) The basic D.C. chopper circuit shown in Figure Q3 is supplied at 200 V and has a load resistance, R_L, of 20 Ω . The value of the load inductor, L₁, is sufficiently high for the load current to be assumed constant and the inductor, L, has Q-factor of 15. The main Thyristor, T₁, is rated at 10 A, and has a turn off time of 25 μ s appropriate to its operating conditions in the chopper. The chopper operates with a mark/space ratio of 7:3 at 5 kHz.
- (I) If T₁ is to operate at its minimum turn-off time, calculate the load voltage (3 Marks)
- (II) Hence, or, otherwise, calculate the minimum value of C to ensure minimum turn-off time of T₁. (2 Marks) + 1 = 3
- (III) If the peak value of current through T₁ is not to exceed twice its maximum rating, calculate the minimum value of inductance, L. (3 Marks) + 2 = 5
- (IV) If the conduction period of T₁ 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. (3 Marks) + 2 = 5

4. (a) Sketch the output voltage and current waveforms of the Half-Bridge Inverter with an inductive load shown in Figure Q4. (5 Marks)
- (b) With the aid of a circuit diagram explain how a transistor half bridge (operating as an SPDT switch) may be used to cyclically reverse output polarity of a centre-tapped source. (5 Marks)
- (c) With the aid of a block diagram describe a basic HVDC transmission line connecting two a.c.systems at different frequencies. (10 Marks)
- 5 A fully controlled three-phase bridge Rectifier is operated in the inversion mode at $\alpha=120^\circ$ and with a completely smoothed dc line current of 150 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 delay angle α and hence determine the D.C. line voltage and the power. (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 $\cos \delta$. 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)
- 6 (a) Draw a diagram, which shows the operation of a fully controlled AC/DC Converter in terms of quadrants as viewed from the D.C. terminals. (10 Marks)
- (b) With the aid of a diagram explain how a two-pulse fully controlled converters may be used to control a D.C. motor for both forward and reverse starting and regenerative braking in both directions. (10 Marks)
- 7(a) What are the effects of inductance in the D.C. and a.c. circuits of a Rectifier. What is the source of inductance in the a.c. circuit of a rectifier? (3 Marks)
- (b) A three-phase common cathode thyristor rectifier is fed from a star-connected transformer secondary and supplies a highly inductive load.
- (I) Sketch the circuit diagram. (3 Marks)
- (II) Derive an expression for the D.C. output voltage reduction in terms of output D.C. current, I_D , the a.c. source reactance, X_S , the commutating angle ν and the delay angle α . (10 Marks)
- (III) The a.c. input line to line voltage is 400 V, and α is set to 45° . The voltage reduction due to commutation overlap is 10 V at 500 A. Using the expression derived above or otherwise, determine the commutating angle at this load, and the line to neutral commutating inductance. (4 Marks)
- $f = 50 \text{ Hz}$
- 8 (a) Define cycloconversion. (3 Marks)
- (b) Demonstrate the principle of a cycloconverter by using the simplest possible single phase input to single phase output with a pure resistance as a load, for the situation when the firing angle is zero, and the converters are fired to produce a 3-pulse output wave form per half cycle of the input voltage. (15 Marks)
- (b) What is the output frequency for the above condition? (2 Marks)

FIGURES Q1,Q2,Q3 &Q4 FOLLOW

END OF EXAMINATION

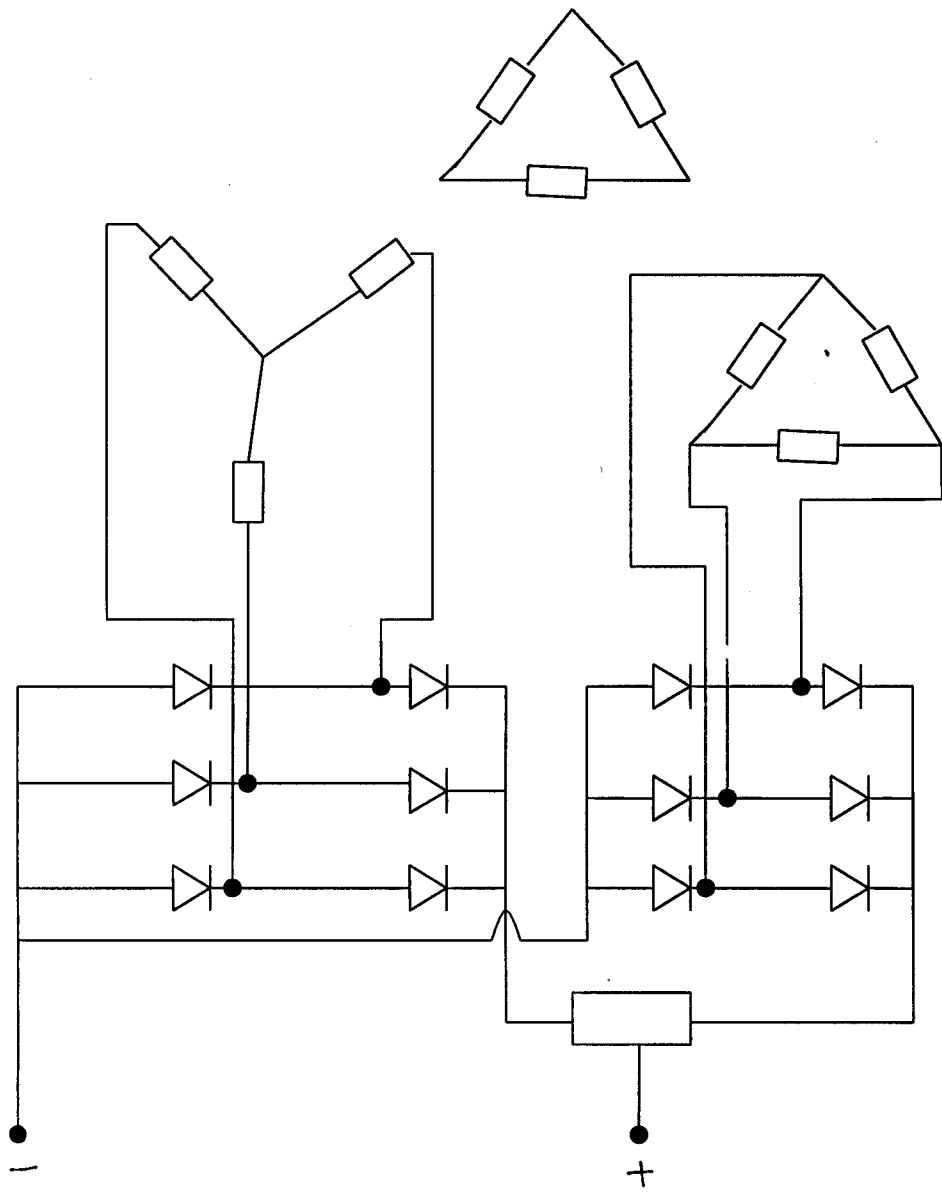


Fig. Q 1

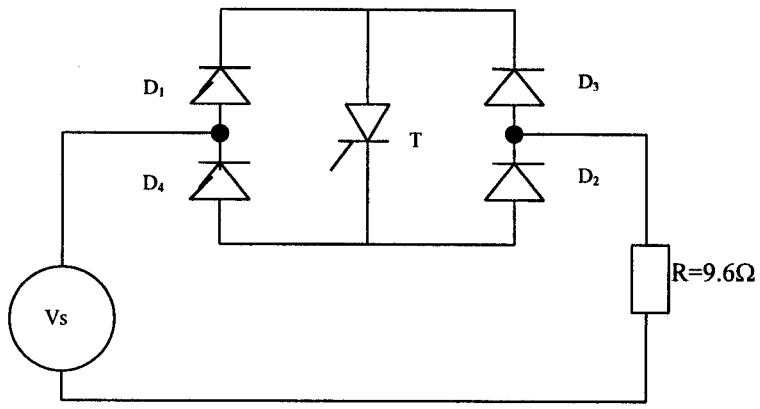


Fig. Q 2

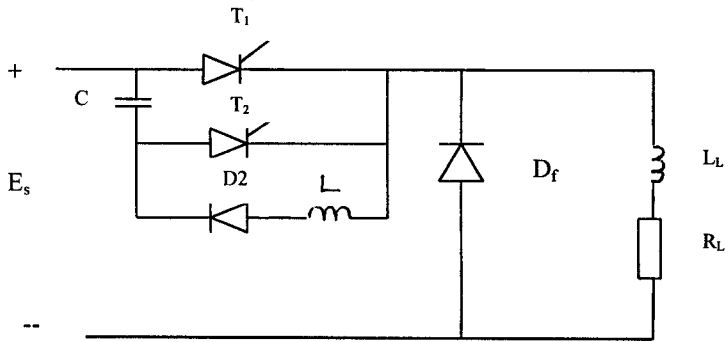


Fig. Q 3

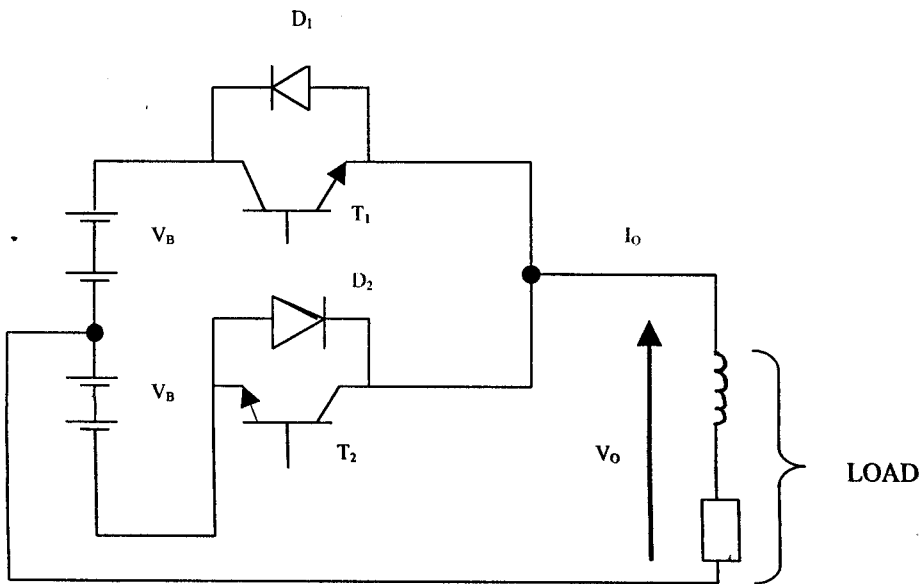
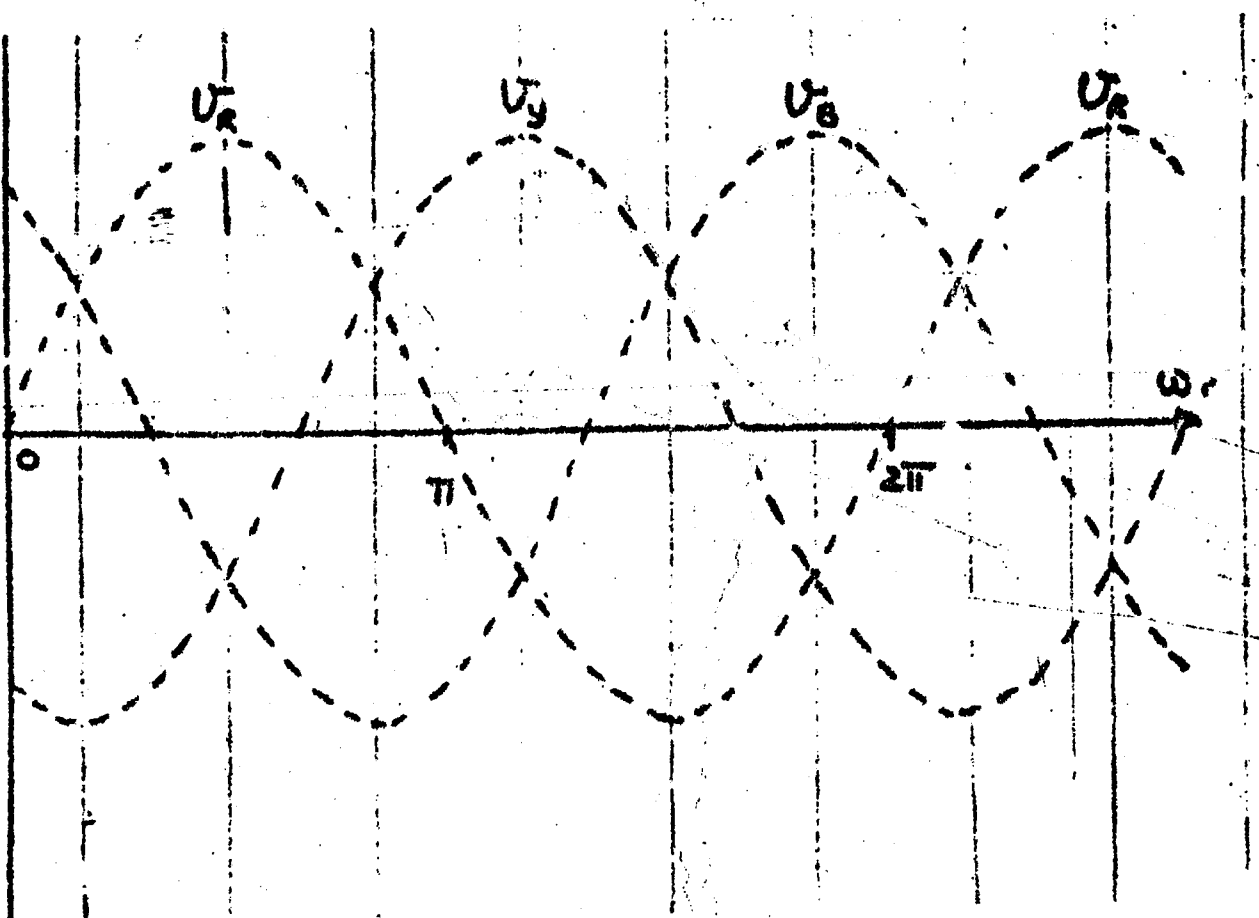


Fig. Q 4



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

UNIVERSITY EXAMINATION - MAY 2000

EE 541 ELECTRONIC ENGINEERING III

TIME: 3 HOURS

ANSWER FIVE QUESTIONS

Q1.

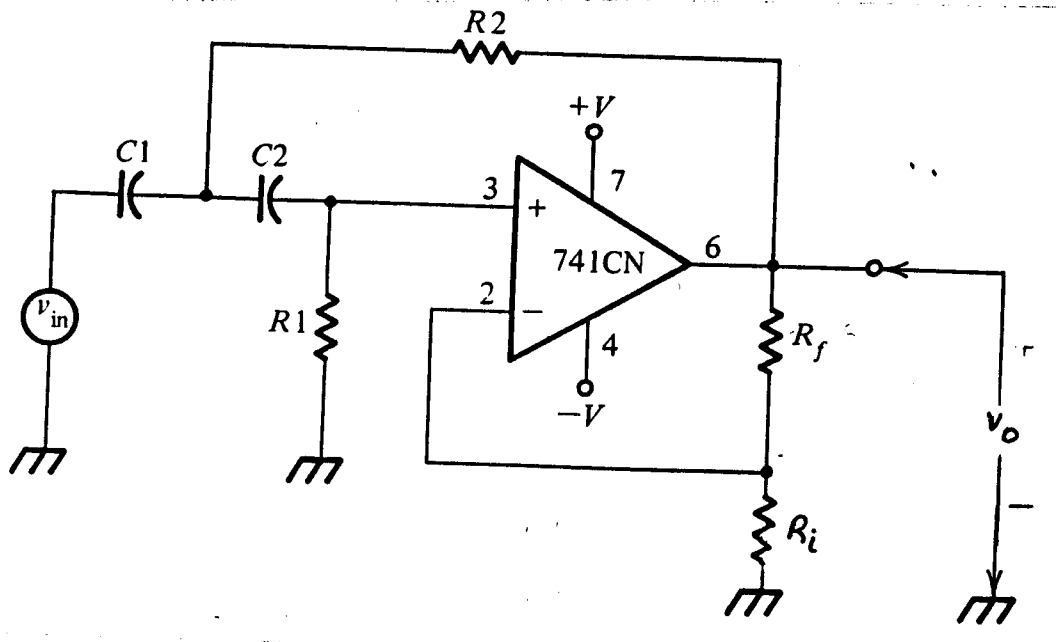
Design a decade counter. This network should contain four flip flops whose outputs form a code word interpreted as a BCD-coded decimal value. On each clock pulse the code value is incremented, and when a nine (9) is reached, it returns to 0 on the next clock pulse. On the 9-to-0 transition the network activates an output line to indicate the counter overflowed. For simplicity in design, use Toggle flip flops.

$$Q^{v+1} = \overline{Q^v}$$

Q2.

- (a) Describe the physics of light sensors and light emitters, devices of semiconductor Optoelectronics.
- (b) Describe how photoresistors, and photovoltaics, work.
- (c) Draw a circuit that will operate as a slave cell for electronic flash.
- (d) Draw a radiation energy spectrum.

Fig.2

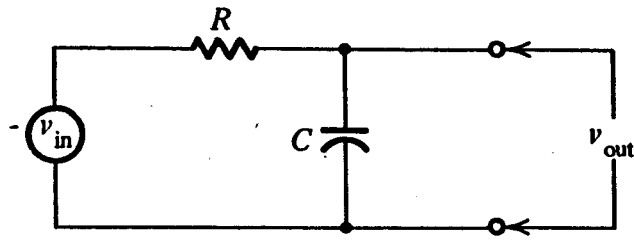


Q4.

The circuit shown above is an active high pass filter. Analyse the circuit completely to determine.

- (a) The critical frequency ω_0
- (b) The damping factor α
- (c) The gain and phase relationships

Fig.3



(a) Frequency domain (regular) schematic

Q5.

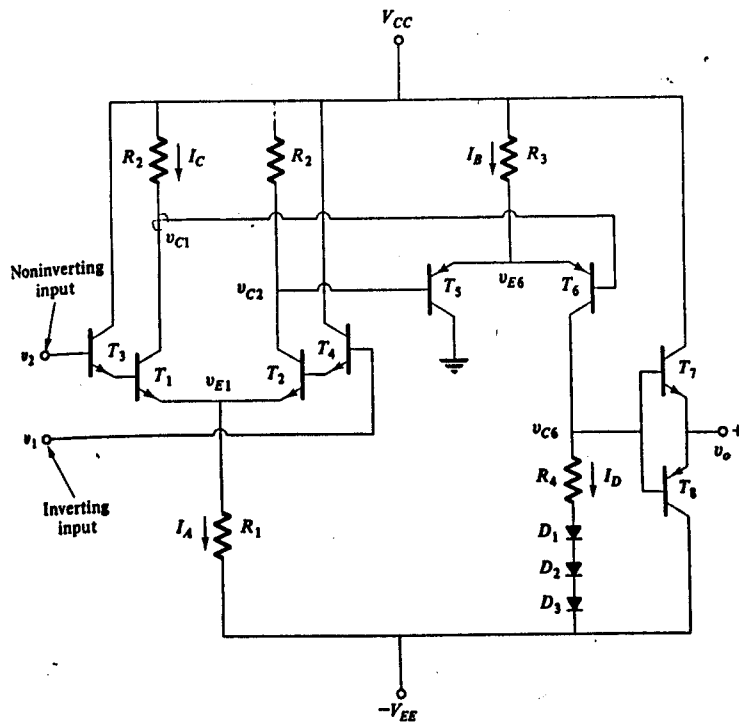
- (a) Determine the transfer function for the above circuit.
- (b) For $R=500k\Omega$ and $C=1\mu F$ calculate and plot the frequency response (both gain and phase).

For

$\omega=0.1, 0.6, 1, 4, 8, 10, 100$

- Q6. The circuit given is a multiple transistor circuit of a typical Op-amp. This op-amp has two input terminals at v_1 and v_2 and output v_0 . Analyse the circuit for DC condition, by setting $v_1=v_2=0$, to determine values of R_1 to R_4 which will ensure that $v_0=0$ independent of temperature and supply variations.

Fig.4



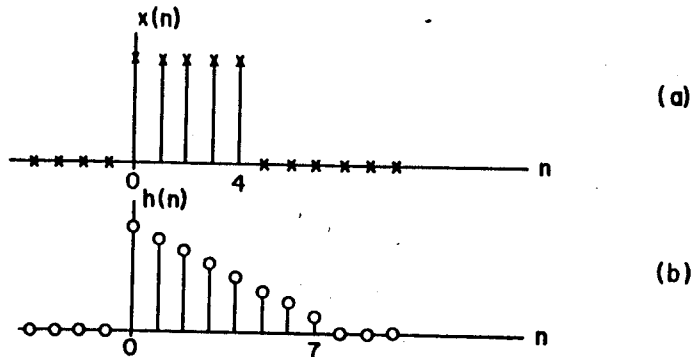
- (a) Fig.5(a) Shows a typical input sequence $x(n)$ that is non zero in the range $0 \leq n \leq 4$.

Fig.5(b) Shows a typical impulse response sequence $h(n)$ that is non zero in the interval $0 \leq n \leq 7$.

- (a) For $n = 0, 2, 10$ and 11 plot simultaneous plots of $x(m)$ and $h(n-m)$
 (b) From these plots, determine the desired convolution $y(n)$.

$$y(n) = \sum_{m=-\infty}^{\infty} x(m)h(n-m) = \sum_{m=-\infty}^{\infty} h(m)x(n-m)$$

Fig.5(a) and (b)



Q8:

- (a) Define Frequency-Division Multiplexing.
 (b) For J, K, flip-flop and S.C. flip flop, using the present value inputs and output make tables and derive the next state of the flip-flop equation Q^{v+1} ,
 (c) Complete the timing diagram for Y and X of the given flip-flop in Fig.6
 (d) For the given circuit Fig.7 Write the equations for
 (a) $J_{y1}, K_{y1}, J_{y0}, K_{y0}$,
 (b) y_1^{v+1} and y_0^{v+1}

Fig.6

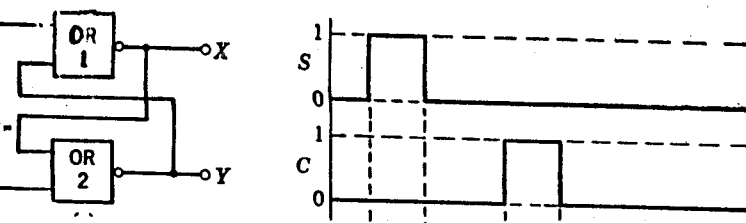
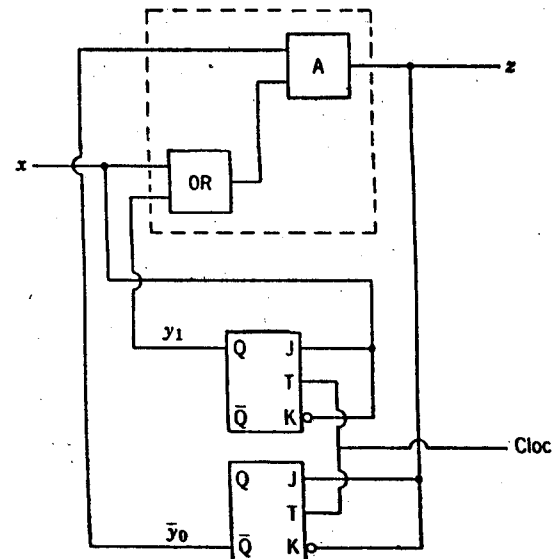


Fig. 7





THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS MAY 2000

EE 562: Systems and Control Engineering II

TIME: THREE (3) HOURS

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

1. a) State the Nyquist stability criterion and explain the meaning of *gain margin* and *phase margin* in terms of the Nyquist diagram. [8 Marks
- b) Sketch the Nyquist diagram for the following transfer functions and for each case determine the range of values of K for stability.
- i.) $G(s) = \frac{K(1+s)^2}{s^3}$ [6 Marks
- ii.) $G(s) = \frac{K(s+2)}{(s+3)(s-1)}$ [6 Marks
2. a) Draw a schematic diagram of a computer controlled process defining all the major components involved. Briefly explain the control process. [6 Marks
- b) Explain the main function of a Zero Order Hold (ZOH) device in a computer controlled process and derive its transfer function. [6 Marks
- c) A first-order system with time constant *20 seconds* is controlled by an industrial computer using a sample time of *3 sec*.
- i.) Determine the pulse transfer function as seen by the computer. [6 Marks
- ii.) State the condition for stability in the Z-plane. [1 Mark
- iii.) Determine whether the system is stable or not. [1 Mark

3. a) State the criterion for complete controllability and complete observability. [6 Marks]
- b) A single-input single-output system (SISO) is described by the following transfer function
- $$G(s) = \frac{s^3 + 3s^2 + 5s + 8}{s^4 + 7s^3 + 14s^2 + 8s + 10}$$
- i.) Derive the observable canonical form representation of the state equation and draw the simulation diagram. [9 Marks]
- ii.) Derive the controllable canonical representation in matrix form in terms of the controllable canonical variables. [5 Marks]

4. For the system described by the state equation: $\dot{\underline{X}} = \begin{bmatrix} -3 & -1 \\ 2 & 0 \end{bmatrix} \underline{X} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$ $y = x_1$
- a) Draw an appropriate simulation diagram. [3 Marks]
- b) Derive the system transfer function from the simulation diagram. [5 Marks]
- c) For zero initial state and for unit step input evaluate $x_1(t)$ and $x_2(t)$. [6 Marks]
- d) State whether the system is completely controllable and comment on the stability of the system. [6 Marks]

5. The block diagram representation of a certain control system is shown in Fig. 1.

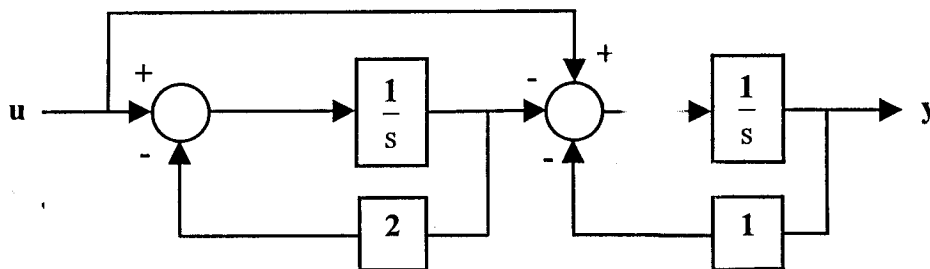


Fig.1

- a) Derive the system state space representation in matrix form. [3 Marks]
- b) Derive the eigenvalues from the state equation and the transfer function. [7 Marks]
- c) Find the transformation matrix T that transforms the general state space representation into canonical form representation. [7 Marks]
- d) Draw a simulation diagram based on the canonical representation. [3 Marks]

6. a) State the main properties of a Linear Quadratic Regulator (LQR). [4 Marks]
- b) An open-loop system has a transfer function $G(s) = \frac{1}{(s+3)(s+5)(s+8)}$.
- i.) For this system, obtain a state equation $\dot{\underline{X}} = \underline{A}\underline{X} + \underline{B}u$ in companion form relating the state vector, \underline{X} , to the input u . [5 Marks]
- Measurements of the state variables are used to provide negative feedback for the system.
- ii.) Show that the resulting closed-loop system has a state equation $\dot{\underline{X}} = \underline{A}\underline{X} + \underline{B}(r - \underline{K}^T \underline{X})$ where r is the set point, and \underline{K} is the vector of the transducer constants in the feedback paths. [5 Marks]
- iii.) Obtain the vector \underline{K} for which the closed-loop system has poles $s = -20, s = -4 + j2, s = -4 - j2$. [6 Marks]

7. a) State the main time design specifications that are usually considered when designing digital filters. [5 Marks]
- b) A discrete time filter with a sample frequency of 10Hz can be described by the second-order difference equation: $2y(i) = 3y(i-1) + x(i-2)$.
- i.) Obtain the pulse transfer function of the digital filter. [3 Marks]
- ii.) Determine the pole locations, which would give the filter a step response with 5% settling time of 0.2 seconds and a damping ratio of 0.5 . [10 Marks]
- iii.) Comment on the stability of the filter. [2 Marks]

8. a) Fig.2 shows the amplitude Bode plot, straight-line asymptotic approximation, of a certain system function, $G(j\omega)$. Determine $G(s)$, assuming the damping factor $\xi=1$. [8 Marks]

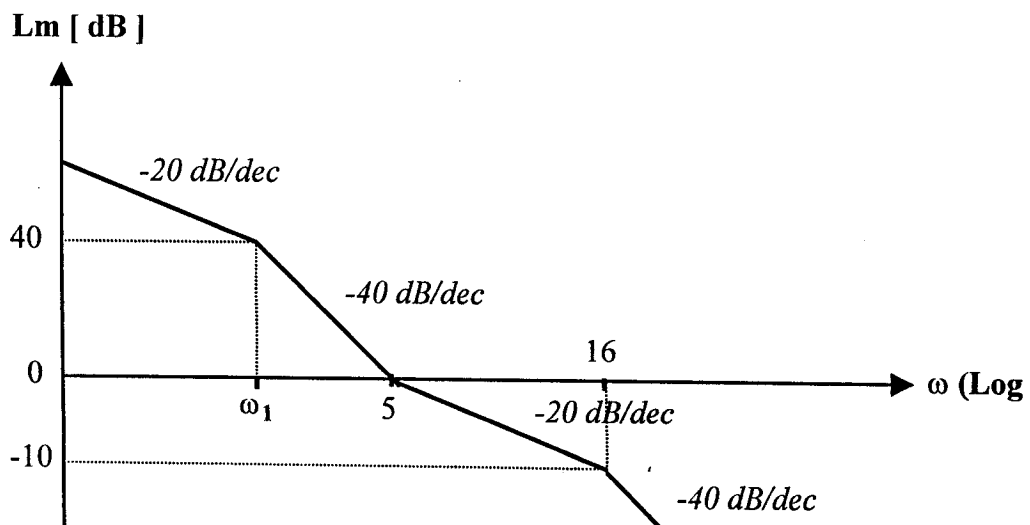


Fig.2.

- b) Given the transfer function for a phase lead compensator as $G(s) = \frac{s + 0.8547}{s + 12.5}$. Design an equivalent digital filter using the pole-zero mapping technique and a sampling period of $T=0.1$ seconds. [6 Marks]
- c) State the main attraction of the PID controller and then derive the equivalent discrete transfer function. [6 Marks]
-

END OF EXAMINATION

Table 1. Laplace and z-Transforms

(T = Sampling period in seconds)

$f(t)$	$F(s)$	$F(z)$
$\delta(t)$	1	1
$\delta(t - T)$	e^{-Ts}	$\frac{1}{z}$
$\delta(t - nT)$	e^{-nTs}	$\frac{1}{z^n}$
$u(t)$	$\frac{1}{s}$	$\frac{z}{z-1}$
$u(t - T)$	$\frac{1}{s}e^{-Ts}$	$\frac{1}{z-1}$
$u(t - nT)$	$\frac{1}{s}e^{-nTs}$	$\frac{1}{z^n - 1(z-1)}$
t	$\frac{1}{s^2}$	$\frac{Tz}{(z-1)^2}$
t^2	$\frac{2}{s^3}$	$\frac{T^2z(z+1)}{(z-1)^3}$
e^{-at}	$\frac{1}{s+a}$	$\frac{z}{z - e^{-aT}}$
te^{-at}	$\frac{1}{(s+a)^2}$	$\frac{Tze^{-aT}}{(z - e^{-aT})^2}$
t^2e^{-at}	$\frac{2}{(s+a)^3}$	$\frac{T^2ze^{-aT}(z + e^{-aT})}{(z - e^{-aT})^3}$
$\sin at$	$\frac{a}{s^2 + a^2}$	$\frac{z \sin aT}{z^2 - 2z \cos aT + 1}$
$\cos at$	$\frac{s}{s^2 + a^2}$	$\frac{z(z - \cos aT)}{z^2 - 2z \cos aT + 1}$
$1 - e^{-at}$	$\frac{a}{s(s+a)}$	$\frac{z(1 - e^{-aT})}{(z-1)(z - e^{-aT})}$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
Department of Electrical and Electronic Engineering
UNIVERSITY EXAMINATIONS - MAY 2000
EE572: TELECOMMUNICATION SYSTEMS

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

$\mu_0 = 4\pi \times 10^{-7}$ henry per metre is the permeability of vacuum or free space, $\epsilon_0 = 8.854 \times 10^{-12}$ farad per metre is the dielectric permittivity of vacuum or free space, $\frac{1}{32\pi} \times 10^{-9}$ farad per metre is the dielectric permittivity of vacuum or free space, $c = 3 \times 10^8$ metre/sec is the velocity of light in vacuum or free space.

- Q1. (a) Write down Maxwell's equations. Explain the significance of the equations.
(b) Define a complex Poynting vector. Derive the equation for the complex Poynting theorem. State the theorem.
(c) State the properties of the electromagnetic plane waves. If the direction of propagation is positive z direction then write down the wave equations in time domain for the electric and magnetic intensities in rectangular co-ordinates when the medium is a lossless dielectric. Derive the formula for the intrinsic impedance of free space.
(d) Determine the phase velocity of a uniform plane wave propagating in a lossless dielectric medium when the relative permittivity of the medium is 1.21. Find the values of the intrinsic impedance of free space and the above dielectric medium. [4+6+6+4]
- Q2. (a) Consider a microwave waveguide used to guide an electromagnetic wave. Where are the electric and magnetic fields confined in a rectangular waveguide? Write down the electric and magnetic wave equations in frequency domain.
(b) What is the propagation constant γ_g in a rectangular waveguide? The direction of propagation of the wave in the guide is conventionally assumed to be in the positive z direction of the rectangular co-ordinate system.
(c) How do you characterize the TE_{mn} and TM_{mn} modes in a rectangular waveguide? Write down the corresponding Helmholtz's equations. Present the field equations for both the modes in the partial differential equation form. Consider a lossless dielectric. Derive the equations for different field components for TE_{mn} mode only.
(d) An air filled rectangular waveguide of inside dimensions 2.5x5cm operated in TE_{01} dominant mode. (i) find the cutoff frequency. (ii) Determine the phase velocity of the wave in the guide at a frequency of 5 GHz. [3+3+10+4]
- Q3. (a) Draw the block diagram of an optical communication system and explain the diagram.
(b) 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.
(c) Calculate the multipath time dispersion of an unclad glass fiber when the refractive index of glass is 1.5. The velocity of light in vacuum is 3×10^8 m/sec. When it is clad with glass having the refractive index 1.3, find the multipath time dispersion.
What are the three effects we get after cladding the core with glass having a slightly lower refractive index than that of the core? The glass fiber was originally an unclad one.
(d) The numerical aperture of a step-index fiber is 0.173. Find the fraction of the optical power from a diffuse source that the fiber will propagate. [4+8+6+2]

(CONTINUED IN PAGE 2)

- Q4. (a) What is an isotropic antenna ? Discuss its usefulness .
 (b) What is a dipole antenna ? Show the current distribution on resonant dipoles of lengths $\lambda/2, \lambda, \frac{3}{2}\lambda, 2\lambda$.
 (c) Distinguish between (i) Directive gain and directivity (ii) Radiation resistance and loss resistance (iii) Bandwidth and beamwidth.
 (d) Describe the Yagi-Uda antenna.
 (e) 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 9 GHz. Find the effective radiated power of the antenna if the actual power fed to the primary antenna is 1 Watt.

[2+4+3+4+7]

- Q5. (a) Explain the operation of a basic radar system by means of a simple block diagram. Show the detailed block diagram of the pulsed radar set. Explain the detailed diagram.
 (b) Develop an expression for the maximum range of a radar in terms of the minimum receivable power of its receiver. Discuss the factors that influence the maximum range.
 (c) Calculate the maximum range of a radar system which operates at 2.5 cm (wavelength) with a peak pulse power of 600kW, 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 $20m^2$.

[8+8+4]

- Q6. (a) Describe briefly a token bus LAN. Explain the token bus MAC sublayer protocol giving the IEEE standard 802.4 frame format. Show the frame format of the IEEE standard 802.3 and compare these two standards.
 (b) Show the names and meanings of the token bus control frames in a tabular form and explain how the logical ring maintenance is done by using the control frames.
 (c) In a token bus LAN there are 100 stations. The parameters of the network running at 10Mbps have been adjusted to give priority 6 traffic half of the bandwidth. Calculate the guaranteed 'kbps' each station has for priority 6 traffic.

[10+6+4]

- Q7. (a) Describe briefly a token ring LAN. If the cable breaks somewhere the ring dies. How do you solve this problem ? Explain with the help of a diagram.
 (b) Explain the token ring MAC sublayer protocol. Show the token format and the data frame format.
 (c) Discuss B-ISDN and ATM. What are the permanent virtual circuits and the switched virtual circuits in ATM network ? Explain by means of a suitable diagram the virtual circuits used in 'ATM network'.
 (d) Calculate the signal propagation speed in a 1-Mbps ring whose circumference is 2000 metres. The ring can contain only 10 bits on it at once.

[5+5+6+4]

- Q8. Write short notes on any four:
 (a) Transmission line (b) Superheterodyne receiver (c) N-ISDN architecture (d) Digital bit pipes in N-ISDN system (e) TCP/IP (f) A one bit sliding window protocol (g) Satellite communication and its applications (h) Microwave tubes.

[20]

1

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
SEMESTER II FINAL EXAMINATIONS - MAY 2000

EG 212 WORKSHOP TECHNOLOGY

Closed Book.

TIME: THREE HOURS.

ANSWER: PARTS A, B, C, D AND E QUESTIONS AS STATED.

NOTE: EACH PART SHOULD BE ANSWERED IN SEPARATE ANSWER SHEET AND BE CLEARLY MARKED AS PART A, B, C, D OR E

PART A: AGRICULTURAL ENGINEERING WORKSHOP SECTION

ANSWER ONE QUESTION ONLY FROM PART A.

Each Question carries 15 marks in this Section.

- Q1. (i) With reference to Figure Q1 list the parts A to G. [7 marks]
(ii) What type of engine is this? Give reasons for your answer [3 marks]
(iii) Describe how ignition is achieved in this engine. [5 marks]

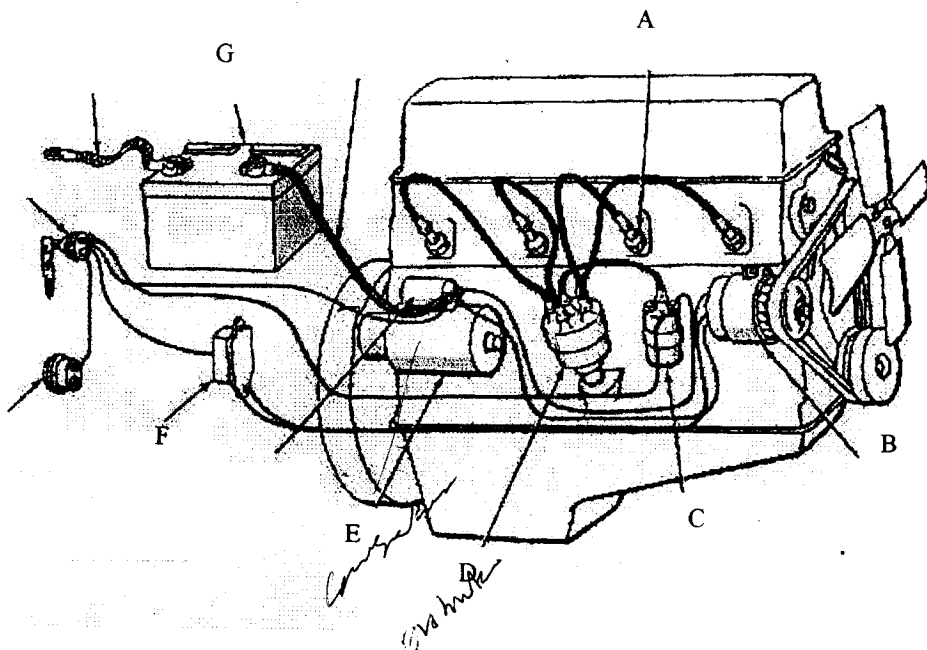


Figure Q1

- Q2. What angle has the crankshaft got to travel between each power stroke and the next in a:
- (i)(a) One cylinder four stroke engine [1 mark]
(b) Four cylinder four stroke engine [1 mark]
(c) Two cylinder two stroke engine [1 mark]
(d) Six cylinder four stroke engine [1 mark]
- (ii) In a workshop, you are given a task of wiring of the ignition and electrical system of a newly rebuilt engine. Describe how you would determine the firing order of the engine keeping in mind that the cylinder closest to the radiator is cylinder 1. [11 marks]

PART B: CIVIL ENGINEERING WORKSHOP SECTION

ANSWER Q3. IN PART B.

The Question carries 15 marks.

- Q3. (a) State the objectives of design in Civil Engineering. [3 marks]
(b) Compare the properties of steel and concrete as building materials. [5 marks]
(c) Name three types of environmental 'actions' on engineering structures. [3 marks]
(d) State the function of each of each of the following elements in a building structure. [4 marks]
- (i) foundation
 - (ii) damp proof course
 - (iii) lintel
 - (iv) conforce

PART C: ELECTRICAL ENGINEERING WORKSHOP SECTION

ANSWER ALL QUESTIONS IN PART C.

Each question carries 5 marks.

- Q4. (i) Why should product standardisation be a good business for Zambia to effectively compete in the COMESA regional market? [3 marks]
(ii) What is standardisation? [2 marks]
- Q5. (i) What are the two methods of making permanent magnets? Give an example of an isotropic permanent magnet. [2 marks]
(ii) State in your own words the network terminal reliability inequality in terms of the bounds on the actual system reliability in terms of the path-set and cut-set system reliability measures. [3 marks]
- Q6. (i) Explain to your grandmother the safety advantages of having her metal-cased-cooker earthed using a TN-S system instead of a TN-C system. [3 marks]
(ii) Demonstrate your answer with a sketches of the cooker electrical connections. [2 marks]

PART D: SURVEYING ENGINEERING WORKSHOP SECTION

ANSWER ONE ONLY OF THE TWO QUESTIONS IN PART D.

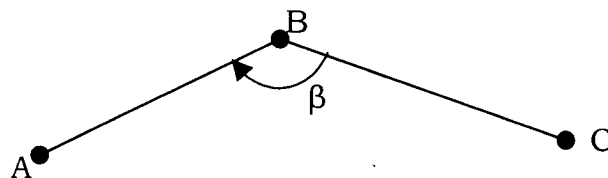
Each question carries 15 marks.

Q7. a) Define the following terms

- i) Bearing
- ii) Join
- iii) Polar

b) From figure Q7 below, a man is standing at a point A with coordinates (Y = 88830.000, X = 25760.000). The other man is standing at point B with coordinates (Y = 88930.000, X = 25790.000). If another man is standing at point C. 60 m from point B at a clockwise angle (β) of 120° as shown in figure Q7, calculate:

- i) the bearing of a man at point C from a man at point B
- ii) the coordinates of a man at point C



[3+12 marks]

Figure Q7

Q8. a) Define the following terms

- i) Datum
- ii) Reduced level (RL)

b) The table below shows leveling data, which was obtained in the field. Carry out the required computations and checks for determining the reduced levels of points 1 to 5.

[2+13 marks]

Q8. (b) (continued)

Rise and Fall Method

Pt	Readings		Height Diff.		Reduced Level	Remarks
	BS	FS	Rise	Fall		
BM1	1.100				1200.056	BM1
1	2.760	1.274				
2	1.094	1.389				
3	1.344	2.671				
4	0.567	2.032				
5	2.000	2.403				
BM2		1.450			1197.702	BM2

NB: Use the **spaces in the table** for your answers. Make sure you hand in this page together with other answer scripts.

Examination: EG 212 Workshop Technology - Surveying

Student Computer No:.....

PART E: MECHANICAL ENGINEERING WORKSHOP SECTION

ANSWER ALL QUESTIONS IN PART E.

This section carries 40 marks.

- Q9. (a) Discuss the specific roles performed by each of the following in order to promote industrial safety and health:
- (i) Employees' Trade Union
 - (ii) Employers' Federation
 - (iii) MMD Government.

[15 marks]

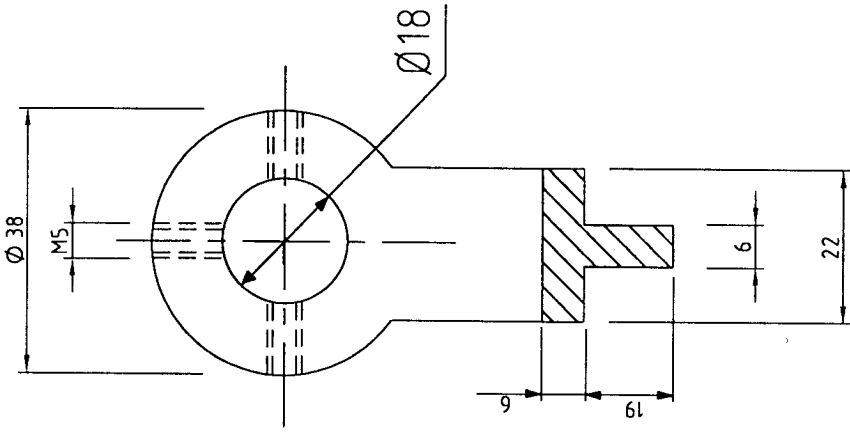
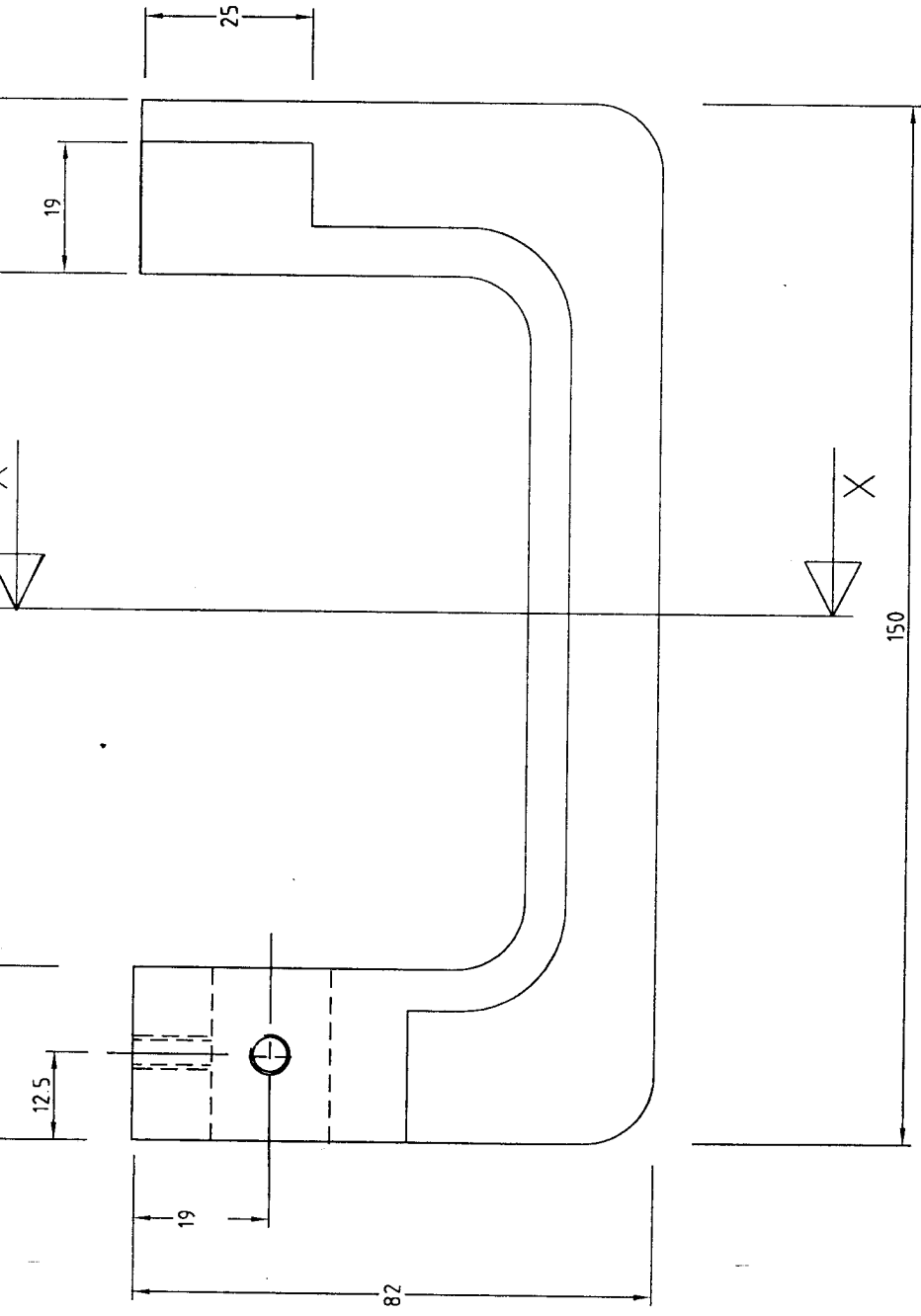
- Q10. Study the appended Mechanical Engineering Drawing representing a design of the body of a G-Clamp.

Discuss with help of clearly labelled sketches, workshop processes you would use to produce the G-clamp body. Material to be used for the body is scrap aluminium.

What problems are you likely to encounter when using the processes you have chosen?
What would be the remedies?

[25 marks]

END OF EXAMINATION



SECTION X - X

EG-212 SECOND SEMESTER EXAMINATION



**The University of Zambia
School of Engineering**

Semester I Final Examinations – January 2001

EG 269: Information Technology

Instructions:

Time: Three Hours

Answer Five (5) question in total. Three questions from Section A and Two questions from Section B.

Please! Answer Section A and Section B on separate answer booklets! DO NOT tie the two sections together.

Section A: Answer all three (3) questions from this section

1. Distinguish between a microcomputer and a mainframe computer. Explain your answer in terms of input, processor, output, and storage devices.

(Total: 20 Marks)

- 2 a) Write brief notes on each of the following programming languages

- i) Assembly Languages (4 Marks)
- ii) Fourth Generation Languages (4 Marks)
- iii) Event driven programming languages (4 Marks)

- b) What is the purpose of the following software?

- i) Utility software
- ii) Spreadsheet software
- iii) Desk top publishing software
- iv) Database Management Software

(8 Marks)

(Total: 20 Marks)

3. Use C++ programming language to answer the following questions.

a) What kind of program elements are the following?

- i) 215
- ii) 's'
- iii) 17. 9870
- iv) firstitem
- v) paragraph()

(5 Marks)

b) What will the following programs print out ?

i) `#include <iostream.h>`

```
void main()
{
    int ans=35;
    ans += 15;
    cout << endl << ans;
    ans -= 5
    cout << endl << ans;
    ans *= 2;
    cout << endl << ans;
    ans /= 3;
    cout << endl << ans;
    ans %= 3;
    cout << endl << ans;
    cout << endl << ans ++ ;
    cout << endl << ans -- ;
    cout << endl << ++ ans;
}
```

(8 Marks)

ii) `#include <iostream.h>`

```
void main()
{
    int a=0, b=-20,c;
    c=((a>b) ? b*b : 0);
    cout << c;
}
```

(2 Marks)

c) Write a C++ program to display odd numbers between 0 and 20.

(5 Marks)

(Total: 20 Marks)

Section B: Answer question four (4) and any other from this section

Question 4: (25)

You have just graduated from the University of Zambia with a Bachelor of engineering degree. Like in most cases, life is not so linear and you have not yet got employment. Meanwhile, your wealthy Uncle is ready to offload some of his money and let you start-up a small workshop. This is just a simple workshop that will be involved in metal products such as window frames, door frames and other metal furniture.

Since you have the sole responsibility of running this venture, you realize that you need to employ other workers to assist you in areas you are not experienced or qualified for. Of course the list of clients will increase when they see your products. Therefore, you will need to keep records about your clients. This may include their contact numbers, business names, postal addresses, location and the orders they will be making together with the quantities ordered.

In order to evaluate your profits, you will surely need to keep record of your assets (fixed or whatever). Therefore, you will have to keep record of the machinery type and name, cost, date purchased, expiry date or service date and some information about the capacity.

Basically this is the conceptual analysis of your mini-world. To assist you create a database to manage your workshop, answer the following questions.

- a) Create the database schema for this mini-world (*you may have to fill in some other details not included above to make the schema complete*).
- b) Identify the relationships between the entities in your database.
- c) For each entity type, identify the attribute(s) that can be used as primary keys.

Question 5: (3+12)

A data dictionary is one among other database system utilities. Explain what it is (or simply its use in the database). Mention also the other database system utility functions.

Question 6: (9+6)

- a) Mention two (2) of the disciplines that are involved in GIS spatial data acquisition and one (1) involved in Non spatial data collection. For each discipline mentioned, explain briefly how the data is collected.
- b) Explain what is involved in GIS spatial analysis. What is the importance of having topologically structured data in GIS spatial operations?

The End

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - MAY, 2000
EG 475
ENGINEERING, MANAGEMENT AND SOCIETY I

ANSWER SECTION A AND B IN A SEPARATE ANSWER BOOKLETS.
TIME : THREE (3) HOURS

SECTION A

Attempt: QUESTION ONE and any THREE QUESTIONS A. Do not write any more than one page on any one question.

Q1. The goal of development may be summarized as 'more and more for more people in a sustainable way'.

Discuss this statement. (15 MARKS)

Q2. List three 'domestic' problems and two 'foreign' problems facing Zambia today. (10 MARKS)

In the last few years, the Zambian Government has been relatively reducing budgetary allocations to tertiary education while emphasizing more on basic education.

Explain what would be the justification of such a policy? (10 MARKS)

Q3. Describe the process of industrial transformation as observed from 1780 onwards in the Western world. Use hypothetical data to illustrate the shifts in the shares of labour force in agriculture, industry and services? (7 MARKS)

State and explain reasons why countries consider industrial development desirable? (7 MARKS)

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 an industrialized country? *Explain* your answer. *What* could account for a 'high' industrial share of Zambia's income and yet a small manufacturing sector share. (6 MARKS)

Q4. (a) *Which options* does a developing country have to accumulate capital? (5 MARKS)

(b) *Define* import substitution industrialization (2 MARKS).

Discuss reasons why import substitution, combined with public investment, generally fails to boost industrial development.
(7 MARKS)

(c) What strategy elements would you incorporate in a Zambian industrial policy? Justify your answer. (6 MARKS)

(Q5) A number of models have been proposed to delineate the process of indigenous technology development.

Outline two linear models and indicate the policy implications of these models. (8 MARKS)

List five channels of international technology transfer. (5 MARKS)

Explain any two major sources of failure of technology transfer between developed and developing countries. (7 MARKS)

SECTION B

NOTE: Answer QUESTION 6 and ANY OTHER question.

6(a) The University of Zambia contributes to environmental degradation, in one way or the other. Looking at the University's infrastructure, consumption patterns and practices, list ways in which Re-use, Reduction, Recycling (the 3Rs) may be practised. Discuss each intervention separately.

(b) What is meant by Cleaner Production (CP)?
List and briefly explain the main barriers to CP in Zambia.
(10+5)

7(a) The passage below is part an application for an engineering job. It contains twelve (12) spelling mistakes. Spot the 12 mistakes giving the correct spellings. Do not rewrite the passage.

Additional information to support my application

My principle reason for applying for this post is that I feel that Zulu Burrow (Z) Ltd is a company which can be proud of it's record in Civil Engineering. Your activities in environmental management (to which I beleive I can contribute) perfectly compliment your stature in engineering. I am interested in post ZB2005 (Infrastructure Engineer), but would like to be considered for alternate positions. My main interest for now, is not so much based on the remuneration you offer but rather the training that you will offer.

My main liesure activity is swimming, and have many meddals to my credit. Ocassionally, I represent the School of Engineering at chase competitions at

University of Zambia. I am a certified electronic technician; I instal new processors in computers. I also possess creative skills in software engineering.

(b) Delete personal elements from the following sentences

- (i) Experience has shown that either method of defining lines needs the same amount of hardware.
- (ii) It should be noted that the numeric drum storage has a code number.
- (iii) It will be seen that clock pulse combines with non-clock time-data elements.
- (iv) A study of the data shows where the uncertainty lies.
- (v) A second modification was added to the motor, which increased reliability.
- (vi) It is felt that a simple design will save money.
- (vii) Pads made out of rubber improve the damping characteristics.
- (viii) It is believed that engineers are good dancers.

(6+4)

8(a) Rewrite the following passage, removing redundancies, rearranging (new paragraphs, punctuation, etc.), using active voice and reducing the number of words from 126 to 86 or less. Indicate the number of words.

Zambia's major source of energy for mining, farming, manufacturing and export is derived from turbines driven by water. This energy accounts for about 29% of the total energy consumed in Zambia. Imported oil forms 36% of the total energy consumed in Zambia. Fuel-wood and charcoal are the most important fuels for families, both in rural and urban areas, supplying them about 90% of the energy for cooking, heating and lighting of homes.

Zambia Electricity Supply Corporation generates most of the electricity in Zambia. Although Zambia Electricity Supply Corporation collects money for electricity supplied to homes, on a regular basis, the amounts are reducing due to increased tariffs. Most families who live in urban and surrounding areas are now resorting to charcoal for cooking and heating purposes.

(b) Delete redundancies from the following sentences.

- (i) We replaced it with a simple, dynamic, inexpensive type of calibrator.
- (ii) The motions are short in nature.
- (iii) The alarm has a built-in delay feature.
- (iv) The themionic emitter is the one best suited to develop such a beam.

(c) Rewrite the following sentences in active voice

- (i) In the following paragraph, the theory of operation is given.
- (ii) However, in the final test, four cycles were used.
- (iii) In Option 2, no increase in scanning rate is required.
- (iv) Several authors have discussed the limitations that are imposed on power by back -biased diodes.

(6+2+2)

END OF EXAM

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS MAY 2000

EM212 - ENGINEERING MATHEMATICS II

-
- INSTRUCTIONS:**
1. Answer ANY Four (4) questions.
 2. Show all essential working.
 3. Calculators are not allowed.

TIME ALLOWED: Three (3) Hours.

1. a) If $u = f(x,y)$ and $x = r\cos\theta$, $y = r\sin\theta$, prove that

$$\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 = \left(\frac{\partial u}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial u}{\partial \theta}\right)^2$$

- b) Solve

$$\frac{dy}{dx} = \frac{y^2 - y - 2}{x^2 + x}$$

- c) Solve

$$y'' + y' = 4x^2; y(0) = 3, y'(0) = -1$$

2. a) Define the following

- i) a symmetric matrix
- ii) a skew-symmetric matrix
- iii) an orthogonal matrix

- b) If A and B are symmetric and skew-symmetric matrices respectively and $AB = BA$ and $A + B$ is non-singular.

Prove that

- i) $(A-B)(A+B) = (A+B)(A-B)$
- ii) $(A-B)^{-1}(A+B)^{-1} = (A+B)^{-1}(A-B)^{-1}$
- iii) $(A+B)^{-1}(A-B)$ is orthogonal

c) Solve $\frac{dy}{dx} + \frac{4xy}{x^2 + 1} = 3x; y(0) = 4$

3. a) If $w = x^2 + y^2$, $x = u - v$, $y = ve^{2u}$

Find

i) $\frac{\partial w}{\partial u}$ expressing your answer in terms of x and y .

ii) $\frac{\partial w}{\partial v}$ expressing your answer in terms of u and v .

b) Solve

$$4y'' + 20y' + 25y = 0; y(0) = 1, y'(0) = 2$$

c) Find the eigenvalues and eigenvectors of the matrix

$$B = \begin{pmatrix} 0 & -2 & -3 \\ -1 & 1 & -1 \\ 2 & 2 & 5 \end{pmatrix}$$

Hence or otherwise find an invertible matrix P such that $P^{-1}AP$ is a diagonal matrix.

4. (a) Define the following

i) a subspace W of V over K .

ii) a K -basis for V .

b) Show that

i) $W = W_1 + W_2 + \dots + W_k$ is a subspace where W_1, W_2, \dots, W_k are subspaces of a vector space V over K .

ii) $\{(1,0,3), (5,2,1), (0,1,6)\}$ is an \mathbf{R} -basis for $V_3(\mathbf{R})$.

- c) Find the particular solution of
 $y'' - y' - 6y = e^x - 7\cos x$.

5. a) Define a vector space V over K

- b) i) Solve the following systems of linear equations using Gaussian elimination

$$\begin{aligned}x_1 - x_2 + 2x_3 + 3x_4 &= -7 \\2x_1 - x_2 + 6x_3 + 6x_4 &= -2 \\-2x_1 + x_2 - 4x_3 - 3x_4 &= 0 \\3x_1 - 2x_2 + 9x_3 + 10x_4 &= -5\end{aligned}$$

- ii) Evaluate

$$\begin{vmatrix}(x-a)^2 & (x+a)^2 & 2y^2 + 2z^2 \\(y-a)^2 & (y+a)^2 & 2z^2 + 2x^2 \\(z-a)^2 & (z+a)^2 & 2x^2 + 2y^2\end{vmatrix}$$

expressing your answer in factorised form

c) Solve

i) $\left(3y - x \cos \frac{y}{x}\right) dx - 3x dy = 0$

ii) $(1 + y^2) dx + (2xy + y^2 + 1) dy = 0$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS

JULY 2000

EM312 - ENGINEERING MATHEMATICS III

INSTRUCTIONS

1. Attempt five (5) questions.
2. Show *all your work* to earn full credit.
3. Every problem must be solved step by step with minimal assumptions.
4. All the questions carry equal marks.
5. You may use calculators.

TIME ALLOWED: Three (3) hours

- [1]. (a) Prove that every normal line to the sphere $x^2 + y^2 + z^2 = a^2$ passing through the point $p(x_0, y_0, z_0)$ on the sphere, also passes through the center of the sphere.
(Derive all the steps)
- (b) Find the symmetric equations of the *tangent line* and the *normal line* to the curve of intersection of the surfaces $3x^2 + 2y^2 + z^2 = 49$ and $x^2 + y^2 - 2z^2 = 10$ at the point $(3, -3, 2)$.
(Derive all the steps)
- [2] (a) Evaluate the line integral $\int_C \frac{dy}{\sqrt{x} + y}$
- (i). Where C is the segment of the straight line $y = x$, from A:(1, 1) to B:(2, 4)
 - (ii). Where C is the segment of the curve $y = x^2$ from A:(1, 1) to B:(2, 4)
- (b) (i) State Green's Theorem in the Plane and
(ii) Verify Green's Theorem in the Plane for the integral
 $\int (x - y)dx + (x + y)dy$ taken around the circle $x^2 + y^2 = a^2$.
(Show all the details)
- [3] (a) An equation of the surface of a mountain is $z = 1200 - 3x^2 - 2y^2$, where distance is measured in feet, the x-axis points to the east, and the y-axis points to the north. A climber is at the point corresponding to $(-10, 5, 850)$.
(Show all the details stating direction in the form of unit vectors)
- (i). What is the direction of the steepest ascent?
 - (ii). If the climber moves in the east direction, is he ascending or descending, and what is his rate?
 - (iii). If the climber moves in the southwest direction, is he ascending or descending, and what is his rate?

- (iv). In what direction is he traveling a level path?
- (b) The temperature is T degrees at any point on a heated circular plate and

$$T = \frac{44}{x^2 + y^2 + 9}$$

where distance is measured in inches from the origin to the center of the plate.

- (i) Find the rate of change of the temperature at the point $(3, 2)$ in the direction of the vector $\cos \frac{1}{6} \pi \mathbf{i} + \sin \frac{1}{6} \pi \mathbf{j}$.
- (ii) Find the direction and magnitude of the greatest rate of change of T at the point $(3, 2)$.
- [4]. The integral form of the Divergence Theorem is given by $\iiint_V \text{div } \mathbf{F} dV = \iint_S \mathbf{F} \cdot \mathbf{n} dS$.
- (a) (i) A region R of volume V is bounded by $2x + 2y + z = 6$, $x = 0$, $y = 0$. Sketch the region R in three-space and be sure to indicate the equations of the edges of the region.
- (ii) How many faces border the region R ?
- (b) Verify the divergence theorem for $\mathbf{F} = (2xy + z)\mathbf{i} + y^2\mathbf{j} - (x + 3y)\mathbf{k}$ taken over the region given in (a) above.
- (Be sure to show the value of the integral for each of the faces found in (a) (ii) somewhere in your verification)*

- [5]. Television sets are given a final inspection following assembly. Three types of defects are identified as *critical*, *major*, and *minor defects* and are coded A, B, and C, respectively. Data are analyzed with the following results

CATEGORY	PERCENTAGE OF SETS WITH DEFECTS
Sets having only critical defects	2%
Sets having only major defects	5%
Sets having only minor defects	7%
Sets having only critical <i>and</i> major defects	3%
Sets having only critical <i>and</i> minor defects	4%
Sets having only major <i>and</i> minor defects	3%
Sets having all three defects	1%

- (i) Write down the event, in set notation, that a set has no defect using the codes A, B, and C.
- (ii) What is the probability that a set has no defects?
- (iii) Sets with either critical defects or major defects (or both) get a complete rework. Write down the event, in set notation, that a set gets a complete rework, again using the codes A, B, and C.
- (iv) What is the probability that a set gets a complete rework?

- (v) Among the sets that do not get a complete rework what percentage have minor defects.
- (b) A student is asked to answer 10 *true OR false* questions in a test. Unfortunately, the student did not study the material, hence, she will guess the answer to each question. Consequently, the probability that she gets any question right is 0.5. Assume that the number of questions answered correctly has a binomial distribution.
- (i) Find the probability that she gets at least one question right.
- (ii) Find the probability that she gets exactly 3 right.
- (iii) Find the probability that her score is 80% or better.
- [6]. (a) Find the total work done in moving an object along the given arc C if the motion is caused the given force field. Assume the arc is measured in inches and the force is measure in pounds.
- (i) $F(x, y) = 2xy\mathbf{i} + (x^2 + y^2)\mathbf{j}$; C: the line segment from the origin to the point (1, 1)
- (ii) $F(x, y) = (y - x)\mathbf{i} + x^2y\mathbf{j}$; C: the arc of the parabola $y = x^2$ from the point (1, 1) to (2, 4)
- (b) Find the work W by the force $\mathbf{p} = yz\mathbf{i} + xz\mathbf{j} + xy\mathbf{k}$ in the displacement of a particle along;
- (i) the straight segment C from A(1, 1, 1) to B(2, 4, 8)
- (ii) the curve $\mathbf{r}(t) = t\mathbf{i} + t^2\mathbf{j} + t^3\mathbf{k}$ from A(1, 1, 1) to B(2, 4, 8)
- (iii) From your answer in (i) and (ii) what can you reasonably speculate about the work W by the force \mathbf{p} along a path C.
(*Show all the details*)

END OF EXAMINATION

SCHOOL OF ENGINEERING
THE UNIVERSITY OF ZAMBIA
MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS

MAY, 2000

ME252 PROPERTIES OF ENGINEERING MATERIALS I

ANSWER: FIVE QUESTIONS

TIME: 3 HOURS

ALL QUESTIONS CARRY EQUAL MARKS

1. (a) Describe the group of materials called ceramics stating in detail the composition of three oxide ceramics.
(b) Discuss briefly the group of materials called composites.
 2. (a) Discuss, with the help of a phase diagram, partial solid solubility of metallic materials.
(b) What is natural rubber?
 3. Describe in detail the Iron-Carbon phase diagram, with particular detail to the explanation of eutectoid, hypo-eutectoid and hyper-eutectoid steels.
 4. Discuss the following heat treatment processes
 - (a) Full annealing
 - (b) Spheroidising annealing
 - (c) Hardening
 - (d) Tempering
 5. (a) Discuss in detail the classification of crystalline materials in reference to their atomic arrangement
(b) What are black heart and white heart cast irons?
 6. Describe in detail the following polymers:
 - (a) Poly ethylene (PE)
 - (b) Polyvinyl chloride (PVC)
 - (c) Polytetra fluoroethylene (PTFE)
 7. (a) Name and describe the composition and properties of three types of stainless steel.
(b) Briefly discuss the group of materials called glasses
-

END OF EXAMINATION

Dr. C.K. Wamukwamba, May, 2000

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

1998/2000 UNIVERSITY SEMESTER II EXAMINATIONS - MAY 2000

ME 375 - DYNAMICS

Time: **THREE (3) HOURS**

CLOSED BOOK

Instructions: Answer **Question 1 AND any FOUR (4) others** (i.e. Five (5) Questions in total)
QUESTION 1 CARRIES 24 MARKS. ALL OTHER QUESTIONS CARRY EQUAL MARKS

- Q1. The circular disk rotates about O with a constant angular velocity of 10 rad/s. When OA is 30° from the vertical as shown in Figure Q1, link AB is horizontal and arm CBD is vertical. For this instant and using a graphical approach, determine:
- the angular velocity of the arm and the velocity of point D .
 - the angular acceleration of the arm BC and the acceleration of point D .

- Q2. The disk with the circular slot of 200 mm radius as shown in Figure Q2 rotates about O with a constant angular velocity $\omega = 15$ rad/s. Determine the acceleration of the slide A at the instant when it passes the centre of the disk. At that moment, it is given that:

$$\frac{d\theta}{dt} = 12 \text{ rad/s}; \quad \frac{d^2\theta}{dt^2} = 0$$

- Q3. Wheel D rotates at an angular speed ω_1 of 2 rad/s counterclockwise in Figure Q3. Find the angular speed ω_E of gear E (radius 0.3 m) relative to the ground at the instant shown in the diagram.
- Q4. A cylinder with a mass of 25 kg is released from rest on an incline, as shown in Figure Q4. The diameter of the cylinder is 0.60 m. If the cylinder rolls without slipping, compute the speed of the centre line C after it has moved 1.6 m along the incline, given that the kinetic energy of a cylinder rotating about its own stationary axis is $\frac{1}{2}MR^2\omega^2$, where ω is the angular speed in rad/s. Also, ascertain the friction force acting on the cylinder.
- Q5. The 30-kg block shown in Figure Q5 rests on the smooth plane. It is attached by a flexible inextensible cord over frictionless, weightless pulleys to the 45-kg mass and a support. In what distance will the block on the plane attain a speed of 3 m/s?
- Q6. The 2-kg piece of putty in Figure Q6 is dropped onto the 18-kg block initially at rest on the two springs, each with a stiffness $k = 1.2$ kN/m. Calculate:
- the percentage energy loss of the impact, if the putty adheres to the block upon contact.
 - the deflection δ of the springs due to the impact of the putty.
- Q7. The weights of four masses W_1, W_2, W_3 and W_4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 20 cm, 15 cm, 25 cm and 30 cm respectively and the angles between successive masses are $45^\circ, 75^\circ$ and 135° . Find the position and magnitude of the balance weight required, if its radius of rotation is 20 cm.
- Q8. The uniform cylinder of mass M and radius R on an inclined plane in Figure Q8 is maintained in a position of equilibrium by a linear spring having a spring constant K . If the cylinder rolls without slipping, determine its natural frequency of vibration when it is disturbed from its equilibrium position.

END OF ME375 EXAMINATION

Dr A N Ng'andu

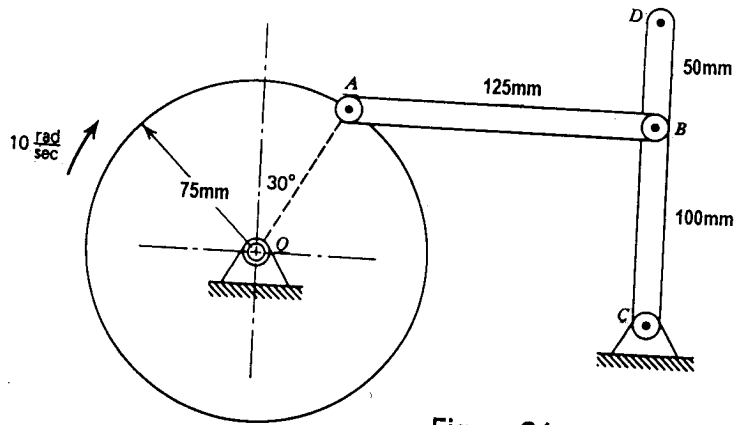


Figure Q1

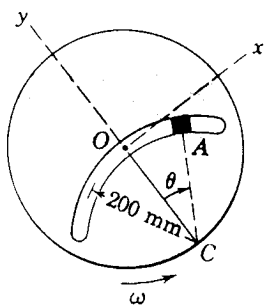


Figure Q2

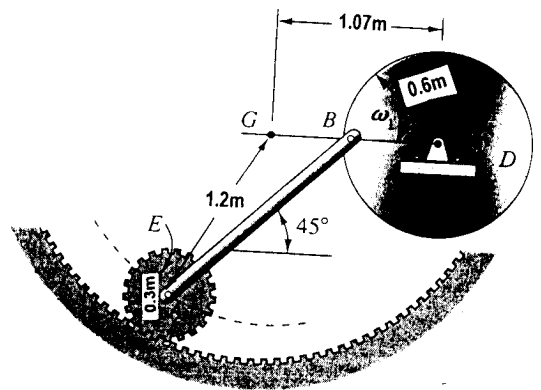


Figure Q3

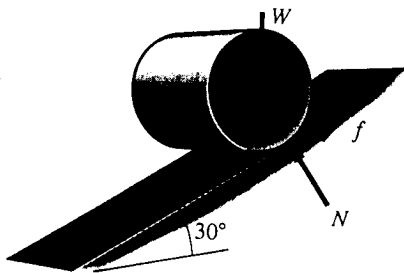


Figure Q4

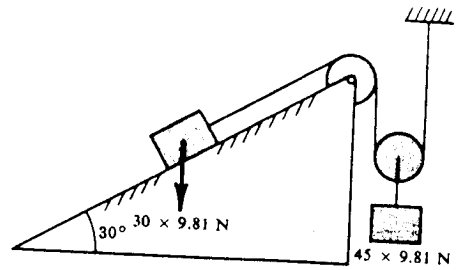


Figure Q5

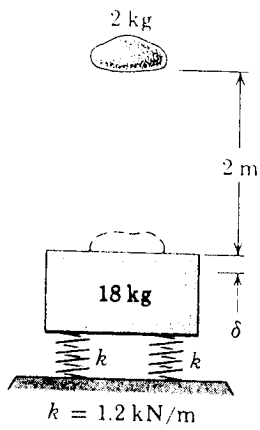


Figure Q6

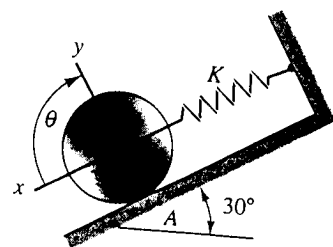


Figure Q8

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING**

UNIVERSITY EXAMINATIONS

**SEMESTER I EXAMINATIONS - 1999/2001
JANUARY 2001**

ME 415 – PRODUCTION TECHNOLOGY I

ANSWER: FIVE (5) QUESTIONS: QUESTION ONE (Q1), THREE (3) QUESTIONS FROM SECTION B, AND ONE (1) QUESTION FROM SECTION C.

CLOSED BOOK

ALL QUESTIONS CARRY EQUAL MARKS TIME ALLOWED: THREE HOURS

This Question Paper has THREE (3) printed pages

SECTION A: THIS QUESTION IS COMPULSORY

- Q1 a) Explain in brief, the fundamental principles of Jig and Fixture design. [8 Marks]
- b) Figure Q1 on page 3 shows two views of a steering gear bracket made of cast iron.
- i) Give a graphic representation of the locator and holding force system to facilitate the mass drilling of the 10mm through hole. (Use the figure provided for the place of locator.) [6 Marks]
- ii) Based on the selected graphic locator and holding force system, produce a sketch of an appropriate jig that would be used to drill the above-mentioned hole. [6 Marks]

SECTION B: ANSWER ANY THREE (3) QUESTIONS FROM THIS SECTION

- Q2 a) Discuss the types of errors in mechanical measurements. [10 Marks]
- b) Explain the principle of Superposition of errors. [10 Marks]
- Q3 a) What quality problems are associated with Green Sand casting and how can such problems be avoided? [8 Marks]
- b) Figure Q3 on page 3 shows an aluminium key blank to be cast in mass using the Investment Casting process. With the help of sketches, discuss the steps to be taken to produce at least six (6) of this product using the above-mentioned casting process. Give two (2) examples of other products that can be produced using this process. [12 Marks]

Figures Q1 and Q3 are on Page 3.

Q4 a) A machining operation is being carried out with a cutting fluid that is effective as a lubricant. Explain the changes in the mechanics of cutting operation and total energy consumption if the same fluid is shut off. [6 Marks]

b) (i) Using Merchant's Circle, derive an expression for the coefficient of friction μ_r at the chip-tool rake plain interface during single point cutting. [7 Marks]

(ii) From single point cutting geometry, derive the following expression:

$$V_s = \frac{V \cdot \cos \gamma}{\cos (\phi - \gamma)}$$

where V_s = Shear velocity
 V = Cutting velocity

[7 Marks]

Q5 a) What are the basic differences between turning and milling? [10 marks]

b) Name four types of equipment that can be used to produce a round hole and briefly explain how this can be done in two of the types of equipment. [10 marks]

SECTION C: ANSWER ANY ONE (1) QUESTION FROM THIS SECTION

Q6 (a) Describe the Sunderland method of gear cutting. [10 Marks]

(b) Select the differential change gears and the index plate and determine the number of revolutions of the index crank for cutting a gear with 227 teeth. [10 Marks]

Q7 Describe the principle of gear cutting using:

(a) A form cutter on a milling machine. [5 Marks]

(b) Generation with a hob cutter. [10 Marks]

(c) Which of the above processes would produce more accurate gears. Give reasons for your answer. [5 Marks]

END OF ME 415 EXAMINATION

Mr. C. G. Chizyuka & Mr. G. M. Munakaampe, Dr. J. Phiri

Figures Q1 and Q3 are on Page 3.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY EXAMINATIONS
SEMESTER I EXAMINATIONS - 1999/2001
JANUARY 2001
ME 431 – STRENGTH OF MATERIALS II

ANSWER: ANY FIVE (5) QUESTIONS

CLOSED BOOK

ALL QUESTIONS CARRY EQUAL MARKS

TIME ALLOWED: THREE (3) HOURS

This Question Paper has three (3) printed pages

Q1 a) Derive the hoop and longitudinal stresses of a pressure vessel under internal pressure p if its internal diameter is d , wall thickness t and length l . [6 marks]

b) A pressure vessel of 7-mm steel plate has the shape of a paraboloid closed by a thick flat plate, as shown in Figure Q1. The equation of the generating parabola is given by the equation $y = x^2/100$, where x and y are in millimetres.

Determine the axial and hoop stresses in the shell at a point 400 mm above the bottom due to an internal gas pressure of 2.00 MPa gauge. You are given that the radius of curvature in the xy plane at the point of consideration is 3.505 m. [14 marks]

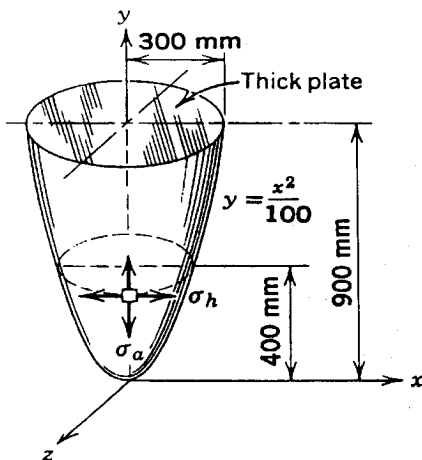


Figure Q1

Q2 a) From first principles or otherwise, derive the expression for the Euler buckling load for a column of length L and with both ends fixed against rotation. [10 marks]

b) An aluminium column of length $L = 3.2$ m has an inside and outside diameters $d_1 = 125$ mm and $d_2 = 150$ mm, respectively. If the column is fixed at both ends, calculate the critical load P_{cr} . Assume $E = 70$ GPa. [5 marks]

c) What is the diameter of an equivalent solid shaft under similar loading conditions? [5 marks]

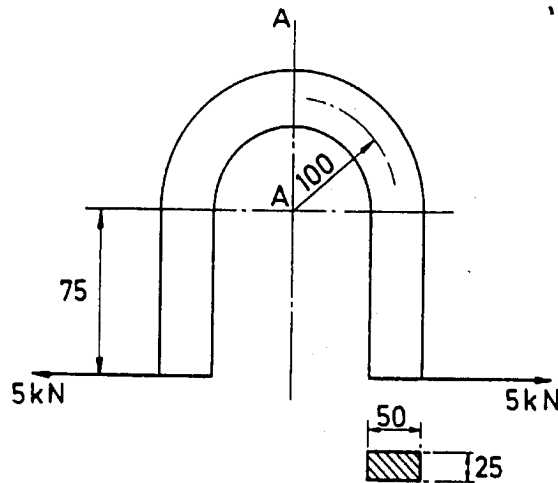
- Q3 a) A disc of uniform strength is rotating at an angular velocity ω rad/s. Show that the thickness t at any radius r is given by:

$$t = t_0 e^{-(\rho r^2 \omega^2 / 2\sigma)}, \text{ where } t_0 \text{ is the disc thickness at } r = 0, \rho \text{ is the density of the disc and } \sigma \text{ is the uniform stress.}$$

[12 marks]

- b) A turbine rotor disc is 0.6 m diameter at the blade ring, and is keyed to a 50 mm diameter shaft. If the minimum thickness is 9.5 mm, what should be the thickness at the shaft for a uniform stress of 200 MPa at 10,000 rpm? Take the density to be 7700 kg/m³.
- [8 marks]

- Q4 Find the maximum tensile and compressive stresses at the section AA of the curved bar shown in Figure Q4 below.
- [20 marks]



Dimensions in mm

Figure Q4

- Q5 a) For an open-coiled helical spring of mean coil diameter D , wire length l , wire diameter d and with a helix angle α , derive the total strain energy equation due to bending under applied load W and torque T .
- [10 marks]
- b) From the result in Q5 a), obtain expressions for the axial extension, x and the angle of twist, ϕ without the applied torque.
- [7 marks]
- c) An open-coiled helical spring is made having ten turns wound to a mean diameter of 120 mm. The wire diameter is 10 mm and the coils make an angle of 30° with the perpendicular to the axis of the coil. Find the axial extension under a load of 100 N and the angle the free end will turn through with a load if free to rotate. Assume $E = 208$ GPa, $G = 83$ GPa.
- [3 marks]

- Q6 A cantilever, Figure Q6, carrying a concentrated load W at the mid-span, is horizontally fixed at one end and simply supported at the other end giving a negative deflection, Δ . Derive expressions for P , reaction R and the fixing moment M_0 in terms of W and Δ . [20 marks]

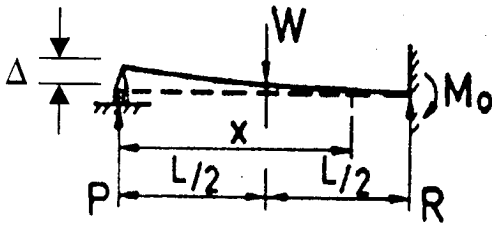


Figure Q6

- Q7 A solid circular plate of diameter 1.8 m, 10 mm thick and firmly clamped round the edge is carrying a uniform load of 10 kN/m^2 . Taking Young's modulus and Poisson's ratio as 200 GPa and 0.3, respectively,
- Calculate the maximum deflection of the plate. [7 marks]
 - Calculate the maximum bending stresses, $\sigma_{x_{\max}}$ in the YOX and $\sigma_{z_{\max}}$ in the YOZ planes, respectively. [10 marks]
 - What is the significance of the results in b) above? [3 marks]

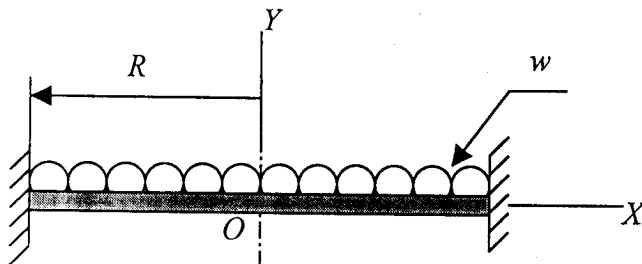


Figure Q7

END OF ME 431 EXAMINATION

Dr C. K. Wamukwamba, Dr. S. B. Kanyanga & Mr. G. M. Munakaampe

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY SEMESTER I FINAL EXAMINATIONS – JANUARY 2001

ME 515 – PRODUCTION TECHNOLOGY II – PAPER I

DURATION: Three (3) hours

CLOSED BOOK EXAMINATION

Answer five (5) questions with at least two questions from each section – Sections A and B. Use a separate answer booklets for each section.

SECTION A

QUESTION 1.

- (a) Describe (using diagrams) the general features of extruder screw design and indicate the methods of compressing the melt. Outline the process of extrusion coating of wire, indicating any key features of the process.

[12 marks]

- (b) A telephone provider has decided to use plastic coins (radius 14 mm, thickness 2 mm) for its public phones. The coins have to be manufactured out of polystyrene by injection moulding and the only presses that can be obtained have a maximum clamping capacity of 250 tonnes. If the injection moulding unit should generate mould cavity pressures of 50 MPa to obtain suitable filling, about how many coins can be moulded per cycle? What shot capacity does this correspond to? (Neglect the runner and sprue volumes.)

[8 marks]

QUESTION 2.

- (a) Give an outline of the conventional method of shaping powder metal. List its advantages, limitations, and typical products.

[15 marks]

- (b) Given that the linear shrinkage in a solid-state bonding during sintering of a powder-metal green compact is 4 percent, what should be the density of the green compact if the desired sintered density is 95 percent of the theoretical density of the metal?

[5 marks]

QUESTION 3.

- (a) A CNC machine operates under the instructions of a program. Explain the three methods of developing a CNC program.

[5 marks]

- (b) The component shown in figure A1-Q3 is to be machined on a Vertical Machining Centre (VMC).
- Develop a process plan to show the machining sequence, tools used, spindle speeds (rpm), and feed rates (mm/min).
 - Write a part program for the component, including explanations for each block. Use the profile outline as the programmed path. The program should use absolute dimensions, and allocate tool offsets. Relevant details are provided in the figure. The G- and M- codes supported by the VMC are in Tables A1-Q3 and A2-Q3.

[15 marks]

QUESTION 4.

- What is meant by the term polymerisation? Describe the structure and properties of the three main polymer groups – thermoplastic polymers, thermosetting polymers, and elastomers.
- Define the following as related to plastics technology:
 - Stabilisers,
 - Plasticisers, and
 - Coupling agents.

[14 marks]

[6 marks]

SECTION B

Some useful equations and graph to use in this section are given in Table B and Figure B, respectively.

QUESTION 1.

- Rolling mills are classified with respect to the number and arrangement of the rolls. Explain the reason for designing rolling mills with complex clusters of rolls such as in figure B1-Q1.

[5 marks]

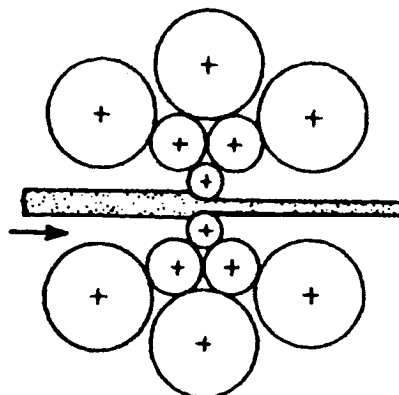


FIGURE B1-Q1: CLUSTER MILL

- (b) Determine the maximum possible reduction for cold rolling a 400 mm thick slab when $\mu = 0.08$ and the roll diameter is 700 mm. What is the maximum reduction on the same mill for hot rolling when $\mu = 0.5$? [5 marks]
- (c) Calculate the rolling load if steel is hot rolled 25% from a 40 mm thick slab using a 800 mm diameter roll. The slab is 750mm wide. Assume $\mu = 0.25$. The plain strain flow stress 150 MPa at the entrance and 215 MPa at the exit from the roll gap due to the increasing velocity. [5 marks]
- (d) A 280 mm wide aluminium alloy strip is hot rolled in thickness from 22 to 18 mm. The rolls are 200mm in diameter and operate at 120 rpm. The uniaxial flow stress for the aluminium alloy can be expressed as $\sigma = 130\epsilon^{0.22}$ MPa. Determine the rolling load and the power required for this hot reduction. Assume $\mu = 0.5$ and $K = 130$. [5 marks]

QUESTION 2.

- (a) Briefly outline the process of wire drawing with the aid of a diagram of wire drawing die cross section. Derive the Johnson and Rowe formula for the draw stress. [10 marks]
- (b) Determine the draw stress to produce a 20% reduction in a 10 mm stainless steel wire. The flow stress is given by $\sigma_o = 1500\epsilon^{0.30}$ MPa. The die angle is 12° and $\mu = 0.08$. If the wire is moving through a die at 4m.s^{-1} , determine the power required to produce the deformation. [5 marks]
- (c) For the material drawn in (b), what is the largest possible reduction given that the first approximation for the limit on drawing reduction occurs when $\sigma_{\text{sa}} = \sigma$. [5 marks]

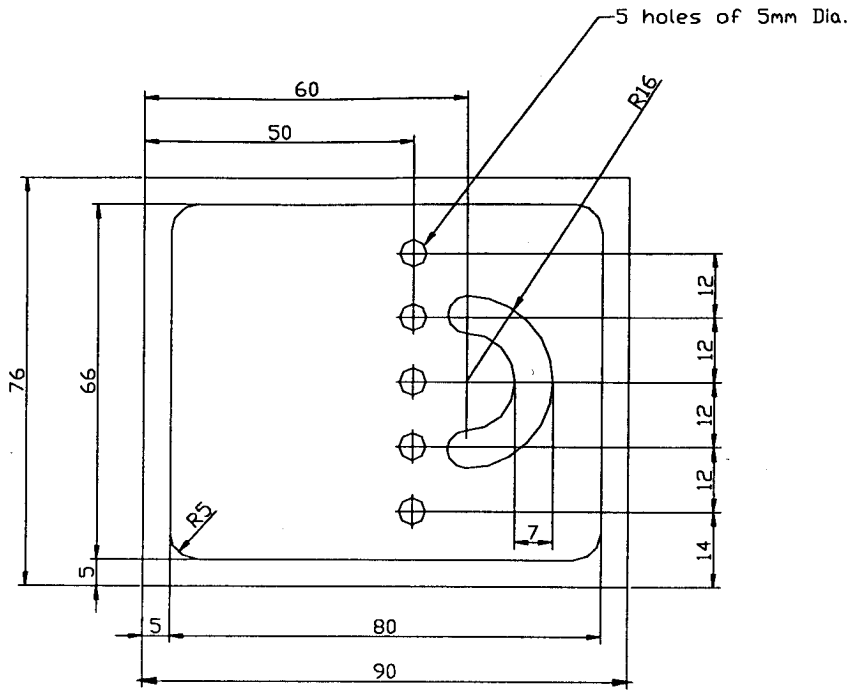
QUESTION 3.

- (a) Sketch the main features of Electro-Discharge Machining (EDM) and briefly describe how the process works. Given that the machine runs at a particular voltage, how can production rate be increased? What are the likely disadvantages of high production rates on quality? [15 marks]
- (b) EDM is generally a very expensive metal removal process as compared to the more traditional methods of metal removal. What factors influence the decision EDM? [5 marks]

Dr. L. Siaminwe/Dr. J. Phiri

END OF EXAMINATION

FIGURE A1-Q3: COMPONENT TO BE MACHINED



All dimensions are in mm.
Part material: Aluminium alloy.

Cutting speed (m/min):

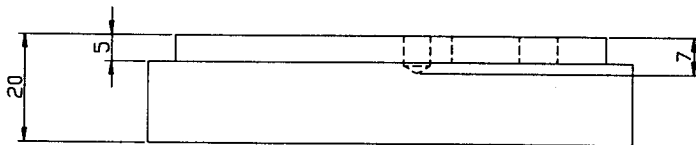
Milling 100

Drilling 80

Machine feed rates:

Milling 0.17 mm/tooth

Drilling 0.10 mm/rev



TOOL TABLE

Tool Number	Description	Flute Length (mm)	Cutting Length (mm)	Number of Teeth
T2	HSS Centre Drill	-	-	-
T3	HSS Drill $\phi 5$	62	55	2
T4	HSS Slotting Mill $\phi 7$	28	11	2
T5	HSS End Mill $\phi 12$	39	30	2

Table 1A-Q3: Preparatory Functions (G-codes)

Code	Function	Type
G00	Positioning	Modal
G01	Linear Interpolation	Modal
G02	Circular Interpolation (CW)	Modal
G03	Circular Interpolation (CCW)	Modal
G04	Dwell	
G17	XY Plane	Modal
G18	XZ Plane	Modal
G19	YZ Plane	Modal
G20	Inch Units	Modal
G21	Metric Units	Modal
G28	Automatic Return to Reference Point	
G29	Automatic Return from Reference Point	
G40	Cutter Compensation Cancel	Modal
G41	Cutter Compensation Left	Modal
G42	Cutter Compensation Right	Modal
G43	Tool Length Compensation (Plus)	Modal
G44	Tool Length Compensation (Minus)	Modal
G49	Tool Length Compensation Cancel	Modal
G54	Workpiece coordinate system 1 selection	Modal
G55	Workpiece coordinate system 2 selection	
G56	Workpiece coordinate system 3 selection	
G69	Coordinate Rotation Cancel	Modal
G80	Cancel Canned Cycles	Modal
G81	Drilling Cycle	Modal
G82	Counter Boring Cycle	Modal
G83	Deep Hole Drilling Cycle	Modal
G90	Absolute Positioning	Modal
G91	Incremental Positioning	Modal
G92	Reposition Origin Point	
G98	Set Initial Plane Default	
G99	Return to Retract (Rapid) Plane	

Table A2-Q3 Miscellaneous Functions (M-codes)

Code	Function
M00	Program Stop
M01	Optional Program Stop
M02	Program End
M03	Spindle On Clockwise
M04	Spindle On Counterclockwise
M05	Spindle Stop
M06	Tool Change
M08	Coolant On
M09	Coolant Off
M10	Clamps On
M11	Clamps Off
M19	Spindle Orientation
M30	Program End, Reset to Start

TABLE B: ROLLING AND DRAWING EQUATIONS

$$Q = \frac{\mu \times L_p}{\bar{h}}$$

$$P = \bar{\sigma}_0 \left[\frac{1}{Q} (e^{\epsilon} - 1) b \sqrt{R \Delta h} \right]$$

$$\epsilon = \ln \frac{1}{1-r}$$

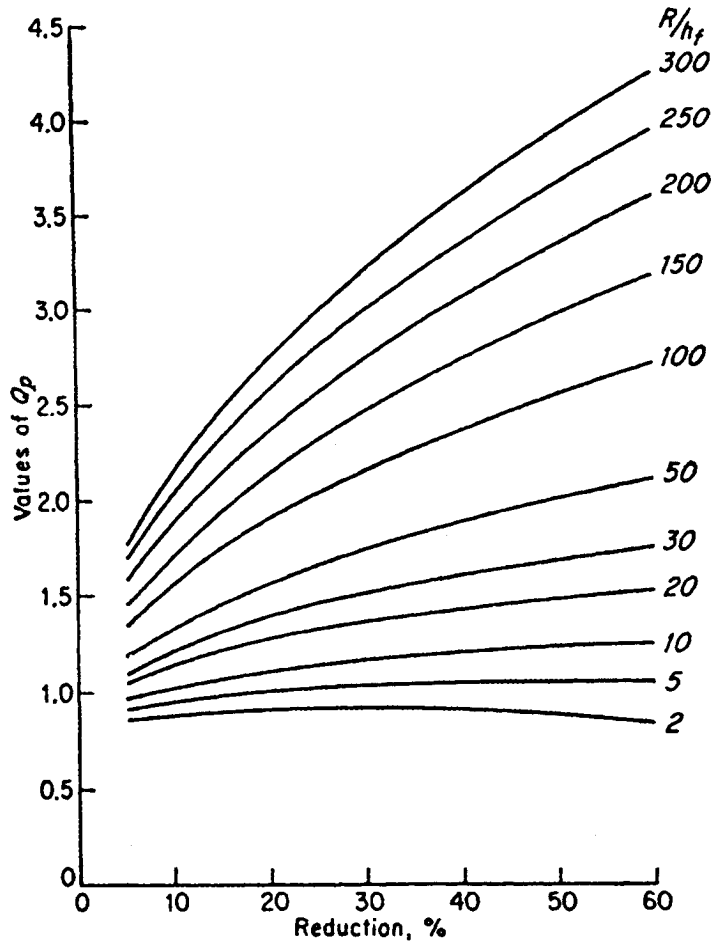
$$P = \frac{2}{\sqrt{3}} \sigma_{0_0} [R(h_0 - h_f)]^{1/2} Q_p$$

$$\sigma_{xa} = \bar{\sigma} \left(\frac{1+B}{B} \right) \left[1 - \left(\frac{A_a}{A_b} \right)^B \right]$$

$$\bar{\sigma} = \frac{K \epsilon^n}{n+1}$$

$$\sigma_{xa} = \sigma_0 \left(\frac{1+B}{B} \right) \left[1 - (1-r)^B \right]$$

FIGURE B: VALUES OF Q_p



University of Zambia
School of Engineering
Department of Surveying

May 2000 Examinations
SE 332 – Photogrammetry I

Answer ALL questions from section A and ONLY 3 from Section B
Time Allowed: 3 Hrs

SECTION A

Question 1 (20)

- (a) Define the following terms and give their use in photogrammetric applications;
1. Intervalometer
 2. Electromagnetic spectrum
 3. Spectral signature
 4. Diapositive
 5. Photographic material
- (b) Given a photogrammetric project covering a rectangular area measuring 50 x 35 Km and that the client desires a mapping scale of 1:5000 by means of a stereoplotter with photo/model ratio of 1:1, calculate the flying height of the aircraft above datum and above ground if the terrain is flat at an altitude of 1260m using a 15/23 camera.

Question 2 (20)

- (a) What is meant by the term camera calibration? Give any one detailed method used for calibration in a laboratory environment.
- (b) Give at least five of the interior orientation parameters determined during the camera calibration process?

SECTION B

Question 1 (20)

- (a) What are the major systematic errors that are corrected during refinement of coordinates?
- (b) Derive from first principles the formula for calculating the distortions due to relief displacement of vertical photographs

Question 2 (20)

A project area is 16Km in East-West and 10.4 Km in North-South. The project area is to be mapped by photogrammetric techniques at a scale of 1:12000. The end and side lap for the project is 60% and 30% respectively using a 15/23 camera. Calculate the following parameters.

- (a) Dimensions of the square ground coverage
- (b) Distance between two successive strip
- (c) Number of flight lines
- (d) The air base
- (e) Total number of photos required to cover the project area

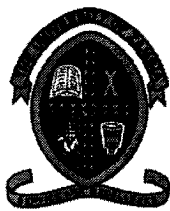
Question 3 (20)

- (a) Using a well-labelled diagram, explain what is meant by optical and differential rectification? Give examples in which the two methods are applied.
- (b) In making photo controls, artificial targets are used in practice. However, such targets have disadvantages when used. Clearly describe the two main disadvantages
- (c) Give the three main methods used in the establishment of ground control points in photogrammetric mapping.

Question 4 (20)

- (a) Describe the five main ways in which electromagnetic radiation is propagated during interaction with earth objects.
- (b) Name the seven main direct and indirect characteristics used in photo interpretation
- (c) Give the main advantages of colour infrared photographs. State the applications where CIR photographs are highly suitable compared to Black and White photographs.

*End of exam
Good Luck!!!!!!!!!!*



**The University of Zambia
School of Engineering
Department of Surveying
SE 352 – Land Law, Cadastre and Survey Regulations
Second Semester Examination – May 2000.**

Time : 3hrs
Total Marks : 100

Answer questions one, two and any other three questions.

Question 1

Your uncle Mubukwanu Nyambe owns about two thousand hectares of land in the Zambezi plains near Mongu in the Western province of Zambia. The land falls under a customary area as defined under the Lands Act, 1995. Mubukwanu Nyambe was last month approached by Ox-farm a British Non Government Charitable organisation with the irresistible offer of K100 million to buy the parcel of land. Ox-farm would wish to use the parcel of land for rice growing project. Ox-farm wants to introduce a better quality and breed of rice than is grown by people of the Western province. Ox-farm insists that Mubukwanu Nyambe must first obtain a certificate of Title or Title deeds to the property in his name before the transaction or deal can be sealed.

Mubukwanu Nyambe inherited the piece of land in issue from his late father Sipopa Nyambe and in accordance with the Lozi customary law of inheritance, Mubukwanu's young brothers Sekeleti and Longwani have some interest in the piece of land.

Your uncle Mubukwanu Nyambe has approached you for some piece of advice on the matter. He cannot manage to retain or hire a Lawyer for advice but he is aware that you have studied Land Law and he is also aware that you have been an A+ student ever since you entered university and hence he is assured of the best advice.

Advice him on the steps he would have to take to secure the certificate of Title which should be beyond reproach or dispute and the likely problems he may face or encounter.

(24 marks)

Question 2

- a) State and briefly explain the features or consideration of a monument for boundary definitions?
- b) What do you understand by an indicatory beacon? Give examples of situations where this concept is applied.
- c) Discuss the types of surveys under cadastral surveying.
- d) Give three disadvantages and advantages of land registration to an individual.

(19 marks)

Questions 3

Write short notes on the following: -

- a) The sources of land Law in Zambia.
- b) The disadvantages or inadequacies of customary tenure in Zambia.
- c) The Essentials of lease.
- d) The Lands Tribunal established under The Lands act, 1995.

(19 marks)

Questions 4

The Lands act, 1995 repealed among others the Zambia (State Lands and Reserves) Orders, 1928 to 1964 which Orders created the Crownland and Native reserves, the Zambia Trustland Orders 1947 to 1964 which Orders created Native Trustland Reserve.

- a) What led to the policy of Land Reservation or the categorization of land into Native reserves, Crownland and Native Trustland reserves?
- b) What were the differences among the three categories of land?

(19 marks)

Questions 5

Compare and contrast: -

- a) An easement from a profit a'prendre.
- b) A contractual licence from a licence coupled with an interest.
- c) A freehold estate from a leasehold estate.
- d) A licence from a lease.

(19 marks)

Questions 6

Describe the procedures that the Survey Control Board will have to follow once a complaint is made against a Land Surveyor and the punishment that may be meted out inflicted at the end of enquiry.

(19 marks)

Good Luck!
Have a nice vacation!



THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF SURVEYING

SE412 NUMERICAL METHODS AND PROGRAMMING FOR SURVEYORS
FINAL UNIVERSITY EXAMINATIONS 1998/2000 SECOND SEMESTER

Instructions:

Answer Question 1 and any other three (3) questions

Total: 100 points

Duration: Three Hours

Question 1 (4+8+13)

- (i) Mr. Jere wants to write a program using Turbo Pascal. What would you advise him on the four rules that govern the choice of identifiers.
- (ii) Mr. Jere happens to be solving a complicated problem and needs to plan carefully in order for him to succeed. He approaches you for advice. Give him the six steps that he should consider in solving the problem.
- iii) Write a function that computes the maximum norm, $\|x\|_{\infty}$ of a vector $x \in \mathbb{R}^n$, i.e.

$$\|x\|_{\infty} = \max_i |x_i|$$

(Assume that the type vector has already been declared).

type vector=array[1..10] of real;

Complete the solution

```
function max_norm(n:integer; x:vector):real;
{local variables declared here}
begin
{body of function}
end; {ends function}
```

Question 2 (8+3+2+4+8)

- a) Define the following terms as used in numerical methods
- (i) relative error
 - (ii) error bound
 - (iii) loss of significance
 - (iv) overflow
- b) Mention the three methods used in finding the solution the equation $f(x)=0$.
- (c) Is convergence guaranteed in these methods?
- (d) Sketch the graphs of the methods in (b).
- (e) State the properties of an inner product.
-

Question 3 (25)

Given that

$$A = \begin{pmatrix} 4 & 7 & 4 \\ 7 & 3 & 10 \\ 4 & 10 & 3 \end{pmatrix} \quad \text{and} \quad A^{-1} = \begin{pmatrix} 91 & 19 & 58 \\ 19 & -4 & -12 \\ 58 & 12 & -37 \end{pmatrix}$$

and that the eigenvalues of A are given below.
What are the approximate or exact values of

- a) $\|A\|_2$, $cond_2(A)$
- c) $\|A\|_\infty$, $cond_\infty(A)$
- b) $\|A\|_1$, $cond_1(A)$
- d) $cond_2(A^t A)$?

$$\lambda_1 \approx 17.5322, \quad \lambda_2 \approx -7.5247, \quad \lambda_3 \approx 7.5801 \cdot 10^{-3}$$

Question 4 (25)

To the linear system $Ax=b$

$$A = \begin{pmatrix} 0.780 & 0.563 \\ 0.913 & 0.659 \end{pmatrix}, \quad b = \begin{pmatrix} 0.217 \\ 0.254 \end{pmatrix}$$

two different approximate solutions are proposed:

$$x_1 \approx \begin{pmatrix} 0.999 \\ -1.001 \end{pmatrix}, \quad x_2 \approx \begin{pmatrix} 0.341 \\ -0.087 \end{pmatrix}$$

- (a) Compute the residual vector corresponding to these two approximate solutions.
(b) Determine the errors in the two proposed solutions.
-

Question 5(25)

Describe briefly the numerical methods used to solve the problem

$$\min \|Ax - b\|_2 \quad x \in \mathbb{R}^n$$

where A is an $m \times n$ matrix, and the vector

$$b \in \mathbb{R}^m$$

are given.

Question 6 (25)

Given the following system of non-linear equations

$$f_1(x_1, x_2) = x_1^2 x_2 - x_2^2 - 1 = 0$$

$$f_2(x_1, x_2) = x_1 x_2^3 + x_2 - 6 = 0$$

with $x^{(k)} = (3, 2)^T$

Set up the Newton equations.

End of Questions

Good Luck!!

M. Phiri
F07

Time: 3 hours Instructions: Answer *Question 1* and any other 3 *Questions*

Question 1 –Compulsory

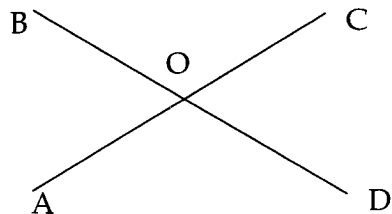
- Draw a cross section of a vehicle going round a curve and show clearly all the forces acting on it. (3)
- Derive a formula for maximum *theoretical* super-elevation(SE). (4)
- Compute the required SE at a point 75m into a transition curve of total length 200m when the circular section of the curve has radius = 500m. Width of the road =7m and design speed= 90kph. (5)
- Given that the through chainage of the intersection point I is 385m, compute and tabulate setting out data for the first three points on the entry transition. Deflection angle of the curve = 44.44 gons. (12)
- Outline *practical* steps involved in setting out a small circular curve from the long chord. Assume the intersection point is accessible. Necessary formulae must be stated. (6)

Answer any three questions from this section

Question 2

- State the properties of the UTM system used in Zambia. (5)
- Two lines AC and BD bisect each other at O. The grid coordinates of A and C are (200.000, 175.000) and (1000.234, 2522.511) respectively. The following measurements were taken with an EDM and theodolite:

Slope Distance A-C = 2500.181
Slope Distance B-D = 3613.200
Angle B-O-C = 57.000°
Heights above msl
A=250m, B= 500m, C= 125, D=450m



Given that the radius of earth is 6361000m.

Compute the grid coordinates of B and D. (18)

Question 3

- State and briefly describe three important instrumental errors found in the EDM. (9)
- For one of the errors given in (a), explain clearly how it can be detected and eliminated (or minimised). Give necessary sketches or formulae (8)
- The accuracy of an EDM is stated as $\pm 10 \text{ mm} \pm 3 \text{ ppm}$. Explain the two terms in this expression and compute the standard error if the same instrument is used to measure a length of 5367.412. (6)

Question 4

- Mention two applications of laser equipment at a construction site stating the advantages of each compared to the usage of traditional surveying equipment. (6)
- State at least 3 precautions that must be taken when using laser equipment. (3)
- A section of sewer is to be laid between two manholes A and B, which are 95m apart. Sight rails have been established based on the staff readings in the table below:

BS	IS	FS	Distance	Remarks
1.480			50	BM X RL 48.290
	0.855		75	Sight rail at A
	2.105		40	Sight rail at B
		1.480	50	BM X

The distance refers to the lengths of sight from the instrument.

If the sewer is to be constructed using a traveller of 3.25m length determine invert levels at the manholes and gradient of sewer as designed. (10)

- If another MH-c is to be constructed 110m away from MH-b with the sewer rising from B at 1 in 107, calculate the staff reading on top of a sight rail which is 1.2m above ground. (4)

Question 5

- a. What are the most important aims of setting out? (4)
- b. During redevelopment in a city area, a block of flats rectangular in plan is to be built with the long elevation orientated due east-west. The building which measures $92.04 \times 25.30\text{m}$ is located initially by means of a peg at the north-east corner (point A, 600m E, 1300m N). The remainder of the building cannot be set out as existing properties have not yet been demolished and it is essential to check the clearance from the proposed new building line. The observations below are therefore made:

Line	Bearing ($^{\circ}$)	Horizontal distance (m)
AP	281.50	80.29
PQ	229.86	47.51

Point Q is located on a proposed building line which is straight with a whole circle bearing of $116^{\circ}26'59''$.

Calculate the minimum distance from the proposed development to the new building line. (19)



The University of Zambia
School of engineering
Department of surveying

1st Semester Supplementary/Deferred Examinations

SE 481: Introduction to Surveying

March 2001

Instructions

Time: Three (3) hours.

Answer four (4) questions in total

Three (3) from section A and One (1) question from section B

PLEASE! Answer different sections on separate answer Booklet(s). DO NOT tie them together.

Section A: Answer any three (3) questions from this section

Question 1 (10+9+6)

- Define Surveying and discuss at least four of the disciplines it is divided into.
- With the aid of diagrams, describe the three types of levelling instruments.
- Show and explain the three main axes of the theodolite.

Question 2 (15+10)

In order to determine the horizontal distance between two points A and B set on the floor of a tunnel, measuring heads were set up over those points. A new 30 m steel tape, standardized on the flat under a pull of 49 N at 20°C, is suspended in catenary between the measuring heads, and a pull of 150 N is applied. The mean tape readings at the measuring heads are observed to be 0.422 m and 29.872 m, and the difference in level between the heads is found to be 0.078 m. Determine the corrected horizontal distance AB.

The mean tape temperature during the observations was 26°C, the cross-sectional area of the tape was 0.406 cm². Mass of the tape was 0.27 g/cm, while the coefficient of linear expansion of steel is given as 1.15 x 10⁻⁵/ °C. The modulus of elasticity of steel is given as 207 000 N/mm²

Question 3 (8+9+8)

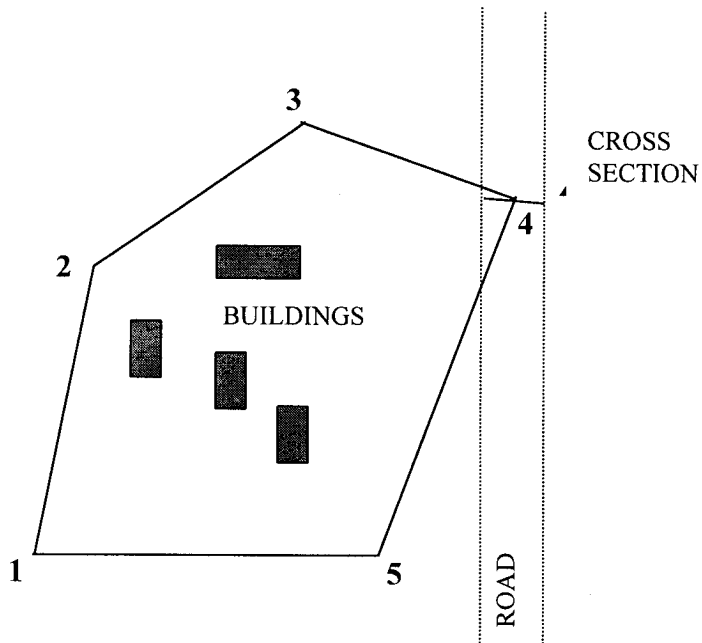
A farm in Makeni was surveyed in 1999. The farm owner has the diagram showing the corners of his property and now he wants the boundaries of his farm retraced following a dispute with his adjoining neighbour. After the re-survey, the coordinates of the corner points have been accurately determined as:

A	2675.65mE	4998.76mN
B	3551.25mE	4585.15mN
C	3182.68mE	4567.83mN
D	2187.94mE	4687.75mN

You are required to Calculate the distances and bearings if lines AB, BC, CD and DA. The reference direction for the bearings is the South. The farmer wants the bearings in both the sexigesimal (degrees, minutes and seconds) and the centesimal systems.

Question 4 (5+5+10+5)

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 centerline 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:
Date:

Instrument:
Weather:

LEVELLING

POINT	READINGS			DISTANCE		HEIGHT DIFF		REDUCED LEVEL	REMARKS
	BS	IS	FS	BS	FS	RISE	FALL		
1	1.576			49.6				1262.813	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

- Complete the booking form.
- Calculate the misclosure in the loop and state whether or not it is acceptable (assuming $\sigma = 20\text{mm}$).
- Give a list of the adjusted RL's of the five pegs.
- Draw the cross-section at peg 4 at an appropriate scale.

Section B: Engineering & Agricultural Science students only.
Answer any question from this section

Question 5 (12+10+3)

- a) You have been asked to advise an organisation on the establishment of a GIS unit. What guidelines would you specify to them?
- b) Describe (very briefly) the activities that would be involved in the unit once it is fully established.
- c) What factors influence the accuracy of GIS datasets?

Question 6 (10+9+6)

- a) Differentiate the two types of data structures used in GIS data acquisition and storage, giving at least two areas of practical usage for each.
- b) Name three basic elements used to represent features in GIS data sets. For each element, give at least three examples of what will be represented from the spatial database of the University of Zambia.
- c) Which component of GIS is considered to be the most costly? Explain what makes this component costly.

END OF DEFERRED EXAM



**SCHOOL OF ENGINEERING
DEPARTMENT OF SURVEYING**

**Second Semester University Examinations
1999/2000 Academic Year**

GEODESY II -SE 542

Instructions

Time: Three hours

Answer all questions

Question 1. (10+3+12)

(a) UZ 104 has the following geodetic coordinates in Clarke 1880 reference ellipsoid:

$$\nu = 15^{\circ} 23' 37.3780'' \text{ S}$$

$$\lambda = 28^{\circ} 19' 57.2427'' \text{ E}$$

$$h = 1268.814 \text{ m}$$

$$\text{with } a = 6378249.145 \text{ m, } 1/f = 293.465$$

The same point was also occupied with one Leica GPS 299/333 receiver set and the single point solution was found as below:

$$\nu = 15^{\circ} 23' 42.04419'' \text{ S}$$

$$\lambda = 28^{\circ} 19' 57.41494'' \text{ E}$$

$$h = 1262.8170 \text{ m}$$

$$\text{with WGS 84 parameters as } a = 6378137.0\text{m, } 1/f = 298.465$$

Determine the three datum shift parameters in metres.

(b) what does the term geodetic datum mean?

(c) Using the results of (a), transform the following WGS 84 point to Clarke 1880, expressing the results in geodetic coordinates:

$$\varphi = 15^{\circ} 23' 32.2657''$$

$$\lambda = 28^{\circ} 19' 55.4575''$$

$$h = 1256.678 \text{ m}$$

Question 2 (15 + 6 +4)

- a) Compute the period of revolution, T, the mean motion, n, and the velocity v, of satellite in a circular orbit with height above the earth of 20200km.
Use $GM = 3.986E14 \text{ m}^3/\text{s}^2$ and $R = 6371 \text{ m}$.
- b) If the height above the earth is 600km, what will be the velocity of the satellite?
Discuss the difference in velocity to the result in (a).
- c) List the six Keplerian elements, and describe them

Question 3 (10 + 5)

- (a) Define or explain the following terms:
 - i. Precise ephemeris
 - ii. Broadcast ephemeris
 - iii. Anti-spoofing
 - iv. Double differencing
 - v. Ambiguity resolution
- (b) Contrast the method of satellite surveying to conventional methods

Question 4 (10 +10+5)

- (a) Using a sketch define or explain the following
 - i. Height anomaly
 - ii. Orthometric correction
 - iii. Normal height
 - iv. Geoidal height
 - v. Bouguer anomaly
- (b) In a gravity survey, the following data were obtained at station S49 with latitude $\phi = 19^\circ 12.4''$ and longitude $\lambda = 27^\circ 43.9''$:

Observed gravity, g , = 978167.59mGal

Height, H, = 1234.56m

Using the 1980 gravity formula given below, compute the free-air and Bouguer anomalies

$$\gamma = 978032.68(1 + 0.0053024 \sin^2 \phi - 0.0000058 \sin^2 2\phi) \text{ mGal}$$

- (c) Discuss three uses of gravity anomalies

Question 5 (10)

Answer true or false

- i. Clairaut's equation for the geodesic is $N \cos \phi \sin \lambda = \text{Constant}$

- ii. Helmert's projection means that you project first onto the geoid and then on the ellipsoid
- iii. The best-fitting ellipsoid for a region, σ , is defined as the one where the geoidal height obeys the condition $\iint_{\sigma} N^2 d\sigma = \text{minimum}$
- iv. $b = a(1-e^2)$
- v. Triangulation gives the position with respect to the geoid and not the ellipsoid.



The University of Zambia
School of Engineering
Department of Surveying

Semester I Final Examinations – January 2001

SE 561: Principles of Land/Geographic Information Systems

Instructions

Time: Three (3) hours

Questions 1 – 4 carry equal marks

Answer question five (5) and any other three (3) from the remaining four (4) questions

Question 1 (5+5+5+5)

Explain the following terms with the aid of diagrams if possible:

- a) Overlaying
- b) Recoding
- c) Map dissolve
- d) Reclassification

Question 2 (2+18)

- a) What is meant by 'georeferencing'?
- a) Name and briefly discuss the components of data quality.

Question 3 (8+8+4)

- a) Name the main sources of data used in GIS and give two (2) examples of each.
- b) Why is on-screen digitising gaining popularity over manual digitising?
- c) What are the criteria to consider for choosing the modes of spatial data input?

Question 4 (20)

Given a data set containing the X, Y, Z coordinates of randomly surveyed points in an area, mention the different types of Digital Terrain Models that can be generated and explain, with figures, how these are generated.

Question 5 (25+15) – Compulsory

- a) Given below (in figure 1) is a portion of a Lusaka cadastral map. Show how this map will be represented in the Arc, Node and Polygon attribute tables

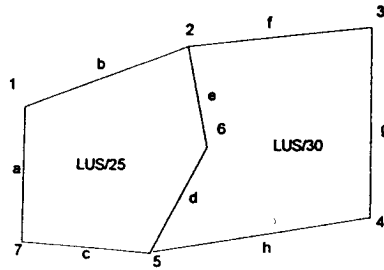


Figure 1

- b) Overlaying can be done on raster or vector spatial data. In the diagram shown in figure 2 there are two layers, each of which consists of a spatial component and a corresponding attribute table:

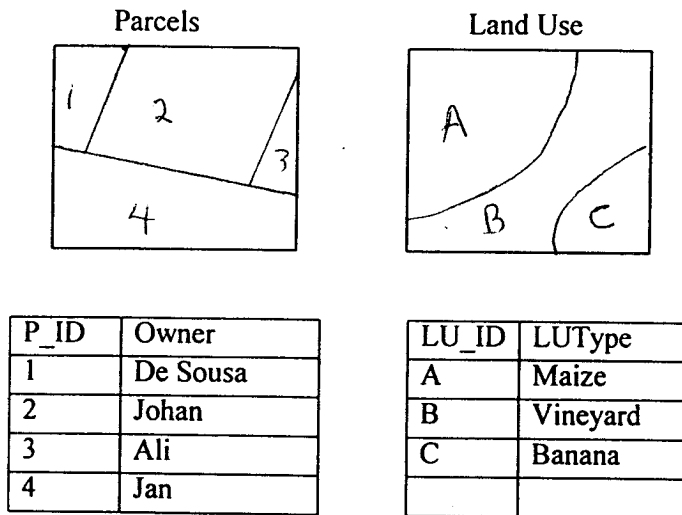


Figure 2

- i). Overlay the two layers and draw the resultant spatial layer
- ii). Tabulate the RESULTANT attribute table (Use the information given in the attribute tables of figure 2, NOT the arc, node and polygon tables as 2 a).)

End of Examinations

Good Luck



The University of Zambia
School of Engineering

Semester II Final Examinations - May 2000

SE 562: Land Resources Planning

Instructions:

Time: Three Hours

All questions carry equal marks

Answer Five (5) question in total. Two (2) questions from Section A and Three (3) questions from Section B.

Answer Section A and Section B on separate answer booklets!

Section A: Answer question One (1) and ONE other question from this section

Question One (10 + 10)

- a) State the main fears to land registration despite all its great advantages. How could these fears be overcome?
- b) Explain (very briefly) the procedures of land registration in the following areas:
 - i). Agricultural lands - Scheduled Farms
 - ii). Agricultural lands - not scheduled
 - iii). Urban land

Question Two (8+6+6)

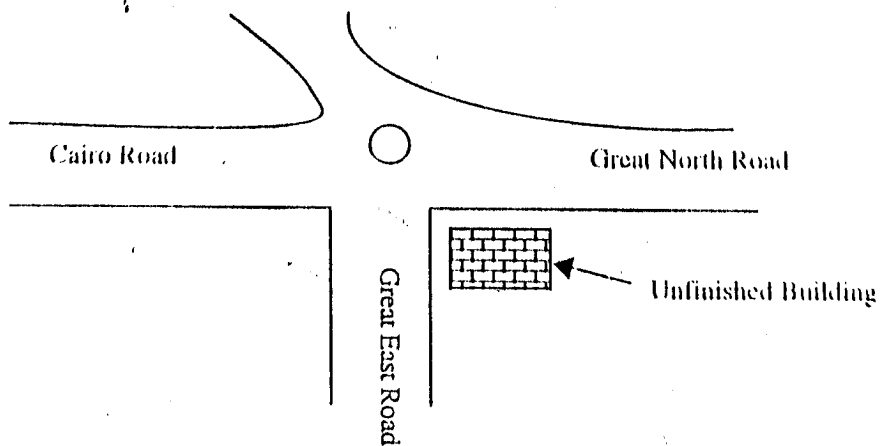
- a) What is the meaning of land use and land use planning?
- b) What factors influence the land use dynamics?
- c) Outline the activities involved in land use planning

Question Three (3+12+5)

a) Define the market value of a property.

b) Which valuation methods (with reasons) would you use to value the following properties:

- i). University of Zambia Sports hall
- ii). The unfinished building at Kabwe roundabout (said to belong to Mr. Kavindele). See map below.
- iii). Chez Ntemba nightclub.



Map for question Three (3) b). (ii).

e) How will the planning control affect the value of properties situated in the same area?

Section B: Answer question four (4) and ANY other two (2) questions from this section

Question Four (6+7+7)

- a) Briefly discuss the difference between a dendritic and an intermeshed market system
- b) Which of the two market systems in (a) compares with the Zambian system of centres? Give reasons
- c) What is the relevance of a carefully planned network of centres within a region and national framework?

Question Five (5+10+5)

- a) What are the criteria for human waste disposal?
- b) Discuss briefly the various technologies and methods available for human waste disposal
- c) Which of the technologies in (b) may be most appropriate for a developing nation like Zambia?

Question Six (5+4+3+8)

- a) What do central place theories study and what assumptions underlie all central place theories
- b) Explain the meaning of "range of goods" and "threshold value"?
- c) Besides the two factors in (b), what other factors affect the determination of central places and their surroundings?
- d) Why do hierarchies of centers distinguished in the real world fail to display regular patterns as described in models like Christaller's?

Question Seven (5+4+4+4+3)

Bottom up and top down planning seeks to mobilize the experience, resilience and local knowledge of the land users and local technical staff to identify development priorities, draw up plans and implement them.

- a) give the advantages of this approach
- b) give the disadvantages of this approach
- c) give two ways in which you can assess environmental impact
- d) differentiate land characteristics from land qualities
- e) differentiate current suitability from potential suitability

End of Examination

Good luck and enjoy your vacation

University of Zambia
School of Engineering
Dept of Surveying
SE571-Engineering Surveying
University Examinations October 1999

Duration 3 hours:

Answer Question 1 and any other 3 questions

Section A (Compulsory Question)

Question 1 (10 +15)

- (a) Explain the term *convergence of meridians*. Show how this factor has to be taken into account when running long survey lines by gyrotheodolite.
- (b) It was required to determine a grid bearing of XY using a gyrotheodolite. The gyro azimuth of a line was found to be $84^{\circ}59'$. In an earlier experiment the same gyro was set up at point A on the surface and it gave the circle reading of the true north as $56^{\circ}17'$ and that of AB as $92^{\circ}00'$. The line AB has always been known to have the grid bearing of $37^{\circ}15'$.
Compute the grid bearing XY.

Given that:

Diameter of earth = 12720km,
Easting of A = 470 km,
Easting of X = 300km,
Easting of central meridian = 500km
Mean latitudes of line AB $38^{\circ}00'00''$ south
And XY $18^{\circ}50'00''$ North
Ignore (t-T) correction.
Assume gyro-constant (E) is same all over the earth

Section B Answer any 3 Questions

Question 2 (12+13)

- a. What is Engineering surveying and what issues does a surveying engineer attend to at each of the following stages:
- i. Design
 - ii. Construction
 - iii. After construction
- of a structure such as a dam and why?
- b. Outline major steps in the process of triangulation stating necessary consideration for each step

Question 3 (10+15)

- (a) Briefly discuss the use of simultaneous reciprocal trigonometric levelling. Stating why this operation may be necessary.
- (b) Two points A and B are 8km apart and at levels of 102.50 and 286.50 AD respectively. The height of the target at A is 1.50m and at B 3.00m while the height of instrument in both cases is 1.50m. If 31m on the earth subtends 1" of arc at the center of the earth and the effect of refraction is one seventh of that of curvature, what are the observed angles from A to B and from B to A?

Question 4(6+19)

- a. Give reasons why the estimation of areas and volumes may be important in engineering projects.
- b. A tank whose horizontal base ABCD is 40m long by 20m wide, is to be constructed in ground having a slope of 1 in 10' in the direction of larger dimensions BA and CD. The depths of excavation at A and D are to be 10 m, the side slope being 1 vertical to 1 horizontal. Calculate the volume of excavation required.

Question 5 (25)

The data on the next page was collected along the centre line of the proposed road. The reduced level of formation at regular intervals are given. Construct the mass haul diagram for this section of the road. Comment on the results.

Additional information:

The existing ground has no cross fall

Side slopes are 1 in 2

The proposed road will be 10m wide

You may use the table provided

