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

1. CE 219	-	Static's and Introduction to Strength of Materials
2. CE 365	-	Soil Science Roads and Hydrology
3. CE 425	-	soil Mechanics and Foundation Engineering
4. CE 581	-	Construction Techniques and Management
5. EE 209	-	Principles of Electricity
6. EE 311	-	Electrical and Electronic Engineering
7. EE 321	-	Electromechanics and Electrical Mechanics
8. EE 431 & EE 441	-	Electronics and Electronic Engineering
9. EE 471	-	Telecommunications
10. EE 581	-	Telecommunication Theory
11. EG 212	-	Workshop Technology
12. EM 311	-	Engineering Mathematics III
13. GE 371	-	Surveying I
14. GE 481	-	Introduction to Survey
15. GE 561	-	Principles of GIS/LIS
16. ME 209	-	Engineering Drawing I
17. ME 209	-	Electrical Component
18. ME 331	-	Properties of Engineering Materials
19. ME 375	-	Dynamics
20. ME 415	-	Production Technology I
21. ME 545	-	Alternative Energy Sources

THE UNIVERSITY OF ZAMBIA.

UNIVERSITY SECOND SEMESTER EXAMINATION – AUGUST 2003.

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. For the force system shown in the figure:
   (a) Find the moment produced by the force of 70kN about the origin O.
   (b) Find the moment produced by the force of 70kN about the point P.
   (c) Find the moment produced by the force of 70kN about the axis OP.

2. The threaded shaft shown has a ball and socket support at B. The 1800N load can be raised or lowered by rotating the threaded shaft, causing the threaded collar at C to move relative to the shaft. Neglect the weights of all members. The pitch of the single threaded shaft is 6mm, the mean radius of the thread is 25mm, and the coefficient of friction between the thread and the mating groove in the collar is 0.24. If the system is stationary in the position shown, what couple is necessary to start the shaft rotating to raise the load?

(Hint: Determine the component of reaction at C along the axis of the screw first. The shaft is a two-force member, and the direction of the force is known).

3. The vertical member is rigid and it is connected to two links as shown. The links both have the modulus of 200 GPa. The cross sectional areas and lengths of the links are shown in the figure. Determine the maximum allowable force F_{allow} if the maximum allowable stress (tensile or compressive) in either link is 50 MPa. Neglect forces due to gravity.

4. A Baltimore truss with a total span of 32m is supported by a pin at A and a roller at I. The roadway is transimitting downward forces of 4kN, 6kN, and 4kN to lower joints C, D, and E respectively. Assume that the lower joints A through I are equally spaced at 4m intervals.

   (a) Identify all members with member force of 0kN (Zero-force members), and eliminate them from the truss.
   (b) Find the force in LK
   (c) Find the force in OE

Section – B.

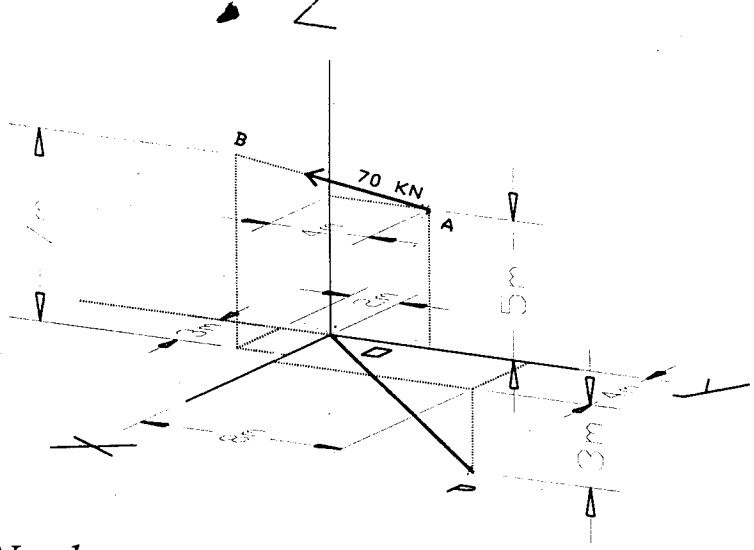
5. Determine the I_x , Iy, and Ixy of the composite area about the centroidal axes indicated as X and Y.

6. Draw the Mohr Circle of stress for the state of stress at a point shown in the figure. Use trigonometrical calculations on the Mohr Circle to accomplish the following:

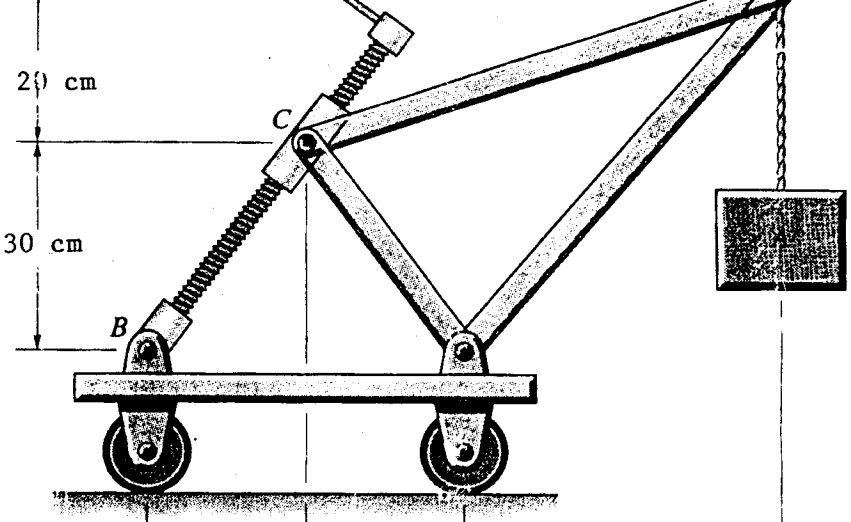
   (a) Determine and show on a sketch the magnitude and orientation of the principle stresses.
   (b) Determine and show the stress components on the plane inclined at 60 deg from the vertical as shown.

7. Draw the Shear Force and the Bending Moment Diagrams for the beam and loading shown.

END OF EXAMINATION



Question No. 1



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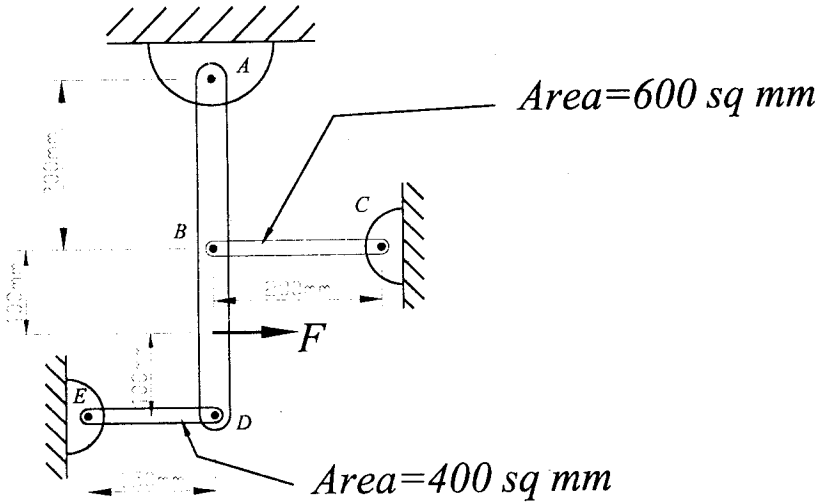

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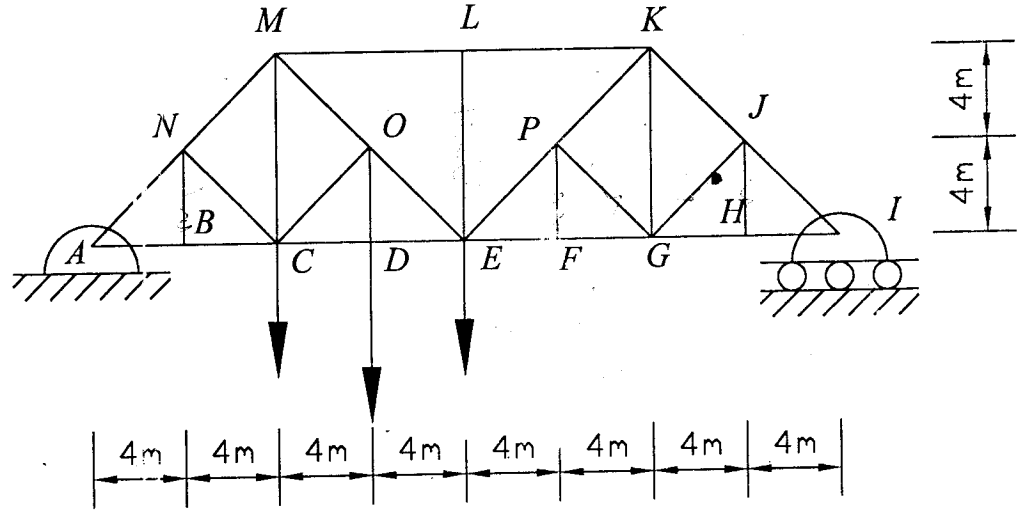

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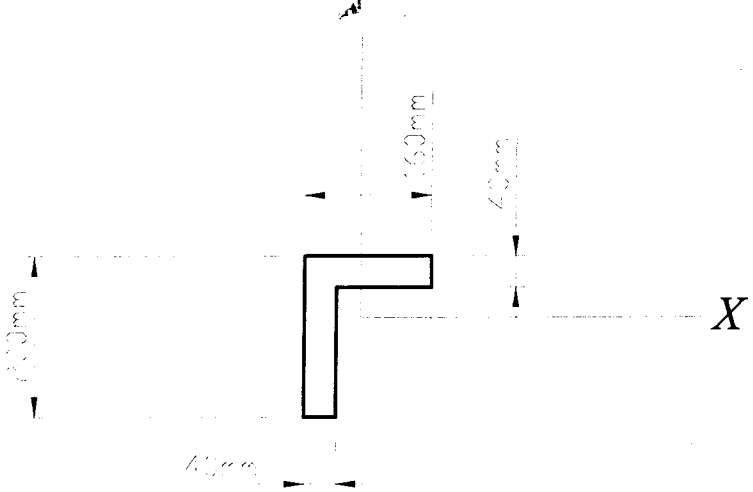
UNIVERSITY OF ZAMBIA EXAMINATIONS -- AUGUST 2003



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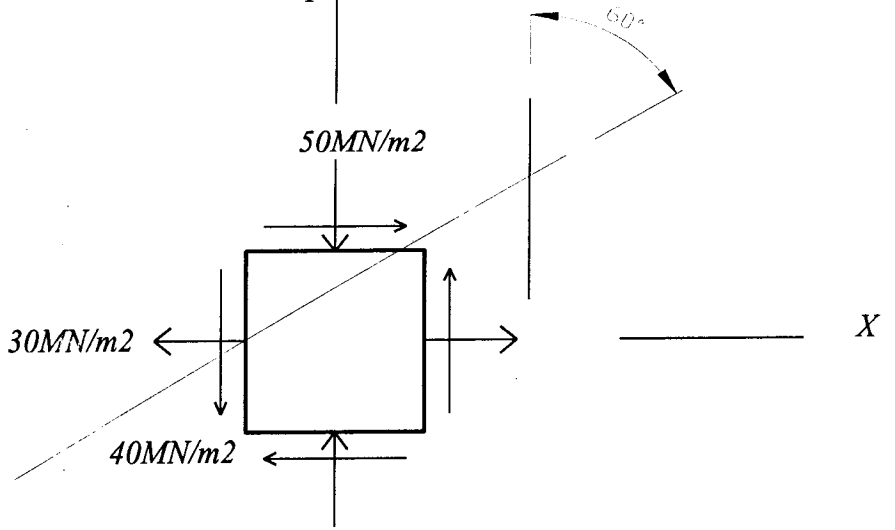
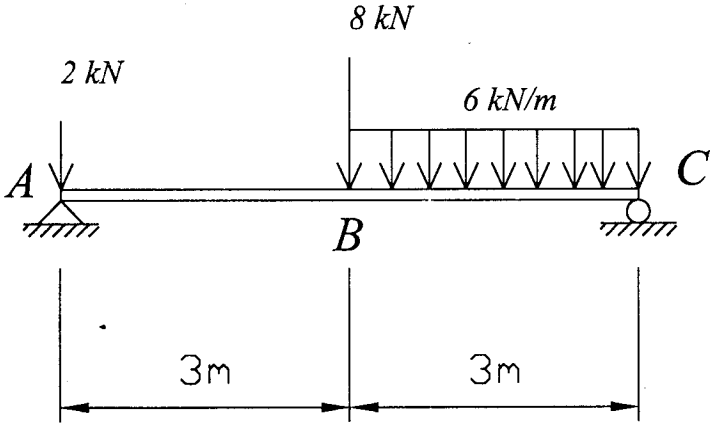


Question No. 6



Question No. 7

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
UNIVERSITY SEMESTER I EXAMINATIONS 2003
(AUGUST 2003)

CE 365 – SOIL SCIENCE, ROADS AND HYDROLOGY

INSTRUCTIONS

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

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

SECTION A: ATTEMPT ANY FOUR QUESTIONS.

Question 1

The natural bulk density of soil from a borrow pit is 1.92g/cm^3, and its moisture content is 9.3 per cent. It has been found that the maximum dry density (MDD) of the soil is 1.86g/cm^3 at an optimum moisture content (OMC) of 13.5 per cent. The specific gravity of the soil particles is 2.65.

a) If the embankment layer is to be compacted to the maximum dry density (MDD), at optimum moisture content (OMC), determine the quantity of water to be added per cubic meter of borrow soil. (10 Marks)

b) Determine the quantity of borrow area needed for one kilometer of road if the embankment has a top width of 12m, side slopes of 2:1 and a height of 2m, and the depth of the borrow pits is to be restricted to 0.6m. (10 Marks)

Question 2

The Table below shows four different types of aggregates that will be used to produce a blended aggregate for use in the manufacture of asphalt concrete.

Material	Percentage by Weight	Bulk Specific Gravity
A	35	2.58
B	40	2.65
C	15	2.60
D	10	2.55

a) Determine the bulk specific gravity of the aggregate mix. (5 Marks)

b) Explain why a small percentage of void is important in asphalt concrete. (5 Marks)

c) Distinguish between straight-run bitumen, cutback bitumen, and emulsion bitumen. (10 Marks)

Question 3

Explain what you understand by the following traffic engineering parameters, indicating their use and how they are measured in the field

a) Annual Average Daily Traffic (AADT). (10 Marks)

b) Average Daily Traffic (ADT). (10 Marks)

Question 4

A two-lane two-way road is at present carrying a traffic of 1000 commercial vehicles per day (cv/day). It is to be strengthened for the growing traffic needs. The vehicle damage factor has been found to be 3.0. The rate of growth of traffic is 10 per cent per annum. The period of construction is 5 years. The pavement is to be designed for 15 years after completion.

Calculate the cumulative standard axles to be used in design. (20 Marks)

Question 5

For each of the following listed soil stabilization methods, briefly describe (i) mechanisms (ii) improvements gained in soil mechanical properties, and (iii) state your recommendation on the type of soils suitable under each method:

a) Lime – Soil – Pozzolana stabilization. (10 Marks)

b) Lime – Soil stabilization. (5 Marks)

c) Cement – Soil stabilization. (5 Marks)

SECTION B: ATTEMPT ANY ONE QUESTION

Question 6

The following field notes were taken at a nest of piezometers installed side by side at a single site:

Piezometer	A	B	C
Elevation at surface (m above sea level)	450	450	450
Depth of piezometer (m) or depth to where head is measured	150	100	50
Depth to water (m)	27	47	36

Let **A**,**B**, and **C** refer to the points of measurement of piezometers **a**, **b**, and **c**. Calculate:

a) The hydraulic head at A, B, and C (m). (hint: head = elevation head + pressure head, and you need to select a datum when you calculate the head) (5 Marks)

b) The pressure head at A, B, and C (m). (5 Marks)

c) The elevation head at A, B, and C (m). (5 Marks)

d) The fluid pressure at B (N/m^2). (3 Marks)

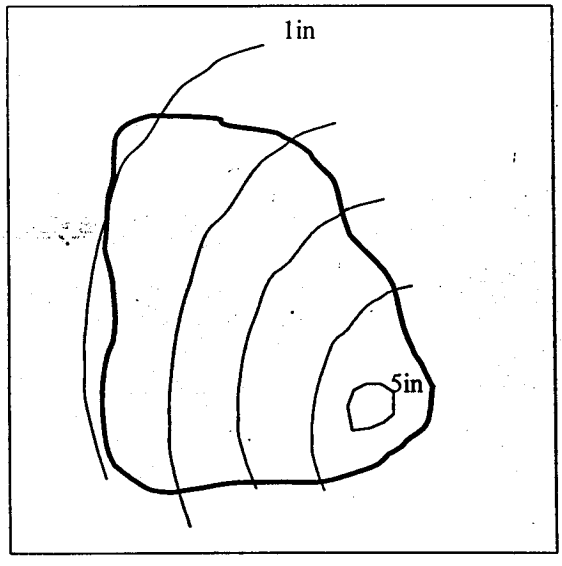
e) The hydraulic gradients between A and B and between B and C. (2 Marks)

Question 7

a) Describe the main features of a stream flow hydrograph. (5 Marks)

b) Give detailed descriptions of the methods one would use to separate base flow and direct runoff. (5 Marks)

c) From the isohyetal map and the table below, compute the average precipitation for the area. (10 Marks)



Isohyet	Area enclosed (mi^2)
5	13
4	90
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Question 8

A constant head permeameter was used to determine the hydraulic conductivity of coarse sand in the laboratory. The results of the test are given in Table 1. The fluid used for testing was water. Figure 1 is a schematic drawing of the laboratory permeameter. The inside diameter of the sample tubing is 4.8cm and the length of the sand sample is 15.2cm. The experiment consisted of ten individual tests each with a different position of the constant head (the head difference between the constant head and the head of the permeameter outlet is given in Table 1). The flow rate for each test was determined by measuring the volume of water collected at the outlet and the corresponding time.

Calculate the Hydraulic Conductivity of the sample. (20 Marks)

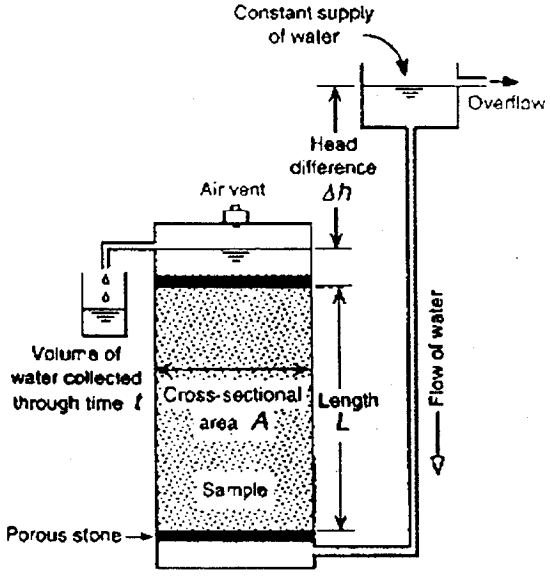

Figure 1 Schematic representation of the constant head permeameter used for testing the sand sample

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Time (sec)	125	92	106	112	46	92	48	34	61	45

END OF EXAMINATION

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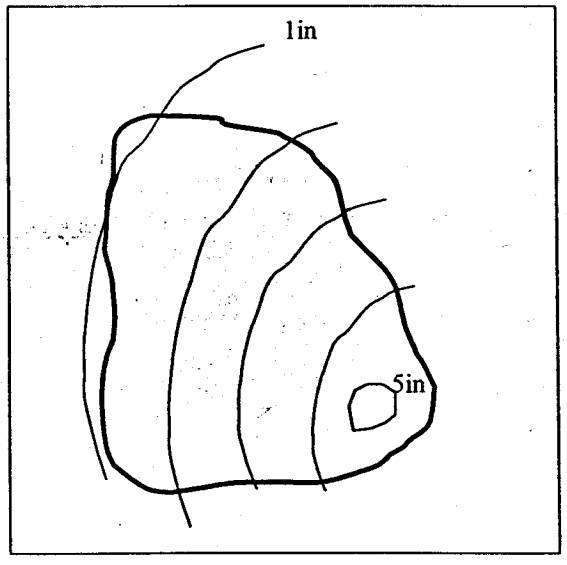

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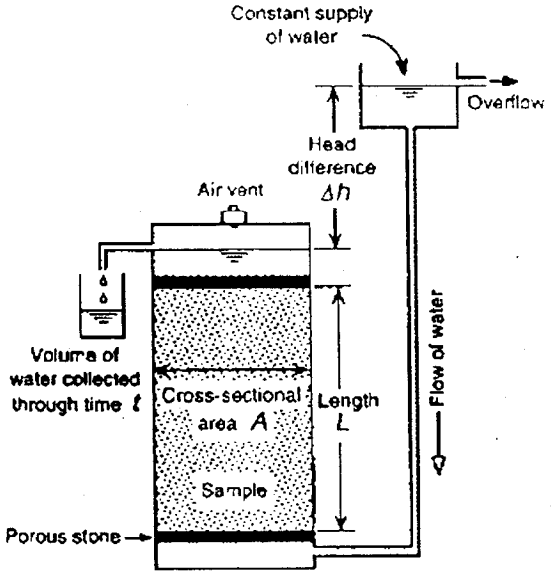

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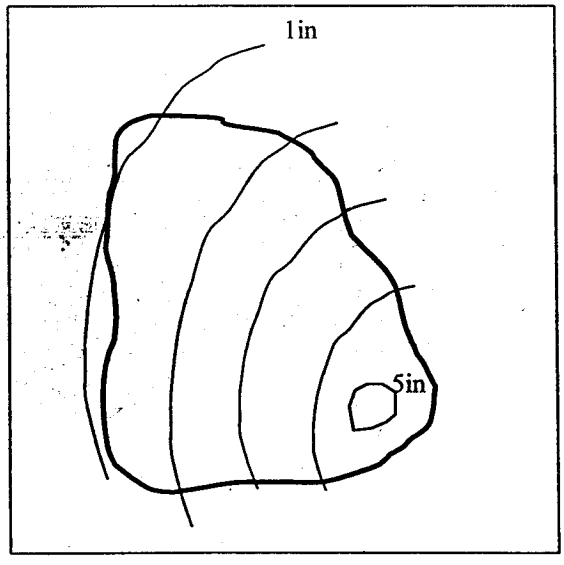

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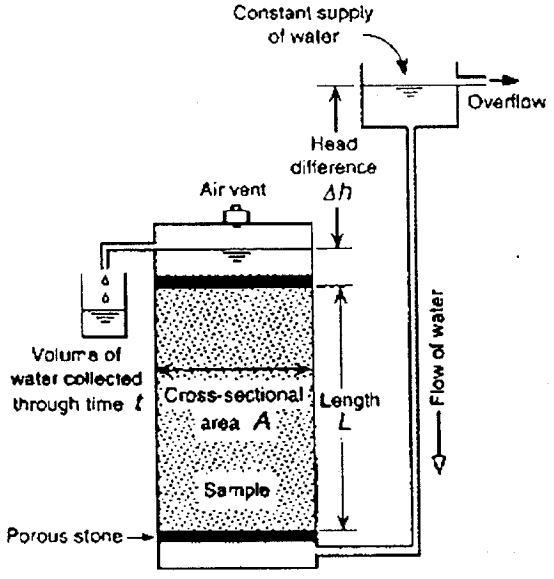

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS

AUGUST, 2003

SOIL MECHANICS AND FOUNDATION ENGINEERING

Time allowed: 3 hours
CLOSED BOOK

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

Instructions: Attempt any **THREE** questions from **SECTION A** and **BOTH** questions from **SECTION B.**

All questions in each section carry equal marks (thus **25%** in **section A** and 12 ½ % in **section B**). Marks for sub-questions are indicated at the end of each sub-section.

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

SECTION A

QUESTION ONE – CONSISTENCY OF SOILS

(a) The following were obtained as results of a shrinkage limit test:-

- initial volume of soil in a saturated state is $24.6\,cm^3$;
- final volume of soil in a dry state is $15.9\,cm^3$;
- initial mass in a saturated state is 44g;
- final mass in a dry state is 30.1g.

Determine the shrinkage limit of the soil.

(10 marks)

(b) With the use of the Cassagrande Apparatus, a liquid and plastic limit determination on a soil gave the following results:-

LIQUID LIMIT TEST

Test No.	Tin mass (g)	Tin + wet soil (g)	Tin + dry soil (g)
1	23.68	40.86	34.68
2	22.93	42.62	35.78
3	26.27	38.02	34.27

PLASTIC LIMIT TEST

Test No.	Tin mass (g)	Tin + wet soil (g)	Tin + dry soil (g)
1	25.34	32.17	31.01
2	24.83	30.48	29.51

(i) Determine the plasticity index of the soil.

(10 marks)

(ii) Which one of the two tests above would have been done by the use of the Cassagrande apparatus?

(5 marks)
(25 marks)

QUESTION TWO – SOIL COMPACTION

The following results were obtained from a compaction test using the 2.5kg rammer:-

Mass of mould + wet soil (g)	2783	3057	3224	3281	3250	3196
Water content (%)	8.1	9.9	12.0	14.3	16.1	18.2

The mass of the compaction mould less its collar and base was 1130g and the soil had a particle specific gravity of 2.7.

(i) Plot the diagram and determine the most appropriate moisture content.

(15 marks)

(ii) Plot on the same diagram, the curves that represent zero air voids, five air voids and ten air voids.

(10 marks)
(25 marks)

QUESTION THREE – EFFECTIVE STRESS

A soil profile was found to consist of three layers in a bore hole; as follows:-

- Dry sand with unit weight of $16.5\,kN/m^3$ and six metres thick, overlies the clay soil with saturated unit weight of $19.25\,kN/m^3$ and thirteen metres thick.
- An impermeable layer underlies the clay soil while the ground phreatic surface is at the boundary of the sand and clay.

(i) Calculate the
(a) total stress,
(b) effective stress,
at points A, B, C and D such that:-

- D is a point at the top surface of the impermeable layer;
- A is a point at the ground surface;
- C is a point on the ground water level, while;

- B is a point situated half way in the sand layer depth.

(10 marks)

(ii) Sketch the soil profile of layers showing all points A, B, C and D.

(10 marks)

(iii) Draw the variations with depth of;-
(a) Total stress;
(b) Pore water pressure
(c) Effective stress.

(5 marks)
(25 marks)

QUESTION FOUR – DRAINED TRIAXIAL TEST

A consolidated drained test was conducted on a normally consolidated clay.

$\sigma_3 = 276\,kN/m^3$

$(\Delta\sigma_d)f - 276\,kN/m^2$

Determine:-

(a) angle of friction;

(10 marks)

(b) angle of inclination that the failure plane makes with the major principal plane; and

(5 marks)

(c) effective normal stress and shear stress on the failure plane.

(10 marks)
(25 marks)

SECTION B

QUESTION FIVE – LATERAL EARTH PRESSURE

Outline the concept of lateral earth pressure. Show how you understand the following:-

- Earth pressure at rest;
- Rankine's theory of active pressure;
- Rankine's theory of passive pressure.

(12 ½ marks)

QUESTION SIX – SLOPE STABILITY ANALYSIS

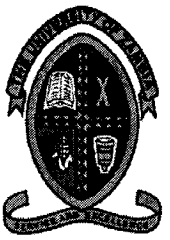
Explain in detail the meaning of slope stability targeting your thinking to factors of safety in:-

- Slopes of soils that possess both cohesive and frictional characteristics;
- Slopes with cohesion, and;
- Slopes without cohesion.

You are required to indicate forces that act on a soil mass.

(12 ½ marks)

END OF EXAMINATION
GOOD LUCK!



THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS

AUGUST, 2003

SOIL MECHANICS AND FOUNDATION ENGINEERING

Time allowed: 3 hours
CLOSED BOOK

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Instructions: Attempt any **THREE** questions from **SECTION A** and **BOTH** questions from **SECTION B.**

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SECTION A

QUESTION ONE – CONSISTENCY OF SOILS

(a) The following were obtained as results of a shrinkage limit test:-

- initial volume of soil in a saturated state is $24.6\,cm^3$;
- final volume of soil in a dry state is $15.9\,cm^3$;
- initial mass in a saturated state is 44g;
- final mass in a dry state is 30.1g.

Determine the shrinkage limit of the soil.

(10 marks)

(b) With the use of the Cassagrande Apparatus, a liquid and plastic limit determination on a soil gave the following results:-

LIQUID LIMIT TEST

Test No.	Tin mass (g)	Tin + wet soil (g)	Tin + dry soil (g)
1	23.68	40.86	34.68
2	22.93	42.62	35.78
3	26.27	38.02	34.27

PLASTIC LIMIT TEST

Test No.	Tin mass (g)	Tin + wet soil (g)	Tin + dry soil (g)
1	25.34	32.17	31.01
2	24.83	30.48	29.51

(i) Determine the plasticity index of the soil.

(10 marks)

(ii) Which one of the two tests above would have been done by the use of the Cassagrande apparatus?

(5 marks)
(25 marks)

QUESTION TWO – SOIL COMPACTION

The following results were obtained from a compaction test using the 2.5kg rammer:-

Mass of mould + wet soil (g)	2783	3057	3224	3281	3250	3196
Water content (%)	8.1	9.9	12.0	14.3	16.1	18.2

The mass of the compaction mould less its collar and base was 1130g and the soil had a particle specific gravity of 2.7.

(i) Plot the diagram and determine the most appropriate moisture content.

(15 marks)

(ii) Plot on the same diagram, the curves that represent zero air voids, five air voids and ten air voids.

(10 marks)
(25 marks)

QUESTION THREE – EFFECTIVE STRESS

A soil profile was found to consist of three layers in a bore hole; as follows:-

- Dry sand with unit weight of $16.5\,kN/m^3$ and six metres thick, overlies the clay soil with saturated unit weight of $19.25\,kN/m^3$ and thirteen metres thick.
- An impermeable layer underlies the clay soil while the ground phreatic surface is at the boundary of the sand and clay.

(i) Calculate the
(a) total stress,
(b) effective stress,
at points A, B, C and D such that:-

- D is a point at the top surface of the impermeable layer;
- A is a point at the ground surface;
- C is a point on the ground water level, while;

- B is a point situated half way in the sand layer depth.

(10 marks)

(ii) Sketch the soil profile of layers showing all points A, B, C and D.

(10 marks)

(iii) Draw the variations with depth of;-
(a) Total stress;
(b) Pore water pressure
(c) Effective stress.

(5 marks)
(25 marks)

QUESTION FOUR – DRAINED TRIAXIAL TEST

A consolidated drained test was conducted on a normally consolidated clay.

$\sigma_3 = 276\,kN/m^3$

$(\Delta\sigma_d)f = 276\,kN/m^3$

Determine:-

(a) angle of friction;

(10 marks)

(b) angle of inclination that the failure plane makes with the major principal plane; and

(5 marks)

(c) effective normal stress and shear stress on the failure plane.

(10 marks)
(25 marks)

SECTION B

QUESTION FIVE – LATERAL EARTH PRESSURE

Outline the concept of lateral earth pressure. Show how you understand the following:-

- Earth pressure at rest;
- Rankine's theory of active pressure;
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(12 ½ marks)

QUESTION SIX – SLOPE STABILITY ANALYSIS

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- Slopes of soils that possess both cohesive and frictional characteristics;
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You are required to indicate forces that act on a soil mass.

(12 ½ marks)

END OF EXAMINATION
GOOD LUCK!

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS

AUGUST, 2003

SOIL MECHANICS AND FOUNDATION ENGINEERING

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CLOSED BOOK

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- initial mass in a saturated state is 44g;
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Determine the shrinkage limit of the soil.

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Test No.	Tin mass (g)	Tin + wet soil (g)	Tin + dry soil (g)
1	23.68	40.86	34.68
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3	26.27	38.02	34.27

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Test No.	Tin mass (g)	Tin + wet soil (g)	Tin + dry soil (g)
1	25.34	32.17	31.01
2	24.83	30.48	29.51

(i) Determine the plasticity index of the soil.

(10 marks)

(ii) Which one of the two tests above would have been done by the use of the Cassagrande apparatus?

(5 marks)
(25 marks)

QUESTION TWO – SOIL COMPACTION

The following results were obtained from a compaction test using the 2.5kg rammer:-

Mass of mould + wet soil (g)	2783	3057	3224	3281	3250	3196
Water content (%)	8.1	9.9	12.0	14.3	16.1	18.2

The mass of the compaction mould less its collar and base was 1130g and the soil had a particle specific gravity of 2.7.

(i) Plot the diagram and determine the most appropriate moisture content.

(15 marks)

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(10 marks)
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A consolidated drained test was conducted on a normally consolidated clay.

$\sigma_3 = 276\,kN/m^3$

$(\Delta\sigma_d)f = 276\,kN/m^3$

Determine:-

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(10 marks)

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END OF EXAMINATION
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THE UNIVERSITY OF ZAMBIA
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(10 marks)

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Determine:-

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(b) angle of inclination that the failure plane makes with the major principal plane; and

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(c) effective normal stress and shear stress on the failure plane.

(10 marks)
(25 marks)

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(12 ½ marks)

END OF EXAMINATION
GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2003

CE 582 – CONSTRUCTION TECHNIQUES AND MANAGEMENT

INSTRUCTIONS

TIME: THREE (3) HOURS

ATTEMPT: **FIVE (5)** QUESTIONS FROM THE GIVEN SEVEN (7)

Q1 The construction plan for a house is shown in Figure Q1. Table Q1 gives the manhours required and the team size for each operation.

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

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

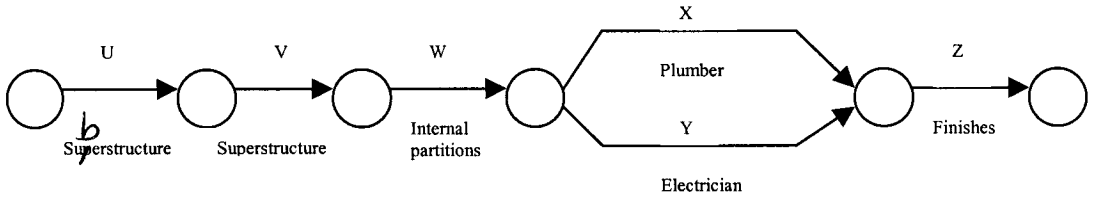

Figure Q1: Construction plan for one house

Table Q1: Manhours and team size

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

(marks: 10 + 5 + 5)

Q2 (a) When choosing a contractor to execute a project, what factors are examined when looking at:
(i) past performance; and
(ii) tender basis?

(b) List five items project costs can be divided into?

(marks: 10 + 10)

Q3 (a) What activities need to be performed by a planner before a construction schedule can be prepared?

(b) Differentiate between a construction operation and a construction stage.

(marks: 10 + 10)

Q4 A contractor has a US$47,700 contract for which the contract budget is shown in Table Q4.1. 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 O/H' are salaries of supervisors. At the end of month 7, a progress check shows the following percentage completions: A, B, C, D, E, F and G all 100%; H, 80%; I, 50%; J, 30%; K, 30%; L, 10%.

The cost allocations at the end of month 7 are shown in Table Q4.2

TableQ4.1

			Cost Headings							
Code	Item	Labour Category	Labour (US$)	Plant (US$)	Materials (US$)	Sub-contractors (US$)	Site O/H (US$)	Head Office O/H (US$)	Profit (US$)	Total value (US$)
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. G to 1st	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 and 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
Totals			$8 600	$5 800	$9 200	$11 000	$4 500	$4 500	$4 100	$47 700

TableQ4.2

Labour categories					Plant	Materials	Subcontractors	Site O/H	Total site costs
1	2	3	4	5					
$4 800	$370	$200	$100	$600	$5 000	$4 200	$3 300	$2 300	$20 870

(a) Draw up a table of variances;

(b) Calculate the percentage variance of the value completed and forecast the profit for the complete project if present trends continue; and

(c) If you were the project manager, what advice would you give the site agent?

(marks: 10 + 5 +5)

TABULATIONS OF INTEREST AND TIME RELATIONSHIPS FOR INTEREST RATES OF 10% AND 15%

Table A.1 Interest factors for 10%

Year or period (n)	$(1+i)^n$ Compound amount of a single sum	$\frac{1}{(1+i)^n}$ Present value of a single sum	$\frac{(1+i)^n-1}{i}$ Compound amount of a uniform series	$\frac{i}{(1+i)^n-1}$ Sinking fund deposit	$\frac{i(1+i)^n-1}{i(1+i)^n}$ Present worth of a uniform series	$\frac{i(1+i)^n}{(1+i)^n-1}$ Capital recovery
1	1·100 0	0·909 09	1·000	1·000 00	0·909 0	1·100 00
2	1·209 9	0·826 44	2·099	0·476 19	1·735 5	0·576 19
3	1·330 9	0·751 31	3·309	0·302 11	2·486 8	0·402 11
4	1·464 0	0·683 01	4·640	0·215 47	3·169 8	0·315 47
5	1·610 5	0·620 92	6·105	0·163 79	3·790 7	0·263 79
6	1·771 5	0·564 47	7·715	0·129 60	4·355 2	0·229 60
7	1·948 7	0·513 15	9·487	0·105 40	4·868 4	0·205 40
8	2·143 5	0·466 50	11·435	0·087 44	5·334 9	0·187 44
9	2·357 9	0·424 09	13·579	0·073 64	5·759 0	0·173 64
10	2·593 7	0·385 54	15·937	0·062 74	6·144 5	0·162 74
11	2·853 1	0·350 49	18·531	0·053 96	6·495 0	0·153 96
12	3·138 4	0·318 63	21·384	0·046 76	6·813 6	0·146 76
13	3·452 2	0·289 66	24·522	0·040 77	7·103 3	0·140 77
14	3·797 4	0·263 33	27·974	0·035 74	7·366 6	0·135 74
15	4·177 2	0·239 39	31·722	0·031 47	7·606 0	0·131 47
16	4·594 9	0·217 62	35·949	0·027 81	7·923 7	0·127 81
17	5·054 4	0·197 84	40·544	0·024 66	8·021 5	0·124 66
18	5·559 9	0·179 85	45·599	0·021 93	8·201 4	0·121 93
19	6·115 9	0·163 50	51·159	0·019 54	8·364 9	0·119 54
20	6·727 4	0·148 64	57·274	0·017 45	8·513 5	0·117 45
21	7·400 2	0·135 13	64·002	0·015 62	8·648 6	0·115 62
22	8·140 2	0·122 84	71·402	0·014 00	8·771 5	0·114 00
23	8·954 3	0·111 67	79·543	0·012 57	8·883 2	0·112 57
24	9·849 7	0·101 52	88·497	0·011 29	8·984 7	0·111 29
25	10·834 7	0·092 29	98·347	0·010 16	9·077 0	0·110 16
26	11·918 1	0·083 90	109·181	0·009 15	9·160 9	0·109 15
27	13·109 9	0·076 27	121·099	0·008 25	9·237 2	0·108 25
28	14·420 9	0·069 34	134·209	0·007 45	9·306 5	0·107 45
29	15·863 0	0·063 03	148·630	0·006 72	9·369 6	0·106 72
30	17·449 4	0·057 30	164·494	0·006 07	9·426 9	0·106 07
35	28·102 4	0·035 58	271·024	0·003 68	9·644 1	0·103 68
40	45·259 2	0·022 09	442·592	0·002 25	9·779 0	0·102 25
45	72·890 4	0·013 71	718·904	0·001 39	9·862 8	0·101 39
50	117·390 8	0·008 51	1 163·908	0·000 85	9·914 8	0·100 85

Table A.2 Interest factors for 15%

Year or period (n)	$(1+i)^n$ Compound amount of a single sum	$\frac{1}{(1+i)^n}$ Present worth of a single sum	$\frac{(1+i)^n-1}{i}$ Compound amount of a uniform series	$\frac{i}{(1+i)^n-1}$ Sinking fund deposit	$\frac{(1+i)^n-1}{i(1+i)^n}$ Present worth of a uniform series	$\frac{i(1+i)^n}{(1+i)^n-1}$ Capital recovery
1	1·150 0	0·869 56	1·000	1·000 00	0·869 5	1·150 00
2	1·322 4	0·756 14	2·149	0·465 11	1·625 7	0·615 11
3	1·520 8	0·657 51	3·472	0·287 97	2·283 2	0·437 97
4	1·749 0	0·571 75	4·993	0·200 26	2·854 9	0·350 26
5	2·011 3	0·497 17	6·742	0·148 31	3·352 1	0·298 31
6	2·313 0	0·432 32	8·753	0·114 23	3·784 4	0·264 23
7	2·660 0	0·375 93	11·066	0·090 36	4·160 4	0·240 36
8	3·059 0	0·326 90	13·725	0·072 85	4·487 3	0·222 85
9	3·517 8	0·284 26	16·785	0·059 57	4·771 5	0·209 57
10	4·045 5	0·247 18	20·303	0·049 25	5·018 7	0·199 25
11	4·652 3	0·214 94	24·349	0·041 06	5·233 7	0·191 06
12	5·350 2	0·186 90	29·001	0·034 48	5·420 6	0·184 48
13	6·152 7	0·162 52	34·351	0·029 11	5·583 1	0·179 11
14	7·075 7	0·141 32	40·504	0·024 68	5·724 4	0·174 68
15	8·137 0	0·122 89	47·580	0·021 01	5·847 3	0·171 01
16	9·357 6	0·106 86	55·717	0·017 94	5·954 2	0·167 94
17	10·761 2	0·092 92	65·075	0·015 36	6·047 1	0·165 36
18	12·375 4	0·080 80	75·836	0·013 18	6·127 9	0·163 18
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40	267·863 5	0·003 73	1 779·090	0·000 56	6·641 7	0·150 56
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Interest on capital	15% p.a.
Fuel consumption	2 litres per hour
Cost of fuel	30 cents per litre
Oil and grease	10% of fuel cost
Repairs to machine	10% of initial price p.a.
Operator	'all in' cost of $1.50 per hour
Insurance and tax	1.5% of initial price p.a.
Average working hours per year	2 000

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ENDS

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2003

CE 581 – CONSTRUCTION TECHNIQUES AND MANAGEMENT

INSTRUCTIONS

TIME: THREE (3) HOURS

ATTEMPT: **FIVE (5)** QUESTIONS FROM THE GIVEN SEVEN (7)

Q1 The construction plan for a house is shown in Figure Q1. Table Q1 gives the manhours required and the team size for each operation.

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

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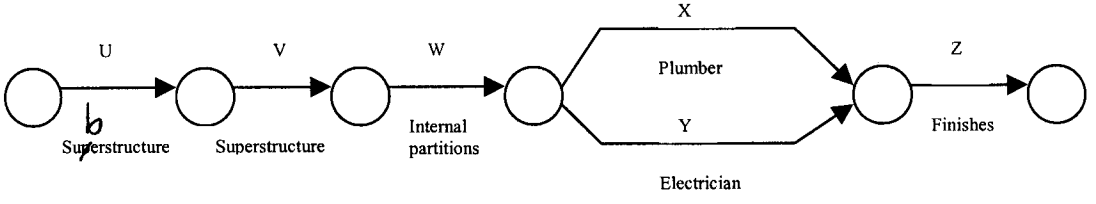

Figure Q1: Construction plan for one house

Table Q1: Manhours and team size

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Manhours per house	120	290	250	40	30	220
Men per team	3	6	4	3	2	5

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- different labour categories
- Plant
- materials
- Site overheads
- Head office overheads

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

The cost allocations at the end of month 7 are shown in Table Q4.2

TableQ4.1

			Cost Headings							
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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. G to 1st	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 and cladding	4	200	600	1 000	1 000	400	400	400	4 000
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Totals			$8 600	$5 800	$9 200	$11 000	$4 500	$4 500	$4 100	$47 700

TableQ4.2

Labour categories					Plant	Materials	Subcontractors	Site O/H	Total site costs
1	2	3	4	5					
$4 800	$370	$200	$100	$600	$5 000	$4 200	$3 300	$2 300	$20 870

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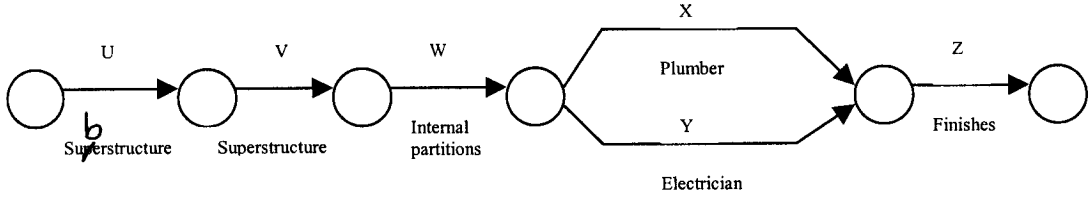

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C	Conc. Founds	1	600	400	600	-	200	200	500	2 500
D	G. F. slabs	1	1 000	600	600	-	300	300	400	3 200
E	Cols. G to 1st	1	400	400	400	-	200	200	300	1 900
F	1st Slab	1	1 200	800	800	-	300	300	400	3 800
G	Cols. 1st to roof	1	500	600	400	-	300	300	300	2 400
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 and 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
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Labour categories					Plant	Materials	Subcontractors	Site O/H	Total site costs
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TABULATIONS OF INTEREST AND TIME RELATIONSHIPS FOR INTEREST RATES OF 10% AND 15%

Table A.1 Interest factors for 10%

Year or period (n)	$(1+i)^n$ Compound amount of a single sum	$\frac{1}{(1+i)^n}$ Present value of a single sum	$\frac{(1+i)^n-1}{i}$ Compound amount of a uniform series	$\frac{i}{(1+i)^n-1}$ Sinking fund deposit	$\frac{i(1+i)^n-1}{i(1+i)^n}$ Present worth of a uniform series	$\frac{i(1+i)^n}{(1+i)^n-1}$ Capital recovery
1	1·100 0	0·909 09	1·000	1·000 00	0·909 0	1·100 00
2	1·209 9	0·826 44	2·099	0·476 19	1·735 5	0·576 19
3	1·330 9	0·751 31	3·309	0·302 11	2·486 8	0·402 11
4	1·464 0	0·683 01	4·640	0·215 47	3·169 8	0·315 47
5	1·610 5	0·620 92	6·105	0·163 79	3·790 7	0·263 79
6	1·771 5	0·564 47	7·715	0·129 60	4·355 2	0·229 60
7	1·948 7	0·513 15	9·487	0·105 40	4·868 4	0·205 40
8	2·143 5	0·466 50	11·435	0·087 44	5·334 9	0·187 44
9	2·357 9	0·424 09	13·579	0·073 64	5·759 0	0·173 64
10	2·593 7	0·385 54	15·937	0·062 74	6·144 5	0·162 74
11	2·853 1	0·350 49	18·531	0·053 96	6·495 0	0·153 96
12	3·138 4	0·318 63	21·384	0·046 76	6·813 6	0·146 76
13	3·452 2	0·289 66	24·522	0·040 77	7·103 3	0·140 77
14	3·797 4	0·263 33	27 974	0·035 74	7·366 6	0·135 74
15	4·177 2	0·239 39	31·722	0·031 47	7·606 0	0·131 47
16	4·594 9	0·217 62	35·949	0·027 81	7·923 7	0·127 81
17	5·054 4	0·197 84	40·544	0·024 66	8·021 5	0·124 66
18	5·559 9	0·179 85	45·599	0·021 93	8·201 4	0·121 93
19	6·115 9	0·163 50	51·159	0·019 54	8·364 9	0·119 54
20	6·727 4	0·148 64	57·274	0·017 45	8·513 5	0·117 45
21	7·400 2	0·135 13	64·002	0·015 62	8·648 6	0·115 62
22	8·140 2	0·122 84	71·402	0·014 00	8·771 5	0·114 00
23	8·954 3	0·111 67	79·543	0·012 57	8·883 2	0·112 57
24	9·849 7	0·101 52	88·497	0·011 29	8·984 7	0·111 29
25	10·834 7	0·092 29	98·347	0·010 16	9·077 0	0·110 16
26	11·918 1	0·083 90	109·181	0·009 15	9·160 9	0·109 15
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30	17·449 4	0·057 30	164·494	0·006 07	9·426 9	0·106 07
35	28·102 4	0·035 58	271·024	0·003 68	9·644 1	0·103 68
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45	72·890 4	0·013 71	718·904	0·001 39	9·862 8	0·101 39
50	117·390 8	0·008 51	1 163·908	0·000 85	9·914 8	0·100 85

Table A.2 Interest factors for 15%

Year or period (n)	$(1+i)^n$ Compound amount of a single sum	$\frac{1}{(1+i)^n}$ Present worth of a single sum	$\frac{(1+i)^n-1}{i}$ Compound amount of a uniform series	$\frac{i}{(1+i)^n-1}$ Sinking fund deposit	$\frac{(1+i)^n-1}{i(1+i)^n}$ Present worth of a uniform series	$\frac{i(1+i)^n}{(1+i)^n-1}$ Capital recovery
1	1·150 0	0·869 56	1·000	1·000 00	0·869 5	1·150 00
2	1·322 4	0·756 14	2·149	0·465 11	1·625 7	0·615 11
3	1·520 8	0·657 51	3·472	0·287 97	2·283 2	0·437 97
4	1·749 0	0·571 75	4·993	0·200 26	2·854 9	0·350 26
5	2·011 3	0·497 17	6·742	0·148 31	3·352 1	0·298 31
6	2·313 0	0·432 32	8·753	0·114 23	3·784 4	0·264 23
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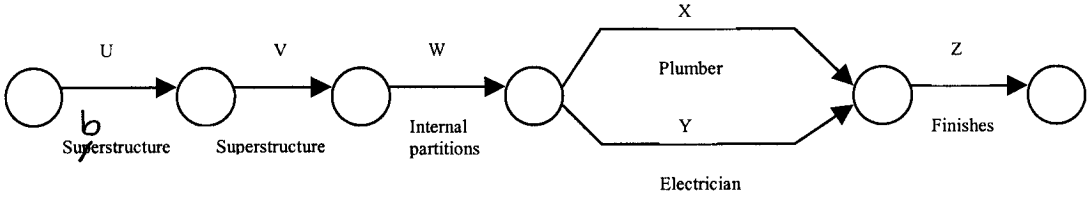

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2	1·209 9	0·826 44	2·099	0·476 19	1·735 5	0·576 19
3	1·330 9	0·751 31	3·309	0·302 11	2·486 8	0·402 11
4	1·464 0	0·683 01	4·640	0·215 47	3·169 8	0·315 47
5	1·610 5	0·620 92	6·105	0·163 79	3·790 7	0·263 79
6	1·771 5	0·564 47	7·715	0·129 60	4·355 2	0·229 60
7	1·948 7	0·513 15	9·487	0·105 40	4·868 4	0·205 40
8	2·143 5	0·466 50	11·435	0·087 44	5·334 9	0·187 44
9	2·357 9	0·424 09	13·579	0·073 64	5·759 0	0·173 64
10	2·593 7	0·385 54	15·937	0·062 74	6·144 5	0·162 74
11	2·853 1	0·350 49	18·531	0·053 96	6·495 0	0·153 96
12	3·138 4	0·318 63	21·384	0·046 76	6·813 6	0·146 76
13	3·452 2	0·289 66	24·522	0·040 77	7·103 3	0·140 77
14	3·797 4	0·263 33	27 974	0·035 74	7·366 6	0·135 74
15	4·177 2	0·239 39	31·722	0·031 47	7·606 0	0·131 47
16	4·594 9	0·217 62	35·949	0·027 81	7·923 7	0·127 81
17	5·054 4	0·197 84	40·544	0·024 66	8·021 5	0·124 66
18	5·559 9	0·179 85	45·599	0·021 93	8·201 4	0·121 93
19	6·115 9	0·163 50	51·159	0·019 54	8·364 9	0·119 54
20	6·727 4	0·148 64	57·274	0·017 45	8·513 5	0·117 45
21	7·400 2	0·135 13	64·002	0·015 62	8·648 6	0·115 62
22	8·140 2	0·122 84	71·402	0·014 00	8·771 5	0·114 00
23	8·954 3	0·111 67	79·543	0·012 57	8·883 2	0·112 57
24	9·849 7	0·101 52	88·497	0·011 29	8·984 7	0·111 29
25	10·834 7	0·092 29	98·347	0·010 16	9·077 0	0·110 16
26	11·918 1	0·083 90	109·181	0·009 15	9·160 9	0·109 15
27	13·109 9	0·076 27	121·099	0·008 25	9·237 2	0·108 25
28	14·420 9	0·069 34	134·209	0·007 45	9·306 5	0·107 45
29	15·863 0	0·063 03	148·630	0·006 72	9·369 6	0·106 72
30	17·449 4	0·057 30	164·494	0·006 07	9·426 9	0·106 07
35	28·102 4	0·035 58	271·024	0·003 68	9·644 1	0·103 68
40	45·259 2	0·022 09	442·592	0·002 25	9·779 0	0·102 25
45	72·890 4	0·013 71	718·904	0·001 39	9·862 8	0·101 39
50	117·390 8	0·008 51	1 163·908	0·000 85	9·914 8	0·100 85

Table A.2 Interest factors for 15%

Year or period (n)	$(1+i)^n$ Compound amount of a single sum	$\frac{1}{(1+i)^n}$ Present worth of a single sum	$\frac{(1+i)^n-1}{i}$ Compound amount of a uniform series	$\frac{i}{(1+i)^n-1}$ Sinking fund deposit	$\frac{(1+i)^n-1}{i(1+i)^n}$ Present worth of a uniform series	$\frac{i(1+i)^n}{(1+i)^n-1}$ Capital recovery
1	1·150 0	0·869 56	1·000	1·000 00	0·869 5	1·150 00
2	1·322 4	0·756 14	2·149	0·465 11	1·625 7	0·615 11
3	1·520 8	0·657 51	3·472	0·287 97	2·283 2	0·437 97
4	1·749 0	0·571 75	4·993	0·200 26	2·854 9	0·350 26
5	2·011 3	0·497 17	6·742	0·148 31	3·352 1	0·298 31
6	2·313 0	0·432 32	8·753	0·114 23	3·784 4	0·264 23
7	2·660 0	0·375 93	11·066	0·090 36	4·160 4	0·240 36
8	3·059 0	0·326 90	13·725	0·072 85	4·487 3	0·222 85
9	3·517 8	0·284 26	16·785	0·059 57	4·771 5	0·209 57
10	4·045 5	0·247 18	20·303	0·049 25	5·018 7	0·199 25
11	4·652 3	0·214 94	24·349	0·041 06	5·233 7	0·191 06
12	5·350 2	0·186 90	29·001	0·034 48	5·420 6	0·184 48
13	6·152 7	0·162 52	34·351	0·029 11	5·583 1	0·179 11
14	7·075 7	0·141 32	40·504	0·024 68	5·724 4	0·174 68
15	8·137 0	0·122 89	47·580	0·021 01	5·847 3	0·171 01
16	9·357 6	0·106 86	55·717	0·017 94	5·954 2	0·167 94
17	10·761 2	0·092 92	65·075	0·015 36	6·047 1	0·165 36
18	12·375 4	0·080 80	75·836	0·013 ▮8	6·127 9	0·163 18
19	14·231 7	0·070 26	88·211	0·011 33	6·198 2	0·161 33
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21	18·821 5	0·053 13	118·810	0·008 41	6·312 4	0·158 41
22	21·644 7	0·046 20	137·631	0·007 26	6·358 6	0·157 26
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26	37·856 7	0·026 41	245·711	0·004 06	6·490 5	0·154 06
27	43·535 3	0·022 96	283·568	0·003 52	6·513 5	0·153 52
28	50·065 6	0·019 97	327·104	0·003 05	6·533 5	0·153 05
29	57·575 4	0·017 36	377·169	0·002 65	6·550 8	0·152 65
30	66·211 7	0·015 10	434·745	0·002 30	6·565 9	0·152 30
35	133·175 5	0·007 50	881·170	0·001 13	6·616 6	0·151 13
40	267·863 5	0·003 73	1 779·090	0·000 56	6·641 7	0·150 56
45	538·769 2	0·001 85	3 585·128	0·000 27	6·654 2	0·150 27
50	1 083·657 3	0·000 92	7 217·715	0·000 13	6·660 5	0·150 13

Q5 (a) Identify and explain the different types of specifications.

(b) Give the names and explain the documents that make a complete construction contract.

(c) What are the advantages for using Standard General Conditions of Contract.

(marks: 8 + 8 + 4)

Q6 (a) Explain what direct and indirect losses are in the context of a construction Accident and itemise the various sources indirect losses that may result from such an accident.

(b) What purpose does insurance serve a contractor. State and explain the various types insurance a construction contractor may use.

(marks: 10 + 10)

7 Determine the direct cost per hour of owning and operating a $^3/_4$ m^3 capacity hydraulic backhoe excavator given the following data:

Initial cost	$15 000
Resale value	Negligible
Useful life	10 years
Interest on capital	15% p.a.
Fuel consumption	2 litres per hour
Cost of fuel	30 cents per litre
Oil and grease	10% of fuel cost
Repairs to machine	10% of initial price p.a.
Operator	'all in' cost of $1.50 per hour
Insurance and tax	1.5% of initial price p.a.
Average working hours per year	2 000

(marks:20)

ENDS

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2003

CE 582 – CONSTRUCTION TECHNIQUES AND MANAGEMENT

INSTRUCTIONS

TIME: THREE (3) HOURS

ATTEMPT: **FIVE (5)** QUESTIONS FROM THE GIVEN SEVEN (7)

Q1 The construction plan for a house is shown in Figure Q1. Table Q1 gives the manhours required and the team size for each operation.

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

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

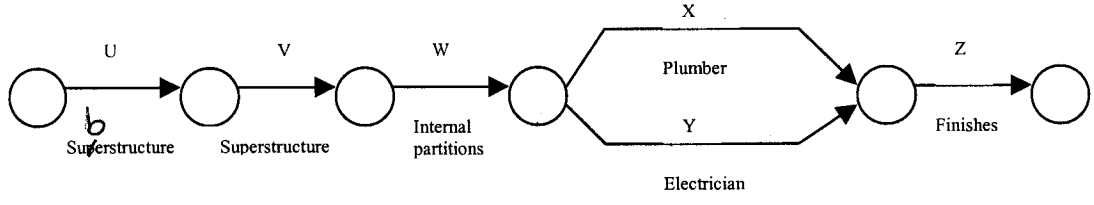

Figure Q1: Construction plan for one house

Table Q1: Manhours and team size

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

(marks: 10 + 5 + 5)

Q2 (a) When choosing a contractor to execute a project, what factors are examined when looking at:
(i) past performance; and
(ii) tender basis?

(b) List five items project costs can be divided into?

(marks: 10 + 10)

Q3 (a) What activities need to be performed by a planner before a construction schedule can be prepared?

(b) Differentiate between a construction operation and a construction stage.

(marks: 10 + 10)

Q4 A contractor has a US$47,700 contract for which the contract budget is shown in Table Q4.1. 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 O/H' are salaries of supervisors. At the end of month 7, a progress check shows the following percentage completions: A, B, C, D, E, F and G all 100%; H, 80%; I, 50%; J, 30%; K, 30%; L, 10%.

The cost allocations at the end of month 7 are shown in Table Q4.2

TableQ4.1

			Cost Headings							
Code	Item	Labour Category	Labour (US$)	Plant (US$)	Materials (US$)	Sub-contractors (US$)	Site O/H (US$)	Head Office O/H (US$)	Profit (US$)	Total value (US$)
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. G to 1st	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 and 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
Totals			$8 600	$5 800	$9 200	$11 000	$4 500	$4 500	$4 100	$47 700

TableQ4.2

Labour categories					Plant	Materials	Subcontractors	Site O/H	Total site costs
1	2	3	4	5					
$4 800	$370	$200	$100	$600	$5 000	$4 200	$3 300	$2 300	$20 870

(a) Draw up a table of variances;

(b) Calculate the percentage variance of the value completed and forecast the profit for the complete project if present trends continue; and

(c) If you were the project manager, what advice would you give the site agent?

(marks: 10 + 5 +5)

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Insurance and tax	1.5% of initial price p.a.
Average working hours per year	2 000

(marks:20)

ENDS

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2003

CE 581 – CONSTRUCTION TECHNIQUES AND MANAGEMENT

INSTRUCTIONS

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ATTEMPT: **FIVE (5)** QUESTIONS FROM THE GIVEN SEVEN (7)

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

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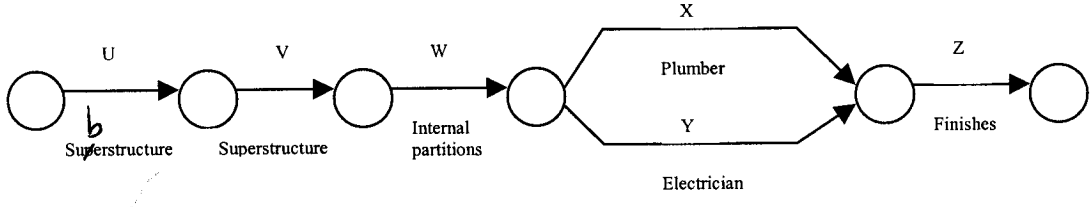

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B	Excavate	1	600	1 000	-	-	400	400	500	2 900
C	Conc. Founds	1	600	400	600	-	200	200	500	2 500
D	G. F. slabs	1	1 000	600	600	-	300	300	400	3 200
E	Cols. G to 1st	1	400	400	400	-	200	200	300	1 900
F	1st Slab	1	1 200	800	800	-	300	300	400	3 800
G	Cols. 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 and 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
Totals			$8 600	$5 800	$9 200	$11 000	$4 500	$4 500	$4 100	$47 700

TableQ4.2

Labour categories					Plant	Materials	Subcontractors	Site O/H	Total site costs
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$4 800	$370	$200	$100	$600	$5 000	$4 200	$3 300	$2 300	$20 870

(a) Draw up a table of variances;

(b) Calculate the percentage variance of the value completed and forecast the profit for the complete project if present trends continue; and

(c) If you were the project manager, what advice would you give the site agent?

(marks: 10 + 5 +5)

TABULATIONS OF INTEREST AND TIME RELATIONSHIPS FOR INTEREST RATES OF 10% AND 15%

Table A.1 Interest factors for 10%

Year or period (n)	$(1+i)^n$ Compound amount of a single sum	$\frac{1}{(1+i)^n}$ Present value of a single sum	$\frac{(1+i)^n-1}{i}$ Compound amount of a uniform series	$\frac{i}{(1+i)^n-1}$ Sinking fund deposit	$\frac{i(1+i)^n-1}{i(1+i)^n}$ Present worth of a uniform series	$\frac{i(1+i)^n}{(1+i)^n-1}$ Capital recovery
1	1·100 0	0·909 09	1·000	1·000 00	0·909 0	1·100 00
2	1·209 9	0·826 44	2·099	0·476 19	1·735 5	0·576 19
3	1·330 9	0·751 31	3·309	0·302 11	2·486 8	0·402 11
4	1·464 0	0·683 01	4·640	0·215 47	3·169 8	0·315 47
5	1·610 5	0·620 92	6·105	0·163 79	3·790 7	0·263 79
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9	2·357 9	0·424 09	13·579	0·073 64	5·759 0	0·173 64
10	2·593 7	0·385 54	15·937	0·062 74	6·144 5	0·162 74
11	2·853 1	0·350 49	18·531	0·053 96	6·495 0	0·153 96
12	3·138 4	0·318 63	21·384	0·046 76	6·813 6	0·146 76
13	3·452 2	0·289 66	24·522	0·040 77	7·103 3	0·140 77
14	3·797 4	0·263 33	27 974	0·035 74	7·366 6	0·135 74
15	4·177 2	0·239 39	31·722	0·031 47	7·606 0	0·131 47
16	4·594 9	0·217 62	35·949	0·027 81	7·923 7	0·127 81
17	5·054 4	0·197 84	40·544	0·024 66	8·021 5	0·124 66
18	5·559 9	0·179 85	45·599	0·021 93	8·201 4	0·121 93
19	6·115 9	0·163 50	51·159	0·019 54	8·364 9	0·119 54
20	6·727 4	0·148 64	57·274	0·017 45	8·513 5	0·117 45
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22	8·140 2	0·122 84	71·402	0·014 00	8·771 5	0·114 00
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50	117·390 8	0·008 51	1 163·908	0·000 85	9·914 8	0·100 85

Table A.2 Interest factors for 15%

Year or period (n)	$(1+i)^n$ Compound amount of a single sum	$\frac{1}{(1+i)^n}$ Present worth of a single sum	$\frac{(1+i)^n-1}{i}$ Compound amount of a uniform series	$\frac{i}{(1+i)^n-1}$ Sinking fund deposit	$\frac{(1+i)^n-1}{i(1+i)^n}$ Present worth of a uniform series	$\frac{i(1+i)^n}{(1+i)^n-1}$ Capital recovery
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Initial cost	$15 000
Resale value	Negligible
Useful life	10 years
Interest on capital	15% p.a.
Fuel consumption	2 litres per hour
Cost of fuel	30 cents per litre
Oil and grease	10% of fuel cost
Repairs to machine	10% of initial price p.a.
Operator	'all in' cost of $1.50 per hour
Insurance and tax	1.5% of initial price p.a.
Average working hours per year	2 000

(marks:20)

ENDS

THE UNIVERSITY OF ZAMBIA
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DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY EXAMINATIONS 18 AUGUST 2003
SEMESTER I

EE209
PRINCIPLES OF ELECTRICITY

Time: Three hours Answer ALL questions Total marks: 100

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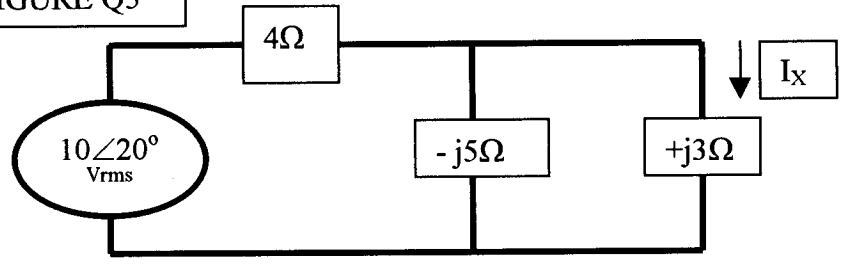

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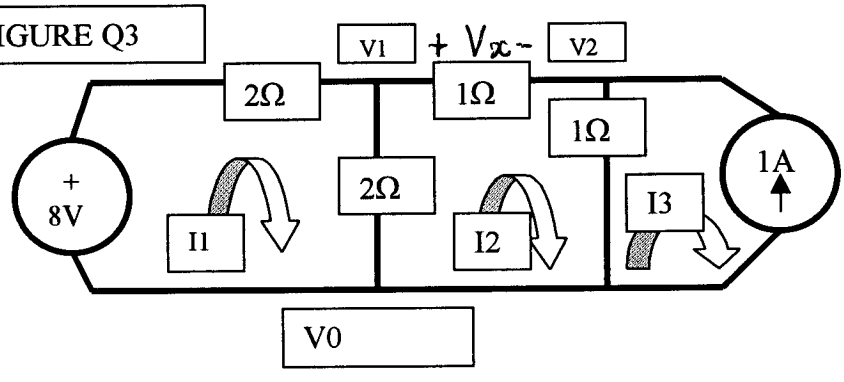

END EE 209 FINAL EXAMINATION

THE UNIVERSITY OF ZAMBIA
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UNIVERSITY EXAMINATIONS 18 AUGUST 2003
SEMESTER I

EE209
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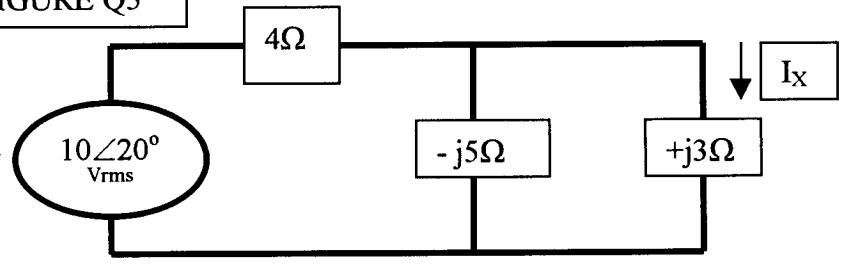

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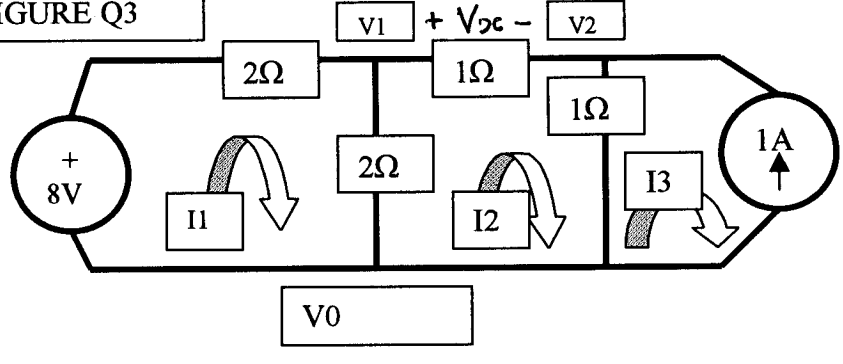

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THE UNIVERSITY OF ZAMBIA
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EE209
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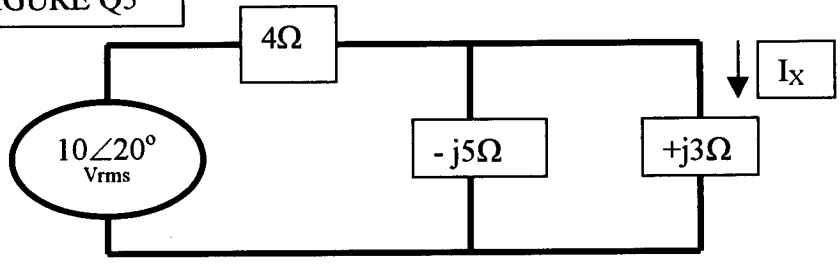

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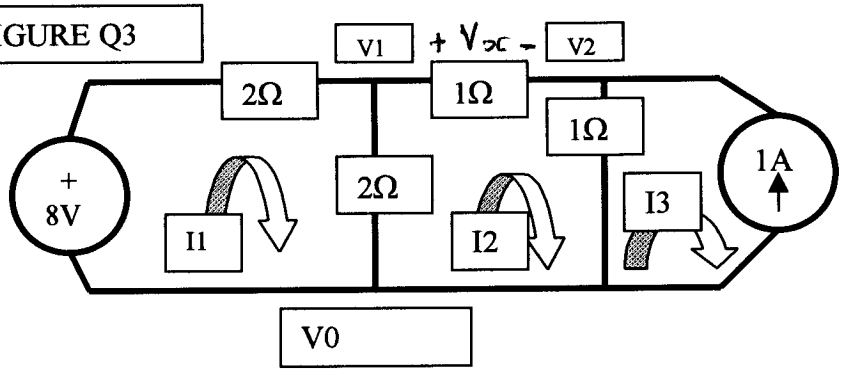

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EE209
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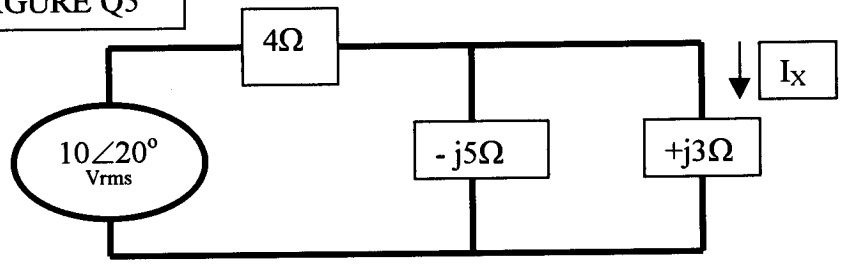

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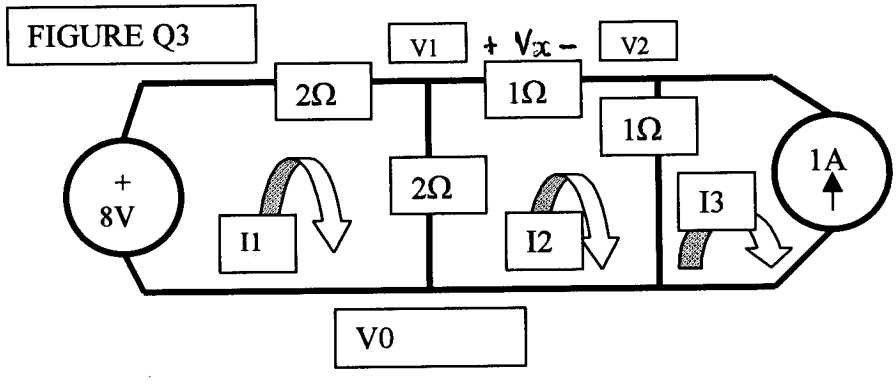

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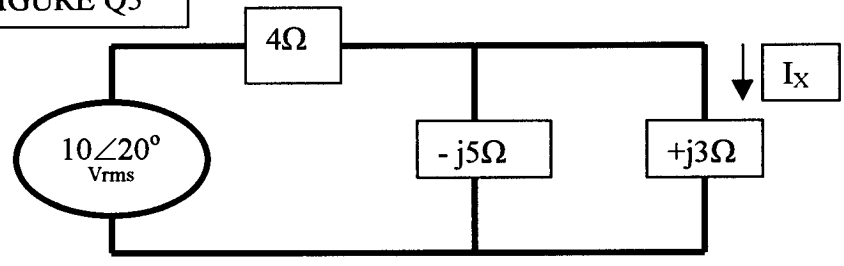
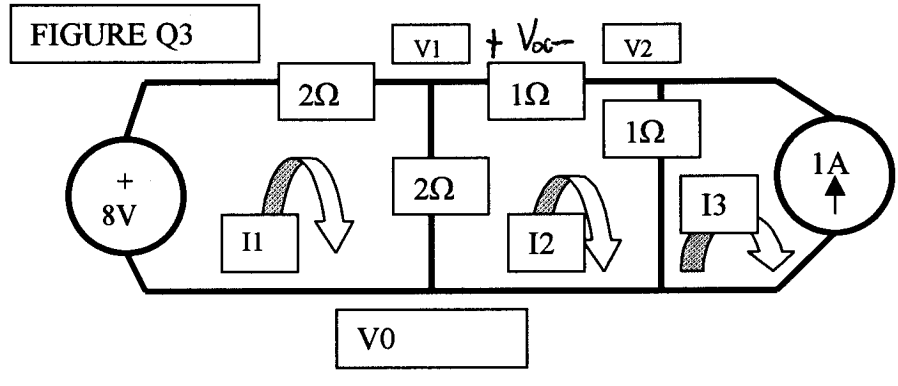


FIGURE Q3



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THE UNIVERSITY OF ZAMBIA
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DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

COURSE: EE 311

END OF SEMESTER EXAMINATION AUGUST 2003

TIME : 3 HOURS

ANSWER : FIVE QUESTIONS

TOTAL MARKS : 100

Q1

a) From the given pole zero diagram in figure 1, plot roughly the amplitude and phase response giving explanations for your plots.

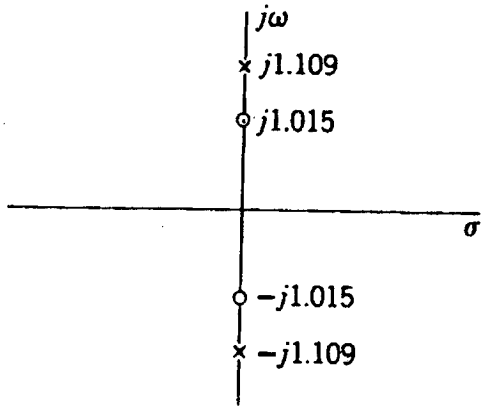


fig.1.a.

b) If now we have a zero at $z = \sigma \pm j\omega_i$ and a pole at $p = \sigma \pm j\omega_i$ where is σ very small compared to ω_i. Draw the amplitude and phase responses.

c) For the given pole zero configuration for a system function H(s). Using any method you please find the undamped frequency ω_o and the bandwidth B, and the Q.

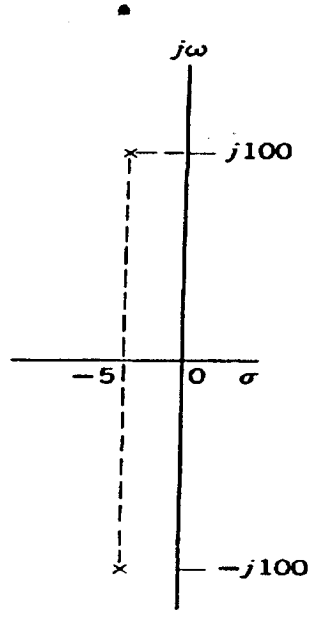


fig.1.b.

Q2

a) The general expression of cisoidal signals is $S(t) = Ae^{st}$.

Where $s = \sigma + j\omega$ is the complex frequency variable. Discuss and plot the different forms of the signal given all condition of the complex frequency s.

b) If the system function of a network is given as

$$H(s) = \frac{1}{(s+2)(s+3)}$$

and if the excitation is

$$E(s) = \frac{3}{s}$$

Find the response $R_{(S)}$. Express your answer in time domain.

Q3

a) Given the half sinusoidal waveform shown in fig. 3.
Using Fourier series determine the coefficients a_o,a_n and b_n

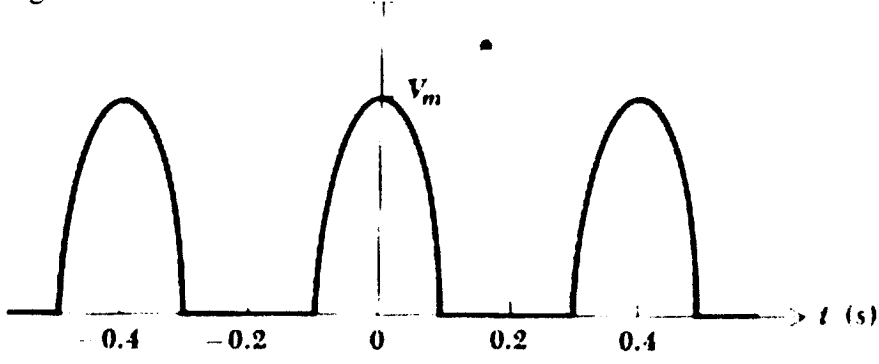


fig.3.

b) Show that the general case Fourier coefficients a_n and b_n exists only for even and odd functions respectively.

Q4

a) Given $S(f)$ as shown in Fig. 4 find the inverse transform of $S_1(f)$.
Explain the implications of what you have just found.

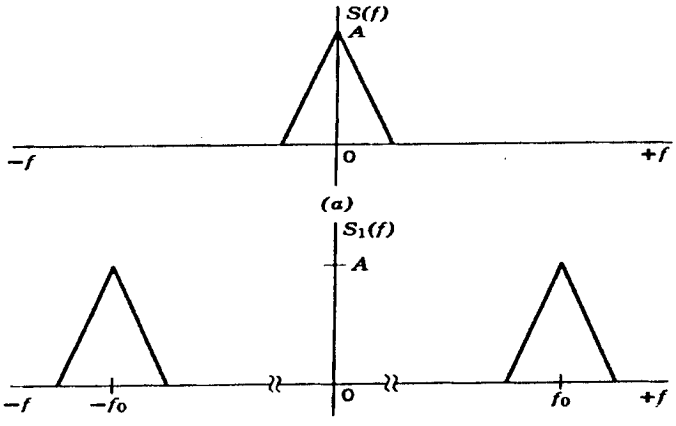


fig 4.

b) Find the inverse transform of $F(jw) = \beta\delta(\omega + \omega o) + \beta\delta(\omega + \omega o)$

c) Show that if $f(t)$ is an even function then its Fourier transform F(jw) is also an even function.

Q5

a) Given the network in figure 5. It can be shown that the free response depend on relative values of the network. If the differential equation describing the network is given as

$$i_g(t) = C\frac{dv}{dt} + Gv + \frac{1}{L}\int_{-} v(t)dt + i_L(o-)$$

Find the response $v_c(t)$ and discuss all the three possible conditions.

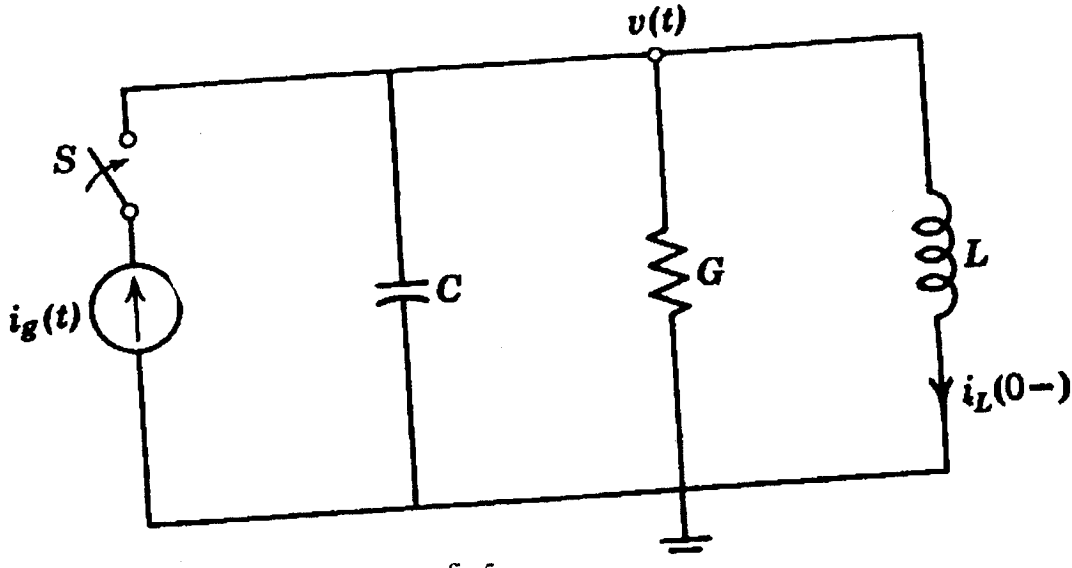


fig.5

b) Find the current i(t)for the network

Q6

(a) Given the system in fig. 6a Determine the system function H(s) = $\frac{V_2(s)}{V_1(s)}$ and draw pole zero diagram of the system function.

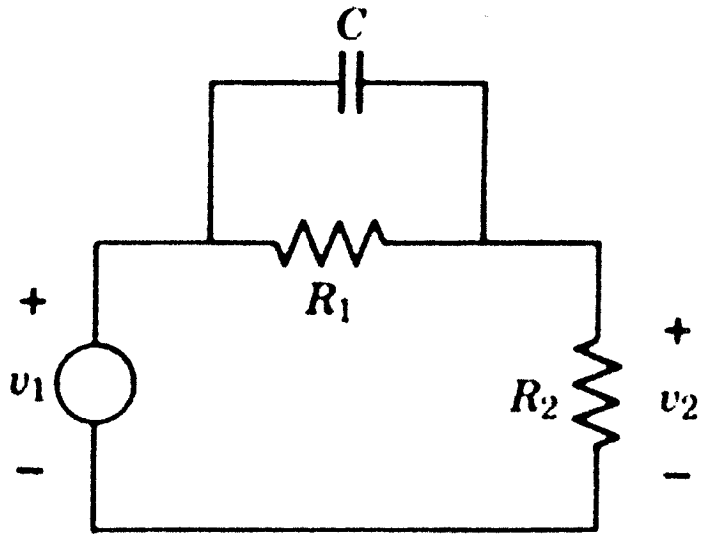
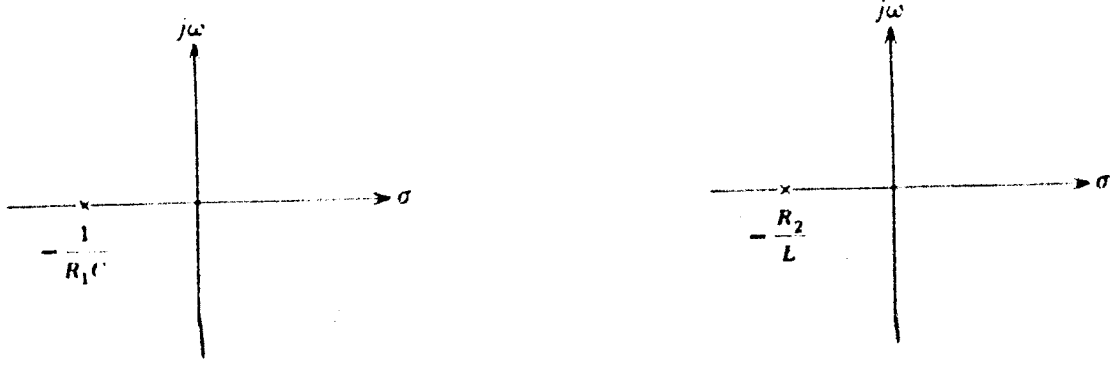


fig.6a.

(b) Given the pole zero diagram in Fig. 6b determine system function representation of the graphical representation and find the impulse response of the systems.



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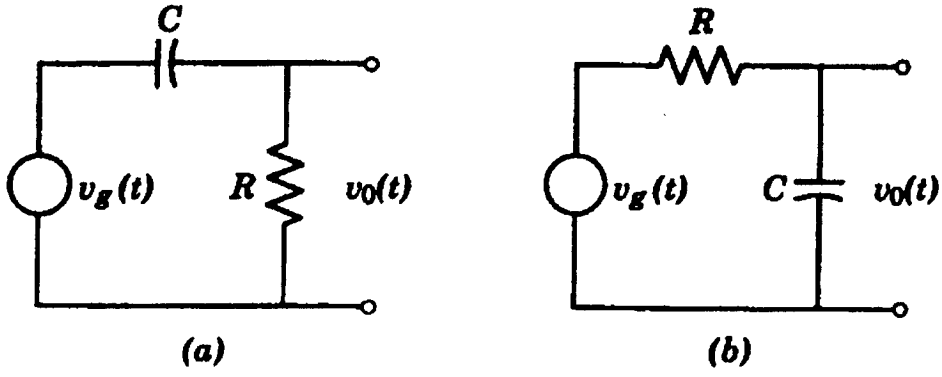
Q7

a) Given R-C differentiator and integrator functions shown in figure 7(a) and (b) show that these are a differentiator and integrator circuits. Make the necessary assumptions.



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b) In the circuit shown (fig (7c) all initial currents and voltages are zero. Find i(t) for t>0 using thevenin's theorem.

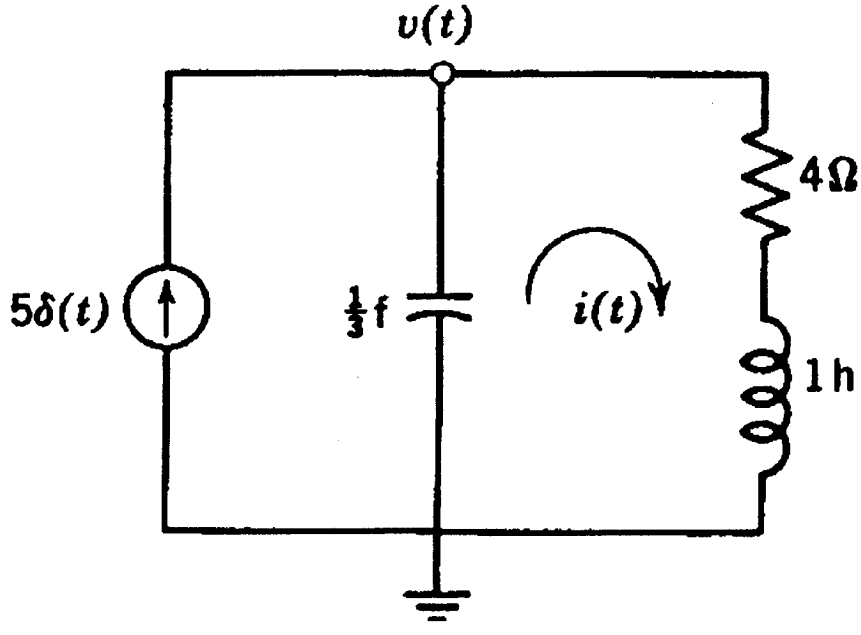

fig7c.

Q8. In this question answer true or false, give reasoning for your answer. Wrong answers shall be penalized.

a. A system function that has poles and zeroes in the right hand side of the s plane and multiple poles on the jω axis is unstable.

b. Dividing a system function by s correspond to differentiating the inverse transform and therefore placing a pole at the origin must correspond to the step response of the system.

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COURSE: EE 311

END OF SEMESTER EXAMINATION AUGUST 2003

TIME : 3 HOURS

ANSWER : FIVE QUESTIONS

TOTAL MARKS : 100

Q1

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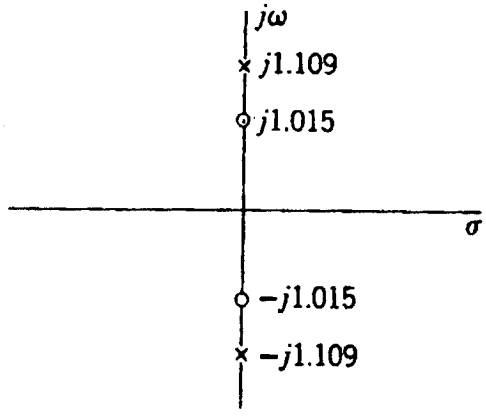

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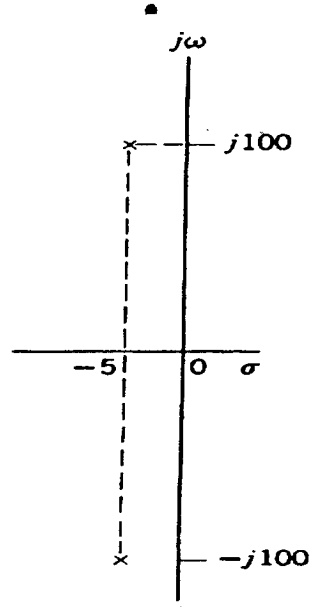


fig.1.b.

Q2

a) The general expression of cisoidal signals is $S(t) = Ae^{st}$.

Where $s = \sigma + j\omega$ is the complex frequency variable. Discuss and plot the different forms of the signal given all condition of the complex frequency s.

b) If the system function of a network is given as

$$H(s) = \frac{1}{(s+2)(s+3)}$$

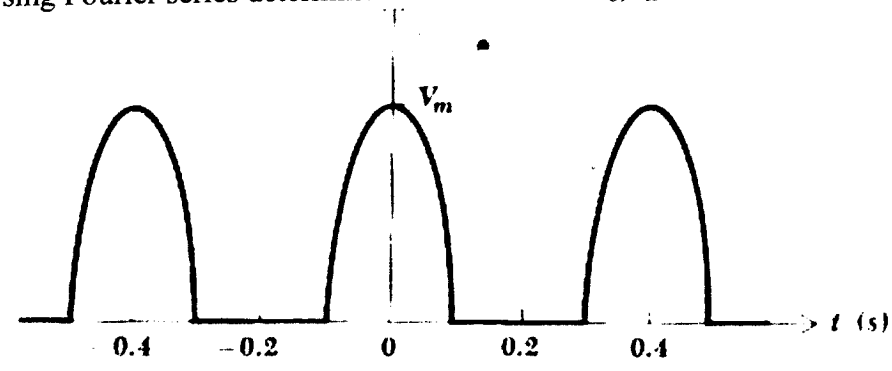
and if the excitation is

$$E(s) = \frac{3}{s}$$

Find the response $R_{(S)}$. Express your answer in time domain.

Q3

a) Given the half sinusoidal waveform shown in fig. 3.
Using Fourier series determine the coefficients a_o,a_n and b_n



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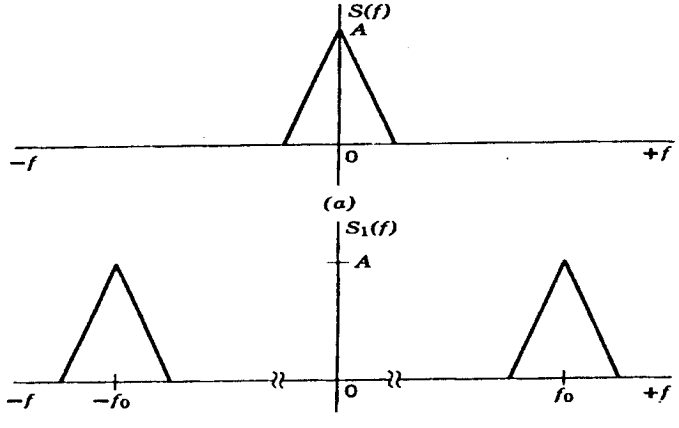
b) Show that the general case Fourier coefficients a_n and b_n exists only for even and odd functions respectively.

Q4

a) Given $S(f)$ as shown in Fig. 4 find the inverse transform of $S_1(f)$.
Explain the implications of what you have just found.



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b) Find the inverse transform of $F(jw) = \beta\delta(\omega + \omega o) + \beta\delta(\omega + \omega o)$

c) Show that if $f(t)$ is an even function then its Fourier transform F(jw) is also an even function.

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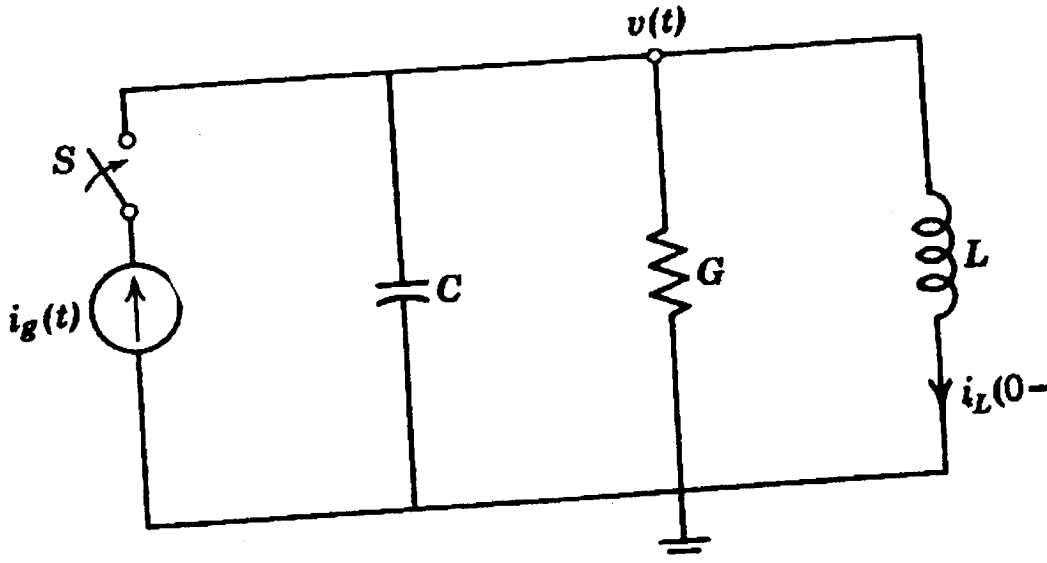

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b) Find the current i(t)for the network

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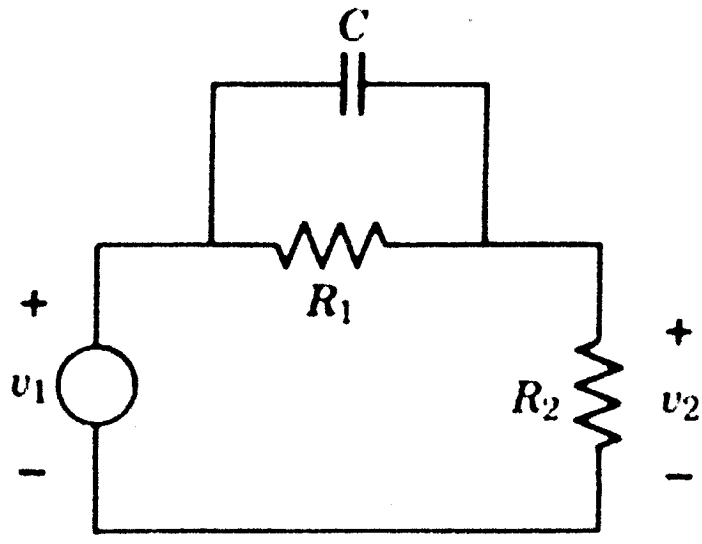

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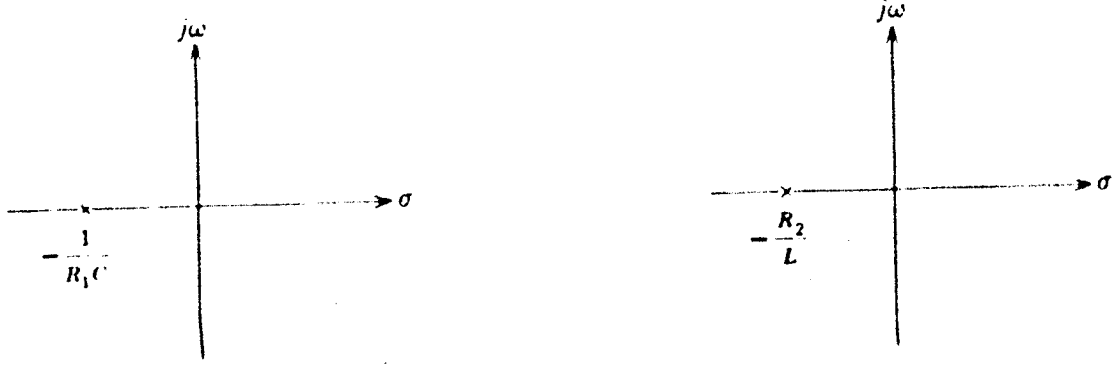

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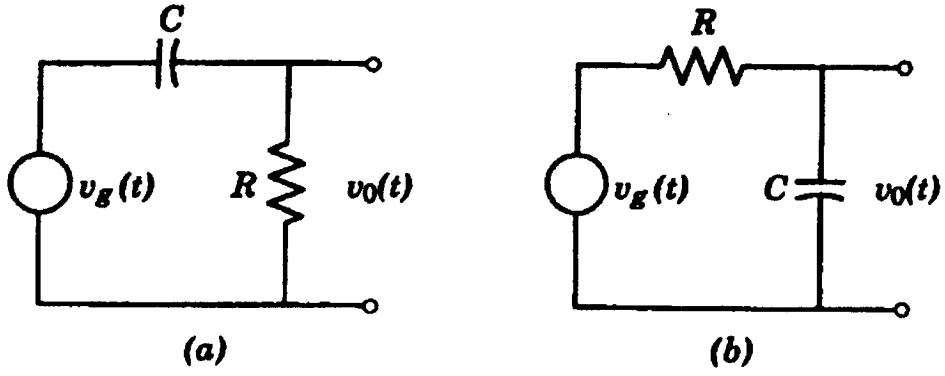

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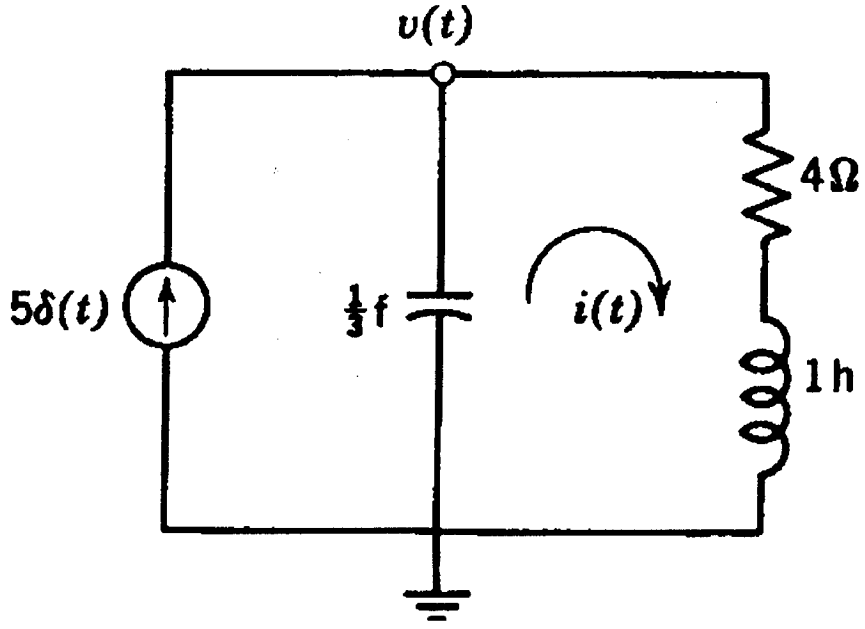

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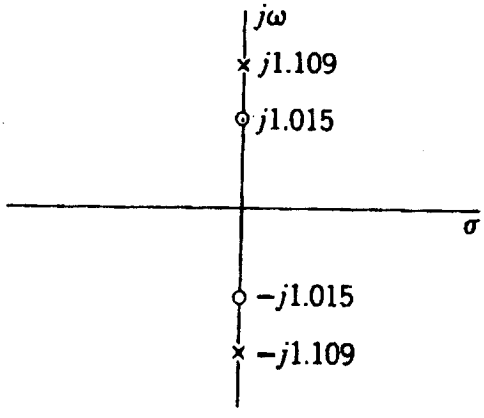

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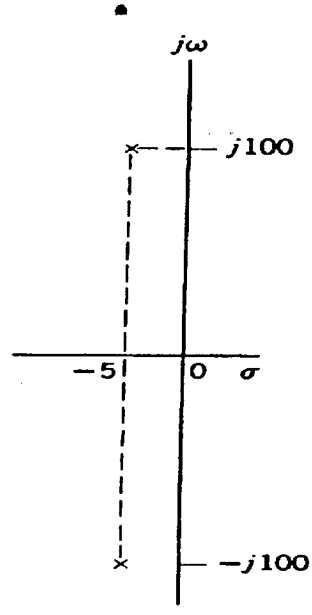

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a) The general expression of cisoidal signals is $S(t) = Ae^{st}$.

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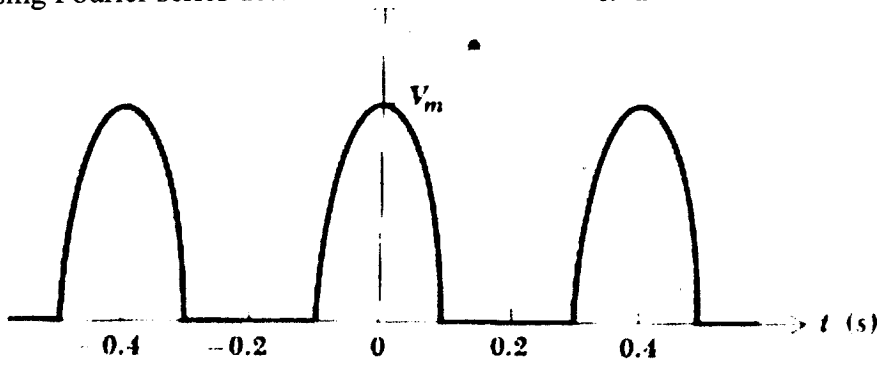

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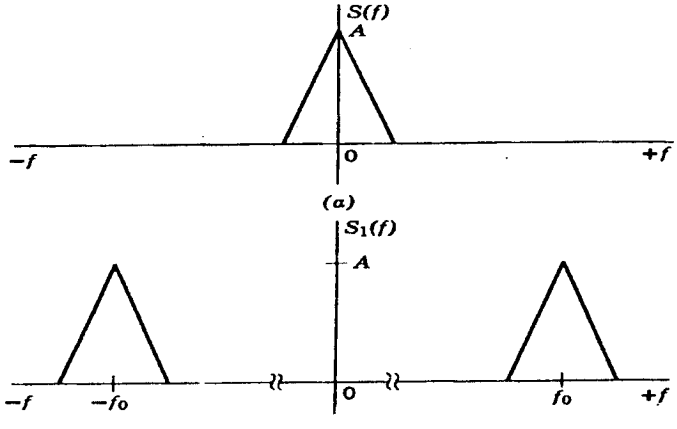

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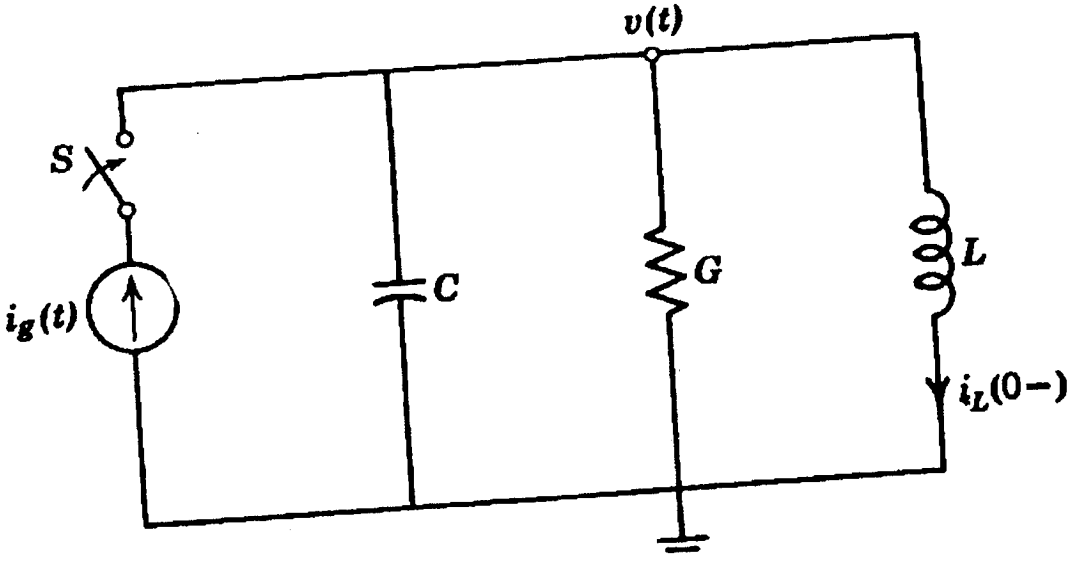

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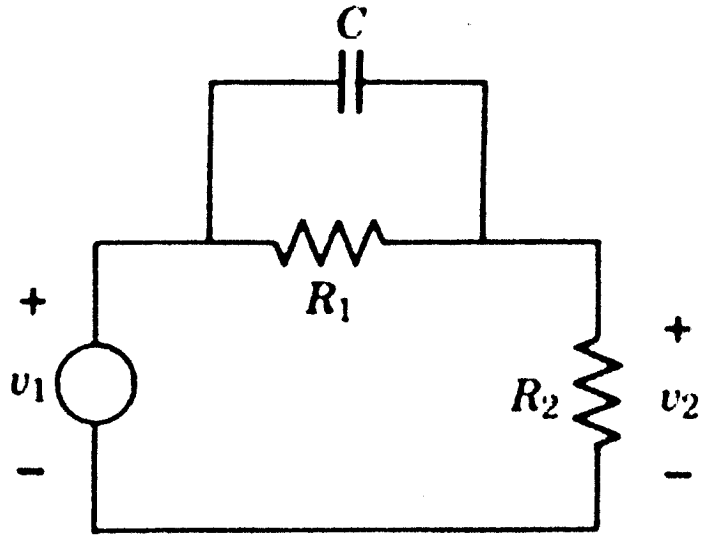

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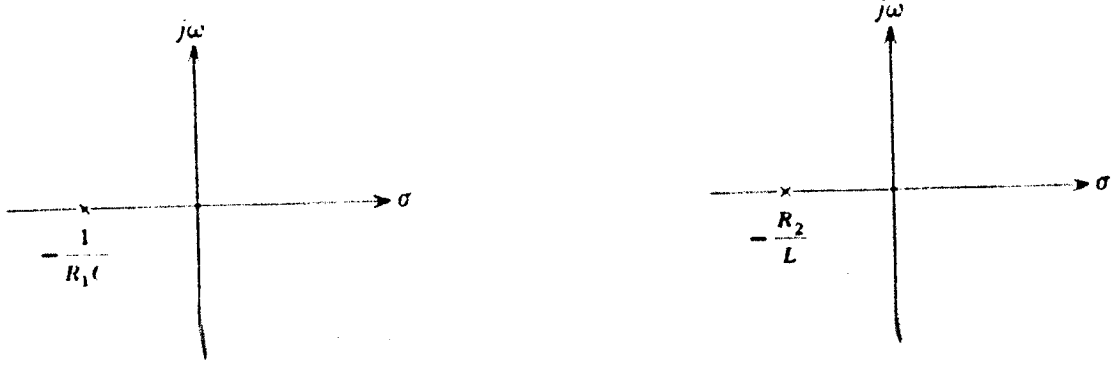

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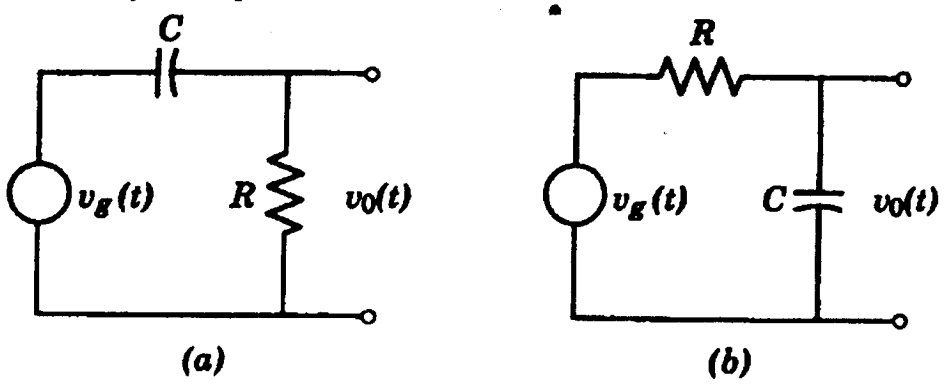

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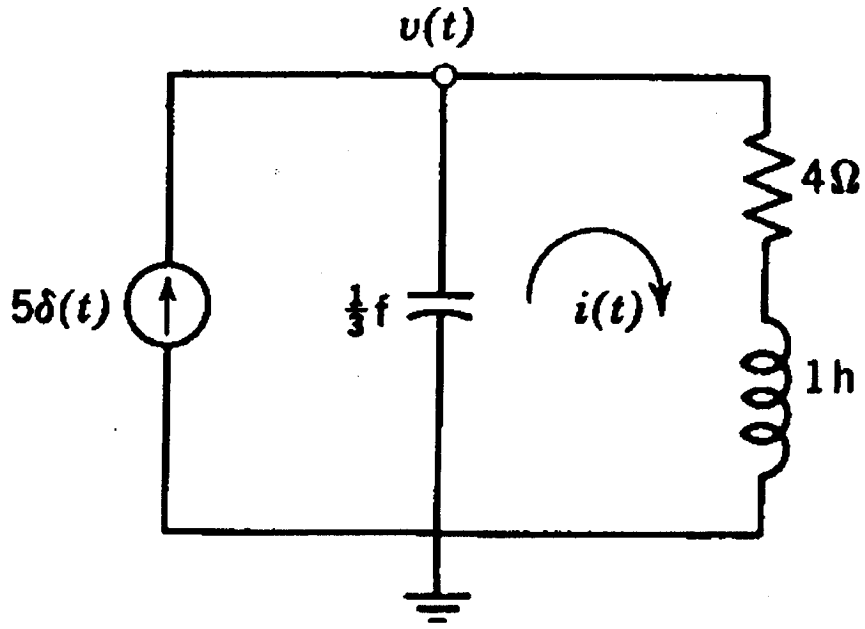

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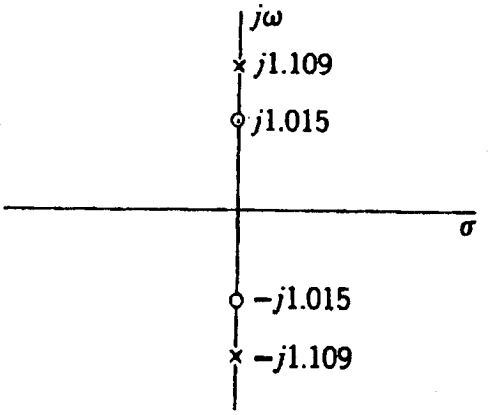

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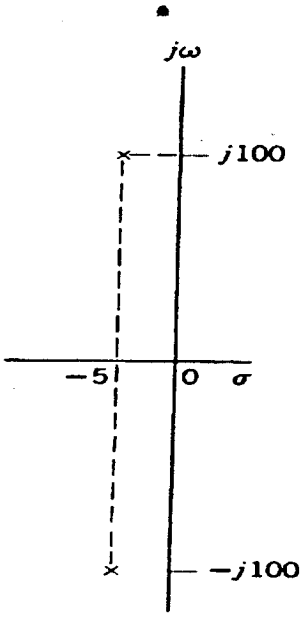

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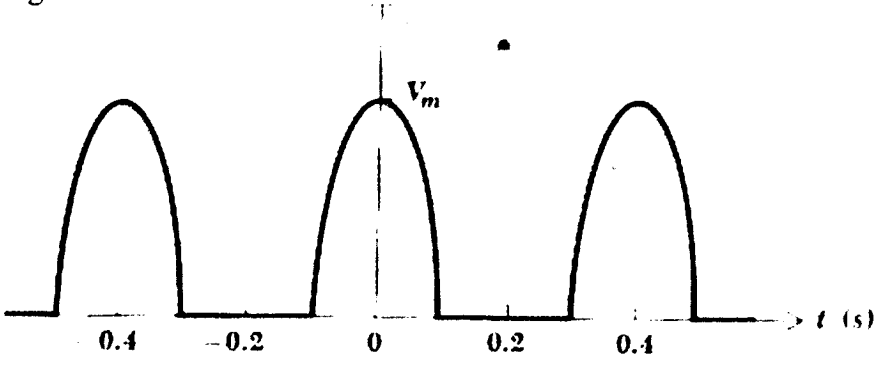

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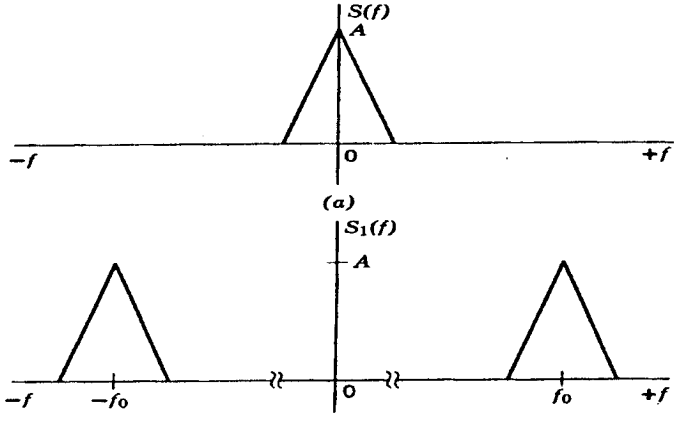

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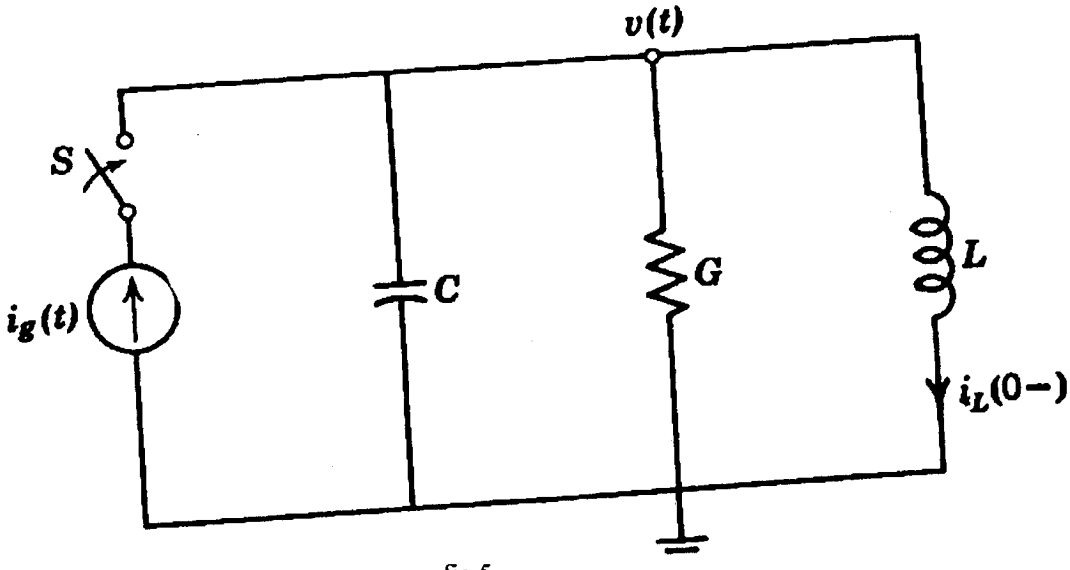

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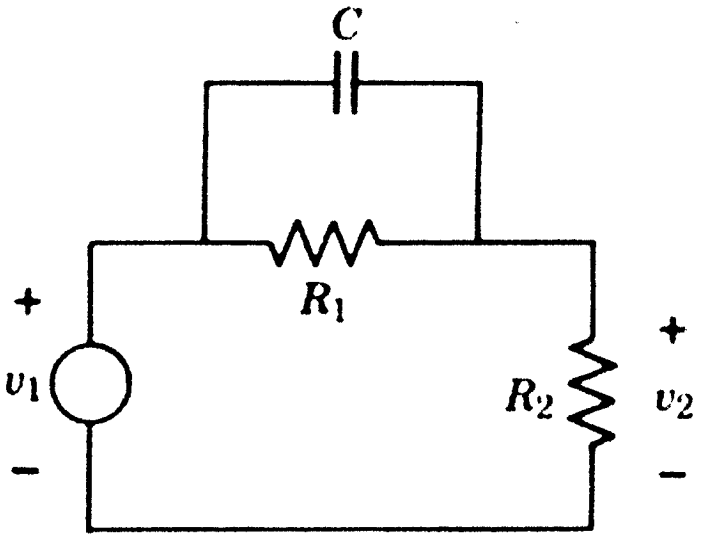

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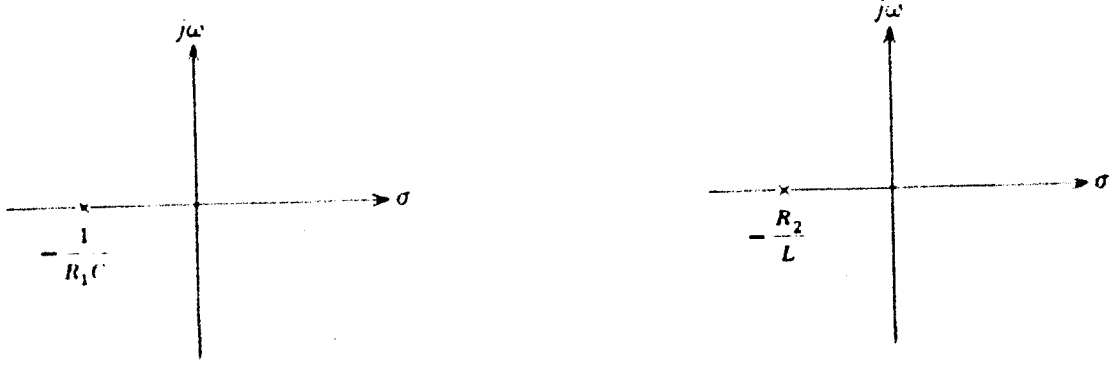

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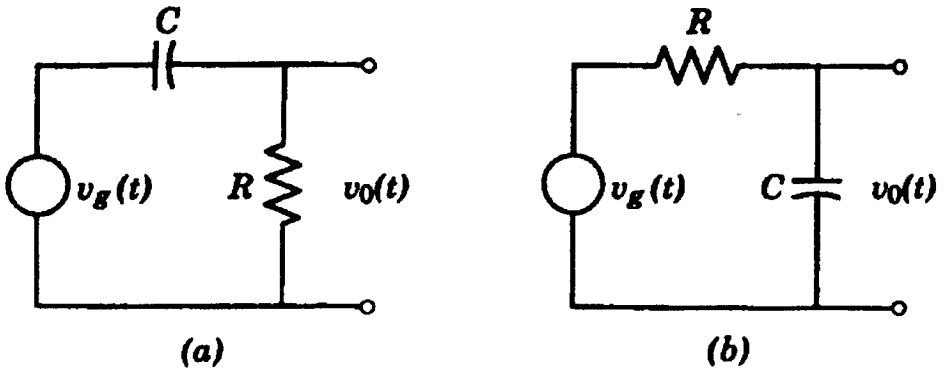

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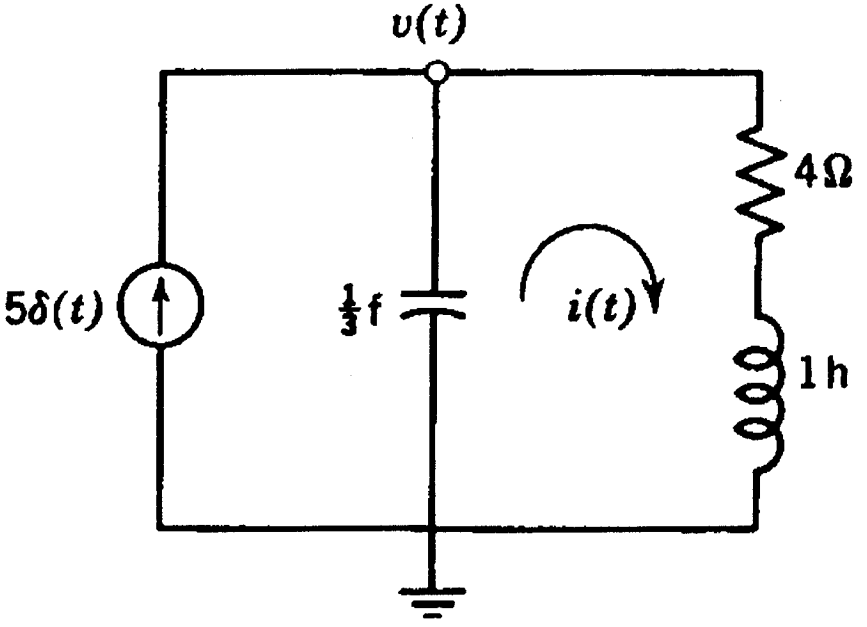

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UNIVERSITY EXAMINATIONS AUGUST 2003

EE321

ELECTROMECHANICS & ELECTRICAL MACHINES

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

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

1.

From basic concepts 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 at a depth *h* from *A*, a point of a light source with luminous intensity *I*.

[10 marks]

A 500-cd lamp emits light uniformly in all directions and is suspended 5 m above the centre of a 10-m-by-20-m working plane. Find the illuminance below the lamp and at each corner of the plane.

[5 marks]

In another application the same plane will be designed to have an illuminance of 300 lx and will have eight lamp positions. If the utilization factor is 48% and maintenance factor is 80% calculate the required mean spherical luminous intensity per lamp.

[5 marks]

2.

From basic principles and defining all the terms, find the expression of the capacitance of a
(a) parallel-plate capacitor
(b) spherical capacitor, that is, one consisting of two concentric spheres, when the outer sphere is earthed.

[10 marks]

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]

3.

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.

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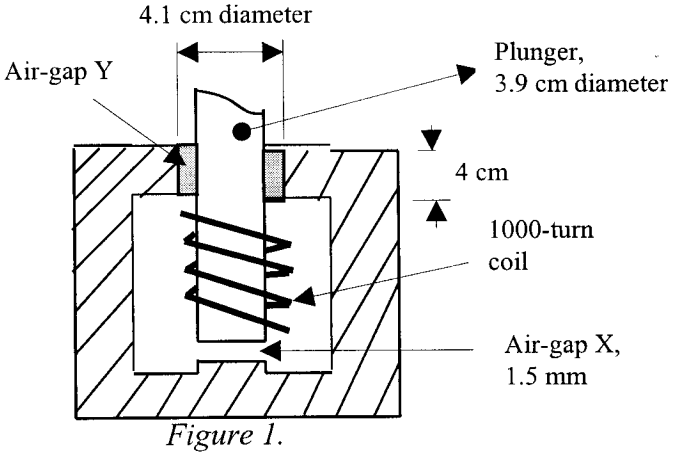

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The primary of a transformer is supplied with a constant voltage of 1000 V, and the secondary voltage on no load is 100 V. When supplying a pure resistance with 20 A the voltage falls to 96 V and when supplying a pure capacitance with 10 A the voltage rises to 104 V. Draw an equivalent circuit of the transformer, showing numerical values of the series components.

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What is the percent regulation of this transformer when supplying 20 A to an inductive load of 0.8 power factor?

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

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6.

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

[10 marks]

A 4-pole machine has 124 lap wound coils each having 2 turns. The flux per pole is 0.015 Wb. Calculate, assuming sinusoidal field distribution,

(i) the dc voltage appearing across a pair of brushes when running as a commutator machine at 1500 rev/min.

[4 marks]

(ii) the rms voltage across a pair of brushes when running as a single-phase slip-ring machine with relative conductor-field speed still at 1500 rev/m.

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7.

(a) Show from basic principles that the torque developed between two coils free to rotate about their axes is $T = \frac{1}{2} i_1^2 \frac{dL_1}{d\theta} + \frac{1}{2} i_2^2 \frac{dL_2}{d\theta} + i_1 i_2 \frac{dM}{d\theta}$, defining all terms.

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

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8.

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

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

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

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(ii) A 400-V dc shunt motor takes 50 A on full-load, and the speed is then 1000 rev/min. For this full-load condition, the field current is 2 A, and the windage, friction and iron losses amount to 600 W. If the armature resistance is 0.5 Ω calculate the total losses, the efficiency and output torque.

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END OF EE321 EXAMINATION

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UNIVERSITY EXAMINATIONS AUGUST 2003

EE321

ELECTROMECHANICS & ELECTRICAL MACHINES

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

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

1.

From basic concepts 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 at a depth *h* from *A*, a point of a light source with luminous intensity *I*.

[10 marks]

A 500-cd lamp emits light uniformly in all directions and is suspended 5 m above the centre of a 10-m-by-20-m working plane. Find the illuminance below the lamp and at each corner of the plane.

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In another application the same plane will be designed to have an illuminance of 300 lx and will have eight lamp positions. If the utilization factor is 48% and maintenance factor is 80% calculate the required mean spherical luminous intensity per lamp.

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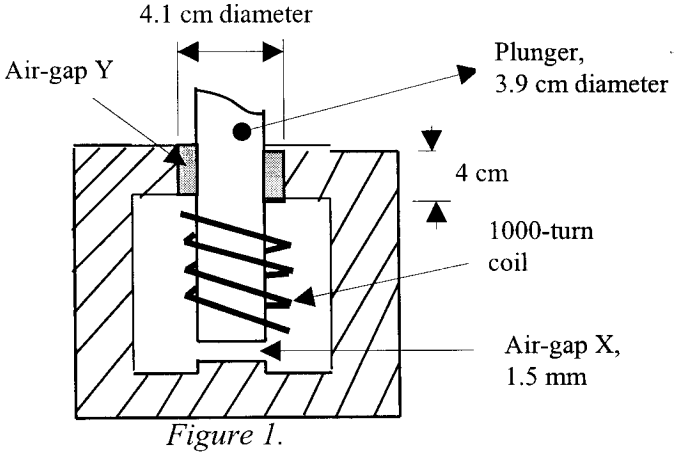

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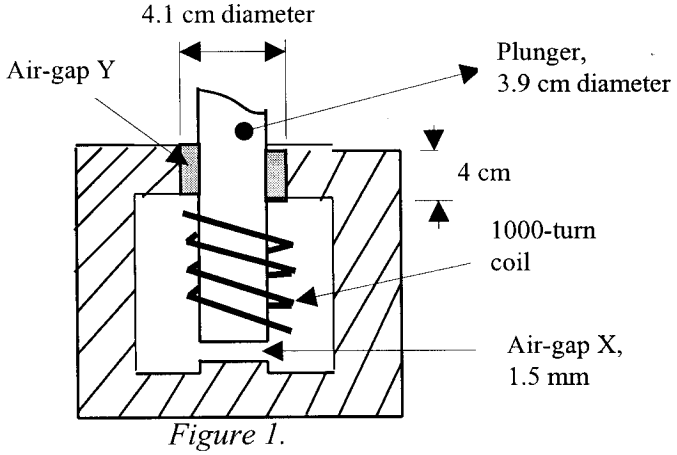

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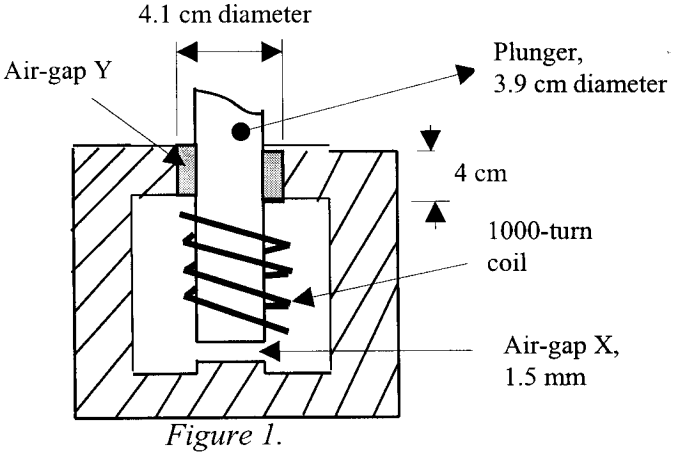

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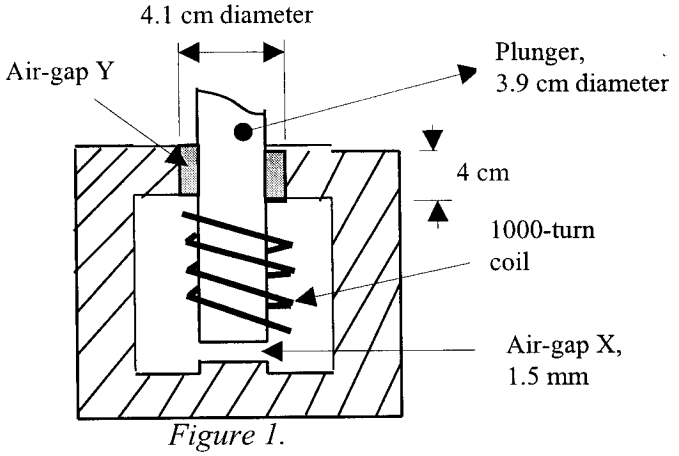

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[10 marks]

END OF EE321 EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

UNIVERSITY EXAMINATIONS (FIRST SEMESTER - DEFFERED)
WEDNESDAY (AM) – 3RD SEPTEMBER 2003

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

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

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Q1.

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

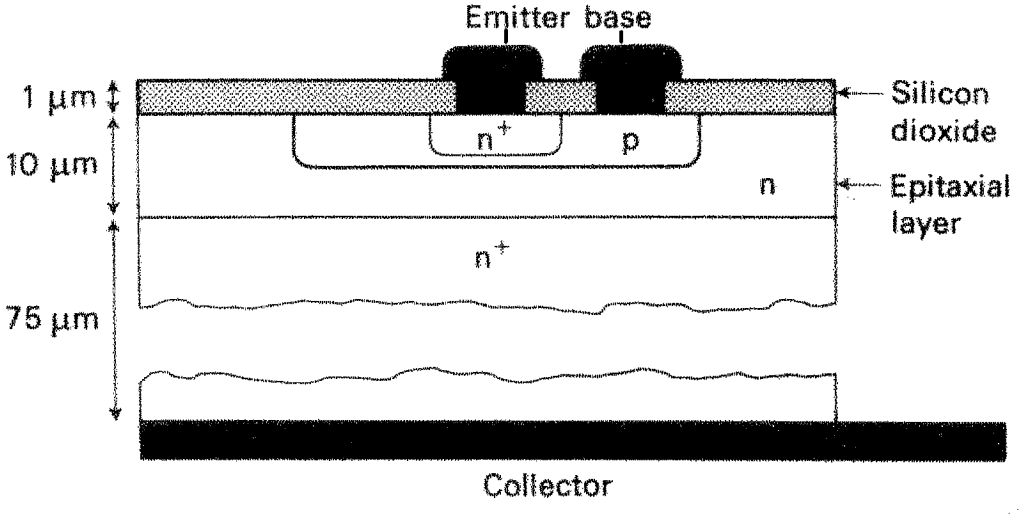

Figure 01. Sectional view of a planar process n^+-p-n silicon bipolar junction transistor

(i) **Describe in detail the processes involved in fabricating the above BJT.** *(3 marks)*

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

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

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

B. An ideal n^+-p-n transistor has a current gain of 90 and is operated on a base current of 20 μA. The recombination time of charge carriers in the base is 0.1μs.

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

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

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

Q2.

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

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

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

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

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

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

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

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

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

Q3.

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

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

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

(iii) Differentiate between a p-n and a p-i-n photodiode. *(2½ marks)*

(iv) How can a photodiode be operated as a solar cell? *(2½ marks)*

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

B. When a semiconductor is illuminated with light, there exists a minimum frequency of the incident radiation at which electron-hole pairs are generated. This minimum frequency at which charge carrier are produced can be related to a maximum limiting wavelength known as threshold.

(i) Derive an expression for threshold wavelength. *(3 marks)*

(ii) Determine threshold wavelength for the compound semiconductor gallium phosphide at room temperature. *(3 marks)*

Q4.

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

(i) Briefly discuss quantum numbers that completely describe the electronic structure of a silicon atom and state the limiting principle. *(2 ½ marks)*

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

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

(iv) Using the concept developed in (iii), describe a metallic conductor, semiconductor and insulator. *(1 ½ marks)*

B. In a pure silicon crystal specimen:

(i) Discuss conditions that determine whether electrons obey Fermi-Dirac and Maxwell-Boltzmann statistics. *(4 ½ marks)*

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

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A. Briefly discuss the following:

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

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

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

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

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

distance along the bar at which the minority carrier concentration drops to half its equilibrium value. *(8 marks)*

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

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

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

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

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

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Q7.

A.

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

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

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

B. An amplifier of effective resistance 6kΩ operates at a current of 4mA over a bandwidth of 10 MHz. If the amplifier is operating at room temperature, determine the square mean:

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

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Q8.

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

(i) Briefly describe any three of these doping methods. *(6 marks)*

(ii) What advantage(s) are derived from doping a pure semiconductor? *(2 mark)*

(iii) Distinguish between an intrinsic and intrinsic-like semiconductor. *(2 marks)*

(iv) Why is silicon dioxide used as an effective mask or barrier against impurities in the manufacture of IC's when the raw material is silicon? *(1 mark)*

B. Boron is adopant for converting pure silicon to an extrinsic semiconductor. For boron atoms to diffuse into silicon, the temperature is maintained at $1000^{o}C$, the concentration of boron at the surface of silicon is maintained at $10^{10}cm^{-3}$ and time for the diffusion process is 1 hour. The total number of dopant atoms per unit area (Q(t)) in a diffused semiconductor is given by the expression $Q(t) = 1.13C_S\sqrt{Dt}$, where C_S is the surface concentration of dopants, D is the diffusivity of the dopants in silicon and t is the time of diffusion.

i. The diffusion length of boron in silicon. *(4½ marks)*

ii. Total number of dopant atoms per unit area in silicon *(4½ marks)*

END OF EXAMINATION

LIST OF USEFUL CONSTANTS AND VARIABLES

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5. Silicon intrinsic carrier concentration $= 1.5\times10^{16}m^{-3}$ at room temperature
6. Gallium phosphide energy gap = 2.24 eV at room temperature
7. Silicon energy gap = 1.12eV at room temperature & 1.16eV at 0K
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12. Electron mobility in silicon $= 1450\ cm^{2}V^{-1}s^{-1}$
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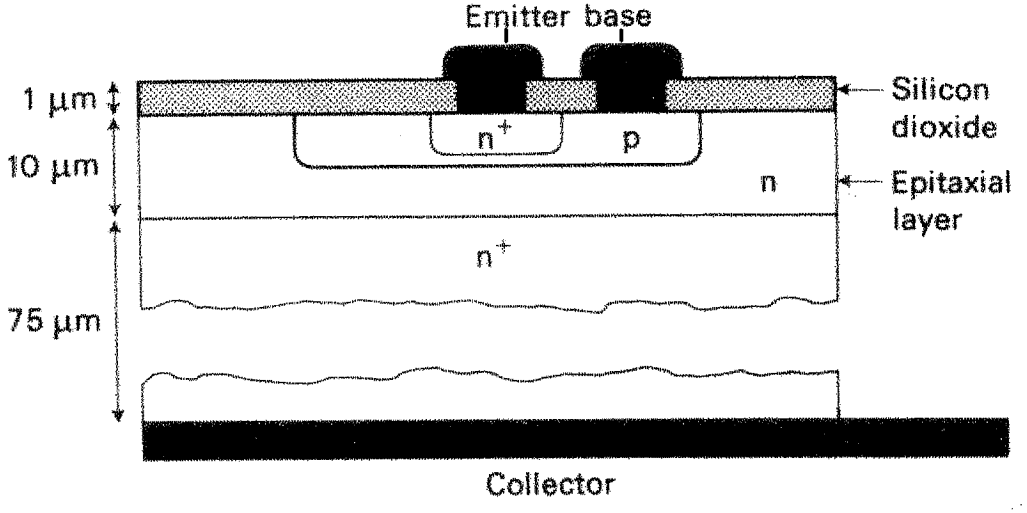

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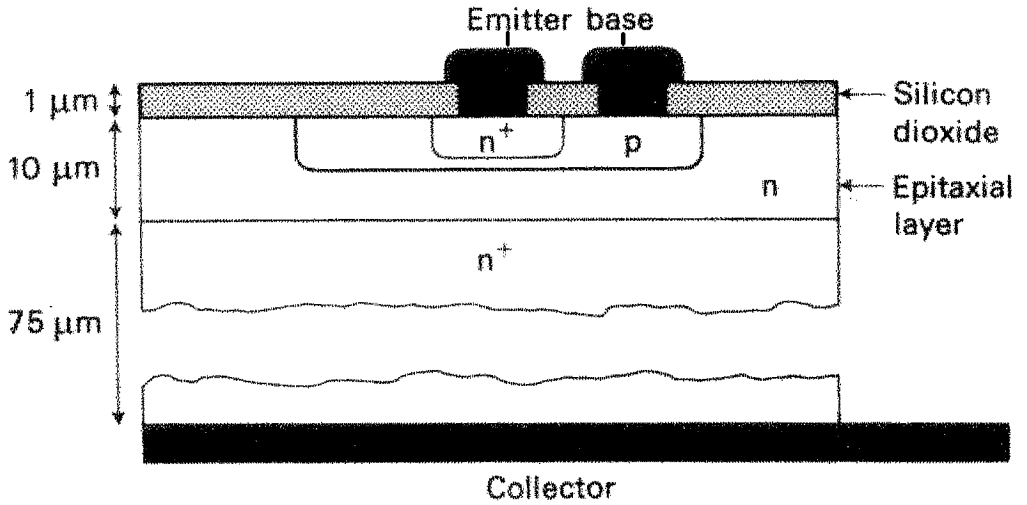

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3. 1 electron volt $= 1.602\times10^{-19}J$
4. Room temperature $= 27^{o}C$
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THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

UNIVERSITY EXAMINATIONS (FIRST SEMESTER - DEFFERED)
WEDNESDAY (AM) – 3RD SEPTEMBER 2003

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

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

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

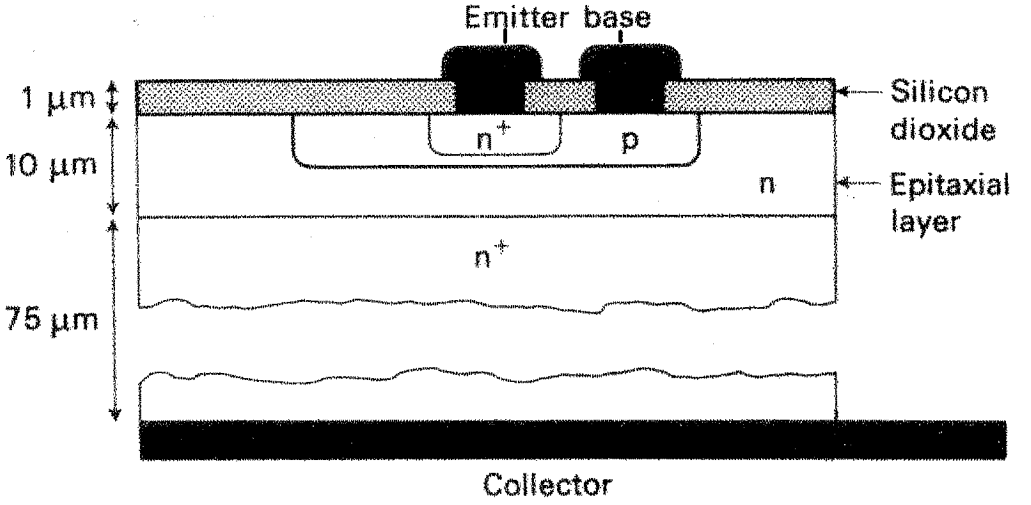

Figure 01. Sectional view of a planar process n^+-p-n silicon bipolar junction transistor

(i) **Describe in detail the processes involved in fabricating the above BJT.** *(3 marks)*

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

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

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

B. An ideal n^+-p-n transistor has a current gain of 90 and is operated on a base current of 20 μA. The recombination time of charge carriers in the base is 0.1μs.

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

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

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Q2.

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

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

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

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

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

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Q3.

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

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

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

(iii) Differentiate between a p-n and a p-i-n photodiode. *(2½ marks)*

(iv) How can a photodiode be operated as a solar cell? *(2½ marks)*

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

B. When a semiconductor is illuminated with light, there exists a minimum frequency of the incident radiation at which electron-hole pairs are generated. This minimum frequency at which charge carrier are produced can be related to a maximum limiting wavelength known as threshold.

(i) Derive an expression for threshold wavelength. *(3 marks)*

(ii) Determine threshold wavelength for the compound semiconductor gallium phosphide at room temperature. *(3 marks)*

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

(i) Briefly discuss quantum numbers that completely describe the electronic structure of a silicon atom and state the limiting principle. *(2 ½ marks)*

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

(iv) Using the concept developed in (iii), describe a metallic conductor, semiconductor and insulator. *(1 ½ marks)*

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A. Briefly discuss the following:

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

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

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

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

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

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

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

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

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

B. An amplifier of effective resistance 6kΩ operates at a current of 4mA over a bandwidth of 10 MHz. If the amplifier is operating at room temperature, determine the square mean:

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

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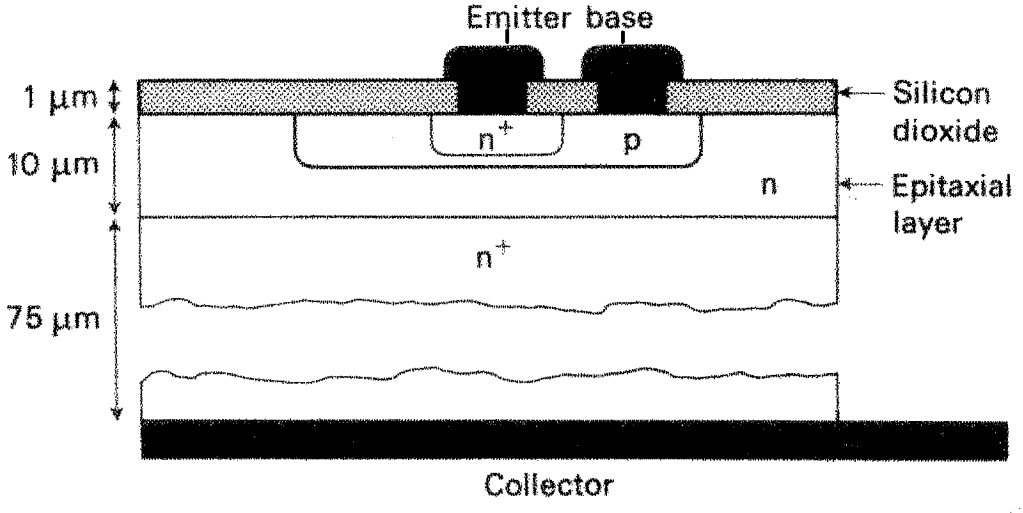

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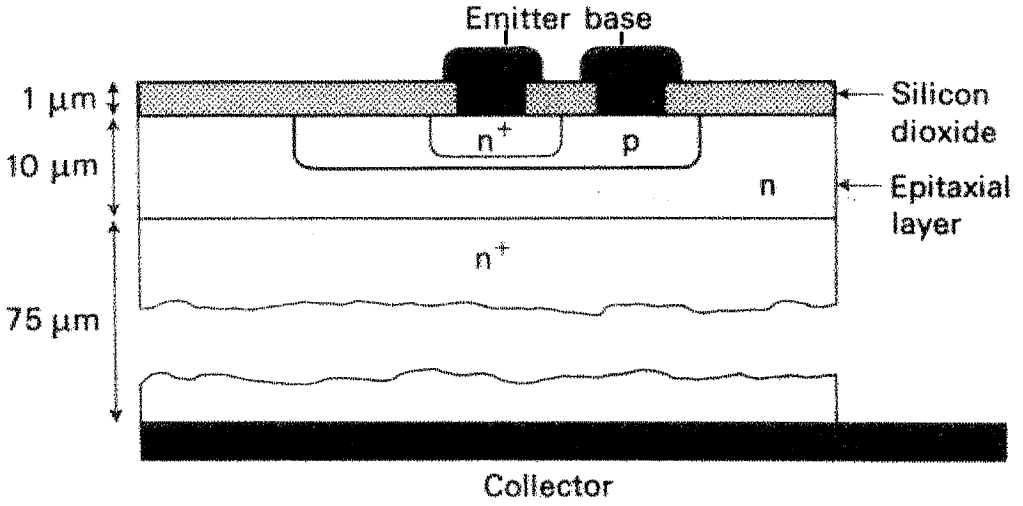

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B. Boron is adopant for converting pure silicon to an extrinsic semiconductor. For boron atoms to diffuse into silicon, the temperature is maintained at $1000^{\circ}C$, the concentration of boron at the surface of silicon is maintained at $10^{10}cm^{-3}$ and time for the diffusion process is 1 hour. The total number of dopant atoms per unit area (Q(t)) in a diffused semiconductor is given by the expression $Q(t) = 1.13C_S\sqrt{Dt}$, where C_S is the surface concentration of dopants, D is the diffusivity of the dopants in silicon and t is the time of diffusion.

i. The diffusion length of boron in silicon. *(4½ marks)*

ii. Total number of dopant atoms per unit area in silicon *(4½ marks)*

END OF EXAMINATION

LIST OF USEFUL CONSTANTS AND VARIABLES

1. Boltzmann constant $= 1.38\times10^{-23}JK^{-1}$
2. Electronic charge $= 1.602\times10^{-19}C$
3. 1 electron volt $= 1.602\times10^{-19}J$
4. Room temperature $= 27^{\circ}C$
5. Silicon intrinsic carrier concentration $= 1.5\times10^{16}m^{-3}$ at room temperature
6. Gallium phosphide energy gap = 2.24 eV at room temperature
7. Silicon energy gap at 0K = 1.12eV at room temperature & 1.16eV
8. Absolute Temperature $= -273^{\circ}C$
9. Planck's constant $= 6.63x10^{-34}Js$
10. Speed of light $= 3.0\times10^{8}m/s$
11. Silicon atom atomic number = 14
12. Electron mobility in silicon $= 1450\ cm^2V^{-1}s^{-1}$
13. The diffusion coefficient of boron in silicon = $2x10^{-14}cm^2s^{-1}$
14. Assume room temperature if not specified.

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

UNIVERSITY EXAMINATIONS – SEMESTER I AUGUST 2003
EE 471- TELECOMMUNICATIONS

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

1.

a) Compare the average transmitter power and channel bandwidth requirements of DSB, SSB, and AM schemes for transmitting an audio signal with a bandwidth of *10 kHz* with a destination signal-to- noise ratio of *50 dB*. Assume that channel introduces a *50 dB* power loss and that the noise power spectral density at the receiver input is 10^{-12} *watt/Hz*. Assume $mS_x = 0.5$ for AM. ***(10 marks)***

b) Compare the transmitted power and bandwidth requirements of an FM system, an AM system, and a DSB system designed to produce $(S/N)_d = 60$ *dB*. The message signal is a video signal with the following characteristics:

$max|X(t)| = 1,\ E\{X^2(t)\} = 0.5,\ and\ f_x = 5\ MHz$

Assume that the channel noise has a *psd* $(0.5)(10^{-14})$ *watt/Hz* and that the channel introduces a 60-*dB* power attenuation. Assume a modulation index of 100% for the AM and a deviation ratio of 5 for the FM. ***(10 marks)***

2.

a) Define *standing waves* on a transmission line. ***(2 marks)***

b) With the help of diagrams illustrate the difference between standing waves on a short-circuited transmission line and that of standing waves on an open-circuited transmission line. ***(4 marks)***

c) A transmission line has a reflection coefficient of 0.6. Calculate the SWR. ***(2 marks)***

d) State and briefly explain *three* major types of energy loss that occur in a transmission line. ***(6 marks)***

e) Draw the *electrical equivalent* of a transmission line and that of a lossless transmission line. And each of these, state their characteristic impedance. ***(4 marks)***

f) Given a *lossless* transmission line with inductive and capacitive values of $0.1\mu H/m$ and *100 pF/m*, calculate the characteristic impedance. ***(2 marks)***

3.

a) An AM waveform is shown in Figure 1. Assume the message signal is sinusoidal.

(i) Calculate the modulation index, *m,* and the percentage of modulation, η. ***(2 marks)***

(ii) Calculate the carrier power (P_c), sideband power (P_{sb}), total power (P_t) and power efficiency (ε). ***(8 marks)***

(iii) State how you can avoid envelope distortion. *(2 marks)*

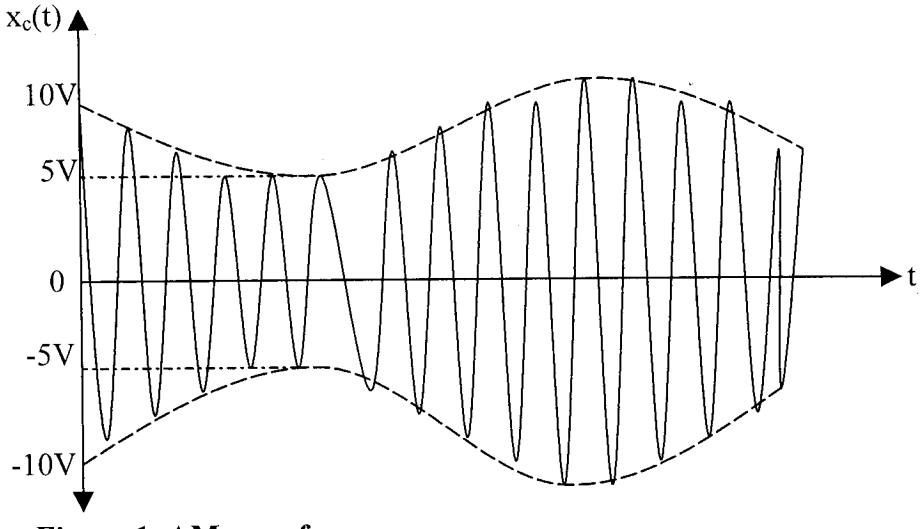

Figure 1. AM waveform

b)

(i) The AM signal $v(t)=(1+m\cos\omega_m t)\cos\omega_c t$, with *m* a constant $(m \le 1)$, is applied to the diode demodulator called envelope detector. If the demodulator is to follow the envelope at all times, 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)***

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

4.

(a) A 20 MHz carrier is frequency modulated by a sinusoidal signal such that the peak frequency deviation is 100 kHz. Determine the modulation index,β, (and state either NBFM or WBFM) and the approximate bandwidth of the FM signal if the frequency of the modulating signal is:

(i) 1 kHz; ***(3 marks)***

(ii) 50 kHz; ***(3 marks)***

(iii) 500 kHz. ***(4 marks)***

(b) For an FM wave represented by the voltage equation $v(t) = 10\sin(8\times10^8 t + 7\sin 6\times10^4 t)$ determine:

(i) The carrier frequency, f_c. ***(2 marks)***

(ii) The modulating frequency, f_m. ***(2 marks)***

(iii) The modulation index,β. ***(2 marks)***

(iv) The maximum deviation, f_Δ. ***(2 marks)***

(v) The power dissipated in an 8 Ω load. *(2 marks)*

5.

a) Consider an audio signal comprised of the sinusoidal term

$s(t) = 3\cos 500\pi t$

(i) Find the signal to quantization noise ratio when this is quantizatized using 10-bit PCM ***(4 marks)***

(ii) How many bits of quantization are needed to achieve a signal to quantization noise ratio of at least 40 dB? ***(4 marks)***

b)

(i) Amplitude shift keying (ASK) is to be used to transmit binary data with a given value of carrier amplitude, A, and noise power per hertz, N_o. Prove that a modulation index of $m = 1$ yields the minimum bit error rate. *(6 marks)*

(ii) Binary information is transmitted at 10 kbps using *on-off keying* (OOK). The carrier frequency is 10 MHz, and the received carrier amplitude is 10^{-2} V. The additive noise power is 5×10^{-10} W/Hz. Design a coherent detector and find the bit error rate. *(6 marks)*

6.

a)

(i) Determine the spacing required for parallel wire transmission line if the wire size is *0.01 cm* and the characteristic impendence is *150 Ω*.. *(3 marks)*

(ii) State briefly *why* the design for a characteristic impedance of *150 Ω*, in part (i), is not a practical configuration. Explain how to accomplish the *150 Ω* impedance. ***(3 marks)***

b) Given a transmission line with $Z_0 = 300\ \Omega$ and a load $Z_L = (450 - j150)\ \Omega$. Using the Smith Chart determine the required locations and value of the $\lambda/4$ section required for impedance matching, if the signal frequency is *600 MHz*, and $v_c = 3 \times 10^{10}$ *cm/s* ***(14 marks)***

7.

a) For AM signals, the percentage of total power that conveys information is used as a measure of *power efficiency*. Show that the maximum efficiency for an arbitrary signal *x(t)* is 50% and that the maximum efficiency for a sine wave message signal is 33.3%. ***(4 marks)***

b) A commercial AM station is broadcasting with an average transmitted power of 10 kW. The modulation index is set at 0.707 for a sinusoidal message signal. Find the transmission power efficiency and the average power in the carrier component of the transmitted signal. ***(8 marks)***

c) State and briefly explain *five* advantages of using modulated signals for information transmission. ***(4 marks)***

d) With the help of a block diagram describe the elements of a communication system. State *five* transmission channels commonly used. *(4 marks)*

8.

a) State the *sampling theorem* and *Nyquist sampling rate*. If voice signal has *4kHz* as a maximum frequency what will be its Nyquist sampling rate. ***(6 marks)***

b) Assume that the band-limited function

$$x(t) = \frac{\sin 20\pi t}{\pi t}$$

is sampled at *19 samples/second*. The sampling function is a unit height pulse train with pulse widths of *1 msec*. The waveform forms the input to a low-pass filter with cut-off frequency of *10 Hz*, as illustrated in Figure 2. Find the output of the low-pass filter and compare this with the original *x(t)*. ***(10 marks)***

c) State *advantages* and *disadvantages* of Pulse Amplitude Modulation (PAM) over both Pulse Width Modulation (PWM) and Pulse Position Modulation (PPM). ***(4 marks)***

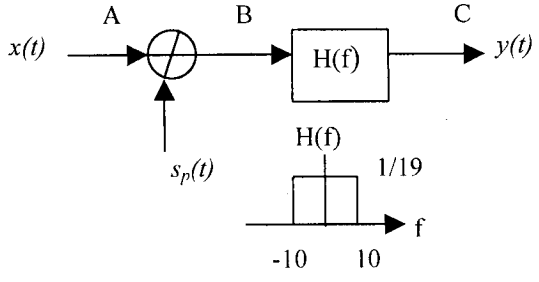

Figure 2

END OF EE 471-TELECOMMUNICATIONS EXAMINATION

Mr. S.TEMBO August 2003

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

UNIVERSITY EXAMINATIONS - AUGUST, 2003
EE 581: TELECOMMUNICATION THEORY

TIME : **THREE HOURS**

ANSWER : **ANY FIVE QUESTIONS**

TOTAL MARKS : **100**

Q1. (a) What are energy and power signals? How do you classify different systems? What are the different systems?

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

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

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

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

[7+7+6]

Q2. (a) Introduce Markoff sequence after considering a random processX(t). What is a homogeneous Markoff sequence?

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

(c) Consider a telegraph source having two symbols, dot and dash. The dot duration is 0.2 second. The dash duration is 4 times the dot duration. The probability of dot's occurring is twice that of the dash, and the time between symbols is 0.3 second. Calculate the entropy and the information rate of the telegraph source.

[5 + 9 + 6]

(CONTINUED IN PAGE 2)

Q3. (a) A discrete source emits one of five symbols once every millisecond. The symbol probabilities are 1/2, 1/4, 1/8, 1/16, and 1/16, respectively. Find the source entropy and information rate.

(b) State Shannon-Hartley theorem. Discuss its implications in the design of communication systems.

(c) A CRT terminal is used to enter alphanumeric data into a computer through a voice grade telephone line having a usable bandwidth of 3000 Hz and an output S/N ratio of 15. Assume that the terminal has 128 characters and that the data sent from the terminal consist of independent sequences of equiprobable characters.

(i) Find the capacity of the channel.

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

[5 + 7 + 8]

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

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

$$\begin{bmatrix} 100 & 110 \\ 010 & 100 \\ 001 & 011 \end{bmatrix}$$

Find the code vectors for the message blocks D = (111) and D = (001). Show the procedure for the computations.

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

(d) Calculate the syndrome if the received vector in a (7,4) block code is R=(1010001). The parity check matrix H is given as

$$H = \begin{bmatrix} 1110 & 100 \\ 1101 & 010 \\ 1011 & 001 \end{bmatrix}$$

If a single bit is in error, determine which bit?

[4 + 5 + 5 + 6]

(CONTINUED IN PAGE 3)

Q5. (a) Show the architecture of the DQDB metropolitan area network. Discuss briefly the working of the DQDB network.

(b) Discuss pure and slotted ALOHA protocols. Derive their formulae for throughputs. Compare them. Indicate clearly their applications.

(c) A group of N stations share a 64-kbps slotted ALOHA channel. Each station outputs a 1000-bit frame on an average of once every100 second, even if the previous one has not been sent (e.g., the stations are buffered). What is the maximum value of N?

[6 + 8 + 6]

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

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

Calculate the total number of bits in the frame and the overall bit rate of T1 carrier.

(c) What are differential PCM systems? What is delta modulation? What is the advantage of delta modulation system?

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

[6 + 5 + 5 + 4]

Q7. (a) Explain 1-persistent CSMA, non-persistent CSMA and p - persistent CSMA protocols. Compare them. Compare them with ALOHA protocols also. Show the throughput versus offered load characteristics of all the protocols in a diagram.

(b) Explain CSMA/CD protocol showing its states in a suitable diagram.

(c) Calculate the contention slot width of the CSMA/CD protocol in a 1-km long coaxial cable when the time for a signal to propagate between the two farthest stations is 5 μsec.

[11 + 6 + 3]

Q8. Write short notes on any four:

(a) Spread spectrum communication
(b) ASK and FSK
(c) Probability mass function
(d) ISO/OSI and TCP/IP reference models
(e) Client-server model
(f) Stationarity, Time Averages, and Ergodicity.

[20]

END OF QUESTION PAPER.

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

UNIVERSITY EXAMINATIONS – SEMESTER I AUGUST 2003
EE 471- TELECOMMUNICATIONS

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

1.

a) Compare the average transmitter power and channel bandwidth requirements of DSB, SSB, and AM schemes for transmitting an audio signal with a bandwidth of *10 kHz* with a destination signal-to- noise ratio of *50 dB*. Assume that channel introduces a *50 dB* power loss and that the noise power spectral density at the receiver input is 10^{-12} *watt/Hz*. Assume mS_x= *0.5* for AM. ***(10 marks)***

b) Compare the transmitted power and bandwidth requirements of an FM system, an AM system, and a DSB system designed to produce $(S/N)_d = 60\ dB$. The message signal is a video signal with the following characteristics:
$max|X(t)| = 1,\ E\{X^2(t)\} = 0.5,\ and\ f_x = 5\ MHz$
Assume that the channel noise has a *psd* $(0.5)(10^{-14})$ *watt/Hz* and that the channel introduces a 60-*dB* power attenuation. Assume a modulation index of 100% for the AM and a deviation ratio of 5 for the FM. ***(10 marks)***

2.

a) Define *standing waves* on a transmission line. ***(2 marks)***

b) With the help of diagrams illustrate the difference between standing waves on a short-circuited transmission line and that of standing waves on an open-circuited transmission line. ***(4 marks)***

c) A transmission line has a reflection coefficient of 0.6. Calculate the SWR. ***(2 marks)***

d) State and briefly explain *three* major types of energy loss that occur in a transmission line. ***(6 marks)***

e) Draw the *electrical equivalent* of a transmission line and that of a lossless transmission line. And each of these, state their characteristic impedance. ***(4 marks)***

f) Given a *lossless* transmission line with inductive and capacitive values of $0.1\mu H/m$ and *100 pF/m*, calculate the characteristic impedance. ***(2 marks)***

3.

a) An AM waveform is shown in Figure 1. Assume the message signal is sinusoidal.

(i) Calculate the modulation index, *m*, and the percentage of modulation, η. ***(2 marks)***

(ii) Calculate the carrier power (P_c), sideband power (P_{sb}), total power (P_t) and power efficiency (ε). ***(8 marks)***

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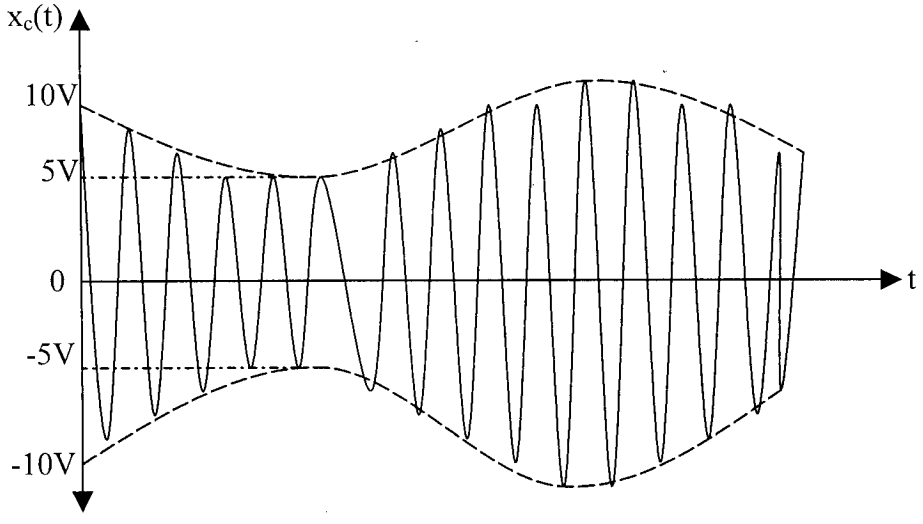

Figure 1. AM waveform

b)

(i) The AM signal $v(t)=(1+m\cos\omega_m t)\cos\omega_c t$, with *m* a constant $(m \le 1)$, is applied to the diode demodulator called envelope detector. If the demodulator is to follow the envelope at all times 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)***

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

4.

(a) A 20 MHz carrier is frequency modulated by a sinusoidal signal such that the peak frequency deviation is 100 kHz. Determine the modulation index,β, (and state either NBFM or WBFM) and the approximate bandwidth of the FM signal if the frequency of the modulating signal is:

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5.

a) Consider an audio signal comprised of the sinusoidal term

$s(t) = 3\cos 500\pi t$

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(i) Amplitude shift keying (ASK) is to be used to transmit binary data with a given value of carrier amplitude, A, and noise power per hertz, N_o. Prove that a modulation index of $m = 1$ yields the minimum bit error rate. *(6 marks)*

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6.

a)

(i) Determine the spacing required for parallel wire transmission line if the wire size is *0.01 cm* and the characteristic impendence is *150 Ω*.. *(3 marks)*

(ii) State briefly *why* the design for a characteristic impedance of *150 Ω*, in part (i), is not a practical configuration. Explain how to accomplish the *150 Ω* impedance. ***(3 marks)***

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7.

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a) State the *sampling theorem* and *Nyquist sampling rate*. If voice signal has *4kHz* as a maximum frequency what will be its Nyquist sampling rate. ***(6 marks)***

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is sampled at *19 samples/second*. The sampling function is a unit height pulse train with pulse widths of *1 msec*. The waveform forms the input to a low-pass filter with cut-off frequency of *10 Hz*, as illustrated in Figure 2. Find the output of the low-pass filter and compare this with the original *x(t)*. ***(10 marks)***

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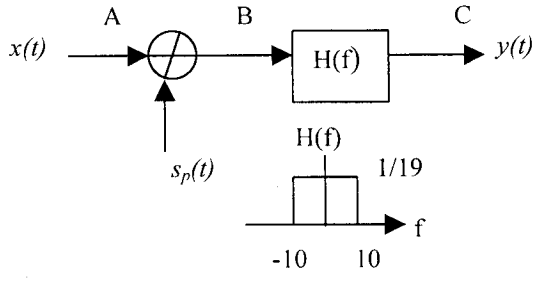

Figure 2

END OF EE 471-TELECOMMUNICATIONS EXAMINATION

Mr. S.TEMBO August 2003

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

UNIVERSITY EXAMINATIONS - AUGUST, 2003
EE 581: TELECOMMUNICATION THEORY

TIME : **THREE HOURS**

ANSWER : **ANY FIVE QUESTIONS**

TOTAL MARKS : **100**

Q1. (a) What are energy and power signals? How do you classify different systems? What are the different systems?

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

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[7+7+6]

Q2. (a) Introduce Markoff sequence after considering a random processX(t). What is a homogeneous Markoff sequence?

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

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[5 + 9 + 6]

(CONTINUED IN PAGE 2)

Q3. (a) A discrete source emits one of five symbols once every millisecond. The symbol probabilities are 1/2, 1/4, 1/8, 1/16, and 1/16, respectively. Find the source entropy and information rate.

(b) State Shannon-Hartley theorem. Discuss its implications in the design of communication systems.

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[20]

END OF QUESTION PAPER.

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

UNIVERSITY EXAMINATIONS - AUGUST, 2003
EE 581: TELECOMMUNICATION THEORY

TIME : **THREE HOURS**

ANSWER : **ANY FIVE QUESTIONS**

TOTAL MARKS : **100**

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

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Q3. (a) A discrete source emits one of five symbols once every millisecond. The symbol probabilities are 1/2, 1/4, 1/8, 1/16, and 1/16, respectively. Find the source entropy and information rate.

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(c) A CRT terminal is used to enter alphanumeric data into a computer through a voice grade telephone line having a usable bandwidth of 3000 Hz and an output S/N ratio of 15. Assume that the terminal has 128 characters and that the data sent from the terminal consist of independent sequences of equiprobable characters.

(i) Find the capacity of the channel.

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$$\begin{bmatrix} 100 & 110 \\ 010 & 100 \\ 001 & 011 \end{bmatrix}$$

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UNIVERSITY EXAMINATIONS - AUGUST, 2003
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THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

SEMESTER I FINAL EXAM – AUGUST 2003

EG 212 WORKSHOP TECHNOLOGY

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

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

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

SECTION A: AGRICULTURAL ENGINEERING

ANSWER: Question 1 OR Question 2

Question 1

a) What takes place in the induction or intake stroke of a four stroke engine. (5 marks)
b) Why is the Fuel Equivalent Power always greater than the Brake power in internal combusti engines. (5 marks)
c) It is desired to investigate the hydropower potential of a site. What two main site characteris would you look at and why. (5 marks)
d) Why is water quality important in irrigation. (5 marks)

Question 2

a) What are the two classes of machinery costs. Give examples. (4 marks)
b) Why is process control necessary in Food Process Engineering. (8 marks)
c) What are the four basic components of a sprinkler irrigation system. (4 marks)
d) What is Biogas. Give two examples of it's use. (4 marks)

SECTION B: CIVIL ENGINEERING

ANSWER: Question 3 OR Question 4

Question 3

a) What is the composition of concrete? (2 marks)
b) Define reinforced concrete. (2 marks)
c) Give the reason for using clean sand when making concrete. (2 marks)
d) Mention two reasons for adding coarse aggregate when making concrete. (3 marks)
e) Concrete can be stronger than the coarse aggregate in it. True or false? (3 marks)
f) What is a pitched roof? (2 marks)
g) What two advantages does a pitched roof have which flat roofs do not. (2 marks)
h) What roof members are connected to the ridge of a roof? (2 marks)
i) What are the main load bearing members of a roof? (2 marks)

Question 4

a) The ratio of cement to sand is not the greatest determining factor for strength, other things b normal. True or false? (3 marks)

b) Does concrete lose strength when sand and cement separate in already mixed concrete? (2 marks)

c) How can you tell that concrete has set? (3 marks)

d) Define a lintel. (2 marks)

e) What can cause sagging of a concrete slab? (2 marks)

f) What is the function (s) of wall plates? (2 marks)

g) Give two basic requirements of roof coverings. (2 marks)

h) Mention the three disadvantages of galvanised steel or iron sheets. (2 marks)

i) What concern is attached to the use of asbestos cement sheets? (2 marks)

SECTION C: ELECTRICAL ENGINEERING

ANSWER: ALL QUESTIONS

Question 5

a) In a domestic installation briefly explain why it is necessary to bond the hot and ~~hot~~ cold water t (2 marks)

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b) Why are most Radio Frequency transformers shielded? (1 mark)

c) Name one typical application of variable air capacitors (1 mark)

d) Give two examples of active components used in electronic circuits (1 mark)

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f) What is engineering maintenance? Mention the two types of maintenance principles. (3 marks)

SECTION D: GEOMATIC ENGINEERING

ANSWER: Question 7 or Question 8

Question 7

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

i. Geomatics
ii. Remote Sensing
iii. Tilting level
iv. Topographic Surveys
v. Whole Circle bearing (WBC)

(2+2+4+2 marks)

b) 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:

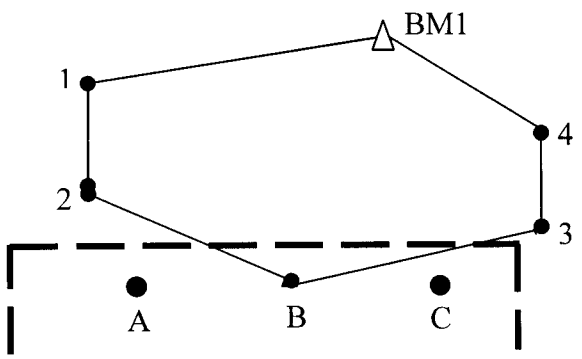
A	2675.65m	4998.76m
B	3551.25m	4585.15m
C	3182.68m	4567.83m
D	2187.94m	4687.75m

Calculate the distances and bearings of lines ***AB, CD*** and ***DA***. The reference direction for the bearings is the South. The farmer wants the bearings in both the sexagesimal (degrees, minutes and seconds) and the centesimal systems.

(3+7 Marks)

Question 8

At a building site there was need to determine the heights of three points. These temporary benchmarks were established through a levelling survey. In the following scenario the levels of the points A, B, and C are to be determined. The loop runs from BM1 to the site and back to BM1. The reduced level of BM1 is 1281.130m.



a) Complete the levelling form provided using the Rise and Fall method and apply the necessary checks.

b) Owing to the existence of random errors in measurements (errors that remain after gross and systematic errors have been eliminated) the measured height difference will differ from th

known. This resulting discrepancy is known as the Misclosure. You are required to calculate actual misclosure for the levelling circuit above. (10+ 5 + 5 marks)

Name: Instrument:
Date: Weather:

LEVELLING

POINT	READINGS			DISTANCE		HEIGHT DIFF		REDUCED LEVEL	REMARKS
	BS	IS	FS	BS	FS	RISE	FALL		
BM1	1.717			55.6				1281.130	
1	1.342		2.321	59.3	53.2				
2	0.983		0.674	58.8	51.4				
A		1.332							
B	2.132		1.523	55.7	57.5				
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3	2.341		1.553	52.6	54.5				
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BM1			2.765		55.7				

SECTION E: MECHANICAL ENGINEERING

ANSWER: Question 9 OR Question 10

Question 9

An aluminium cylinder has the following specifications:

Outside diameter	=	90 mm
Length	=	150 mm
Wall thickness	=	12 mm

Describe how the cylinder could be manufactured using the green sand casting process. Give clea labeled sketches to illustrate your answer. (20 marks)

Question 10

Using clearly labeled sketches give an outline of each one of the following machine shop processe

(i) Drilling
(ii) Turning
(iii) Shaping
(iv) Milling

(20 marks)

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

SEMESTER I FINAL EXAM – AUGUST 2003

EG 212 WORKSHOP TECHNOLOGY

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

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

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

SECTION A: AGRICULTURAL ENGINEERING

ANSWER: Question 1 OR Question 2

Question 1

a) What takes place in the induction or intake stroke of a four stroke engine. (5 marks)
b) Why is the Fuel Equivalent Power always greater than the Brake power in internal combustion engines. (5 marks)
c) It is desired to investigate the hydropower potential of a site. What two main site characteristics would you look at and why. (5 marks)
d) Why is water quality important in irrigation. (5 marks)

Question 2

a) What are the two classes of machinery costs. Give examples. (4 marks)
b) Why is process control necessary in Food Process Engineering. (8 marks)
c) What are the four basic components of a sprinkler irrigation system. (4 marks)
d) What is Biogas. Give two examples of it's use. (4 marks)

SECTION B: CIVIL ENGINEERING

ANSWER: Question 3 OR Question 4

Question 3

a) What is the composition of concrete? (2 marks)
b) Define reinforced concrete. (2 marks)
c) Give the reason for using clean sand when making concrete. (2 marks)
d) Mention two reasons for adding coarse aggregate when making concrete. (3 marks)
e) Concrete can be stronger than the coarse aggregate in it. True or false? (3 marks)
f) What is a pitched roof? (2 marks)
g) What two advantages does a pitched roof have which flat roofs do not. (2 marks)
h) What roof members are connected to the ridge of a roof? (2 marks)
i) What are the main load bearing members of a roof? (2 marks)

Question 4

a) The ratio of cement to sand is not the greatest determining factor for strength, other things bei normal. True or false? (3 marks)

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c) How can you tell that concrete has set? (3 marks)

d) Define a lintel. (2 marks)

e) What can cause sagging of a concrete slab? (2 marks)

f) What is the function (s) of wall plates? (2 marks)

g) Give two basic requirements of roof coverings. (2 marks)

h) Mention the three disadvantages of galvanised steel or iron sheets. (2 marks)

i) What concern is attached to the use of asbestos cement sheets? (2 marks)

SECTION C: ELECTRICAL ENGINEERING

ANSWER: ALL QUESTIONS

Question 5

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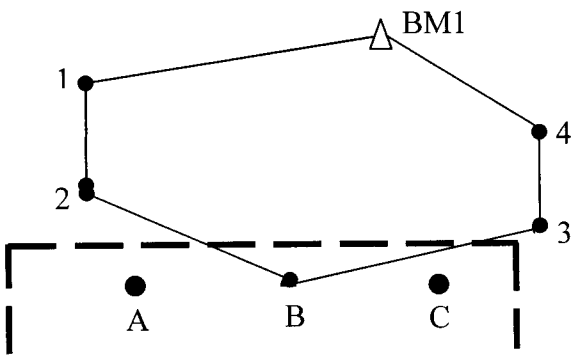

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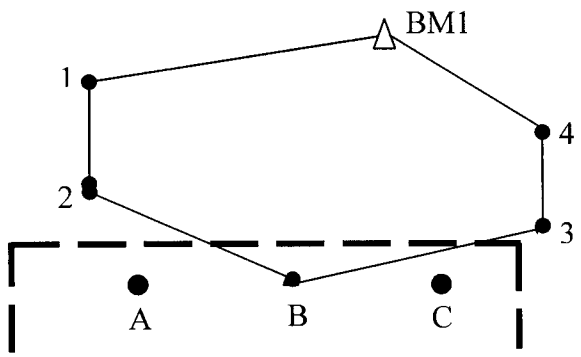

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END OF EXAM

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS

AUGUST 2003

EM 311 – ENGINEERING MATHEMATICS III

INSTRUCTIONS:

1. Answer any FIVE **(5)** questions.
2. All questions carry equal marks.
3. Show all your working to earn full credit.
4. Use of calculators is allowed.

TIME ALLOWED: Three (3) hours.

---

[1] (a) Verify that $y = -\frac{1}{2}x^2e^{-x}$ is a solution of the equation $y''' - 2y = 3e^{-x}$

(b) Find the complete solution of the initial value problem $y''' - 3y' - 2y = 3$

$$y'' + y' + y = 0,\ y(0) = 1,\ y'(0) = 3.$$

[2] Verify that the following equations are exact and find the general solution. Find a particular solution where the initial condition is given.

(a) $\left(4x^3y^3 + \frac{1}{x}\right)dx + \left(3x^4y^2 - \frac{1}{y}\right)dy = 0$, x(e) = 1

(b) $\left(\frac{1}{x} - \frac{y}{x^2+y^2}\right)dx + \left(\frac{x}{x^2+y^2} - \frac{1}{y}\right)dy = 0$

[3] The equation below is in the form of Bernoulli's equation. Find a general solution of the following.

(a) $x^2y^3\frac{dy}{dx} - xy^4 = -\frac{5}{2}x^4y^6$

(b) Find the inverse Laplace transform $\mathcal{L}^{-1}$ (s) of the function below

$$\frac{2s+3}{S^2-2s+5}$$

(c) Solve the system of first order non-homogenous differential simultaneous equations by elimination method.

$$x' = -2x + y$$
$$y' = -4x + 3y + 10\cos t$$

[4] Verify that $y_1(x)$ and $y_2(x)$ are solutions of the given second order differential equations and find a second linear independent solution in each case

(a) $x^2y'' - 2xy' + (x^2 + y^2)y = 0,\ (x > 0)$
$y_1(x) = x\sin x$

(b) $y'' - \left(\frac{2x}{1-x^2}\right)y' + \left(\frac{6}{1-x^2}\right)y = 0,\ |x| < 1,\ y_2(x) = \frac{3x^2 - 1}{2}$

[5] Using the method of undetermined co-efficient , solve the following equation.

(a) $\frac{3xy''}{2} - 18xy' = \frac{3}{2}xe^x \sin x$

(b) (i) Define the unit step function $u_a(a), a > 0$ and sketch its graph.
(ii) State the second shift theorem.
(iii) Solve the initial value problem using Laplace transformation

$y'' + 4y' + 3y = 0 \qquad y(0) = 3, \qquad y'(0) = 1$

[6]. Find the two half range expansions of the following function which is assumed to have the period L

$$f(x) = \begin{cases} \frac{2k}{L}x & \text{if } 0 < x < \frac{L}{2} \\ \frac{2k}{L}(L - x) & \text{if } \frac{L}{2} < x < L \end{cases}$$

END OF EXAMINATION, GOOD LUCK

The University of Zambia
School of Engineering
Department of Geomatic Engineering
End of Semester Exam - 19/08/2003
Course: GE371 Surveying I

Time : 3 hrs
Marks : 100

Answer Any four (4) Questions

Question 1 [4,6,3,6,3,3]

a. Give any four (4) applications of reduced levels.

b. Discuss the effects of curvature and refraction in levelling. Illustrate your answer.

c. Define the term 'differential levelling'.

d. State and briefly explain the two systems in which a feature can be represented in plan surveying.

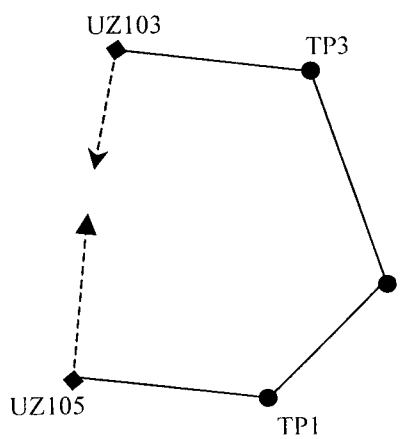
e. If a defective levelling staff is used in a levelling operation and it is such that a piece 10 cr long is cut off from the bottom, what would be the effect on the heigted points.

f. With what distance of the line of sight in levelling can you encounter an error of 10 mm du to effects of curvature of the earth and refraction of the line of sight?

Question 2 [25]

Station	Adjusted Measured Angles			Length (m)
	°	′	″	
UZ105	308	25	22	62.323
TP1	201	17	51	95.246
TP2	229	37	45	71.322
TP3	227	36	~~09~~ 11	79.558
UZ103	293	02	51	

Sketch of the traverse

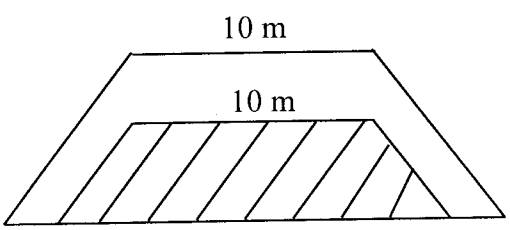


Control Points

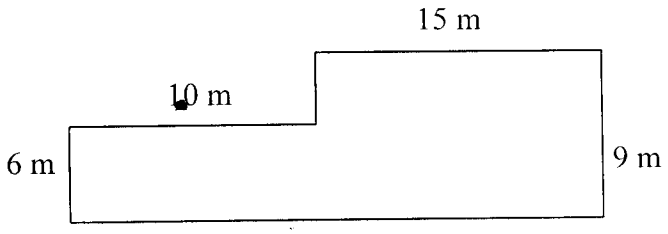
UZ 105	642961.284 m	8297872.029 m
UZ 103	643101.863 m	8298040.530 m

Above is data obtained in a traverse carried out to extend the control within a project site. Compute and adjust the traverse, giving also the relative accuracy of the traverse by Bowditch Method.

Question 3 [25]



Side view



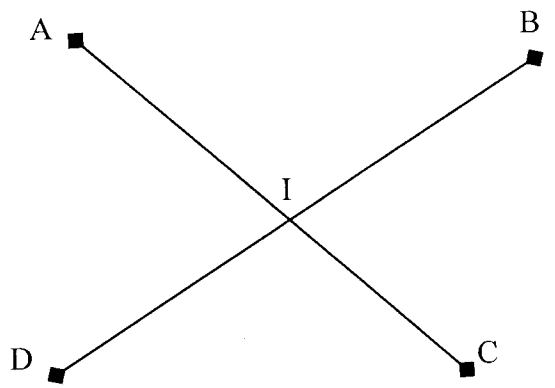
Longitudinal view

(Figures not to scale)

A trainee Geomatic Engineer was tasked to determine the volume of gravel that has to be removed from an embankment that was wrongly established. The height of the embankment that has to be maintained is 6m for the whole length (see shaded size above). Help this trainee engineer to determine the volume by use of cross section areas, given the side slope as 1 in 2.

Question 4 [25]

If point I lies at the intersection of four known points as shown in the figure below, determine its coordinates



Control Points

	Y	X
A	(2040.280,	17000.890) m
B	(2100.120,	16995.573) m
C	(2090.680,	16950.730) m
D	(2035.002,	16950.730) m

Question 5 [6, 4, 5, 6, 2, 2]

a. Mention any two (2) indirect distance measurement methods, mentioning also the types of instruments used and the quantities that are measured in the field.

b. State any four (4) reasons that could render a traverse not to close (or have an unacceptable angular & linear misclosure).

c. A steel tape with nominal length of 30 m was used in a survey to determine the area of a square parcel of land. After computing the area, which was 428.07 m², it was realised that the tape had not been standardised for a long time. After standardisation, it was found to be 29.990m. Determine the actual (true) area of the parcel?

d. If a parcel of land is bordered by both regular and irregular sides, how would you determine its area? Illustrate your explanation, stating also formulas if any.

e. Give two reasons as to why intersection is more applicable than resection in point positioning.

f. With the help of a sketch, state any combination of quantities that can be measured in intersection.

End of Exam

Wishing You a Nice Semester Break!

For Question 2

Computer No:..

TRAVERSE COMPUTATION FORM

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

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

The University of Zambia

School of engineering

Department of Geomatic Engineering

University Examinations – Semester I

GE 481: Introduction to Surveying **August 2003**

Instructions

Time: Three (3) hours.

Answer four (4) questions in total

Three (3) from section A for all students. Use tables provided at the back

One (1) question from section B for Engineering and Agricultural Science Students

One (1) question from section C for Geology Students.

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

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

1. The four corners ***A***, ***B***, ***C*** and ***D*** of a rectangular building were set out by intersection from two control points ***G*** and ***H***. After the setting out had been completed, the reduced levels of ***A***, ***B***, ***C*** and ***D*** were taken and the lengths of the diagonals were measured with a steel tape of length 29.995m. The setting out and measurement data are given in table 1.

Calculate:

i) The bearings required to establish points ***A*** and ***B*** from both control points

ii) The error between the designed value and the set out value of the horizontal length of each diagonal. Assume that the ground slope along each diagonal was uniform.

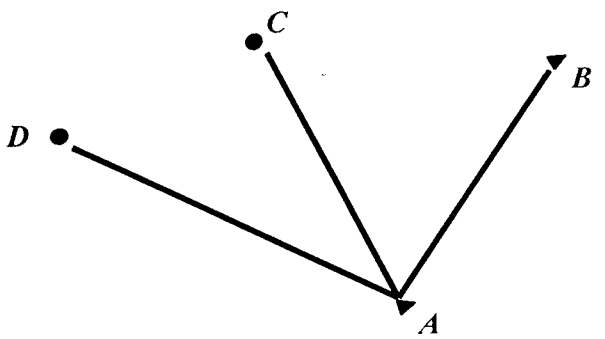
Table 1.

	Coordinates		
Point	*m E*	*m N*	*RL (m)*
A	641.710	513.110	27.120
B	677.065	548.465	28.715
C	705.349	520.181	25.050
D	669.994	484.826	30.475
G	601.520	525.730	
H	720.660	540.125	
Slope length along diagonal ***AC*** = 64.075m			
Slope length along diagonal ***BD*** = 64.080m			

[16 + 9 Marks]

2. In order to determine the plane coordinates of points *C* and *D*, a minute Theodolite was correctly mounted above point A. The distances *AC* and *AD* were measured twice along the slope with a tape as 160.936m and 272.155m. The known coordinates of *A* and *B* are:

A 38853.807mE 11276.044mN
B 38941.835mE 11280.506mN



The horizontal angles from point *A* are observed in two rounds and for the vertical angle only one FL and FR reading are taken.

Horizontal angles ~~(grades)~~ DEGREES

Pnt	Readings		Simple Mean	Reduced Mean	Remarks
	FL	FR			
B	254 52 52	74 52 48			
C	211 27 31	31 27 27			
D	180 10 06	00 10 04			
B	344 50 05	164 50 01			
C	301 24 40	121 24 39			
D	270 07 21	90 07 17			

Vertical angles

Pnt	Readings		Reduced FL	Reduced FR	Mean
	FL	FR			
C	88 39 49	271 20 16			
D	84 45 17	275 14 47			

a) Complete the booking forms.

[7 Marks]

b) Calculate the co-ordinates of points *C* and *D*.

[12 Marks]

c) In order to measure angles with a relatively high order of accuracy, so that the effects of certain systematic and random errors are minimised as much as possible, we use the so-called Bessel –rounds. Describe the rules that must be followed by this approach.

[6 Marks]

3. A leveling trajectory was carried out at a construction site near the University of Cape Town. The circuit began and closed at TBM1 with RL 1284.263. Results arising from that level survey are given in the table below.

Name: Instrument:
Date: Weather:

LEVELLING

PNT	UPPER/ LOWER	READINGS			DISTANCE		HEIGHT DIFF		REDUCED LEVEL
		BS	IS	FS	BS	FS	RISE	FALL	
BM1	1.368/0.904	1.135							
	2.303/1.857			X				0.946	
1	2.415/1.855	X							
	1.801/1.406			X					1283.850
2	2.005/1.754	1.881							
	1.873/1.621		1.746						
	1.821/1.528		X				0.072		
	2.405/1.904		X					0.480	
	2.414/2.140			2.277					
3	2.512/2.095	2.304							
	1.877/1.531		1.704						
	2.198/1.790			1.993					
4	1.951/1.459	1.705							
	1.811/1.303		X				0.147		
	2.115/1.908		X					0.453	
	2.675/2.601		2.638						
	1.258/0.907			1.084					
BM1	2.301/1.867	2.083							
	2.413/1.986			X					
	Σ	**11.244**		**11.237**			**3.041**	**3.034**	

a) Fill in the missing readings and complete the leveling booking form. Carry out all necessary checks.

[10 Marks]

b) Compute the allowable and actual misclosures. State whether the latter is acceptable (assume σ = 30mm).

[5 Marks]

c) Calculate the adjusted levels of all the points in this levelling loop.

[6 Marks]

d) Describe at least two other methods of levelling.

[4 Marks]

4. The Theodolite is said to be the most important instrument in Surveying. From the determination of angles between points to heighting in Mountainous terrain. Describe its various parts with the aid of a clearly labelled diagram. Furthermore, explain what Transitting of the Theodolite is and why it's necessary.

[15 +10 Marks]

End of Section A

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

Question 5

(i) Some of the processes involved in a GIS are Data Collection and Manipulation and analysis. Briefly describe clearly what is involved in:
   a) Data Collection
   b) Manipulation and analysis

(ii) One of the main problems in a GIS realisation is the long development cycle. Briefly explain how this problem affects a GIS realisation.

[16 + 9]

Question 6

(i) List three main benefits of a GIS.
(ii) Briefly explain each of the benefits listed in (i) above.
(iii) In implementing a GIS, why must people in the organisation be made aware of the technology and its benefits?

[6 + 9 + 10]

End of Section B

Section C: Geology Students only.
Answer any question from this Section

Question 7: Geological Mapping Preparations

a) Describe the uses of the following
   i. Aerial photograph
   ii. Topographic map

b) Name two major purposes of a compass
c) Describe four ways by which you determine your position in the field.

[25 Marks]

Question 8: Geological Mapping Procedures

a) Give a detailed description of the stages involved in Geological mapping from your first day in the field till the last.
b) Give a full description of one of the methods used in measuring Geological planes.

[25 Marks]

END OF EXAMINATION

Good Luck

Exam No: **Exam Centre:**

Date:

Table for question 1:

Remember to attach the completed table to your answer booklet for Section A

Horizontal angles (grades)

Pnt	Readings		Simple Mean	Reduced Mean	Remarks
	FL	FR			
B	254 52 52	74 52 48			
C	211 27 31	31 27 27			
D	180 10 06	00 10 04			
B	344 50 05	164 50 01			
C	301 24 40	121 24 39			
D	270 07 21	90 07 17			

Vertical angles

Pnt	Readings		Reduced FL	Reduced FR	Mean
	FL	FR			
C	88 39 49	271 20 16			
D	84 45 17	275 14 47			

Exam No: **Exam Centre:**
Date:

Table for question 3:
Remember to attach the completed table to your answer booklet for Section A

LEVELLING

PNT	UPPER/ LOWER	READINGS			DISTANCE		HEIGHT DIFF		REDUCED LEVEL
		BS	IS	FS	BS	FS	RISE	FALL	
BM1	1.368/0.904	1.135							
	2.303/1.857							0.946	
1	2.415/1.855								
	1.801/1.406								1283.850
2	2.005/1.754	1.881							
	1.873/1.621		1.746						
	1.821/1.528						0.072		
	2.405/1.904							0.480	
	2.414/2.140			2.277					
3	2.512/2.095	2.304							
	1.877/1.531		1.704						
	2.198/1.790			1.993					
4	1.951/1.459	1.705							
	1.811/1.303						0.147		
	2.115/1.908							0.453	
	2.675/2.601		2.638						
	1.258/0.907			1.084					
BM1	2.301/1.867	2.083							
	2.413/1.986								
	Σ	**11.244**		**11.237**			**3.041**	**3.034**	

University of Zambia

Department of Geomatic Engineering

Semester 1 Examination

GE 561 – PRINCIPLES OF GIS/LIS

Duration: 3 hours
Total points: 100
Answer four (4) questions. Question 1 is compulsory.

Question 1 (5+5+5+10 points)

In Lusaka, a number of areas that were once wetlands have been converted into residential areas. The effect is that the City has been losing its biodiversity, which could have adverse effects not only on the physical environment itself but also on the health of the people.

As a GIS professional you are assigned the task of solving this problem by identifying suitable sites for residences.

(a) Describe what the GIS problem here is.
(b) What are the data required to solve the problem for the whole City of Lusaka?
(c) From which sources (or organisations) would you get the data?
(d) Assuming you have all the data in analogue form, what are the activities required to solve the problem?

Question 2 (10+10+5 points)

(a) What is spatial referencing? Give three examples of the spatial referencing items you can find on the Zambian 1:50,000 scale topographic map.
(b) What is the International Terrestrial Reference System (ITRS)?
(c) How can the ITRS be of use to Zambia within the field of GIS?

Question 3 (9+6+10 points)

(a) What are the different digitising techniques? Explain how they are performed.
(b) Which technique would you apply in each of the following cases?
    1. a map with only one type of information
    2. an image with few types of information that require some interpretation

3. an image full of details and symbols e.g. a topographic map

(c) Assuming vector data, mention five clean-up operations that are possible after digitising a paper map.

Question 4 (5+5+5+5+5 points)

GIS functions may be classified as follows:
(a) Measurement, spatial query and classification functions
(b) Overlay functions
(c) Neighbourhood functions
(d) Network functions
(e) 3D data analysis
Briefly explain what each of these functions does in a GIS.

Question 5 (5+6+6+8 points)

(a) What is data visualisation?
(b) Differentiate between GIS spatial data and maps.
(c) Describe three (3) ways in which a time series can be mapped.
(d) Describe four (4) ways in which terrain elevation can be mapped.

Question 6 (5+5+5+5+5 points)

Briefly explain the following concepts and their roles
(a) Data quality
(b) Data standards
(c) Metadata
(d) Spatial Data Infrastructure (SDI)
(e) Clearing house

THE UNIVERSITY OF ZAMBIA
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DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS
SEMESTER I EXAMINATIONS 2003
ME 331 PROPERTIES OF ENGINEERING MATERIALS

ANSWER: FIVE QUESTIONS: CLOSED BOOK
TIME : THREE HOURS ALL QUESTIONS CARRY EQUAL MARKS

Q1. Describe in detail:
(a) Cottrell clouds
(b) Persistent slip bands
(c) Plasticisation of polymers.
(d) Dislocation climb

Q2. (a) Give a brief account of the group of materials called fibre composites.
(b) Discuss the factors that affect solid solution strengthening.

Q3. (a) Discuss the various stages that a material undergoing high temperature creep may be expected to go through.
(b) Discuss briefly four possible groups into which ceramics may be classified.

Q4. (i) Discuss the dependence of deformation in polymers on
(a) temperature
(b) stress

(ii) Discuss in detail the Bauschinger effect.

Q5. (i) Discuss the following:
(a) Intermediate oxides
(b) Fatigue endurance limit
(c) Devitrified glass

(ii) What is Zirconia?

Q6. (i) Discuss how the following parameters affect creep resistance:
(a) Alloy composition
(b) Grains size

(ii) What is the degree of polymerisation and how does it relate to properties of polymers

Q7. (a) Discussion in detail dynamic strain aging in steels
(b) What is stress relaxation

END OF EXAMINATION

Dr. C.K. Wamukwamba
AUGUST 2003

UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

SEMESTER I EXAMINATIONS • AUGUST 2003

SECTION C: ME 209 ELECTRICAL COMPONENT

TIME AS GIVEN IN THE MECHANICAL COMPONENT
ATTEMPT ONE QUESTION **20 MARKS**

---

1. The diagram Fig. Q1C shows part of a circuit used to control a sliding door, PS1(NO) is a Pressure Mat, PS2 (NO) is a Push Button switch. The relay coil C operates a set of four pole change over contacts. The power supply is 6 VDC. The other components not shown are:-

   i) A permanent magnet dc motor M which operates the mechanism for opening and closing a sliding door.

   ii) MS1 (NC) - a limit switch which is activated when the door is fully closed.

   iii) MS2 (NC) - a limit switch which is activated when the door is fully open.

   Using standard symbols and dimensions given in class draw the Fig. Q1C on A2 paper.

   a) Design and insert the relay latch circuit
   b) Add the motor control circuit such that when the relay coil is de-energised the motor closing operation is initiated. Include MS1 and MS2 switches for automatic operation. ***[20 Marks]***

2. Fig Q2C is a circuit which utilizes Transistor Q (NPN) as a switch. Draw the associated Truth Table .It is now desired to redesign the circuit so as to invert the out put as shown by the LED.Redraw the circuit, on part of the A2 size paper and the associated Truth Table, to realise this goal.. .Using the redrawn circuit as a building block,design and draw an AND LOGIC GATE and the associated Truth Table on the rest of the drawing paper. ***[20 Marks]***

DIAGRAMS Fig Q1C & Fig Q2C FOLLOW ON NEXT PAGE

ME209 SEMESTER I EXAMINATION-AUGUST 2003

DIAGRAMS FOR SECTION C

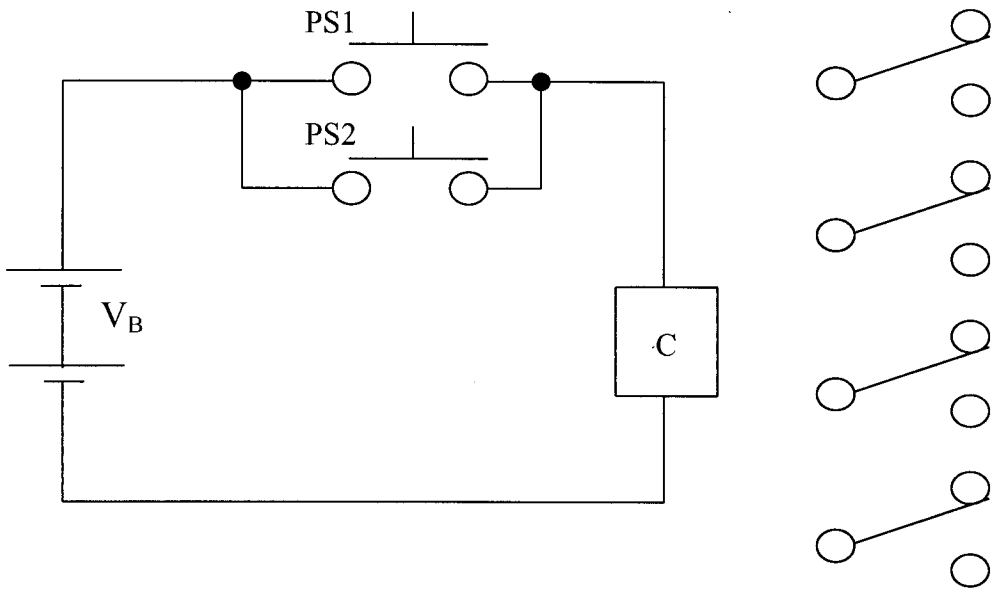

Fig Q 1 C

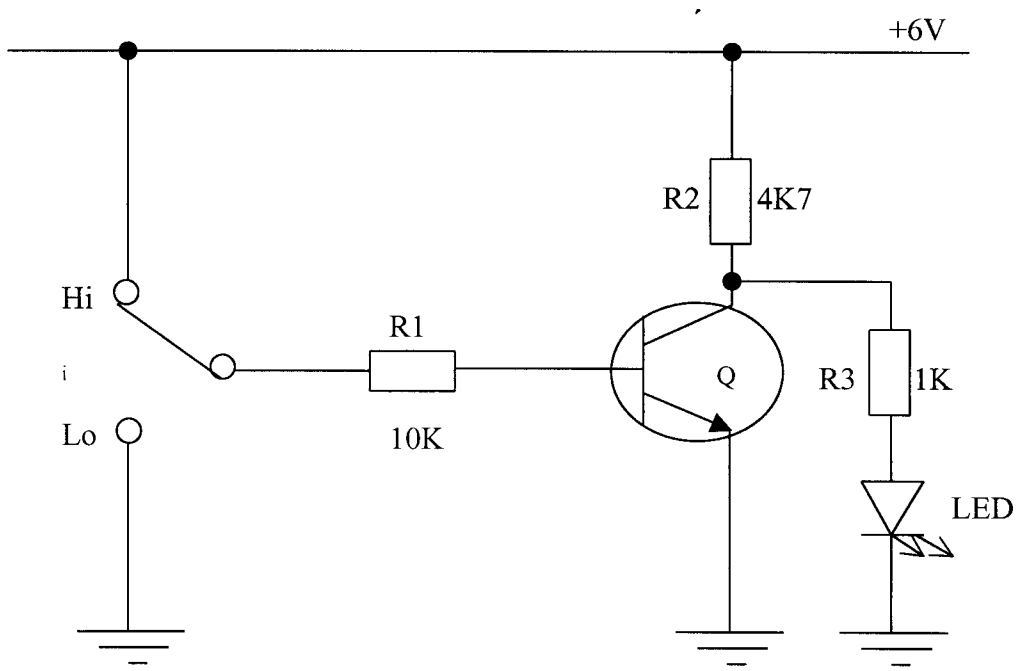

Fig Q 2 C

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UNIVERSITY SEMESTER I EXAMINATIONS 2003

ME 209 – ENGINEERING DRAWING I

TIME ALLOWED: FOUR (4) HOURS
CLOSED BOOK EXAM: TEXT BOOKS AND MARKED TUTORIAL SHEETS ARE NOT ALLOWED

INSTRUCTIONS

1. Answer a total of FOUR (4) questions in the following order:

   SECTION A One question (Compulsory)
   SECTION B Any two (2) questions
   SECTION C Any one (1) Question

2. Indicate your computer number just above the title block & Clearly Label each answered question.

3. Construction lines should not be erased and should be clearly visible.

4. Do not dimension unless otherwise stated.

5. Marks will be awarded for: Correct Solution, Accuracy, Neatness, Layout and Good Line Work

6. All dimensions are in millimeters.

SECTION A (Compulsory)

Q1. **Fig Q1** shows the front and end elevations of a Shift Fork. Draw scale 2-1:

(i) A sectional end elevation along B-B plane and direction
(ii) In place of the given front elevation, a sectional front elevation along A-A plane ar direction
(iii) Show six (6) important dimensions

[40Mark

SECTION B (Answer any TWO (2) questions from this section)

Q2. **Fig Q2** shows the front and plan views of a hexagonal pyramid. Draw to scale 1/1, th pyramid (with edge of base 38mm and vertical height of 100mm), which stands on th horizontal plane with it's axis at 90^0 to the horizontal plane and one diagonal of the bas perpendicular to the vertical plane,

i) a sectioned plan
ii) a sectional front elevation in the direction of the arrow
iii) a sectional end elevation.

[15 Marks

Q3. **Fig Q3 (a)** shows a photograph of a lorry-mounted crane. A line drawing of the crane i its rest position while the lorry is travelling from one place to the other is shown in Fig. **Q3 (b)**

- In use, the arm AB swings clockwise in a vertical arc about A through a maximum o 90^o;
- The arm BC swings clockwise in a vertical arc about B through an angle of 120^o.
- The end C extends from C to C_1.

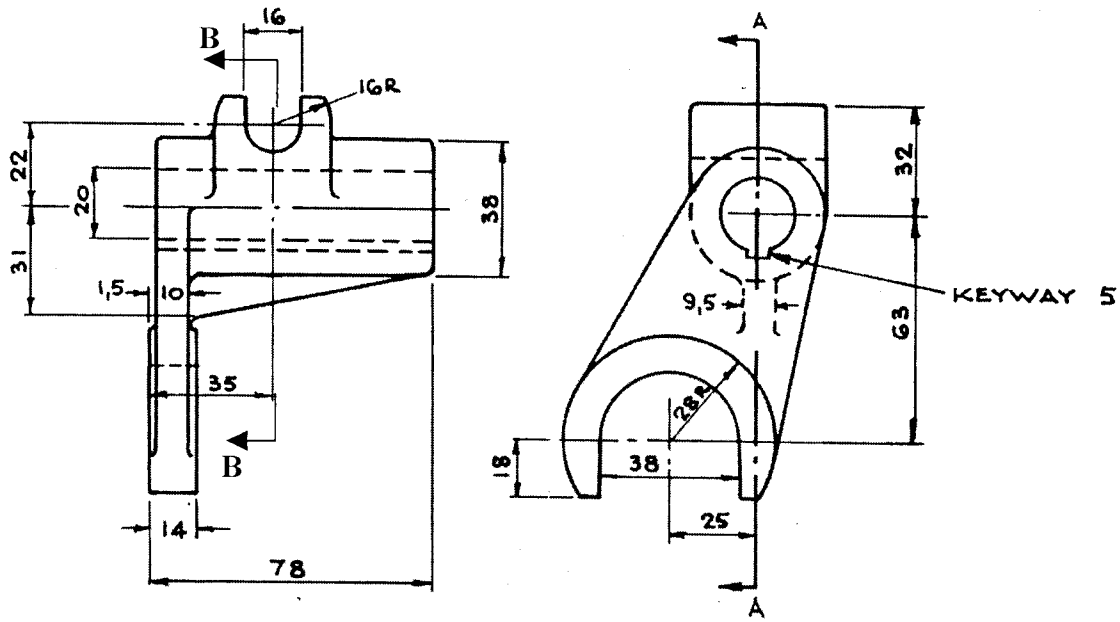
Assuming that each movement is at a uniform velocity and takes place at the same time complete the given view by drawing the locus of C from the given position to the maximun extension of each part of the crane.

[15 Marks

Q4. **Fig. Q4** shows the front elevation of an Oil Can. Draw, scale 1:1,

i) the given front elevation
ii) plan view
iii) an end view
iv) a development surface of part "*B*" with seam located at the stretch labelec 12mm

[15 Marks]



Dimensions in mm

Fig Q1

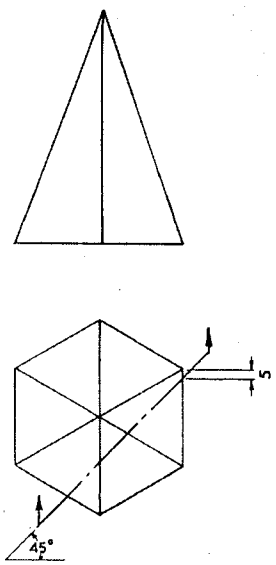


Fig. Q2

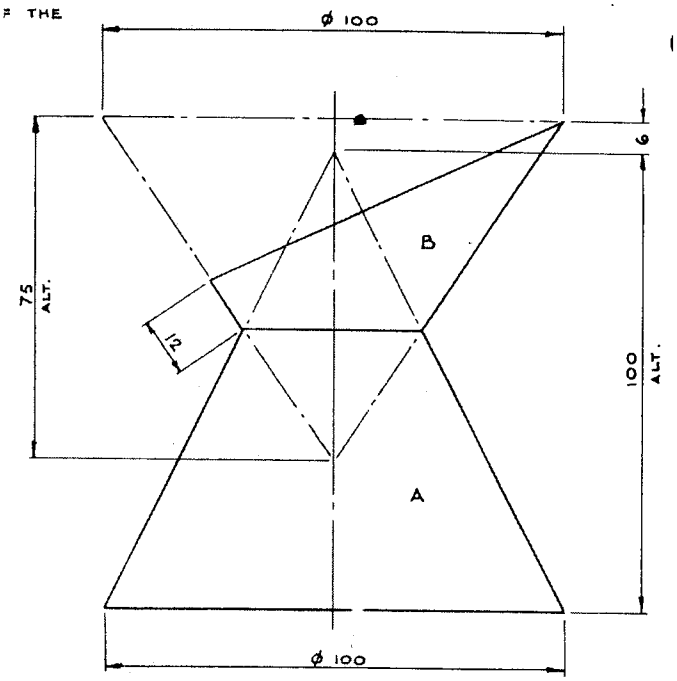


Fig. Q4

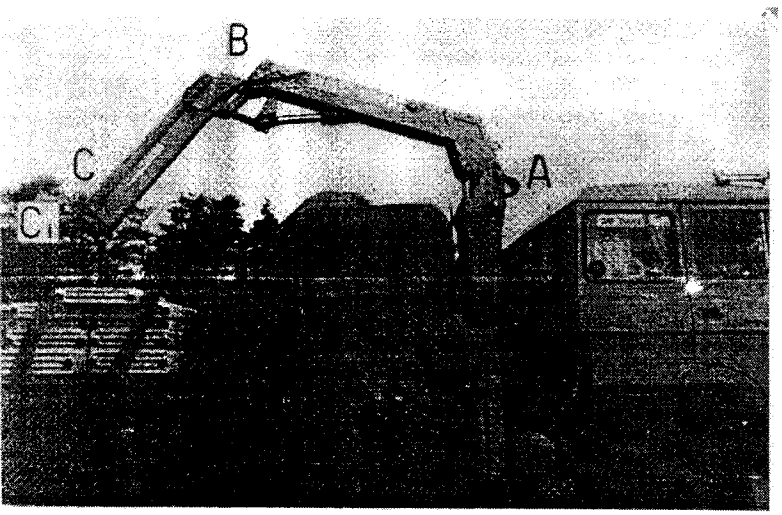


Fig.Q3 (a)

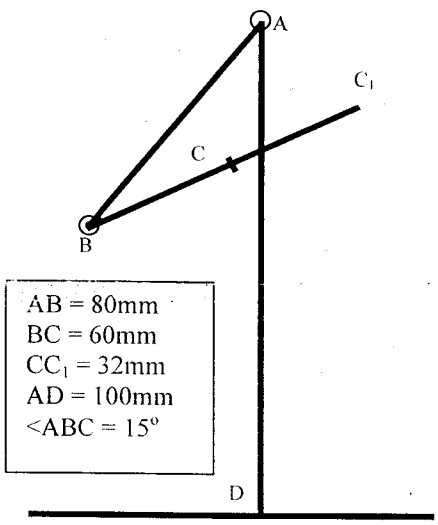


Fig.Q3 (b)

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DEPARTMENT OF MECHANICAL ENGINEERING

2003 UNIVERSITY SEMESTER I EXAMINATIONS - AUGUST 2003

ME 375 – DYNAMICS

Time: THREE (3) HOURS **CLOSED BOOK**

Instructions: Answer Question 1 AND any FOUR (4) others (i.e. Five 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:

(a) The angular velocity of the arm and the velocity of point D.
(b) The angular acceleration of the arm BC and the acceleration of point D.

[24 marks]

Q2. Airplane A is flying north with a constant horizontal velocity of 500 km/hour (see Figure Q2). Airplane B is flying south-west at the same altitude with a velocity of 500 km/hour. From the frame of reference of A, determine the magnitude V_r of the apparent or relative velocity of B. Also find the magnitude of the apparent velocity V_n with which B appears to be moving sideways or normal to its center line.
Would the results be different if the two airplanes were at different but constant altitudes? Explain your answer.

[19 marks]

Q3. A ski jumper moves down the ramp aided only by gravity (Figure Q3). If the skier moves 33 m in the horizontal direction and is to land very smoothly at B, what must be the angle θ for the landing incline? Neglect friction. Also determine *h*.

[19 marks]

Q4. A rotating shaft carries four masses, A, B, C and D, rigidly attached to it; the mass centres are at 30 mm, 36 mm, 39 mm and 33 respectively form the axis of rotation; A, C and D are 7.5 kg, 5 kg and 4 kg; the axial distance between A and B is 400 mm and that between B and C is 500 mm; the eccentricities of A and C are at 90° to one another. Find, for complete balance:

(a) the angles A, B and D
(b) the axial distance between the planes of revolution of C and D, and
(c) the mass B.

[19 marks]

Q5. A circular cylinder of mass m and radius r is connected by a spring of modulus k as shown in Figure Q5. If it is free to roll on the rough horizontal surface without slipping, find its frequency. J_0 is the mass moment of inertia of the cylinder about its center (i.e. $J_o = \frac{1}{2}mr^2$). **[19 marks]**

Q6. In the instant shown in Figure Q6, block A (with a mass of 75kg) is moving down with a velocity of 1.5m/s. The cylinder B of mass 87.5kg is considered a homogeneous solid, rotating in frictionless bearings. The spring of modulus 875N/m is originally compressed by 150mm. The coefficient of kinetic friction between the block C of mass 145kg and the surface is 0.20. Calculate the velocity of the A after dropping 1.25m.

[19 marks]

Q7. An airplane makes complete half circle of 50m radius, towards left, when flying at 200 km/hr. The rotary engine and the propeller of the plane weight 400kg with a radius of gyration of 30cm the engine runs at 2,400 rpm, clock wise, when vied from the rear. Find the gyroscopic couple on the aircraft and state its effect on it. What will be the effect, if the aeroplane turns to its right instead of to the left?

[19 marks]

END OF EXAMINATION – ME 375
Dr A N Ng'andu and Mr. C Siakachoma

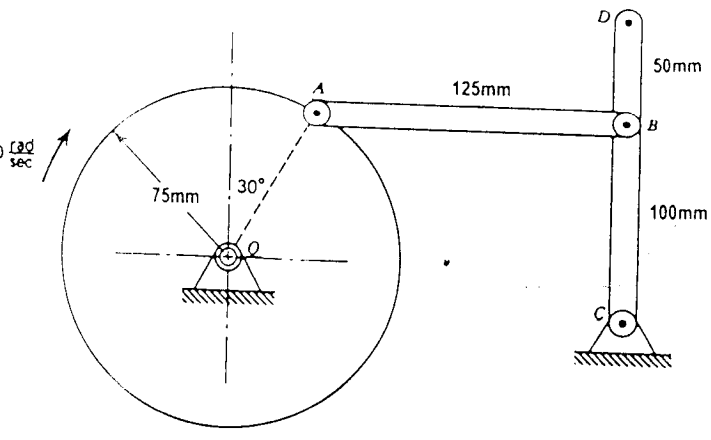

Figure Q1.

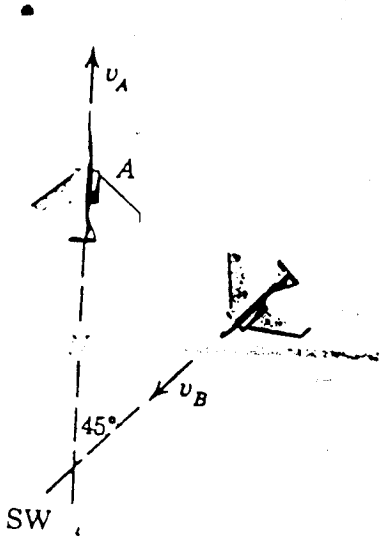

Figure Q2.

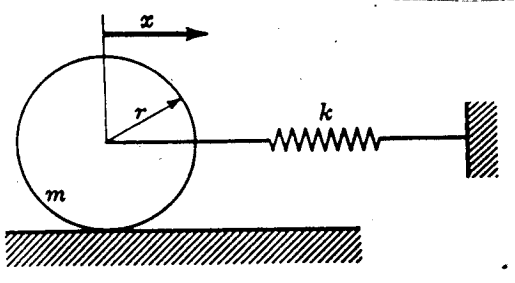

Figure Q 5.

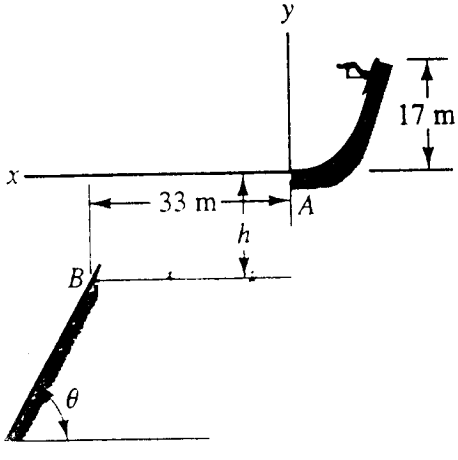

Figure Q3.

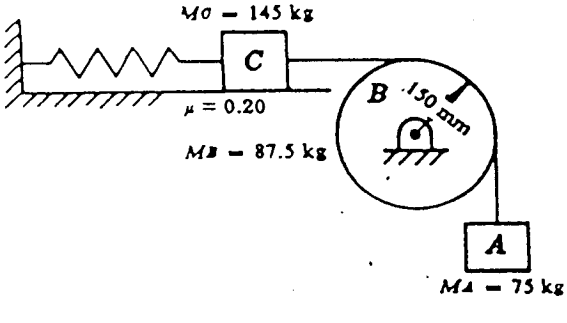

Figure Q6.

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SEMESTER I FINAL EXAM – AUGUST 2003
ME 415 PRODUCTION TECHNOLOGY I

TIME ALLOWED 3 HOURS **CLOSED BOOK**
ANSWER **QUESTION 8**, AND **ANY OTHER 4 QUESTIONS**

ANSWER QUESTION 8 IN A SEPARATE **ANSWER BOOKLET FROM THE OTHER 4 QUESTIONS** AND IT **SHOULD** BE **CLEARLY LABELED AS Q8**

QUESTION 1

a) State the 4 main assumptions of Merchants theory of cutting. (2 marks)

b) Derive from first principles the following expression based on Merchants 'Minimum work principle'.

$$F_f = hb\,\tau_\phi\,(cot^2\phi - 1)$$ (10 marks)

For a given turning operation the cutting conditions are as follows:

Rake angle	=	7
Apparent friction coefficient	=	0.7
Cutting velocity	=	36 m/s
Cutting force	=	1400 N
Depth of cut	=	4.2 mm
Width of cut	=	0.2 mm

Assuming Merchants theory valid with it's shear angle prediction, determine:

c) The shear velocity. (4 marks)

d) The shear stress on the shear plane. (4 marks)

QUESTION 2

a) State the two main classes of welding. (2 marks)

b) Concisely describe with diagram the operation of TIG welding. Further state its main advantages and disadvantages. (10 marks)

c) Outline with diagrams, the welding positions and nomenclature for fillet and groove welds. (8 marks)

QUESTION 8

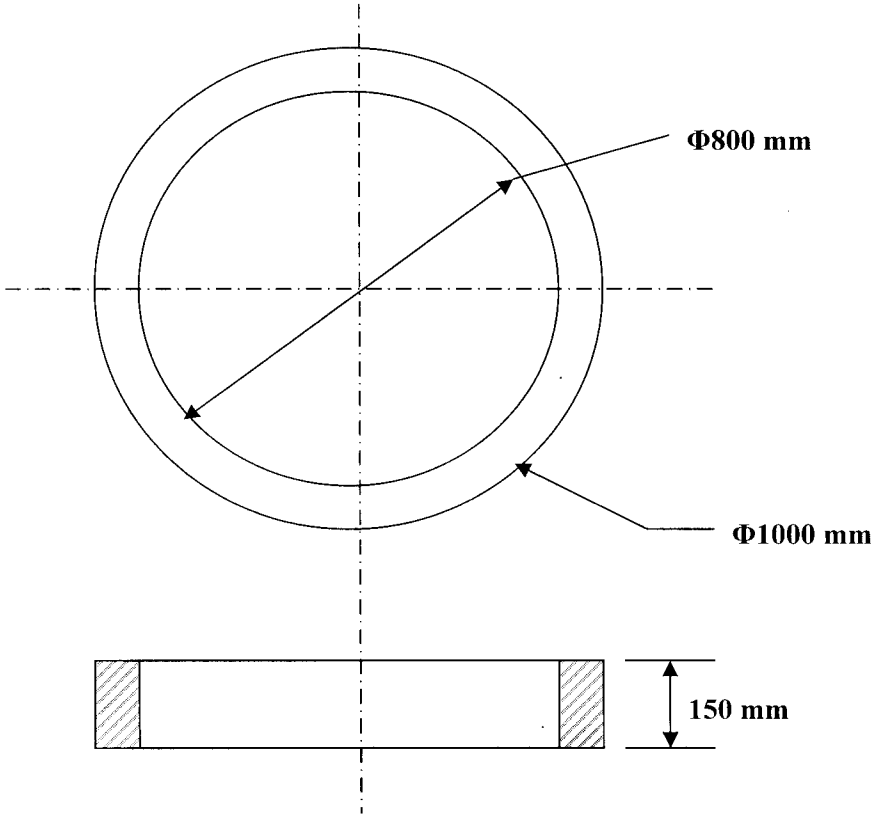
a) Enumerate and explain the criteria used to assist in the sizing and placement of risers/feeders in solid solution alloy castings? (8 marks)

b) With the aid of modulus and feeding distance rules, determine the number of feeders required to optimise the yield, and produce sound, the ring casting shown in figure below. Assume cylindrical feeders have diameter equal to the height and that a supply of suitable chills is available. Exothermic feeders are not to be used. (12 marks)

The formulae for determining the feeder maximum feeding distance are:

$D = 6\sqrt{T}$ with no chill end effect at the cast bar edge; and

$D = 6\sqrt{T} + T$ with chill end effect at the cast bar edge.



RING CASTING

END OF EXAM

QUESTION 6

a) The following values were obtained from a series of straightness tests made to assess the flatness of a surface. The unit measurement is 0.05mm, the results have already been summated, and they are all given with reference to the same datum. Determine, for the intersecting points of the grid, the errors of flatness of the surface tested measured from a mean true plane. (15 marks)

Flatness DATA				
A-A'	0	-0.5	0.1	-0.5
B-B'	0	0.6	0.5	0
C-C'	0	-0.3	-0.4	-0.5
D-D'	0	-0.3	0.6	0.6
a-a'	0	0.3	0	-0.3

b) Briefly describe with diagrams, the working principle of "GO" and "NOT GO" plug gauges. (5 marks)

QUESTION 7

a) Describe with diagrams 4 basic types of slide-ways (12 marks)

b) Determine the efficiency of a 6 mm pitch acme screw, thread angle 32°, 56mm effective diameter when the coefficient of friction is 0.03. (3 marks)

c) Classify and briefly justify, what type of generating system does turning of a tapered shaft fall in. (3 marks)

d) State how many degrees of freedom there are in a standard bathroom tap. Further classify these degrees of freedom. (2 marks)

QUESTION 5

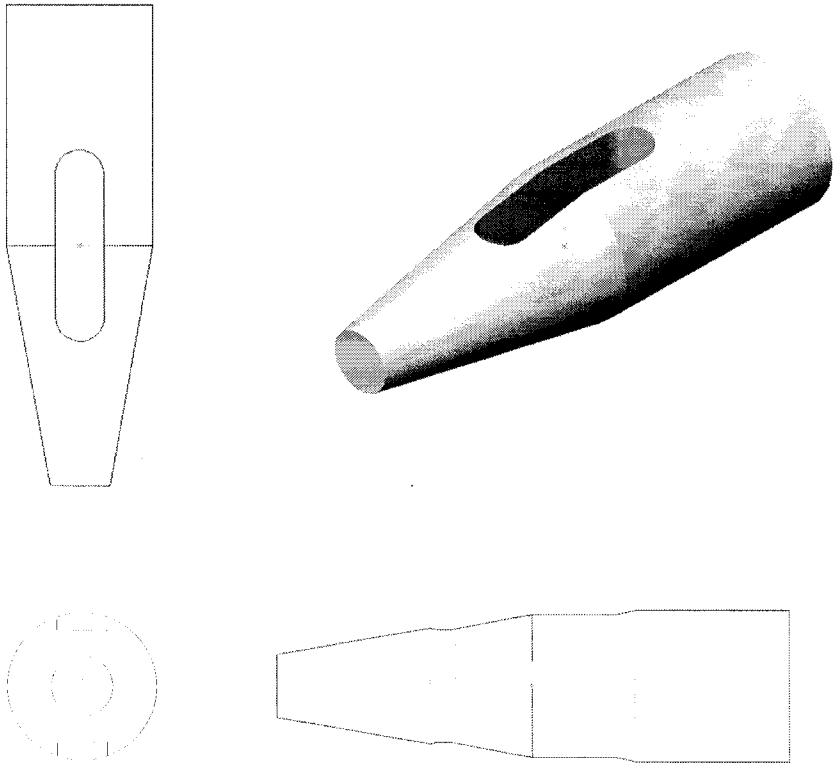
You are the shop floor manager in a Lusaka based engineering firm. You have been requested to produce widgets. Your total machine operating cost is K30,000 /hr, and your total cost per tool change is K10,000 which takes 6 mins. For the given depth of cut and feed, V_{55} = 36 m/min and n = 0.21. Determine:

a) The economic tool life (minimum cost criteria) (4 marks)

b) The economic cutting speed (minimum cost criteria) (4 marks)

c) The economic cutting speed (maximum output criteria) (4 marks)

d) Show the locator placement for milling the central slot on the die cast component below, justifying geometrical and dimensional control. (8 marks)



QUESTION 3

In a milling operation a slot of 100mm long by 25 mm wide by 25 mm deep is to be produced. Given the following cutting conditions:

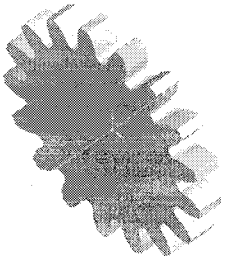
Cutter diameter	80 mm
No. Teeth	16
Cutter speed	25 m/min
Feed	1.006 mm/rev
K_{cmean}	3900 N/mm^2

Assuming a deep cutting condition, determine:

a) The Maximum chip thickness (5 marks)
b) The maximum number of teeth in engagement (5 marks)
c) Power required at the cutter (5 marks)
d) how long will it take to completely mill the slot (5 marks)

QUESTION 4

a) You are required to cut the gear below, calculate the index arm setting required to cut all teeth with equal spacing. The worm gear in the dividing head has 40 teeth. The index plate has the following numbered hole circles: 24, 25, 28, 30, 34, 37, 38, 39, 40, 41, 42, 43. (4 marks)



Given the module for the gear above is 10mm, calculate:

b) The pitch circle diameter of the gear. (2 marks)
c) The settings of the gear-tooth vernier for gear inspection. (6 marks)

d) Briefly describe with diagrams, gear cutting by milling. (8 marks)

QUESTION 5

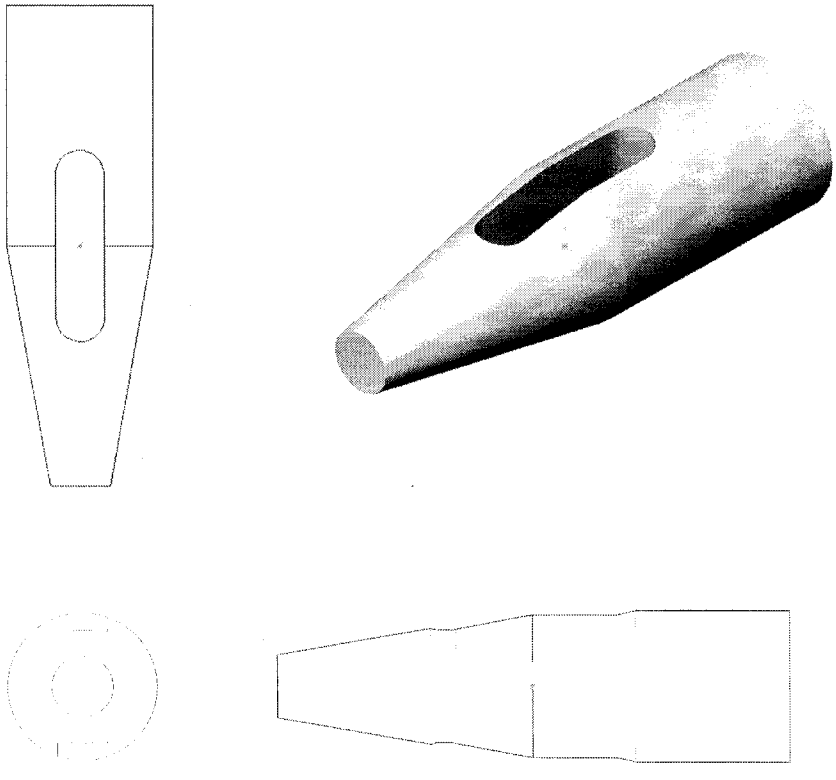
You are the shop floor manager in a Lusaka based engineering firm. You have been requested to produce widgets. Your total machine operating cost is K30,000 /hr, and your total cost per tool change is K10,000 which takes 6 mins. For the given depth of cut and feed, V_{55} = 36 m/min and n = 0.21. Determine:

a) The economic tool life (minimum cost criteria) (4 marks)

b) The economic cutting speed (minimum cost criteria) (4 marks)

c) The economic cutting speed (maximum output criteria) (4 marks)

d) Show the locator placement for milling the central slot on the die cast component below, justifying geometrical and dimensional control. (8 marks)



UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

SEMESTER I FINAL EXAMINATION
AUGUST 2003

ME 545 – ALTERNATIVE ENERGY SOURCES

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

INSTRUCTIONS

1. Answer a **total of FIVE (5) questions**. Any **TWO (2)** questions from SECTION A and any **THREE (3)** questions from SECTION B
2. Draw sketches and graphs where necessary and state clearly any assumptions made.

SECTION A
(Answer any TWO Questions)

Q1 (a) Discuss in detail the Darrieus rotor. What are the advantages and disadvantages of this type of wind machine. [12 Marks]

(b) During the operation of a wind machine, various extraneous loads are imposed on the system which can cause excessive wear and affect the life-cycle of the unit. Which are these possible loads? [8 Marks]

[20 Marks]

Q2 Due to high operational costs, TAZAMA Pipelines, which transports 600,000 tonnes crude oil per year, is contemplating replacing the six old 'diesel engine' pump stations used for transporting oil from Dar-es-salaam to Ndola with hydroelectricity powered electric motors and a cost of US$3 million. The current engines use crude oil fuel, which can be approximated to be heavy fuel oil, with an energy conversion factor of 40.82GJ/tonne, carbon factor of 21.1 kg/GJ and specific gravity of 0.82. Each of the pump stations evenly spread along the 1700km stretch uses 820,000 litres of fuel per annum.

(a) List any local and regional environmental impacts of the current operations. How could these be addressed? [4 Marks]
(b) From the global perspective, as an **energy and environmental** expert, justify the choice of electric motors as opposed to continued use of crude oil fuel. [3 Marks]
(c) Determine the standardised emission factor of CO_2 (tCO_2/t-crude oil pumped). Assume that 99% of carbon is oxidised. [4 Marks]
(d) Calculate, and graphically (sketch) show the amount of CO_2 savings over the 15-year life span of the motors, assuming constant annual national fuel demand. [4 Marks]
(e) Do you think that this undertaking would be eligible as a CDM Project? Discuss. (The market price of CERs is US$5/tonne) [5 Marks]

[20 marks]

Q3 (a) Discuss with the aid of a diagram the design features of a mini-hydro system
(b) Explain the methodological approach required in the system design of a mini-hydro system

[20 marks]

SECTION B
(Answer any THREE Questions)

Q4. Your factory occupies an area of 36,000 m^2. For efficient lighting, the factory is designed in such a way that each 15m^2 of floor contains four 75-Watt incandescent light bulbs, which last 1,000hrs. As part of energy efficiency programme in your company, the incandescent lights are replaced with 15-Watt high efficiency fluorescent lights having similar luminance capacity and last 10,000hrs.

Determine the amount of savings through the energy efficiency programme and simple payback period on your investment over the life cycle of the improved lights if the prices of incandescent lights and high efficiency compact fluorescent light are given as US$0.5 and US$15 each, respectively. The factory operates 20 hours per day for 260 days in a year. The electricity tariff is US$0.05 / kWh.

Q5. Zambia on average grows one million tonnes of maize per annum. If advantage was to be taken of the residue of maize (maize cobs) to be used to produce electricity using modern traditional combustion systems,

(a) Determine the economic energy potential if a residual ratio, calorific value and penetration level of utilization of maize for the purpose of electricity generation were 30%, 14,000 kJ/kg and 60%, respectively.

(b) Determine the actual amount of air required for the purpose of combustion at an excess air coefficient of 1.1 in a furnace of a modern traditional boiler, if the elemental gravimetric composition of maize cobs was given as:

Carbon	50%
Hydrogen	4%
Oxygen	0.05%
Nitrogen	0.5%
Sulphur	0.5%
Carbon content of biomass	10%

Q6. (a) A farmer with a two hectare plot wishes to go into irrigation. You are requested to choose a suitable water pumping system. His water requirement is $40m^3$ per day, and has an existing borehole and water tank with a total head of 25 meters. The daily system efficiency, array mismatch, and solar radiation intensity are given as 40%, 0.85 and $5.5kWh/m^2$.

(b) Determine the investment requirements of such an installation if the average ~~Hp~~ kW cost is US$25, and aver rage daily peak sunshine hours are given as 5 hours.

[20 marks]

Q7. As a consultant, you have been asked to give the size of a 50kg forced convection solar dryer for drying onions in three days in an area having an ambient temperature, relative humidity, and solar intensity of 23°C and 40% and $550W/m^2$ respectively. On the average, the location receives an 8hr sunshine period per day. Determine the:

(i) Average pickup rate
(ii) Necessary air flow rate
(iii) Blower power
(iv) Collector area

The following additional information is given:

Initial/Final moisture contents for onions in wet basis	=	80% / 4% respectively
Maximum temperature	=	55°C
Relative humidity of air leaving the bin	=	75%
Air velocity in the drying bin	=	0.5m/s
Air resistance for onions	=	$4000m^{-1}$
Collector efficiency	=	53%
Motor / Blower efficiency	=	25%

$\rho = 500 kg/m^3$

[20 marks]

END OF EXAMINATION

Prepared by
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