



PAST PAPERS

Faculty	Department / Section/Division
Not Applicable	Learning Resource Centre

Past Papers

Faculty of Engineering and Technology

Bachelor of Science Honours in Engineering

Document Control & Approving Authority	Senior Director – Quality Management & Administration
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1 st Issue Date: 2017.011.30	Revision No.00	Revision Date:279.2.2024	Validated by: Librarian
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FACULTY OF ENGINEERING AND TECHNOLOGY

Bachelor of Science (Honours) in Engineering

Examination paper Batch 4 Semester 7

Module Code : ME4314
Module Title : Automotive Systems Design
Date : 30th November 2024
Time : 09.00 Hrs. to 12.00 Hrs.
Time Allowed : 3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- This question paper consists of six questions.
- Attempt All Questions.

MATERIALS REQUIRED

- Eight-page answer booklets.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.

Question 01

A frequent failure of the cylinder head of a four stroke four-cylinder diesel engine prompted a Design Engineer to investigate the strength of the cylinder head. He has tested the engine on an engine dynamometer, and it revealed that the engine is developing a maximum of 120 kW at 3200 r.p.m. He then determined the Indicated mean effective pressure which is 0.42 N/mm^2 and the mechanical efficiency through a Morse test which is 80 %. He tests a specimen taken from a similar engine and found that the Allowable stress of the material as 60 N/mm^2 . Engine design guidelines stipulate that the design maximum pressure has to be 15 times the indicated mean effective pressure. Further he makes following measurements. Cylinder head thickness – 10mm

- a. Determine the bore diameter of the engine (5 marks)
- b. Assess theoretically whether the thickness of the cylinder head is adequate or not. (10 marks)

Question 02

An ultimate analysis of a liquid fuel (oil) by mass is Carbon (C) 78% and Hydrogen(H_2) 22%. Assuming that air contains 23% of oxygen by mass, determine the following if one kg of fuel is burnt.

- a. Mass of CO_2 produced (1 mark)
- b. Mass of H_2O produced (1 mark)
- c. Mass of oxygen required to burn the fuel (1 mark)
- d. Mass of air required to burn one kg of fuel (5 marks)
- e. Mass of combustion products (2 marks)

Question 03

A car with curb weight of 1750kg has been designed to carry a 400 kg load including the driver. The un-laden (when not loaded) ground clearance is 190 mm and should maintain minimum 160 mm under fully laden (loaded with 500kg load) condition. In order to maintain good ride comfort the damped natural frequency has to be maintained around 100 cycles per minute. To provide good adhesion between road and wheel the damping ratio has to be 0.3. Determine,

- a. the appropriate stiffness of the spring (10 marks)
- b. the damping coefficient for the damper. (10 marks)

Question 04

- a. Starting from fundamentals, derive an expression to determine the acceleration of a reciprocating mass in terms of crank radius, connecting rod length and rotational speed. (10 marks)
- b. If the crank radius and the length of connecting rod are 162 mm and 180 mm respectively and the crank rotates at a constant speed of 3400 rpm,
 - i. determine the velocity and acceleration at 12 degrees from bottom dead Centre. (5 marks)
 - ii. determine the position of the crank at zero acceleration of piston from bottom dead Centre (5 marks)

Question 05

Typical torque variation for an engine is given in **Figure 5**. The enclosed areas are: $A_1 = 570 \text{ J}$, $A_2 = 900 \text{ J}$, $A_3 = 390 \text{ J}$, $A_4 = 60 \text{ J}$. It is necessary to keep the speed within the range 2400 to 2450 rev/min and the radius of gyration of the flywheel to be 0.4 m.

Determine,

- a. the coefficient of fluctuation of speed (3 marks)
- b. the coefficient of fluctuation of energy (5 marks)
- c. moment of inertia (5 marks)
- d. mass of the flywheel (2 marks)

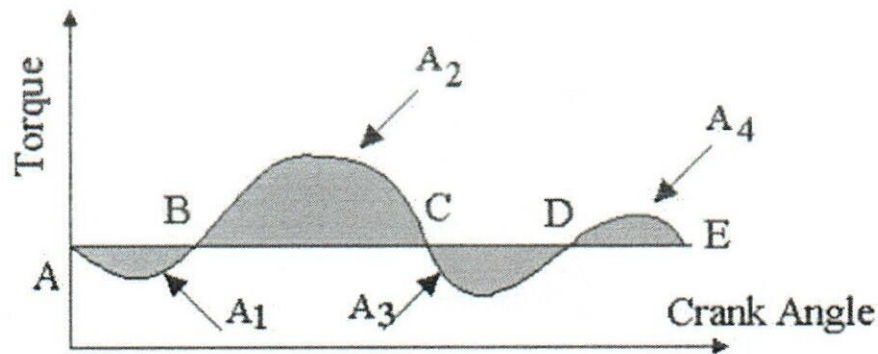


Figure 5

Question 06

- a) Starting from fundamentals, derive an expression to determine the torque transmitted by a single plate clutch assuming uniform pressure.

(10 marks)

- b) A single plate clutch having a single driving plate with contact surfaces on each side is required to transmit 55 kW at 4500 rev/min. The ratio of inner radius to outer radius 0.8. The coefficient of friction is 0.4. Assuming a uniform pressure of 0.21 N/mm² design the clutch with a single disc having contact surfaces on either side.

(5 marks)

- c) Explain what happens to the pressure distribution of the clutch after wearing off for some time.

(5 marks)**END.****Data Sheet****1. The thickness of a cylinder wall**

The thickness of a cylinder wall (t) is usually obtained by using a thin cylindrical formula, i.e.

$$t = \frac{p \times D}{2\sigma_c} + C$$

where

- p = Maximum pressure inside the cylinder in N/mm²,
 D = Inside diameter of the cylinder or cylinder bore in mm,

σ_c = Permissible circumferential or hoop stress for the cylinder material in MPa or N/mm².

C = Allowance for re-boring.

The allowance for re-boring (C) depending upon the cylinder bore (D) for I. C. engines is given in the following table:

D (mm)	75	100	150	200	250	300	350	400	450	500
C (mm)	1.5	2.4	4.0	6.3	8.0	9.5	11.0	12.5	12.5	12.5

2. Design of Cylinder Head

The cylinder head may be approximately taken as a flat circular plate whose thickness (t_h) may be determined from the following relation:

$$t_h = D \sqrt{\frac{C.p}{\sigma_c}}$$

where

D – Cylinder bore in mm,

p - Maximum pressure inside the cylinder in N/mm²,

σ_c - Allowable circumferential stress in MPa or N/mm².

C - Constant whose value is taken as 0.1.

3. The thickness of the piston head for strength

The thickness of the piston head (t_H), according to Grashoff's formula is given by

$$t_H = \sqrt{\frac{3p.D^2}{16\sigma_t}} \text{ (in mm)}$$

Where,

p = Maximum gas pressure or explosion pressure in N/mm²,

D = Cylinder bore or outside diameter of the piston in mm, and

σ_t = Permissible tensile stress for the material of the piston in MPa or N/mm²

Design of piston head for heat transfer

On the basis of second consideration of heat transfer,

$$H = \frac{K_1 \times C \times W \times BP}{A}$$

$$t_H = \frac{H}{12.56k(T_C - T_E)} \text{ (in mm)}$$

A = Cross sectional area in mm^2

K_1 = A constant representing the amount of heat absorbed by the piston = 0.5

K = Heat conductivity ... $\text{W-mm/m}^2\text{ }^\circ\text{C}$

$T_c - T_e$ = Difference in temperature at the center and that at the edge

Standard parameter for square hollow sections

DIMENSIONS AND RATIOS							PROPERTIES				
Designation			Mass per metre	External surface area		Gross section area	About x-, y- and z-axis				
d	b	t		per m	per t		I_x	Z_x	Z_y	S_x	
mm	mm	mm	kg/m	m ² /m	m ² /t	mm ²	10 ⁸ mm ⁴	10 ³ mm ³	10 ³ mm ³	10 ³ mm ²	
250 x 250 x 9.0 SHS			65.9	0.961	14.6	25.8	8400	79.8	639	477	750
6.0 SHS			45.0	0.974	21.7	39.7	5730	56.2	450	330	521
200 x 200 x 9.0 SHS			51.8	0.761	14.7	20.2	6600	39.2	392	297	465
6.0 SHS			35.6	0.774	21.8	31.3	4530	28.0	280	207	327
5.0 SHS			29.9	0.779	26.0	38.0	3810	23.9	239	175	277
150 x 150 x 9.0 SHS			37.7	0.561	14.9	14.7	4800	15.4	205	159	248
6.0 SHS			26.2	0.574	22.0	23.0	3330	11.3	150	113	178
5.0 SHS			22.1	0.579	26.2	28.0	2810	9.70	129	96.1	151
125 x 125 x 9.0 SHS			30.6	0.461	15.1	11.9	3900	8.38	134	106	165
6.0 SHS			21.4	0.474	22.1	18.8	2730	6.29	101	76.5	120
5.0 SHS			18.2	0.479	26.3	23.0	2310	5.44	87.1	65.4	103
4.0 SHS			14.8	0.483	32.7	29.3	1880	4.52	72.3	53.6	84.5
100 x 100 x 9.0 SHS			23.5	0.361	15.4	9.11	3000	3.91	78.1	63.6	98.6
6.0 SHS			16.7	0.374	22.4	14.7	2130	3.04	60.7	47.1	73.5
5.0 SHS			14.2	0.379	26.6	18.0	1810	2.66	53.1	40.5	63.5
4.0 SHS			11.6	0.383	32.9	23.0	1480	2.23	44.6	33.5	52.6
3.0 SHS			8.96	0.390	43.5	31.3	1140	1.77	35.4	26.0	41.2
89 x 89 x 6.0 SHS			14.6	0.330	22.5	12.8	1870	2.06	46.2	36.3	56.6
5.0 SHS			12.5	0.334	26.7	15.8	1590	1.81	40.7	31.4	49.1



CINEC CAMPUS
FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

FINAL EXAMINATION

Module Code	:	FE1311
Module Title	:	Engineering Mathematics I
Academic Year	:	Semester 1- 2024/2025
Date	:	27 th November 2024
Examiner	:	B.S Wijeratne
Time Allowed	:	3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all four questions. Each question carries equal marks.
- Each answer should start on a separate page.
- This paper contains 8 pages.
- Additional information is provided on page 6 -8

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a Scientific calculator. This must not be programmable.

1. a) Find the following limits.

i) $\lim_{x \rightarrow 3} \frac{1/x - 1/3}{x^2 - 9}$

[8 Marks]

ii) $\lim_{x \rightarrow 0} \frac{3^x - 2^x}{x^2 - x}$

[9 Marks]

iii) $\lim_{x \rightarrow 0} \frac{x^2 e^x}{\tan^2 x}$

[18 Marks]

b) i) The forces in three members of a framework are F_1 , F_2 and F_3 . They are related by the simultaneous equations shown below.

$$1.4F_1 + 2.8F_2 + 2.8F_3 = 5.6$$

$$4.2F_1 - 1.4F_2 + 5.6F_3 = 35$$

$$4.2F_1 + 2.8F_2 - 1.4F_3 = -5.6$$

Use Cramer's rule to solve for F_1 , F_2 and F_3 .

[35 Marks]

ii) Solve the following system of equations, using the Gaussian elimination method:

$$x + y + z = 4$$

$$2x - 3y + 4z = 33$$

$$3x - 2y - 2z = 2$$

[30 Marks]

2. a) Consider the following equation,

$$\left| \frac{z-j}{z-1-2j} \right| = \sqrt{2}$$

Show that the locus is a circle with the center at (2,3) and the radius 2 units. sketch the circle.

[25 Marks]

- b) i) Find an expression for $\cos 4\theta$ in terms of $\cos \theta$, using binomial theorem and De Moivre's theorem.

[25 Marks]

- ii) Express $1 - j$ in polar form and find $(1 - j)^{12}$

[15 Marks]

- c) Calculate the radius of curvature at the point (1,1) on the curve whose equation is $x^3 - 2xy + y^3 = 0$ and hence obtain the co-ordinates of center of curvature.

[35 marks]

3. a) An equation for heat generated is given by $H = i^2 R t$. Determine the error in the calculated value if the error in measuring current i is +2%, the error in measuring resistance R is -3% and error in measuring time t is +1%.

[24 Marks]

- b) The area S of a triangle ABC is given by $S = \frac{1}{2} a c \sin B$, where $BC = a$ and $AB = c$. If BC is increasing at 0.4 units/s, AB is decreasing at 0.8 units/s and B is increasing at 0.2 units/s. Find the rate of change of the area of the triangle correct to three significant figures when BC is 3 units, AB is 4 units and B is $\pi/6$ radians.

[30 Marks]

- c) i) An architect designs two housing schemes that are shaped and positioned like a part of the branches of the hyperbola (Figure 1) whose equation is

$$4y^2 - 3x^2 = 36,$$

where x and y are in meters. How far apart are the two housing schemes at their closest points?

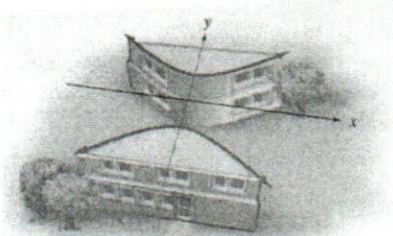


Figure 1: Two housing schemes

[16 Marks]

- ii) Cross section of a nuclear cooling tower (Figure 2) is in the shape of a hyperbola with the equation $\frac{x^2}{900} - \frac{y^2}{1936} = 1$. The tower is 150m tall and the distance from the top of the tower to the center of the hyperbola is half the distance from the base of the tower to the center of the hyperbola. Find the diameters of the top and base of the tower.

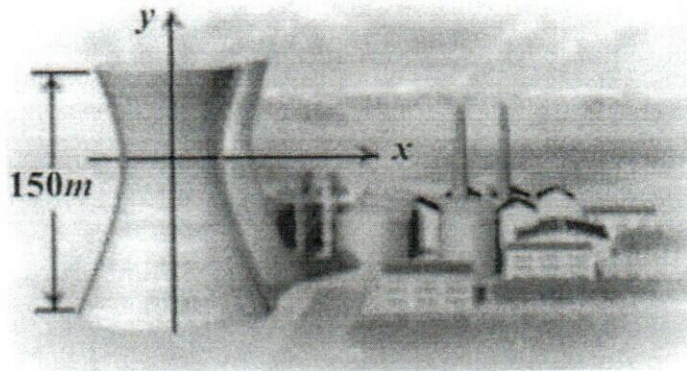


Figure 2: Nuclear cooling tower

[30 Marks]

4. a) Let $P = (2,1,2)$, $Q = (0,1,4)$, $R = (2,5,3)$ and $S = (2,6,1)$

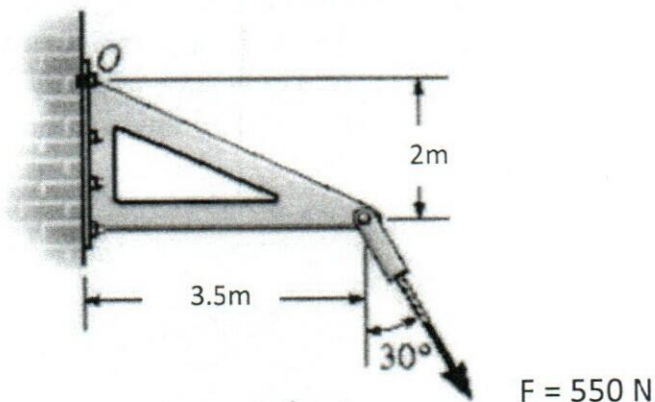
i) Find the vectors $\overrightarrow{PQ}$, $\overrightarrow{PR}$, and $\overrightarrow{PS}$.

ii) Find the volume of the parallelepiped with adjacent edges PQ , PR and PS .

iii) Mark the points P , Q , R and S on a right handed Cartesian coordinate system and hence sketch the parallelepiped.

[20 Marks]

- b) Find the moment of the force F about the point O .



[10 Marks]

c) Evaluate the following integrals using a suitable method.

i) $\int 2\sqrt{1-x^2} \, dx$

[16Marks]

ii) $\int \frac{x^2+4}{3x^3+4x^2-4x} \, dx$

[18 Marks]

iii) $\int \frac{xe^{2x}}{(2x+1)^2} \, dx$

[16Marks]

iv) $\int \sec^4 3x \cdot \tan^3 3x \, dx$

[20Marks]

Additional Information**Partial Derivatives:****1 Small increments (Total differentials of z)**

$$z = f(x, y) \quad \delta z = \frac{\partial z}{\partial x} \delta x + \frac{\partial z}{\partial y} \delta y \quad (a)$$

2 Rates of change (Simple Chain Rule)

$$\frac{dz}{dt} = \frac{\partial z}{\partial x} \cdot \frac{dx}{dt} + \frac{\partial z}{\partial y} \cdot \frac{dy}{dt} \quad (b)$$

3 Implicit functions

$$\frac{dz}{dx} = \frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} \cdot \frac{dy}{dx} \quad (c)$$

4 Change of variables (Chain Rule for Two Sets of Independent Variables,

$$\begin{aligned} \frac{\partial z}{\partial u} &= \frac{\partial z}{\partial x} \cdot \frac{\partial x}{\partial u} + \frac{\partial z}{\partial y} \cdot \frac{\partial y}{\partial u} \\ \frac{\partial z}{\partial v} &= \frac{\partial z}{\partial x} \cdot \frac{\partial x}{\partial v} + \frac{\partial z}{\partial y} \cdot \frac{\partial y}{\partial v} \end{aligned} \quad (d)$$

Standard derivatives:

$F(x)$	$\frac{df(x)}{dx}$
x^n	nx^{n-1}
$\sin ax$	$a \cos ax$
$\cos ax$	$-a \sin ax$
$\tan ax$	$a \sec^2 ax$
$\sec ax$	$a \sec ax \cdot \tan ax$
e^{ax}	ae^{ax}
$\ln ax$	$\frac{a}{x}$

Standard Integrals:

$f(x)$	$\int f(x)dx$
x^n	$\frac{x^{n+1}}{n+1}$, for $x \neq -1$
e^x	e^x
e^{ax}	$\frac{1}{a} e^{ax}$
$\frac{1}{x}$	$\ln x$
$\sin ax$	$-\frac{1}{a} \cos ax$
$\cos ax$	$\frac{1}{a} \sin ax$

Rules of differentiation	$\frac{d}{dx}(uv) = u \frac{dv}{dx} + v \frac{du}{dx}$ $\frac{d}{dx} \left(\frac{u}{v} \right) = \frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2}$ $\frac{dy}{dx} = \frac{dy}{du} \frac{du}{dx}$
Integration by parts equation	$\int u \frac{dv}{dx} dx = uv - \int v \frac{du}{dx} dx$

Radius of Curvature:

$$R = \frac{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}}{\left|\frac{d^2y}{dx^2}\right|}$$

TRIGONOMETRIC IDENTITIES

RECIPROCAL IDENTITIES

$$\cot x = \frac{1}{\tan x} = \frac{\cos x}{\sin x}$$

$$\csc x = \frac{1}{\sin x}$$

$$\sec x = \frac{1}{\cos x}$$

PYTHAGOREAN IDENTITIES

$$\sin^2 x + \cos^2 x = 1$$

$$\sin^2 x = 1 - \cos^2 x$$

$$\cos^2 x = 1 - \sin^2 x$$

$$1 + \tan^2 x = \sec^2 x$$

$$1 + \cot^2 x = \csc^2 x$$

SUM AND DIFFERENCE IDENTITIES

$$\sin(x \pm y) = \sin x \cos y \pm \cos x \sin y$$

$$\cos(x \pm y) = \cos x \cos y \mp \sin x \sin y$$

$$\tan(x \pm y) = \frac{\tan x \pm \tan y}{1 \mp \tan x \tan y}$$

DOUBLE-ANGLE IDENTITIES

$$\sin 2x = 2 \sin x \cos x = \frac{2 \tan x}{1 + \tan^2 x}$$

$$\cos 2x = \cos^2 x - \sin^2 x$$

$$= 2 \cos^2 x - 1$$

$$= 1 - 2 \sin^2 x = \frac{1 - \tan^2 x}{1 + \tan^2 x}$$

$$\tan 2x = \frac{2 \tan x}{1 - \tan^2 x}$$

$$\cot 2x = \frac{\cot^2 x - 1}{2 \cot x}$$

HALF-ANGLE IDENTITIES

$$\sin \frac{x}{2} = \pm \sqrt{\frac{1 - \cos x}{2}}$$

$$\cos \frac{x}{2} = \pm \sqrt{\frac{1 + \cos x}{2}}$$

$$\tan \frac{x}{2} = \pm \sqrt{\frac{1 - \cos x}{1 + \cos x}} = \frac{\sin x}{1 + \cos x} = \frac{1 - \cos x}{\sin x}$$

Binomial Theorem:

$$(a + b)^n = \sum_{k=0}^n \binom{n}{k} a^{n-k} b^k$$

De Moivre's Theorem:

$$z^n = r^n (\cos n\theta + i \sin n\theta)$$



Faculty of Engineering & Technology
Department of Civil Engineering
Bachelor of Science Honours in Engineering
Year 1 Semester 1 Final Examination 2024

Module Code : CE1313
Module Title : Properties of Materials
Date/Time : 25th November 2024 / 01.30pm – 04.30 pm
Examiner : P.W Gavithra Udayakumara
Time Allowed : Three hours only

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- "Section A" consists of 10 Multiple Choice Questions. You should attempt **ALL** questions.
- Section B consists of 4 questions. You should attempt all 4 questions.
- Show all stages of your work.
- This paper contains 09 pages.

MATERIALS REQUIRED

- Answer Booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.
- Extra answer papers (if required)
- Equations are mentioned at the 9th page

Student Number

SECTION A

1. Radioactive materials are using for various purposes. A γ -ray source is delivered with 10mCi of radio-cobalt, half-life 3 months and is due for renewal when the activity has fallen to 1.5mCi. How often will renewal be necessary?
 - a) 4.3 months
 - b) 5.6 months
 - c) 7.4 months
 - d) 8.2 months
 - e) 9.5 months

2. An engineering team is working on designing a critical component for an aircraft that will be subjected to cyclic loading during its operational life. The team is concerned about the potential for fatigue failure and is exploring various materials and design strategies to mitigate this risk. What is the significance of conducting fatigue testing during the design phase of the component?
 - a) To determine the hardness of the material
 - b) To identify the yield strength of the material
 - c) To assess the material's response to cyclic loading and predict fatigue life
 - d) To measure the material's thermal conductivity
 - e) To determine the Ultimate Tensile Strength and Yield Strength of the material

3. Which of the following is true about ductile to brittle transition (DBT) temperature?
 - (a) DBT temperature is not an imported consideration in materials selection for components that operate in low temperature environments.
 - (b) In BCC metals like steel, a slow (gradual) change in behavior is observed over a narrow range of temperature.
 - (c) Above DBT temperature, a metal will absorb high amount of energy before fracturing.
 - (d) Below DBT temperature, a metal will fail in a ductile manner.

4. A photovoltaic cell (solar cell) is designed to convert sunlight into electrical energy. It relies on a p-n junction to generate a voltage when exposed to light. The cell is made using a semiconductor material doped to create p-type and n-type regions. Which of the following statements best explains the role of extrinsic semiconductors in the functioning of a photovoltaic cell?
 - a) Intrinsic semiconductors are used exclusively because they generate electrons and holes equally.
 - b) Extrinsic semiconductors form the p-n junction, which separates charge carriers created by light absorption.
 - c) The p-type material absorbs photons, while the n-type material blocks recombination of charge carriers.
 - d) Extrinsic semiconductors are unnecessary because sunlight itself provides all required carriers.

5. A composite material is made of continuous glass fibers (elastic modulus ($E_f = 70$ GPa,) embedded in an epoxy matrix (elastic modulus ($E_m = 3$ GPa). The fiber volume fraction is $V_f = 0.6$, and the matrix volume fraction is $V_m = 0.4$. Calculate the effective elastic modulus of the composite in the transverse direction using the rule of mixtures for transverse loading
- a) 4.38 GPa
 - b) 5.25 GPa
 - c) 6.10 GPa
 - d) 3.84 GPa
 - e) 4.75 GPa
6. Which of the following statement is true regarding the toughness of the metal.
- a) Energy consumed is less in ductile fracture than brittle fracture
 - b) Energy consumed is more in ductile fracture than brittle fracture
 - c) Energy consumed in the brittle fracture is same as the ductile Fracture
 - d) Energy consumed is more in brittle fracture than ductile fracture
7. What is the role of crack tip radius in fracture toughness?
- a) Larger crack tip radius increases fracture toughness
 - b) Smaller crack tip radius increases fracture toughness
 - c) Crack tip radius does not affect fracture toughness
 - d) Crack tip radius is unrelated to fracture behavior
 - e) No relationship between crack tip radius and fracture toughness.
8. Plastic deformation of metals takes place most commonly by
- (a) Annealing process, involving the removal of dislocations
 - (b) Stretching of bonds under the influence of an externally applied stress.
 - (c) The slip process, involving the movement of dislocations.
 - (d) Work hardening process, involving the entanglement of dislocations.
9. An engineering team is designing a bridge structure. The team is designing a bridge that needs to withstand heavy loads and potential earthquakes. Which type of failure, ductile or brittle, is more desirable for this application, and why?
- a) Ductile failure because it allows for deformation and energy absorption before complete failure, which is crucial for withstanding dynamic loads.
 - b) Brittle failure because it provides early warning signs through visible deformations, allowing for timely maintenance.
 - c) Ductile failure because it results in sudden, catastrophic failure, reducing the chances of progressive collapse.
 - d) Brittle failure because it ensures better load distribution across the structure

10. Which of the following statement is true?

- a) The electrical conductivity is directly proportional to both the number of free electrons and the electron mobility.
- b) The electrical conductivity is inversely proportional to both the number of free electrons and the electron mobility.
- c) The electrical conductivity is directly proportional to the number of free electrons but inversely proportional to the electron mobility.
- d) The electrical conductivity is inversely proportional to the number of free electrons but directly proportional to the electron mobility

SECTION B

Question 01

Composites are using in all engineering disciplines for the purpose of enhancing the efficiency of raw materials. In an aligned and continuous carbon fiber reinforced nylon6,6 composite, the fibers are to carry 97% of a load applied in the longitudinal direction.

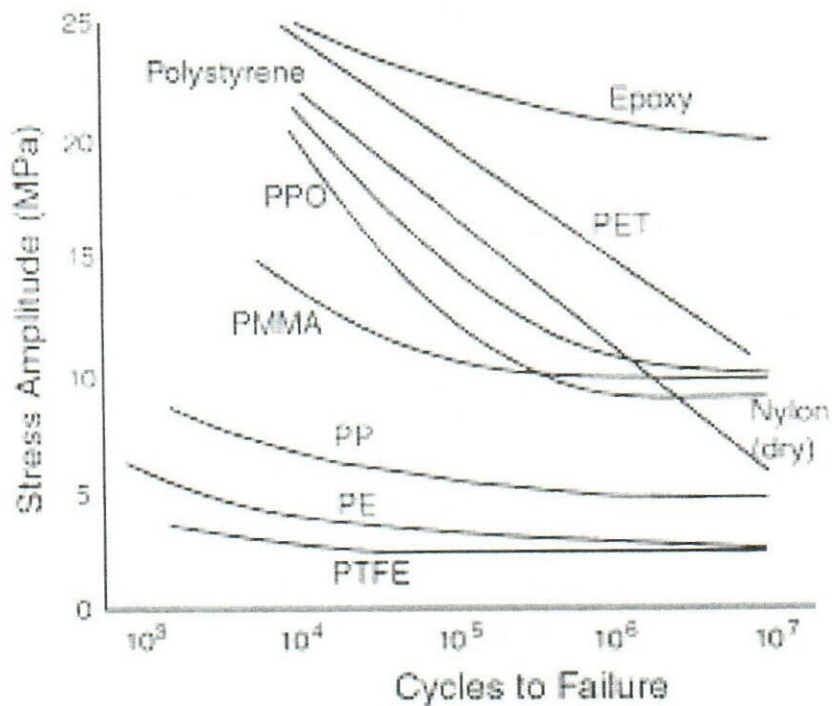
component	Modulus of elasticity (GPa)	Tensile Strength (MPa)
Carbon fiber	260	4000
Nylon 6,6	2.8	76

- Using the Data Provided, determine the volume fraction of fibers that will be required
- What will be the tensile strength of this composite? [Assume that the matrix stress at the fiber failure is 50 MPa]
- Mention 3 Engineering applications of "Ceramic Matrix" composites
- Briefly explain the term "Poisson's ratio"
- A cylindrical steel bar using for concrete subjects to tensile stress along the long axis which is having the diameter of 12 mm. Determine the magnitude of the load required to produce 3×10^{-3} mm change in the diameter if the deformation is entirely elastic. Poisson's ratio is 0.4 and modulus of elasticity of steel is 69 GPa

Question 02

Material failure can be mentioned as unfavorable incidents which lead to economic losses as well as some human injuries as well.

- Explain the mechanism of fatigue failure with the aid of diagram
- Determine the "constant representing the structural detail" and the "Slope coefficient of mean test result line" by using the data given below with reference to the given graph
 - PE $\{(10^3, 6), (10^4, 4)\}$
 - PMMA $\{(10^4, 17), (10^5, 12)\}$



- Determine the endurance limit for above two.
- Briefly explain the importance of "endurance limit" during the selection of material for engineering application.
- Some aircraft component is fabricated from aluminum alloy that has a plane strain fracture toughness of $40 \text{ MPa}\sqrt{\text{m}}$. It has been determined that fracture results at a stress of 300 MPa when the maximum internal crack length is 4.0 mm. For this same component and alloy, will fracture occur at a stress level of 260 MPa when the maximum internal crack length is 6.0 mm? Briefly explain this scenario.

Question 03

The corrosion can be mentioned as a silent destroyer of metals, teaching us that even the strongest materials can fail without vigilance and care.

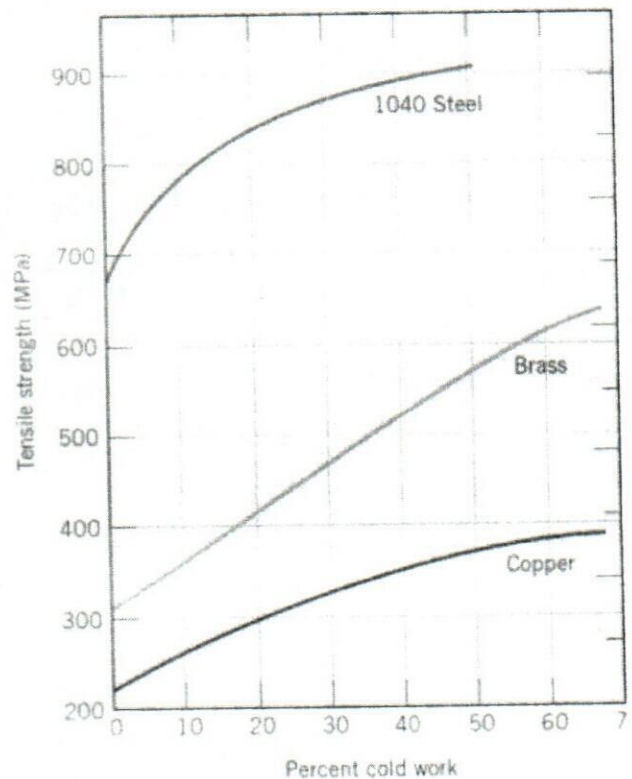
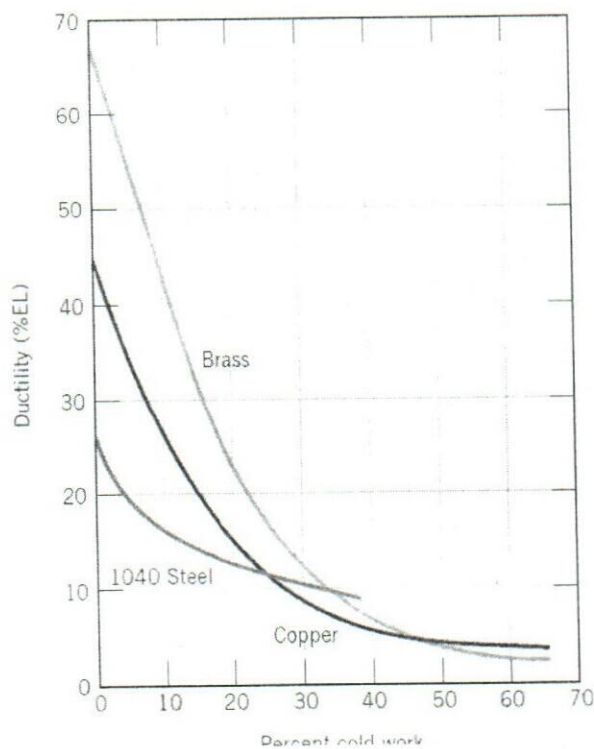
- Discuss the mechanisms of metal corrosion by briefly explaining the two types of corrosions.
- Briefly explain the Crevice corrosion and galvanic corrosion with respective figures.
- Briefly explain 3 methods that can be used to prevent the corrosion of metals with related expels to illustrate the importance in engineering related applications
- A cylindrical rod 500 mm long, having a diameter of 12.7 mm, is to be subjected to a tensile load. If the rod is to experience neither plastic deformation nor an elongation of more than 1.3 mm when the applied load is 29,000 N, which of the four metals or alloys listed below are possible candidates? Justify your choice

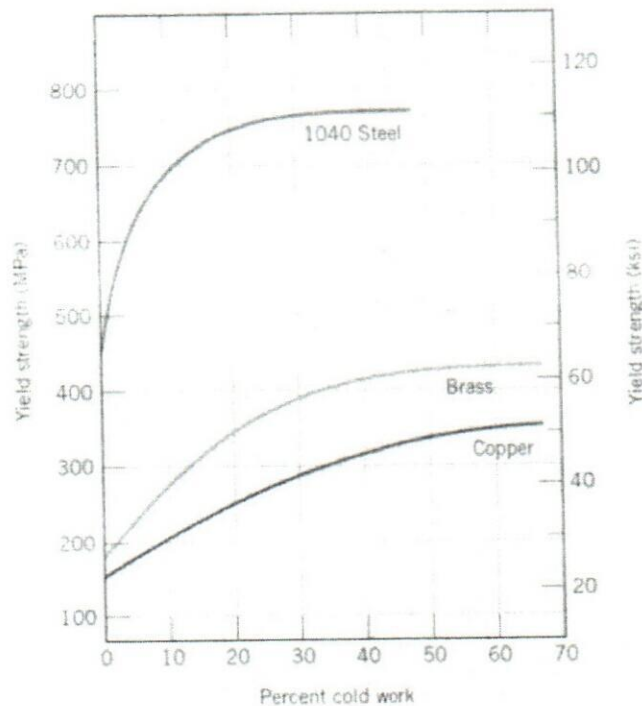
Material	Modulus of elasticity (GPa)	Yield strength (MPa)	Tensile strength (MPa)
Aluminium Alloy	70	255	420
Brass Alloy	100	345	420
Copper	110	210	275
Steel alloy	207	450	550

Question 04

Strain hardening defines as a scenario where a ductile metal becomes harder and stronger when it deforms plastically. This process also called as "Cold Working". Based on the strain hardening process, comment on the below process.

- a) A cylindrical Brass rod having a minimum tensile strength of 450 MPa, a ductility of at least 13% EL, and a final diameter of 12.7 mm is desired. Some 19mm diameter brass stock that has been cold worked 35% is available. Describe the procedure you would follow to obtain this material. Assume that brass experiences cracking at 65% CW.





- b) Perform a brief comparison between the advantages and disadvantages of “Hot working” and “Cold Working” methods.
- c) Briefly explain the advantages of forming metals by extrusion as opposed to the rolling method

Electrical properties of materials play a vital role in deciding the Engineering applications of those. Based on that answer the below questions.

- d) Define the two types of semiconductor with the aid of diagrams
- e) List three engineering applications of semiconductors
- f) For intrinsic silicon, the room-temperature electrical conductivity is $8 \times 10^{-4} \Omega^{-1}\text{m}^{-1}$. The electron and hole mobilities are, 0.24 and $0.064 \text{ m}^2/\text{Vs}$ respectively. Compute the electron and hole concentrations

σ	=	$E\epsilon$
ϵ_A	=	$\{(A_0 - A_f) / A_0\} * 100\%$
MOR	=	$(3PL) / (2bd^2)$
%CW	=	$\{(A_0 - A_d) / A_0\} * 100\%$
σ_c	=	$\{2E\gamma_s / \pi a\}^{1/2}$
$N(S_a)^m$	=	C
P_{LM}	=	$T [C + \log (tr)]$
I	=	$AneV_d$
σ	=	$n e \mu_e + p e \mu_h$
$E_c(u)$	=	$E_m V_m + E_p V_p$
$E_c(l)$	=	$E_m E_p / (E_m V_p + E_p V_m)$
F_c	=	$F_m + F_f$
$\sigma_c A_c$	=	$\sigma_m A_m + \sigma_f A_f$
σ_c	=	$\sigma_m V_m + \sigma_f V_f$
σ_c / ϵ_c	=	$(\sigma_m / \epsilon_m) V_m + (\sigma_f / \epsilon_f) V_f$
E_c	=	$E_m V_m + E_f V_f$
E_c	=	$E_m (1 - V_f) + E_f V_f$
I	=	$I_0 e^{-\lambda t}$
I	=	$I_0 e^{-\mu x}$
K_c	=	$Y \sigma_c \sqrt{\pi a}$



Faculty of Engineering & Technology
Department of Civil Engineering
Bachelor of Science Honours in Engineering
Year 1 Semester 1 Final Examination 2024

Module Code	:	CE1314
Module Title	:	Mechanics
Date/Time	:	22 nd November 2024 / 09.00 am – 12.00 noon
Examiner	:	Prof. Sarath Abayakoon
Time Allowed	:	Three hours

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- You should attempt **ALL** questions.
- This paper contains 4 pages.
- **Attempt all 05 questions.**
- **Three hours will be allocated to answer all the 05 questions**

MATERIALS REQUIRED

- Answer Booklet.
- You may use a scientific calculator.
- Extra answer papers (if required)

Student Number

1. A wind force study resulted in the forces shown in Figure Q1 on a pin connected, geometrically symmetric, roof truss of a small church. The 60.0 kN force is horizontal and the other three forces are perpendicular to DCB .
- Draw the free body diagram for the truss
 - Find the support reactions at A and B
 - Using method of joints, find all member forces and indicate whether they are in tension or compression
- [25 Marks]

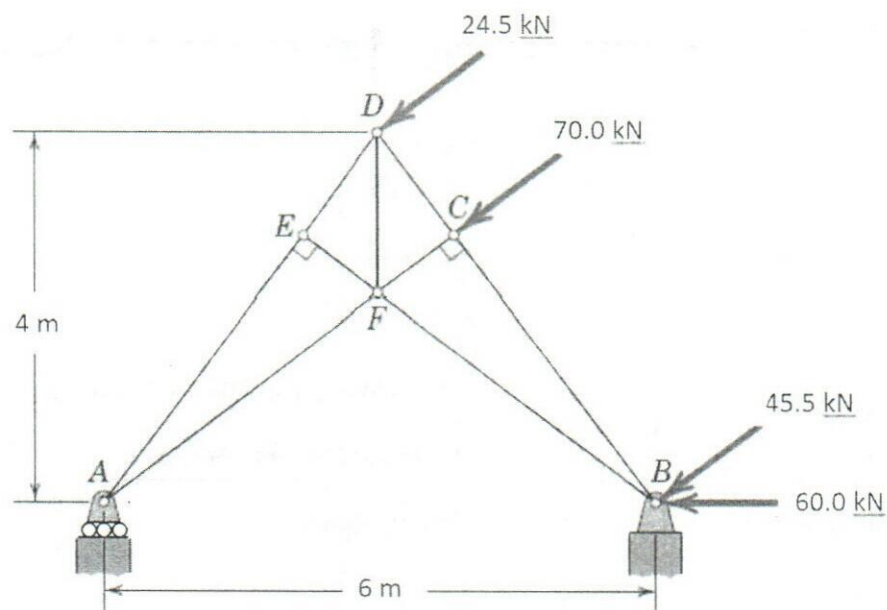


Figure Q1

2. Determine the second moment of area of the section shown in Figure Q2, about the x axis. You may use the information on second moment of areas of three sections, presented in Table Q2.

[15 Marks]

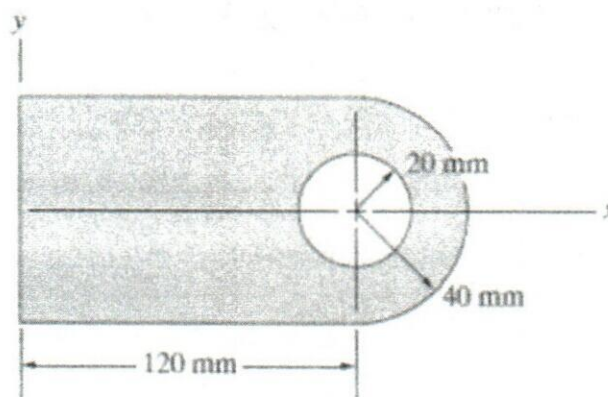


Figure Q2

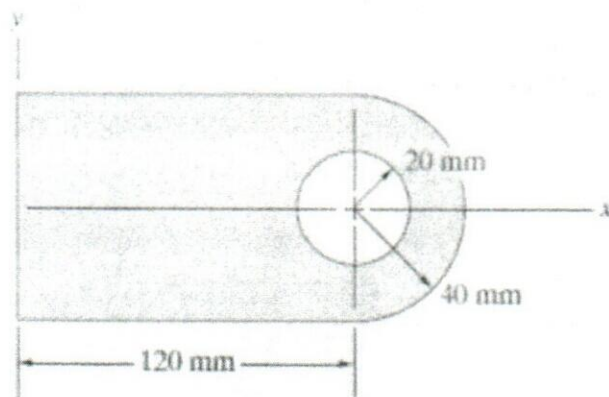


Figure Q2

Rectangle		$I_x = \frac{1}{12}bh^3$ $I_y = \frac{1}{12}hb^3$
Circle		$I_x = I_y = \frac{\pi}{4}r^4$
Semicircle		$I_x = I_y = \frac{\pi}{8}r^4$

Table Q2

3. Draw Shear Force and Bending Moment diagrams for the beam shown in Figure Q3.

[25
Marks]

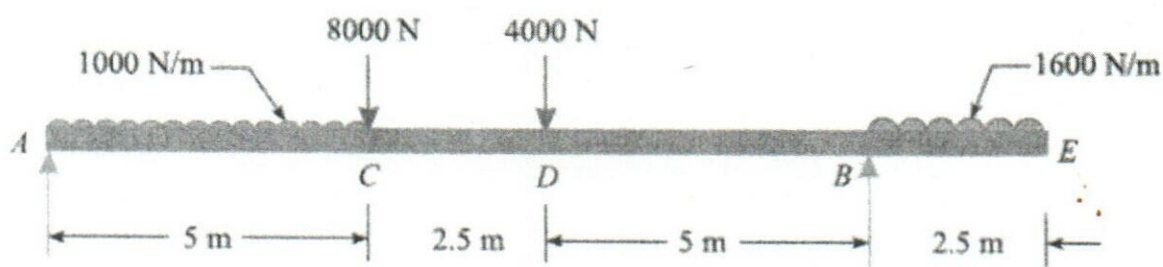


Figure Q3

4. (a) Determine the second moment of area of the section shown in Figure Q4 about its neutral axis, where $B = 200$ mm, $H = 400$ mm, $b = 40$ mm and $h = 50$ mm,
(b) If the beam in Figure Q3 is of the cross section shown in Figure Q4 find the maximum tensile and compressive axial stresses of the beam.

[20 Marks]

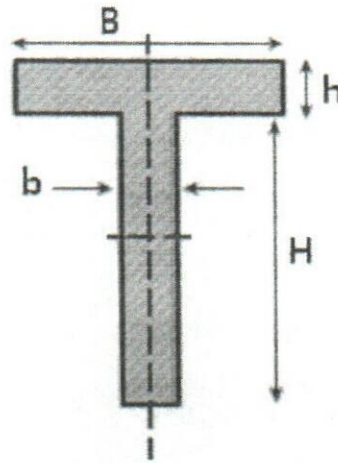


Figure Q4

5. Figure Q5 shows the elevation and plan of an eccentrically loaded column of circular cross section of diameter 13 mm.
(a) Find the section modulus, $Z = I/r$ of the cross section where I is the second moment of area about a centroidal axis and r is the radius of the specimen.
(b) If the maximum axial compressive stress of the specimen, $\sigma = [(P/A) + (M/Z)]$, where A is the cross sectional area of the specimen and M is the bending moment due to eccentricity, is 15% higher than the direct compressive stress P/A , find the eccentricity e .

[15 Marks]

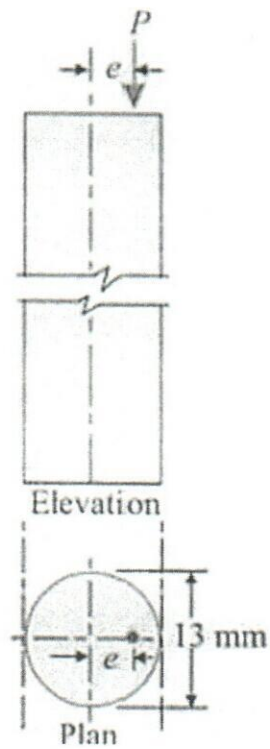


Figure Q5

END OF QUESTIONS



Faculty of Engineering & Technology
Department of Civil Engineering
Bachelor of Science Honours in Engineering
Year 1 Semester 1 Final Examination 2024

Module Code	:	CE1314
Module Title	:	Mechanics
Date/Time	:	22 nd November 2024 / 09.00 am – 12.00 noon
Examiner	:	Prof. Sarath Abayakoon
Time Allowed	:	Three hours

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- You should attempt **ALL** questions.
- This paper contains 4 pages.
- **Attempt all 05 questions.**
- **Three hours will be allocated to answer all the 05 questions**

MATERIALS REQUIRED

- Answer Booklet.
- You may use a scientific calculator.
- Extra answer papers (if required)

Student Number

1. A wind force study resulted in the forces shown in Figure Q1 on a pin connected, geometrically symmetric, roof truss of a small church. The 60.0 kN force is horizontal and the other three forces are perpendicular to DCB .
- Draw the free body diagram for the truss
 - Find the support reactions at A and B
 - Using method of joints, find all member forces and indicate whether they are in tension or compression
- [25 Marks]

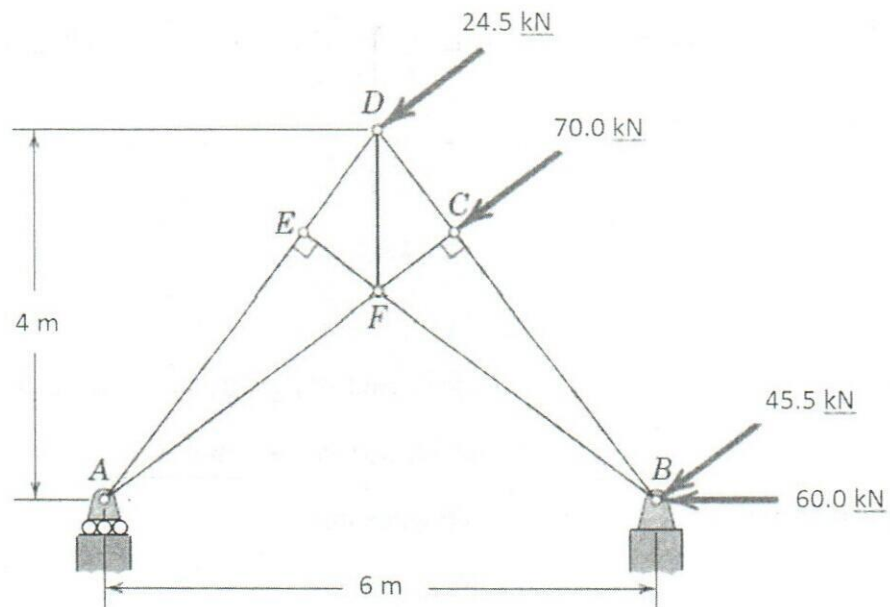


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[15 Marks]

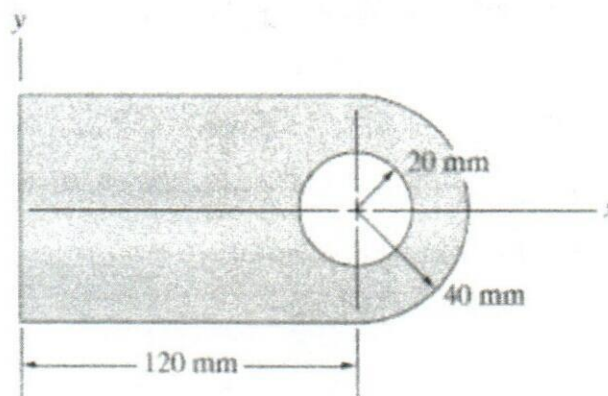


Figure Q2

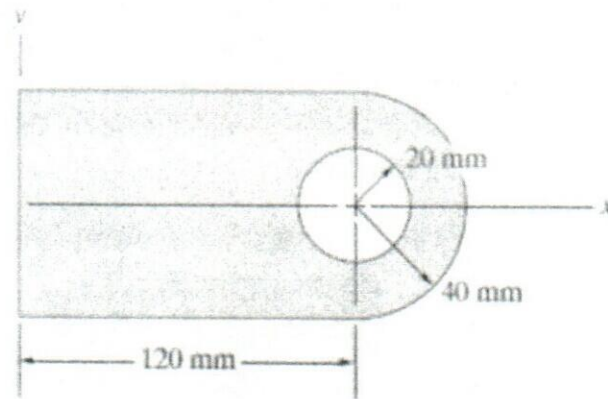


Figure Q2

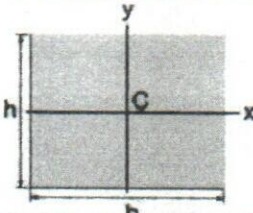
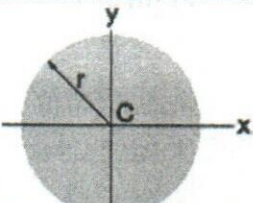
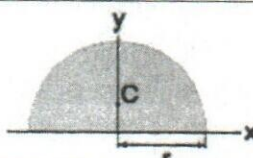
Rectangle		$I_x = \frac{1}{12}bh^3$ $I_y = \frac{1}{12}hb^3$
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Semicircle		$I_x = I_y = \frac{\pi}{8}r^4$

Table Q2

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[25
Marks]

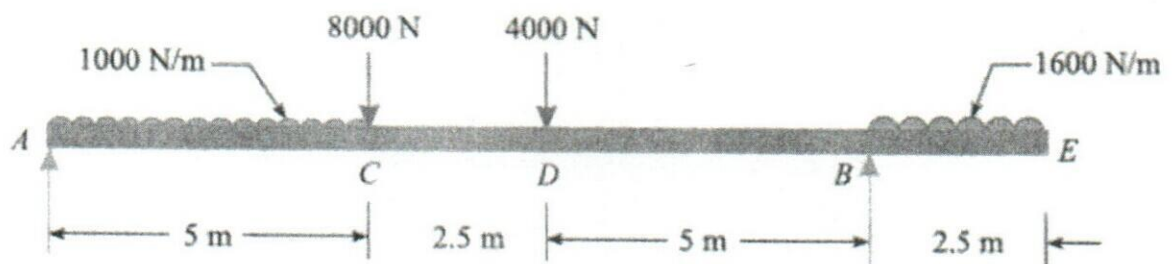


Figure Q3

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[20 Marks]

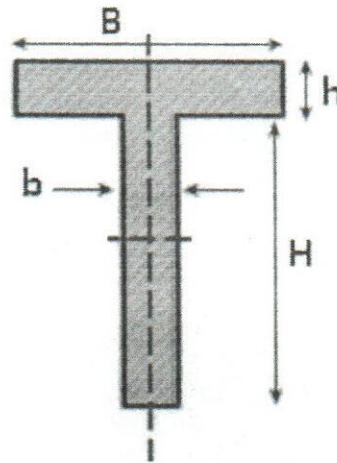


Figure Q4

5. Figure Q5 shows the elevation and plan of an eccentrically loaded column of circular cross section of diameter 13 mm.
(a) Find the section modulus, $Z = I/r$ of the cross section where I is the second moment of area about a centroidal axis and r is the radius of the specimen.
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[15 Marks]

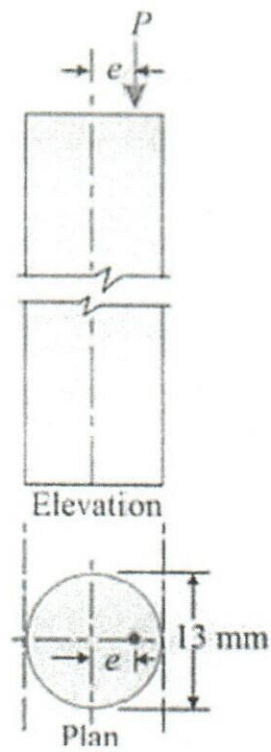


Figure Q5

END OF QUESTIONS

Colombo International Nautical & Engineering College
Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering



ME1312 – Engineering Drawing

EXAMINATION PAPER (Semester 1)

Date : 2024 November
Examiners : Virantha E.A.I
Time Allowed : 3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- The question paper consists of **one** question in two pages.
- Answer all questions.
- Any data which is not given assume.

MATERIALS REQUIRED

- A2 size drawing sheet (Will be provided)
- Drawing tools including compass set and triangles
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.

Q1. The pictorial view of a clamping bracket shown in Figure: 01. Draw the following views in FIRST ANGLE PROJECTION.

1. Sectional Front elevation on **AA**, viewing in the direction of arrow **X**
2. End elevation viewing in the direction of arrow **B**
3. Plan view

Use suitable scale

Complete the drawing by adding title Dimensions and projection symbol.

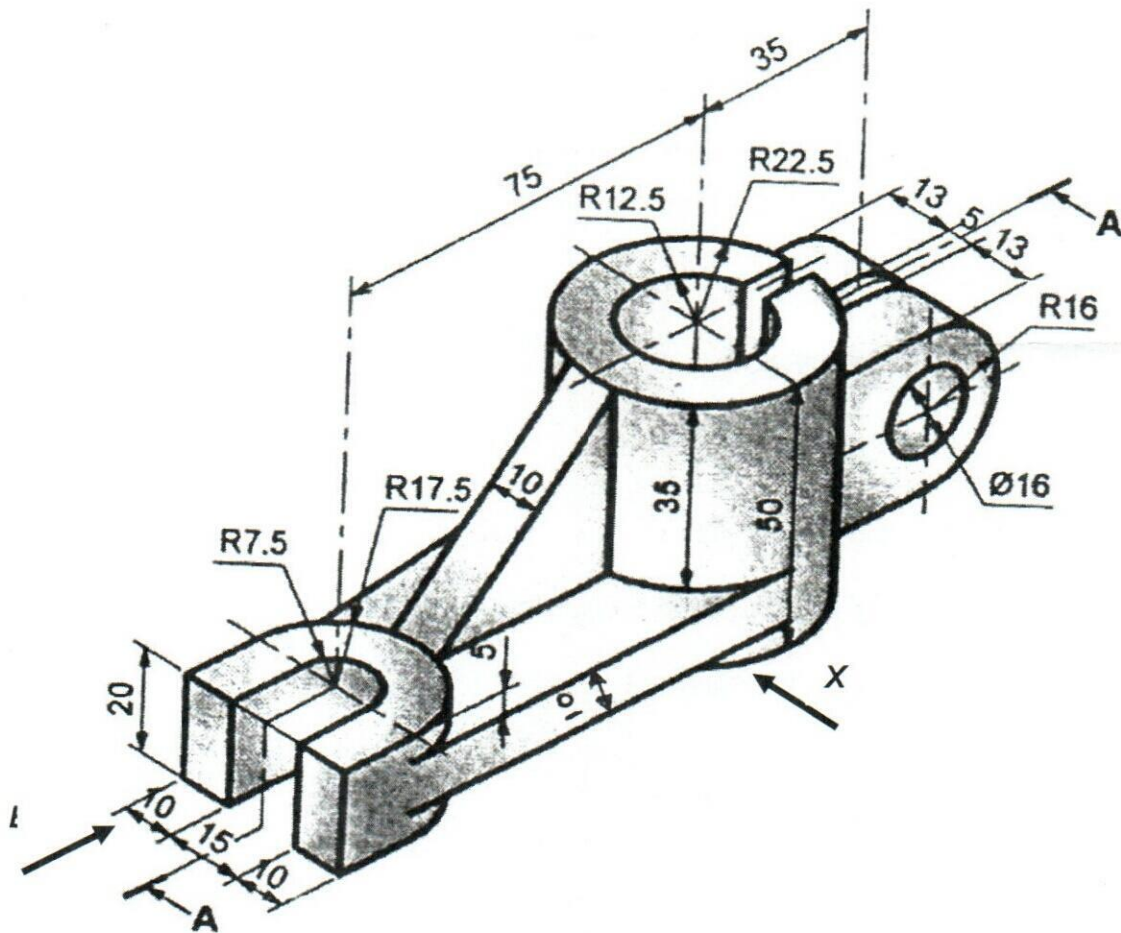


Figure: 01

Marking Scheme

1. Accuracy of view (a)	20 Marks
2. Accuracy of view (b)	20 Marks
3. Accuracy of view (c)	20 Marks
4. Alignment of views	10 Marks
5. Spacing	10 Marks
6. Title block, Projection symbol, Lettering	05 Marks
7. Dimensioning	05 Marks
8. Final Appearance/ Neatness	10 Marks



Faculty of Engineering & Technology
Department of Civil Engineering
Bachelor of Science Honours in Engineering
Year 1 Semester 1 In-Class Examination 2023

Module Code	:	CE1313
Module Title	:	Properties of Materials
Date/Time	:	24 th October 2024 / 09.00 am – 10.00 am
Examiner	:	P.W Gavithra Udayakumara
Time Allowed	:	One hour

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- You should attempt **ALL** questions.
- Show all stages of your work.
- This paper contains 4 pages.
- **Attempt all 06 questions.**
- One hour will be allocated to answer all the 06 questions.

MATERIALS REQUIRED

- Answer Booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.
- Extra answer papers (if required)
- Equations are mentioned at the 4th page

Student Number

1. An aerospace engineer is designing the fuselage of a new aircraft. The objective is to reduce the overall weight while maintaining high strength and resistance to fatigue. The engineer must choose between a range of materials, including metal alloys, polymers, and composite materials.
The engineer chooses a composite material made from carbon fiber and epoxy resin. Which of the following best explains why composite materials are preferred in aerospace applications?
 - a. Composite materials are less expensive than metals.
 - b. Composites offer a high strength-to-weight ratio, reducing weight without compromising structural integrity.
 - c. Composites are easier to manufacture than metal alloys.
 - d. Composites are more resistant to corrosion than polymers

2. An engineer is tasked with designing a bridge component that will experience cyclic loading due to passing vehicles. The material must have a long fatigue life to ensure durability and safety.
The engineer is considering two materials: one with a higher yield strength but no defined endurance limit, and another with a lower yield strength but a well-defined endurance limit. Which material should the engineer choose for this application?
 - a) The material with higher yield strength because it can withstand higher loads.
 - b) The material with a well-defined endurance limit because it can endure cyclic loading over a long period without failure.
 - c) The material with lower yield strength because it will be more cost-effective.
 - d) Both materials are equally suitable since the loads are cyclic

3. A mechanical engineer is designing a rotating shaft for a turbine, which will experience high-speed rotation and continuous cyclic stresses. The goal is to prevent fatigue failure during the turbine's operational life.
Why is it important to consider the endurance limit when selecting the material for the rotating shaft?
 - a) The endurance limit defines the temperature at which the material will fail.
 - b) The endurance limit determines the maximum load the material can withstand during static loading.
 - c) The endurance limit indicates the maximum stress level the material can endure indefinitely without fatigue failure under cyclic loading.
 - d) The endurance limit helps to predict the material's electrical conductivity under cyclic stress

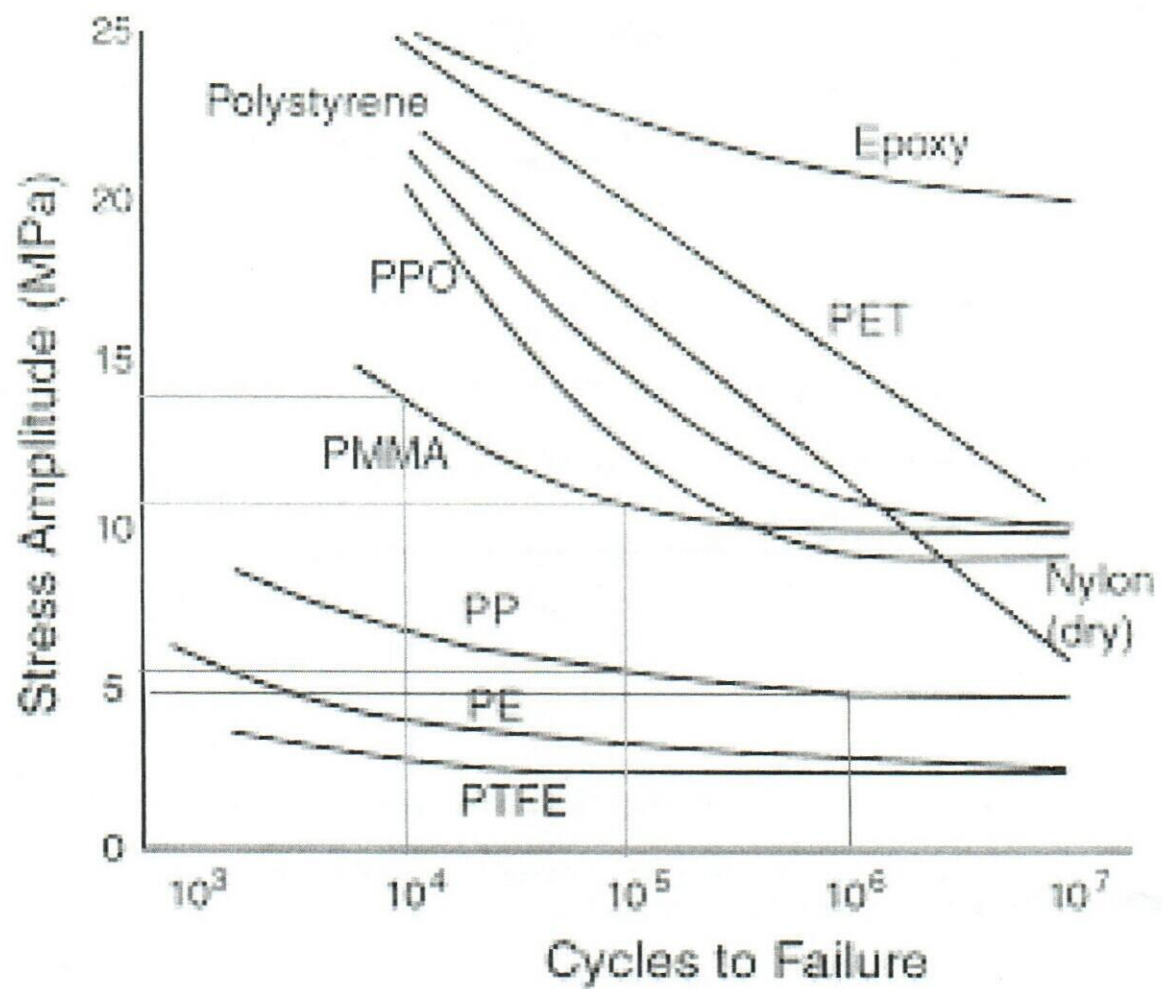
4. Estimate the theoretical fracture strength of a brittle material if it is known that fracture occurs by propagation of an elliptically shaped surface crack length of .8mm and having a tip radius of curvature of 7×10^{-3} mm when a stress of 1080MPa is applied.

5. Below mentioned the details of a bridge to happen a failure with respect to the type of moving vehicles

Type of vehicle s_i (MPa)	No. Applied Cycles by 1 vehicle, N_i	Number of vehicles moving on the bridge	No. Cycles to Failure, N_{fi}
Prime mover	800	X	10,000
bus	80	3	500
car	60	2	320

What will be the minimum number of prime movers(X) that can be moved to fail the bridge?

6. Below figure shows the fatigue test for 9 different type of commonly using thermoplastics in industry. By using the fatigue cycling formula calculate the following.
- Determine the “constant representing the structural detail” and the “Slope coefficient of mean test result line” by using the data given below with reference to the given graph
 PP $\{(10^5, 6), (10^6, 5)\}$
 PMMA $\{(10^4, 14), (10^5, 11)\}$
 - Determine the endurance limit for above two
 - Compare the results and give a brief description on each



$$\sigma_c = \left(\frac{2E\gamma_s}{\pi a} \right)^{1/2}$$

$$\sigma_m = 2\sigma_0 (a/p_t)^{1/2}$$

$$\sum_i n_i / N_{fi} \leq 1$$

$$N(S_a)^m = c$$

FE2312

[Type here]

Economics & Accounting for Engineers

Faculty of Engineering & Technology
Bachelor of Science (Honours) in Engineering

**FE2312 Economics and Accounting for Engineers****Semester-5****2024****(Batch -5)**

Time allowed: 3 hours for the exam 01st Sep 2024 from 09:00a.m. to 12:00 noon

Note:

- Answer **all questions** and all carry equal marks
- All carry equal marks
- Some useful formula given at the end of the question paper

Question 01.

- I. Briefly describe T-accounts and Trial balance in accounting (06 marks)
- II. Explain Assets, Liabilities and Owner's equity of a balance sheet (03marks)
- III. State under which area you update the below transactions.
 - Cash: \$10,000
 - Accounts Receivable: \$5,000
 - Inventory: \$3,000
 - Long-term Loans: \$15,000
 - Accounts Payable: \$2,000(05marks)

Briefly explain six (06) terms given in the list below.

- I. Purchase returns and purchase discounts
 - II. Rate of Return and Minimum Attractive Rate of Return
 - III. Alternative solutions and Opportunity cost
 - IV. Share capital and Retained earnings
 - V. Revenues and Unearned revenues
 - VI. Depreciation
- (06 marks)

Question 02.

- a) Define "time value of money " (05 marks)
- b) Role of Engineering economy and accounting gives marvelous beneficiaries in engineering project investment decision making. Give you comments positively or negatively with the statement (05 marks)
- c) Explain how financial documents aid to make decisions for internal and external customers of the business. (04 marks)
- d) A total of \$1,250 is invested at a simple interest rate of 7% for 8 months. Calculate the interest to be earned on this investment (03 marks)
- e) ABC Bank is offering 5% interest on an account. Saman makes an initial deposit of \$25,000. Calculate the interest earned over 12 years if the bank calculates the interest using compound interest compounded annually. (03 marks)

Question 03.

A firm is considering an investment for which the net cash flows have been estimated as follows.

Year	0	1	2	3	4
NCF, Rs.'000	(1,950)	625	950	965	660

Required to

- a. Calculate net present value of the project for discount rates given below
 - I. 15%
 - II. 20%
 (08 marks)
- b. State whether the project is profitable in each case (02marks)
- c. Select the discount rate for your investment and explain the reason for your selection (04 marks)
- d. Find the Internal Rate of Return (IRR) (06 marks)

Question 04.

- a) Define the payback period of an investment (02 marks)
- b) Explain the importance of the payback period calculation of an investment. (03 marks)
- c) ABC company produces wool apparel, and the current sewing machine used by the company is at the end of its life. As a solution management decided to purchase a new machine and realized that several options available in the market, each of them resulting in cost savings given that they consume less electricity and/or require less maintenance than the current model used.

The company is going through a restructuring phase where there is not much money going around. Therefore, the Chief Financial Officer's decision is to select the machine that will allow the company to recover its money as quick as possible.

The company accounting analyst prepared the following analysis for each of the machine.

Machine	M1	M2	M3
Cost and Installation (\$)	45,000	48,000	70,000
Useful life (years)	10	12	15
Annual depreciation (\$)	5,000	6,000	8,000
Annual cash savings (\$)	7,500	6,500	8,900

Required to,

- I. Compute the payback period of each machine (09 marks)
- II. Recommend the machine based on the CFO's criteria with explanation (03 marks)
- III. State one major disadvantage of payback period calculation (03 marks)

Question 05.

Adjusted trial balances for ABC Company at the end of its fiscal year are presented below;

ABC Company
Adjusted Trial Balance
March 31,2023

	Debit (\$)	Credit (\$)
Cash	11,000	
Accounts Receivable	12,500	
Supplies	1,200	
Prepaid Insurance	3,000	
Equipment	15,000	
Accumulated Depreciation-Equipment		4,000
Accounts Payable		6,000
Salaries and Wages payable		1,200
Unearned Rent Revenue		1,100
Owner's Capital		16,000
Service Revenue		34,000
Rent Revenue		12,900
Salaries and Wages Expense	16,200	
Supplies Expense	1,300	
Rent Expense	13,000	
Insurance Expense	1,500	
Depreciation Expense	500	
	75,200	75,200

Required to prepare;

I. The Income Statement (10 marks)

II. Owner's Equity Statement for the year 2023 (10 marks)

Useful formula & Data:

Compound interest formular,

$$F = P(1+i)^N$$

Where;

F-future value

P-present value

i-interest rate

N-period

DCF formula for Net Present Value; $NPV = \sum_{t=0}^n Ct/(1+i)^n$

Where;

Ct – the net cash flow in a period

t - the period number

i – the discount rate

Discounting factors (DF) at 15% & 20% required rate of return of the project

Year	1	2	3	4
DF for 15%	0.87	0.76	0.66	0.57
DF for 20%	0.83	0.69	0.58	0.48

CINEC Campus

Faculty of Engineering & Technology

Bachelor of Science Honours in Engineering



CE2315 STRUCTURAL ANALYSIS I

FINAL EXAMINATION - RESIT

Date : 24th August 2024
Examiner : Ms. Udayanga Edirisooriya
Time Allowed : 3 hours

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **FOUR** questions in 4 pages.
- Answer **All** questions.
- Show all stages of your work
- You should write legibly in **BLACK** or **BLUE** ink.
- All the answers should be given with respective units.

MATERIALS REQUIRED

- Answer booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination. Programmable calculators, PDAs and mobile phones are not permitted in the exam.

1)

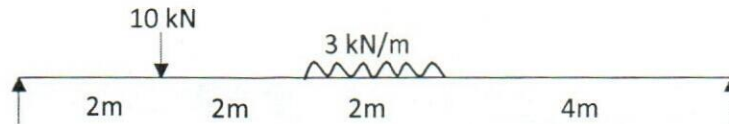


Figure 1.1

- i. Write down an equation for the bending moment (M_x) at any point x in the beam given in Figure 1.1, using singularity functions. (20 marks)
- ii. Solve that equation using Macaulay's method and find the location and value of the maximum deflection. Take $EI = 2 \times 10^3 \text{ kNm}^2$ (60 marks)
- iii. If maximum allowable deflection is "span /200", check whether the calculated deflection can be allowed. (10 marks)
- iv. Write down an equation for the bending moment (M_x) at any point x in the beam given in Figure 1.2. (10 marks)

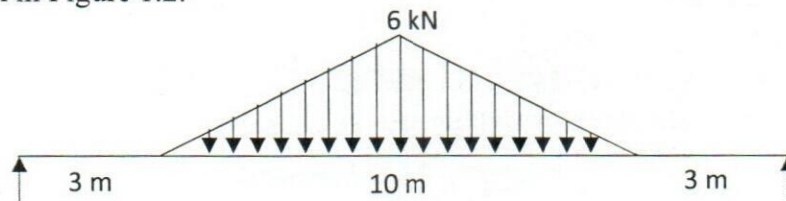


Figure 1.2

2)

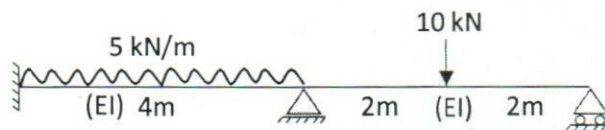


Figure 2

- i. Use slope deflection equations to find support moments of the beam given in Figure 2, if the middle support settles by 10 mm. Take $EI = 3 \times 10^3 \text{ kNm}^2$. (50 marks)
- ii. Verify your answers using moment distribution method. (50 marks)

3)

- a) An unsymmetrical three hinged parabolic arch is given in Figure 3.

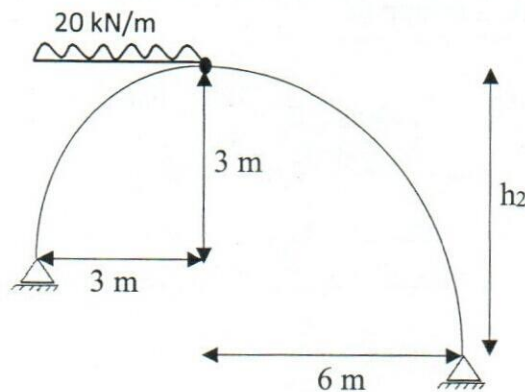


Figure 3

- i. Calculate the value of h_2 . (10 marks)
 - ii. Find the support reactions. (10 marks)
 - iii. Calculate the normal thrust and radial shear force at a section 2 m away from the left support. (30 marks)
- b) A suspension bridge of span 80 m and a dip of 10 m has to be constructed over a wide river. This bridge has two lanes and each lane is designed for 3 kN/m. Determine maximum tension in the cable and the diameter required for the cable if the allowable stress is 400 MPa. (50 marks)

4)

- a) A hollow steel column is 4 m long and has the section given in Figure 4.1. If one end is fixed and the other is free, calculate the Euler Buckling load. Take $E = 2 \times 10^5$ N/mm² for steel.

(50 marks)

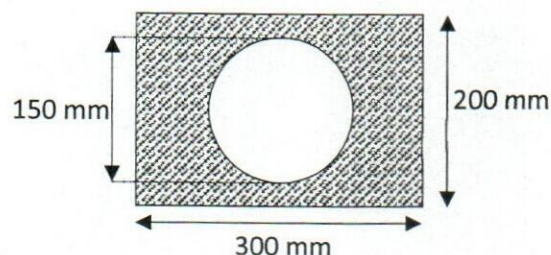


Figure 4.1

- b) A moving load system consists of a uniformly distributed load and four concentrated loads as given in Figure 4.2. The load system is moving from left to right. Calculate the maximum positive shear force and maximum positive bending moment at a section 5 m away from the left support.

(50 marks)

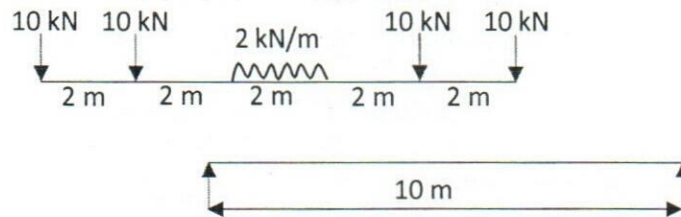


Figure 4.2

FE2311

Resit Examination

Engineering Mathematics III



FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

RESIT EXAMINATION

Module Code	:	FE2311
Module Title	:	Engineering Mathematics III
Academic Year	:	Semester 3/2024
Date	:	20th August 2024
Examiner	:	M.T.M.Ramees
Time Allowed	:	3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all four questions. Each question carries equal marks.
- Each answer should start on a separate page.
- This paper contains 8 pages.
- Additional information is provided on pages 6,7 and 8.

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a Scientific calculator. This must not be programmable and may be inspected during the examination.

1.

- i) Determine the particular solution of $\frac{dy}{dt} + 2y = 2024$ using the integrating factor, given that $y = 1011$ when $t = 0$

[15 Marks]

- ii) The displacement s of a body in a damped mechanical system, with no external forces, satisfies the following differential equation

$$\frac{d^2s}{dt^2} + 12\frac{ds}{dt} + 36s = 0$$

If initially, when $t = 0$, $s = 2$ and $\frac{ds}{dt} = -5$,

Solve the differential equation for s .

[20 Marks]

- iii) Determine the particular solution of the differential equation

$$\frac{d^2y}{dx^2} - 9y = -6 \cos 3x$$

When $x = 0$, $y = \frac{dy}{dx} = 1$

[40 Marks]

iv)

- a) Find the domain and range of function,

$$z = f(x, y) = \sqrt{x^2 + 9y^2} \text{ and then sketch the graph.}$$

[15 Marks]

- b) Determine whether the limit, $\lim_{(x,y) \rightarrow (0,0)} \frac{x^4 + y^3}{x^5 y^3 + y^2}$ exists or not.

[10 Marks]

2.

- i) Find the 2024th derivative of $y = x^2 e^{4x}$ using the Leibnitz's theorem.

[10 Marks]

- ii) Show that the power series solution of the differential equation

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

Using the Leibnitz – Maclaurin method, is given by

$$y = 2 + 4x - e^x$$

Given the boundary conditions that at $x = 0$, $y = 1$ and $\frac{dy}{dx} = 3$.

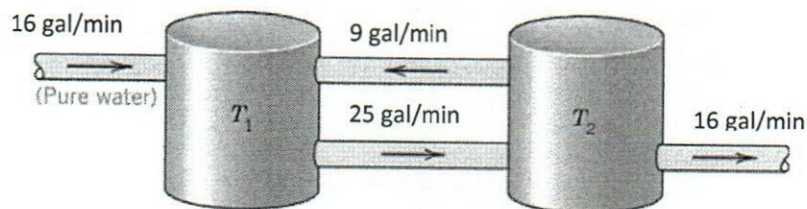
(Note that $e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \dots$)

[45 Marks]

- iii) Let $\frac{dy}{dx} = y + x$, $y(0) = a$
- If $y(0.1) = 1.4415$ using the Improved Euler (Euler-Cauchy) method with a step size of $h = 0.1$ then find the value of a . [10 Marks]
 - Apply the Improved Euler method to find $y(0.3)$. (Consider the step size in a)) [20 Marks]
 - Solve the differential equation using integrating factor method. [10 Marks]
 - Hence, find the percentage error with Improved Euler method for $x = 0.3$. [5 Marks]

3.

- Find the Laplace transform of $f(t) = te^{2t}$ by integration. ($\mathcal{L}\{f(t)\} = \int_0^\infty f(t)e^{-st} dt$). Show the details of your work. [15 Marks]
- Solve the following shifted data IVP by the Laplace transform. Show the details of your work.
 $y'' + 5y' + 4y = 3e^{t-2}$, $y(2) = -2$ and $y'(2) = 5$ [30 Marks]
- Tank T_1 in the figure initially contains 200 gal of water in which 80 lb of salt are dissolved. Tank T_2 initially contains 200 gal of pure water. Liquid is pumped through the system as indicated, and the mixtures are kept uniform by stirring. Find the amounts of salt $y_1(t)$ and $y_2(t)$ in T_1 and T_2 , respectively.



[25 Marks]

- Find the real general solution and sketch or graph some of the trajectories in the phase plane for the following system of equation and determine the type of the critical point.

$$\begin{aligned} y_1' &= -3y_1 + y_2 \\ y_2' &= 3y_1 - 5y_2 \end{aligned}$$

[30 Marks]

4.

- i) Assume that each of your calls to a popular radio station has a probability of 0.04 of connecting, that is, of not obtaining a busy signal. Assume that your calls are independent.
- a) What is the probability that your first call that connects is your 10th call? [6 Marks]
 - b) What is the probability that it requires more than three calls for you to connect? [10 Marks]
 - c) What is the mean number of calls needed to connect? [4 Marks]
- ii) Traffic flow is traditionally modeled as a Poisson distribution. A traffic engineer monitors the traffic flowing through an intersection with an average of four cars per minute. Determine the following probabilities.
- a) What is the probability that no cars pass through the intersection within 30 seconds? [6 Marks]
 - b) What is the probability that more than two cars pass through the intersection within 2 minutes? [14 Marks]
 - c) Calculate the minimum number of cars such that the probability of this number or fewer cars pass through the intersection within 30 seconds is at least 90%. [8 Marks]
 - d) If the variance of the number of cars through the intersection per minute is 20, is the Poisson distribution appropriate? Explain. [2 Marks]

- iii) A utility company might offer electrical rates based on time-of-day consumption to decrease the peak demand in a day. Enough customers need to accept the plan for it to be successful. Suppose that among 50 major customers, 14 would accept the plan. The company selects 10 major customers randomly (without replacement) to contact and promote the plan.
- a) What is the probability that exactly two of the selected major customers accept the plan? [8 Marks]
 - b) What is the probability that at least one of the selected major customers accept the plan? [9 Marks]
 - c) Instead of 14 customers, what is the minimum number of major customers that would need to accept the plan to meet the following objective? The probability that at least 1 selected major customer accepts the plan is greater than or equal to 0.95? [8 Marks]
- iv) A company produces widgets. 45% of the widgets are manufactured in China, 30% of the widgets are manufactured in German, and 25% of the widgets are produced in Korea. In the sample of 10 widgets,
- a) What is the probability that exactly 4, 4 and 2 widgets are manufactured in China, German and Korea, respectively? [7 Marks]
 - b) What is the probability that at least one of the widgets made in China and exactly one of the widgets made in Korea? [8 Marks]
 - c) What is the conditional probability that exactly 3 of the widgets made in China given that exactly 2 of the widgets made in German? [10 Marks]

Table 1 Form of particular integral for different functions

Type	Straightforward cases Try as particular integral:	'Snag' cases Try as particular integral:
(a) $f(x) = \text{a constant}$	$v = k$	$v = kx$ (used when C.F. contains a constant)
(b) $f(x) = \text{polynomial (i.e. } f(x) = L + Mx + Nx^2 + \dots \text{ where any of the coefficients may be zero)}$	$v = a + bx + cx^2 + \dots$	
(c) $f(x) = \text{an exponential function (i.e. } f(x) = Ae^{ax})$	$v = ke^{ax}$	(i) $v = kxe^{ax}$ (used when e^{ax} appears in the C.F.) (ii) $v = kx^2e^{ax}$ (used when e^{ax} and xe^{ax} both appear in the C.F.)
(d) $f(x) = \text{a sine or cosine function (i.e. } f(x) = a \sin px + b \cos px, \text{ where } a \text{ or } b \text{ may be zero)}$	$v = A \sin px + B \cos px$	$v = x(A \sin px + B \cos px)$ (used when $\sin px$ and/or $\cos px$ appears in the C.F.)
(e) $f(x) = \text{a sum e.g.}$ (i) $f(x) = 4x^2 - 3 \sin 2x$ (ii) $f(x) = 2 - x + e^{3x}$	(i) $v = ax^2 + bx + c + d \sin 2x + e \cos 2x$ (ii) $v = ax + b + ce^{3x}$	
(f) $f(x) = \text{a product e.g. } f(x) = 2e^x \cos 2x$	$v = e^x (A \sin 2x + B \cos 2x)$	

Leibnitz's theorem:

$$y^{(n)} = (uv)^{(n)} = u^{(n)}v + nu^{(n-1)}v^{(1)} + \frac{n(n-1)}{2!}u^{(n-2)}v^{(2)} + \frac{n(n-1)(n-2)}{3!}u^{(n-3)}v^{(3)} + \dots$$

Maclaurin's Series:

$$f(x) = f(0) + xf'(0) + \frac{x^2}{2!}f''(0) + \frac{x^3}{3!}f'''(0) + \dots$$

Formulae for Euler-Cauchy Method:

$$y_{p1} = y_0 + hy'_0$$

$$y_{c1} = y_0 + \frac{1}{2}h[y'_0 + f(x_1, y_{p1})]$$

Laplace Transform:

$$F(s) = \mathcal{L}(f) = \int_0^{\infty} e^{-st}f(t) dt.$$

Laplace Transform of Derivatives:

$$\mathcal{L}(f') = s\mathcal{L}(f) - f(0)$$

$$\mathcal{L}(f'') = s^2\mathcal{L}(f) - sf(0) - f'(0).$$

$$\mathcal{L}(f^{(n)}) = s^n\mathcal{L}(f) - s^{n-1}f(0) - s^{n-2}f'(0) - \dots - f^{(n-1)}(0).$$

Some Functions $f(t)$ and Their Laplace Transforms $\mathcal{L}(f)$

	$f(t)$	$\mathcal{L}(f)$		$f(t)$	$\mathcal{L}(f)$
1	1	$1/s$	7	$\cos \omega t$	$\frac{s}{s^2 + \omega^2}$
2	t	$1/s^2$	8	$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$
3	t^2	$2!/s^3$	9	$\cosh at$	$\frac{s}{s^2 - a^2}$
4	t^n ($n = 0, 1, \dots$)	$\frac{n!}{s^{n+1}}$	10	$\sinh at$	$\frac{a}{s^2 - a^2}$
5	t^a (a positive)	$\frac{\Gamma(a+1)}{s^{a+1}}$	11	$e^{at} \cos \omega t$	$\frac{s-a}{(s-a)^2 + \omega^2}$
6	e^{at}	$\frac{1}{s-a}$	12	$e^{at} \sin \omega t$	$\frac{\omega}{(s-a)^2 + \omega^2}$

The Probability Mass Function of Hypergeometric Random Variable X :

$$f(x) = \frac{\binom{K}{x} \binom{N-K}{n-x}}{\binom{N}{n}} \quad x = \max \{0, n+K-N\} \text{ to } \min \{K, n\}$$

A set of N objects contains

K objects classified as successes

$N - K$ objects classified as failures

A sample of size n objects is selected randomly (without replacement) from the N objects where $K \leq N$ and $n \leq N$.

If X is a Hypergeometric Random Variable with parameters N, K and n , then

$$\mu = E(X) = np \quad \text{and} \quad \sigma^2 = V(X) = np(1-p) \left(\frac{N-n}{N-1} \right)$$

where $p = K/N$.

The Probability Mass Function of Poisson Random Variable X :

$$f(x) = \frac{e^{-\lambda T} (\lambda T)^x}{x!} \quad x = 0, 1, 2, \dots$$

The Joint Probability Mass Function of Random Variables $X_1, X_2, \dots, X_k$ which have a Multinomial Distribution:

$$P(X_1 = x_1, X_2 = x_2, \dots, X_k = x_k) = \frac{n!}{x_1! x_2! \dots x_k!} p_1^{x_1} p_2^{x_2} \dots p_k^{x_k}$$

for $x_1 + x_2 + \dots + x_k = n$ and $p_1 + p_2 + \dots + p_k = 1$.

The Probability Mass Function of Negative Binomial Random Variable X :

In a series of Bernoulli trials (independent trials with constant probability p of a success), the random variable X that equals the number of trials until r successes occur is a negative binomial random variable with parameters $0 < p < 1$ and $r = 1, 2, 3, \dots$, and

$$f(x) = \binom{x-1}{r-1} (1-p)^{x-r} p^r \quad x = r, r+1, r+2, \dots$$

If X is a negative binomial random variable with parameters p and r ,

$$\mu = E(X) = r/p \quad \text{and} \quad \sigma^2 = V(X) = r(1-p)/p^2$$

The Probability Mass Function of Geometric Random Variable X :

$$f(x) = (1-p)^{x-1} p \quad x = 1, 2, \dots$$

If X is a Geometric Random Variable with parameters p ,

$$\mu = E(X) = 1/p \quad \text{and} \quad \sigma^2 = V(X) = (1-p)/p^2$$



Faculty of Engineering & Technology
Department of Electrical & Electronic Engineering
Bachelor of Science Honours in Engineering
Year 1 Semester 1 Re-Sit Final Examination 2024

Module Code : EE1315
Module Title : Electricity
Date/Time : 17th August 2024; 09:00 – 12:00h
Examiners : A.A.Hashini Athauda
Time Allowed : 3 hours

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- You should attempt **ALL** questions.
- Show all stages of your work.
- This paper contains 8 pages.

MATERIALS REQUIRED

- Answer Booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.
- Extra answer papers (if required)

Student Number

1)

- a) Use the Thevenin's Theorem to calculate the value of load resistance R_L to which maximum power may be transferred from the circuit shown in Figure 01. Also determine the value of maximum power transferred.

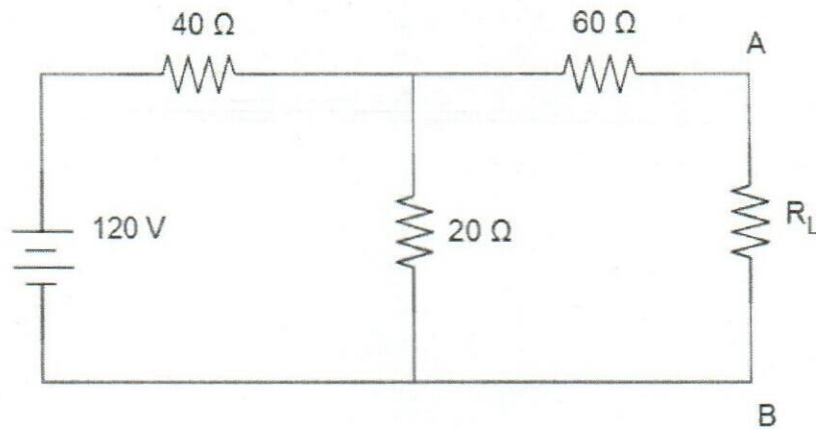


Figure 01

(10 Marks)

- b) Using Millman's theorem, find the current flowing through the load resistance R_L in the circuit of Figure 02

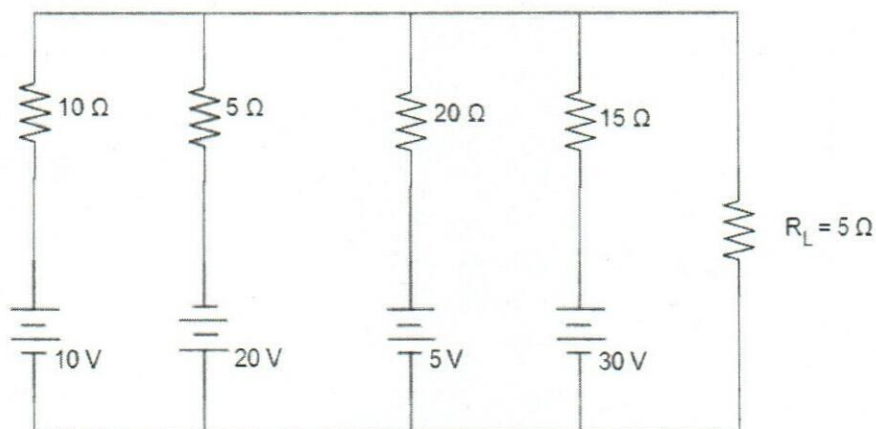


Figure 02

(5 Marks)

2)

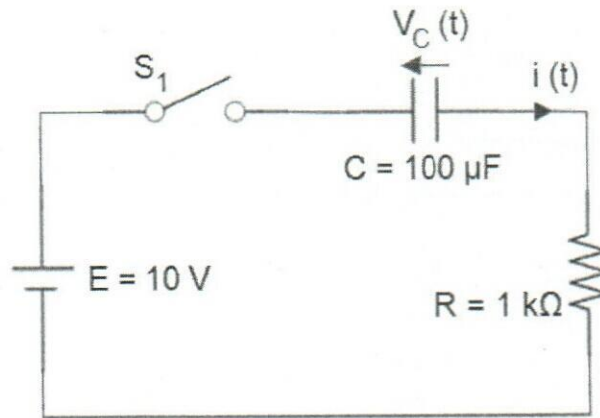
a) Consider the circuit given in Figure 03. The switch S_1 is closed at $t = 0$ s

Figure 03

- i) Write the differential equation to find the current through the circuit after closing the switch S_1 (you may use the current $i(t)$ as the variable) (5 Marks)
- ii) Write the characteristic equation for current through a capacitor. (5 Marks)

- b) Determine the governing differential equation for the following circuit in Figure 04. Express the answer in standard form and determine the capacitor value when the circuit has a critical damping response.

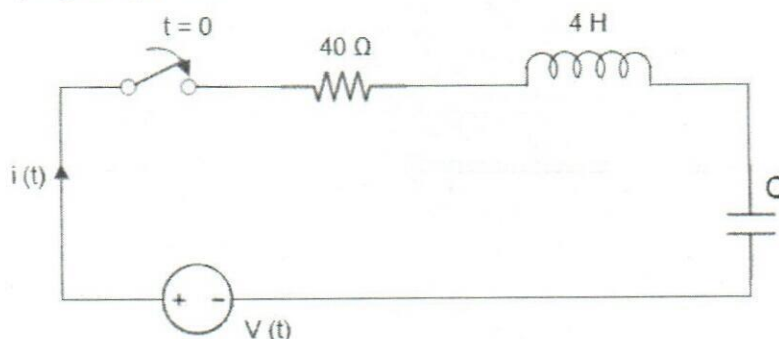


Figure 04

(5 Marks)

3)

- a) In the circuit of Figure 05, it is given that $L=10\text{mH}$, $C=3\mu\text{F}$, and $R=400\Omega$

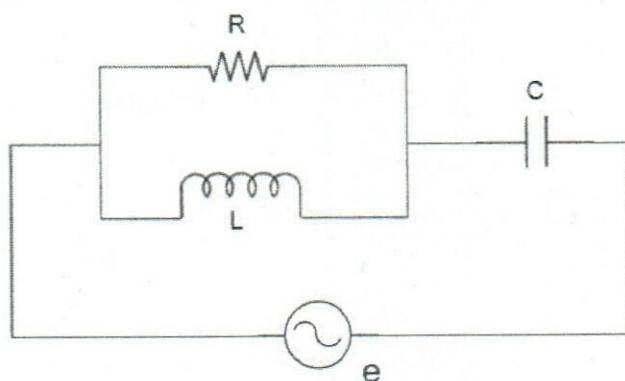


Figure 05

- i) The current and voltage of the capacitor, as measured with a multi-meter at AC setting, read 10mA and 5V respectively. Calculate the current through the R and L (6 Marks)
- ii) Calculate the supply voltage, and express it in the time domain (in the form $V_{rms}=V_p\sin(\omega t\pm\phi)$) (2 Marks)
- iii) Calculate the active power, reactive power, apparent power, and power factor for the given circuit. (4 Marks)
- b) For the circuit in Figure 05, Calculate the resonance frequency. (7Marks)
- c) A capacitor of $50\mu\text{F}$ is connected in parallel with a coil that has a resistance of 20Ω and an inductance of 0.05H . if this parallel combination is connected across 200V , 50Hz supply, as shown in Figure 06.

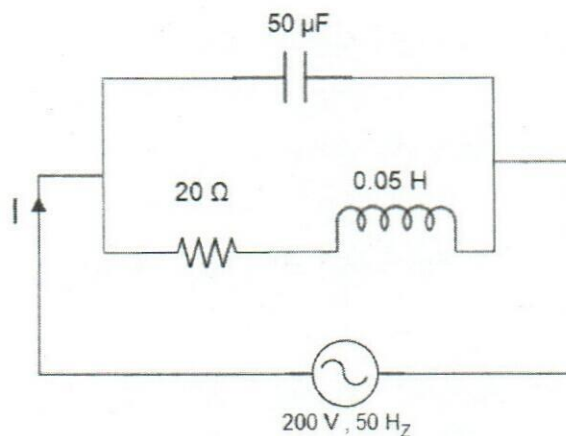


Figure 06

- i) Draw the phasor diagram.
- ii) Calculate the line current. (line current **must** be calculated using a phasor diagram.) (6 Marks)
- d) A coil of resistance 15Ω and inductance 0.5H is connected to a 250V , 50Hz supply. Calculate the capacitance of the capacitor to be connected in parallel with the coil as shown in Figure 07 so that the overall power factor is unity. Also, find the supply current also. (The capacitor value and supply current **must** be calculated using a phasor diagram.)

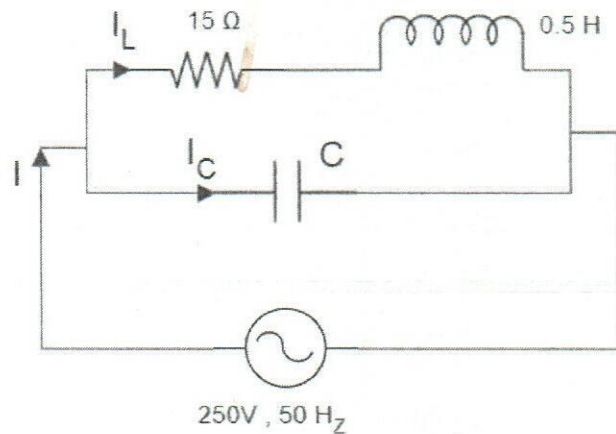


Figure 07

(5 Marks)

4)

a)

i) Draw a sketch of a simple bridge wave rectifier circuit.

(2 Mark)

ii) Sketch the waveform of the output voltage.

(2 Mark)

iii) Explain the behavior of the circuit after connecting a smoothing capacitor.

(4 Marks)

b) A moving coil ammeter has $200\mu\text{A}$ (meter current), A movement with an internal resistance of 500Ω . It is to be converted to,i) A milliammeter with a range of 10mA (full-scale current) andii) An ammeter with a range of 5A (full-scale current), by the use of a shunt. Calculate the value of the shunt required in each case.

(5 Marks)

c)

i) State coulomb's law of electrostatics.

(2 Mark)

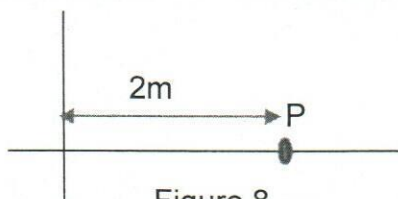
ii) Calculate the force on a unit positive charge at P as shown in Figure 8 on X axis whose coordinates are $(x=2\text{m}, y=0)$ due to the following two charges.

Figure 8

(Assume air as the medium, $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$)

- I. A positive charge of $10^{-9}C$, situated in air the origin ($x=0, y=0$)
- II. A negative charge of $-2 \times 10^{-9}C$, situated on X axis ($x=1m, y=0$)

(4 Marks)

d)

- i) List the types of MCB.

(1 Mark)

- ii) List the components of the MCB.

(1 Mark)

- iii) For what purpose MCB is used?

(1 Mark)

e)

- i) State Faraday's law of electromagnetic induction

(1 Mark)

- ii) A coil of 100 turns is linked by a magnetic flux of 20mWb. If this magnetic flux is reversed in a time of 2ms. Calculate the average e.m.f induced in the coil.

(2 Marks)

5)

- a) Explain Biot-Savart law.

(5 Marks)

b)

- i) With its help derive an expression for the magnetic field at the center of a current-carrying circular loop.

(5 Marks)

- ii) Determine the magnetic field at the centre of a circular coil of radius R, number of turns N, and current I use the above expression (i)

(2 Marks)

- c) Compute the ,magnitude of the magnetic field of a long, straight wire carrying a current of 1A at distance of 1m from it. $\mu_0 = 4\pi \times 10^{-7}$

(3 Marks)

Data Sheet

$$V_c(t) = \frac{1}{C} \int I_c(t) dt$$

$$I_c(t) = C \cdot \frac{dV_c}{dt}$$

$$V_L(t) = L \cdot \frac{dI_L}{dt}$$

$$I_L(t) = \frac{1}{L} \int V_L(t) dt$$

$$\tau = L/R$$

$$\tau = RC$$

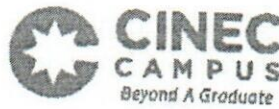
$$V = I(R_n + R_m)$$

$$I_m = \left(\frac{R_n}{R_n + R_m} \right) I_{fs}$$

CE-1313

2024

Final Resit Examination



Faculty of Engineering & Technology
Department of Civil Engineering
Bachelor of Science Honours in Engineering
Year 1 Semester 1 Re-sit Final Examination 2023/2024

Module Code : CE1313
Module Title : Properties of Materials
Date/Time : 13th August 2024 / 09.00 am – 12.00 pm
Examiner : P.W Gavithra Udayakumara
Time Allowed : Three hours

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- "Section A" consists of 05 Multiple Choice Questions. You should attempt **ALL** questions.
- Section B consists of 5 questions. You should attempt all questions.
- Show all stages of your work.
- This paper contains 08 pages.

MATERIALS REQUIRED

- Answer Booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.
- Extra answer papers (if required)
- Equations are mentioned at the 8th page

Student Number

Section A

1. Consider two bars A and B of same material tightly secured between two unyielding walls. Coefficient of thermal expansion of bar A is more than that of B. What are the stresses induced on increasing the temperature?
 - a) Tension in both the materials
 - b) Tension in material A and compression in material B
 - c) Compression in material A and tension in material B
 - d) Compression in both the materials

2. Most engineering metals can deform at a much lower yield strength than the theoretical yield strength because
 - (a) Vacancies in polycrystalline materials will cluster together under the applied stress causing the materials to yield.
 - (b) All engineering materials possess a granular structure allowing the grains to slide past one another.
 - (c) All engineering materials usually contain dislocations which are mobile under applied stresses.
 - (d) The Young's modulus of engineering metals is much lower than that of ideal materials.
 - (e) The number of dislocations in engineering materials is very small.

3. Which of the following statement is true?
 - a) The electrical conductivity is directly proportional to both the number of free electrons and the electron mobility.
 - b) The electrical conductivity is inversely proportional to both the number of free electrons and the electron mobility.
 - c) The electrical conductivity is directly proportional to the number of free electrons but inversely proportional to the electron mobility.
 - d) The electrical conductivity is inversely proportional to the number of free electrons but directly proportional to the electron mobility

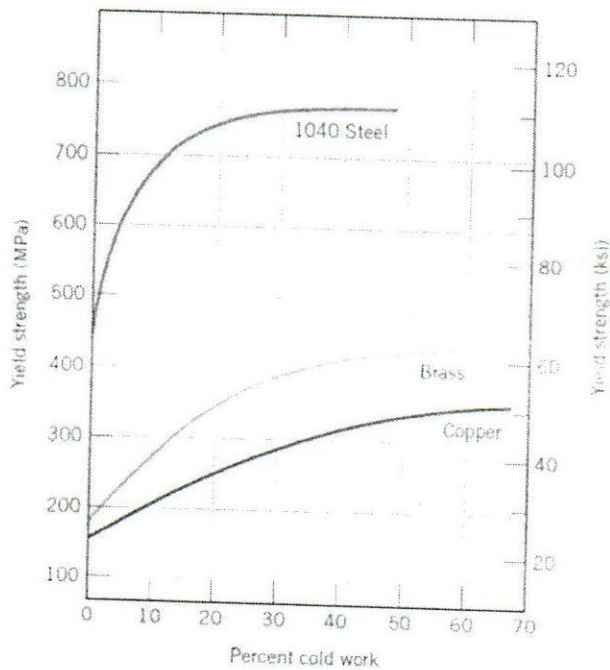
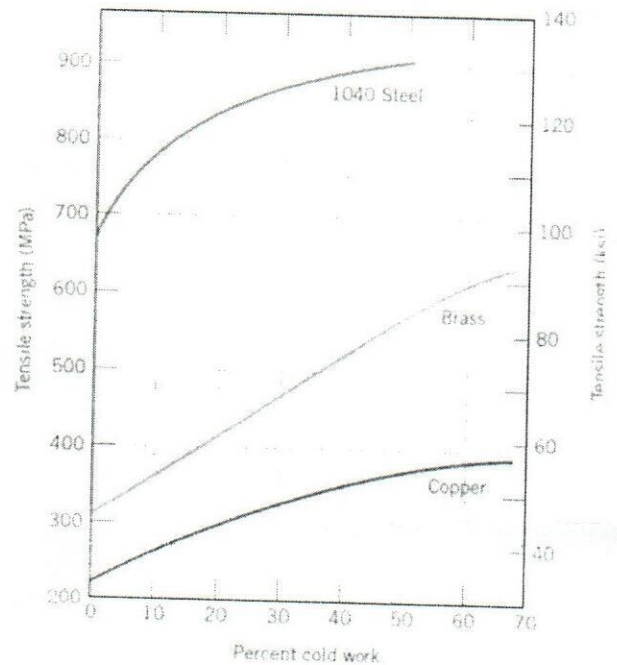
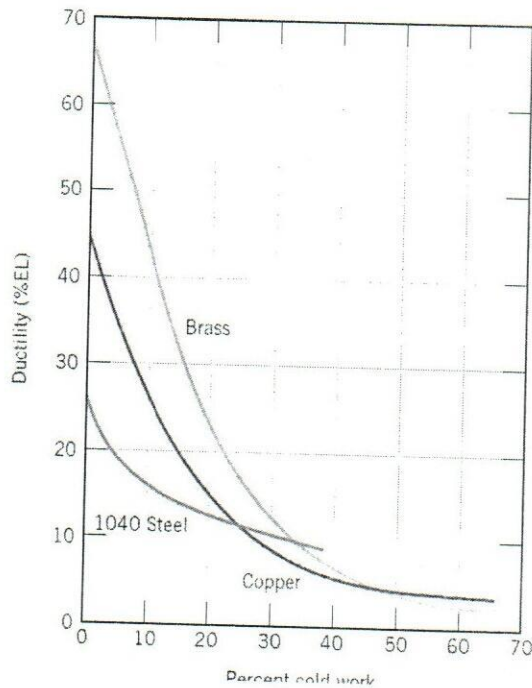
4. Which of the following is true about ductile to brittle transition (DBT) temperature?
 - (a) DBT temperature is not an imported consideration in materials selection for components that operate in low temperature environments.
 - (b) In BCC metals like steel, a slow (gradual) change in behavior is observed over a narrow range of temperature.
 - (c) Above DBT temperature, a metal will absorb high amount of energy before fracturing.
 - (d) Below DBT temperature, a metal will fail in a ductile manner

5. Which of the following is true regarding n-type extrinsic semi-conductors?
- (a) There is an equal number of electrons and holes.
 - (b) There is a donor energy level just below the conduction band.
 - (c) n type extrinsic semiconductors generally have a lower conductivity than intrinsic semiconductors since they only have one type of charge carrier.
 - (d) n-type extrinsic semiconductors are doped with atoms with a valency of 3.

Section B

Question 01

A cylindrical rod of 1040 steel originally 11.4mm in diameter is to be cold worked by drawing, the circular cross section will be maintained during the deformation. A cold-worked tensile strength in excess of 825MPa and ductility of at least 12% EL are desired. Furthermore, the final diameter must be 8.9 mm. explain how this process may be accomplished



Question 02

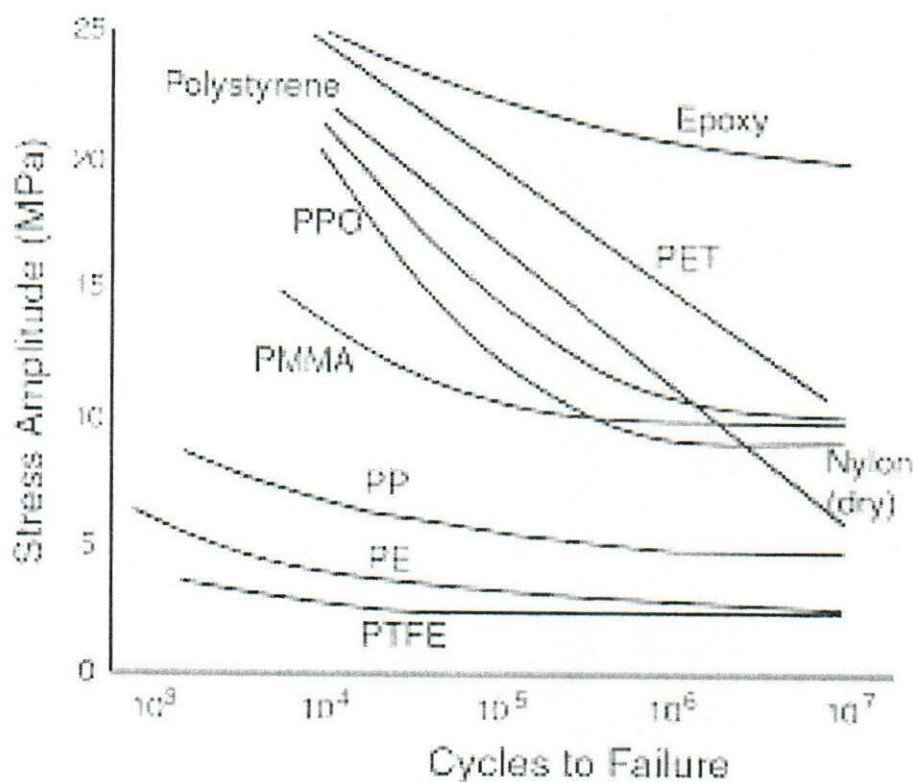
Failures of material can be defined as an undesirable event occurs which lead to economic loss, loss of human lives and loss of time. Therefore it is essential to avoid the occurrence of failures in engineering products.

- a. Determine the “constant representing the structural detail” and the “Slope coefficient of mean test result line” by using the data given below with reference to the given graph

PP $\{(10^5, 6), (10^6, 5)\}$

PMMA $\{(10^4, 14), (10^5, 11)\}$

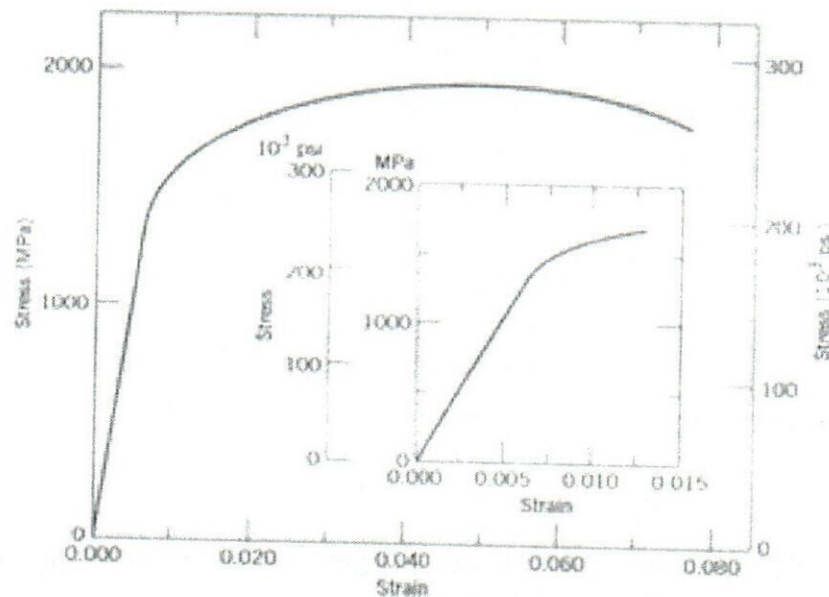
- b. Determine the endurance limit for above two



- c) Assume you have entitled to engineering research team which finds the “root cause for recently failed bridge. Major concern is to determine whether the failure happened due to using of poor quality materials or due to failure of construction”. Comment on the way you propose to compare these two assumptions and how to evaluate the obtained results?
- d) Recommend two methods to enhance the lifetime of a material against rupture failure.

Question 03

A steel alloy specimen having a rectangular cross section of dimensions 19mm * 3.2mm has the stress-strain behavior as shown in below graph. If the specimen subjects to a tensile force of 110,000 N



- Determine the elastic and plastic strain values
- If the original length is 610mm, what will be its final length after above load is applied and then released?
- Briefly explain the term "Poisson's ratio"
- A cylindrical steel bar using for concrete subjects to tensile stress along the long axis which is having the diameter of 12 mm. Determine the magnitude of the load required to produce 3×10^{-3} mm change in the diameter if the deformation is entirely elastic. Poisson's ratio is 0.4 and modulus of elasticity of steel is 69 GPa

Question 04

Mechanical properties of a materials may play a vital role in deciding the accurate engineering application of those materials. Based on the mechanical properties materials are categorizing in to various sections. Based on the mechanical properties of materials answer the below given questions.

- Briefly describe the strength of a brittle material with the aid of a diagram
- Briefly describe the term work hardening
- Briefly describe the toughness of a ductile material and name the test which uses to measure the toughness.

- d) Assume that following observations received from bending test of material.

Breaking load	= 160 N
Distance between the knife edges where sample supported	= 40 mm
Average specimen breadth	= 20 mm
Average specimen depth	= 10 mm

Calculate the tensile strength of the material

- e) Tensile stress is to be applied along the long axis of cylindrical brass rod that has a diameter of 20 mm. Determine the magnitude of the load required to produce a 4.0×10^{-3} mm change in diameter if the deformation is entirely elastic. Poisson's ratio for brass 0.34, modulus of elasticity 97 GPa.

Question 05

Annealing is a critical process in the manufacturing of various products, including metal components, wires, sheets, and other materials where specific mechanical, thermal, or electrical properties are required. It helps optimize the microstructure of the material for its intended applications.

- Briefly describe 3 stages annealing process.
- Mention 5 aims of using annealing as a metal fabrication technique.
- What is the magnitude of the maximum stress that exists at the tip of an internal crack having the curvature of 2.3×10^{-4} mm and a crack length of 4.6×10^{-2} mm when a tensile stress of 280 MPa is applied?

σ	$=E\epsilon$
ϵ_A	$= \{(A_0 - A_f) / A_0\} * 100\%$
MOR	$= (3PL) / (2bd^2)$
%CW	$= \{ (A_0 - A_d) / A_0 \} * 100\%$
σ_c	$= \{2E\gamma_s / \pi a\}^{1/2}$
$N(S_a)^m$	$=C$
P_{LM}	$= T [C + \log (tr)]$
I	$= AneV_d$
σ	$= n e \mu_e + p e \mu_h$
$E_c(u)$	$= E_m V_m + E_p V_p$
$E_c(l)$	$= E_m E_p / (E_m V_p + E_p V_m)$
F_c	$= F_m + F_f$
$\sigma_c A_c$	$= \sigma_m A_m + \sigma_f A_f$
σ_c	$= \sigma_m V_m + \sigma_f V_f$
σ_c / ϵ_c	$= (\sigma_m / \epsilon_m) V_m + (\sigma_f / \epsilon_f) V_f$
E_c	$= E_m V_m + E_f V_f$
E_c	$= E_m (1 - V_f) + E_f V_f$

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Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering

EE2327 – Electrical Power & Machines

First Sit EXAMINATION PAPER (Semester 4)

Date : 29/07/2024

Examiner : Mr. Amila Nuwan Sanjeewa

Time Allowed: 3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- The question paper consists of **five** questions in **four** pages.
- **Answer all questions.**
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.

01. (a)
1. Define power factor of a load. (1 marks)
 2. What is the meaning of lagging power factor and leading power factor? (2 marks)
- (b)
1. What techniques can be used to improve power factor in the power system? (2 marks)
 2. Discuss Benefits of power factor correction. (3 marks)
- (c)
1. Proof that an equation for capacitor which is used in power factor correction. (Relevant sketches also can be use) (3 marks)
 2. State Energy Audit process. (2 marks)
 3. Discuss the role of Energy audit services. (3 marks)
- (d)
- A synchronous motor improves the power factor of a load of 250kW from 0.7 lagging to 0.95 lagging. Simultaneously the motor carries a load of 60kW.
1. Find the leading kVar taken by the motor, kVA rating of the motor, and power factor at which the motor operates.
 2. Instead of a synchronous motor, find the capacitance that can improve the power factor from 0.7 lagging to 0.95 lagging. (5 marks)
02. (a)
1. What is the importance of protection of electrical wiring? (1 marks)
 2. List suitable electrical protection device that can be used for. (2 marks)
 - i. Over current
 - ii. Short circuit
 - iii. Earth leakage
 - iv. Surge
 3. State the difference between ring and radial circuit. (2 marks)
- (b)
1. Draw Single phase consumer connection diagram. (3 marks)
- (c)
1. List important factors to be consider when energy generation planning? (2 marks)

2. What are the cons of variable load in power system?

(2 marks)

(d) Study the power system shown in Figure 2.1. The rated power output of each generator is 120MW. Power ratings of L1, L2, L3 and L4 loads are 80MW, 100MW, 150MW and 120MW respectively. Daily power consumption profile of the three loads is given in the Table 2.1. Draw the daily load curve and the daily load duration curve for the given power system. Find following values for the power plant. (8 marks)

- i. Installed/plant capacity
- ii. Connected load
- iii. Peak demand
- iv. Average load
- v. Reserve capacity
- vi. Demand factor
- vii. Load factor
- viii. Utilization factor

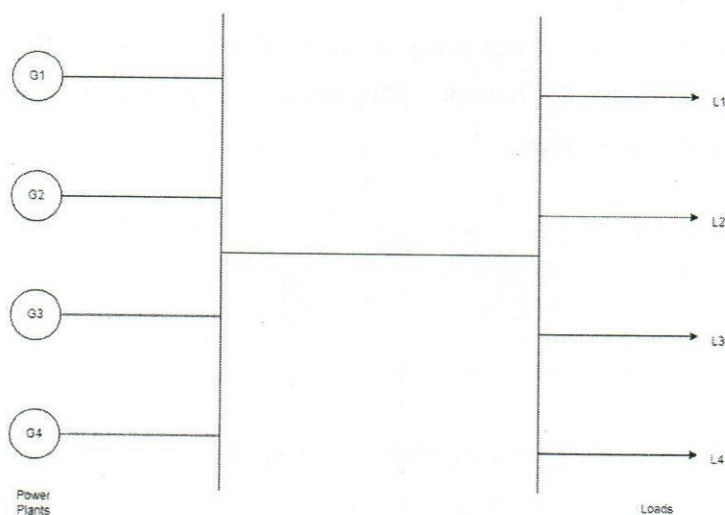


Figure 2.1: Power System

Table 2.1: Daily power consumption profile

	24.00-03.00	03.00-06.00	06.00-09.00	09.00-12.00	12.00-15.00	15.00-18.00	18.00-21.00	21.00-24.00
L1	35	40	50	65	55	70	80	45
L2	45	55	65	75	60	75	90	60
L3	60	70	75	100	80	95	135	115
L4	50	60	100	60	40	20	10	25

03. (a) What are the types of construction for transformer core? (2 marks)
- (b) List the losses associate with the transformer. (3 marks)
- (c) 1. Draw the phasor diagram of a transformer. (3 marks)
- Hint: $\frac{V_p}{a} \cong V_s + R_{eq} I_s \cos\theta + X_{eq} I_s \sin\theta$
2. Draw the equivalent circuit of the transformer and hence obtain the referred to primary circuit with usual notations. (5 marks)
- (d) Solve for the current, load voltage and load power in the circuit shown in figure 3.1 using per unit analysis with an S_B of 200 MVA, and voltage bases of 8 kV, 80 kV and 16 kV, respectively. (7 marks)

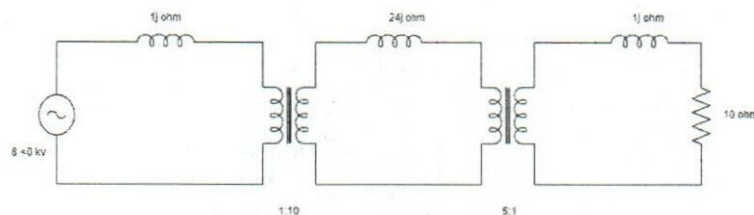


Figure 3.1: Power system circuit

04. (a) 1. Briefly explain the laws associate with the DC motor operation. (2 marks)
2. List main components of DC machine. (3 marks)
- (b) 1. Explain the Open Circuit Characteristic (OCC) for DC machine with essential sketches. (4 marks)
2. What is the meaning of armature reaction? (1 marks)
- (c) 1. Define the DC generator and list the types of it. (2 marks)

2. Sketch the power flow diagram of DC Generator. (2 marks)
 - (d) 1. What are the characteristics of separately excited dc generators? (3 marks)
 2. Draw the performance graph of separately excited dc generators. (3 marks)
05. (a)
1. State the difference between synchronous motor and induction motor. (3 marks)
 2. What is the meaning of excitation in synchronous motor? (3 marks)
 - (b) In brief describe about the losses involve with synchronous motor. (3 marks)
 - (c) Explain about rotating magnetic field of induction motor. (5 marks)
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End of paper



Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering

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Date : 29/07/2024

Examiner : Mr. Amila Nuwan Sanjeewa

Time Allowed: 3 Hours

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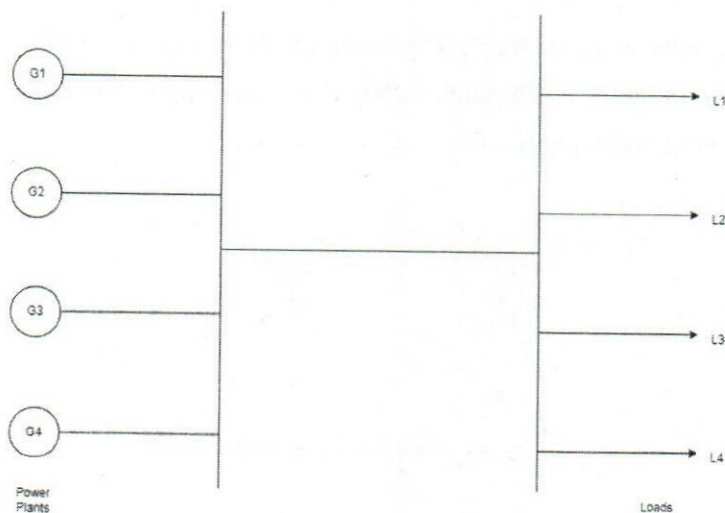


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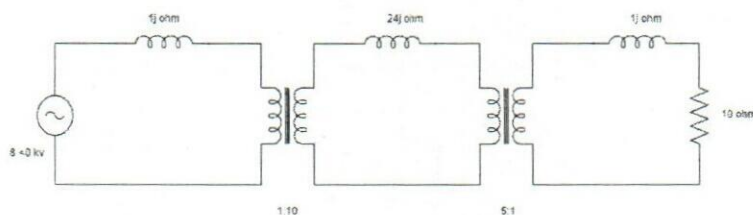


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End of paper

FE2321

Final Examination

Engineering Mathematics IV



FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

FINAL EXAMINATION

Module Code	:	FE2321
Module Title	:	Engineering Mathematics IV
Academic Year	:	Semester 4/2024
Date	:	19 th July 2024
Examiner	:	M.T.M. Ramees
Time Allowed	:	3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all four questions. Each question carries equal marks.
- Each answer should start on a separate page.
- This paper contains 10 pages
- Additional information is provided on pages 6-10.

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a Scientific calculator. This must not be programmable and may be inspected during the examination.

Student Number

1.

- i) Let $f(x, y, z) = xy^2 + z^3$. Find the magnitude of the greatest rate of change of f at $(1, -2, 3)$. (15 Mark)
- ii) Consider the vector field $\mathbf{G} = y^2z^3\mathbf{i} + 2axyz^3\mathbf{j} + bxy^2z^2\mathbf{k}$
 a) Compute the values of 'a' and 'b' if $\mathbf{G}$ is irrotational (15 Mark)
 b) Hence, find the divergence of $\mathbf{G}$ in general terms and at $(0, -1, 1)$. (5 Mark)
- iii) Given the surface $z = f(x, y) = 2x^3 - 3x^2y - 12x^2 - 3y^2$
 a) Find $f_x(x, y)$, $f_y(x, y)$, $f_{xx}(x, y)$, $f_{yy}(x, y)$, $f_{xy}(x, y)$ and $f_{yx}(x, y)$ (10 Mark)
 b) Find and classify the stationary points of f (25 Mark)
- iv) A company is designing a container with an open top is to have 500 cubic meters capacity. The company wants to minimize the material used for constructing the container, which means minimizing the surface area. Find the dimensions of the container (length, width, and height) that will minimize the surface area. (30 Mark)

2.

- i) Let a be a positive integer. If $\int_1^a \int_0^{z^2} \int_0^y \frac{x^2y}{z} dx dy dz = \frac{341}{50}$ then find the value of a . (25 Mark)
- ii) Find the area of the region R enclosed between the curve $y = -x^2 + 18x - 66$ and the line $y = 2x - 3$ using a double integral. (20 Mark)
- iii) Integrate the function $z = x^2y$ over the triangle with vertices at $(0,0)$, $(2,3)$ and $(5,0)$. (25 Mark)

iv) Find the Jacobian

$$J\left(\frac{x, y, z}{u, v, w}\right) = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} & \frac{\partial x}{\partial w} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} & \frac{\partial y}{\partial w} \\ \frac{\partial z}{\partial u} & \frac{\partial z}{\partial v} & \frac{\partial z}{\partial w} \end{vmatrix}$$

If $x = uvw$, $x + y = v^2$ and $x + z = w^2$

(30 Marks)

3.

i) Consider the vector field $\mathbf{F} = 3x^2yz^2\mathbf{i} + x^3z^2\mathbf{j} + 2x^3yz\mathbf{k}$

Let C_1 and C_2 be the curves from $O = (0,0,0)$ to $A = (1,1,3)$ given by

$$C_1 : x = t, \quad y = t, \quad z = 3t \quad (0 \leq t \leq 1)$$

$$C_2 : x = t^2, \quad y = t^2, \quad z = 3t \quad (0 \leq t \leq 1)$$

a) Find $\int_{C_1} \mathbf{F} \cdot d\mathbf{r}$ and $\int_{C_2} \mathbf{F} \cdot d\mathbf{r}$ (30 Marks)

b) Find $\oint_C \mathbf{F} \cdot d\mathbf{r}$ where C is the closed path along C_1 from O to A and back along C_2 from A to O . (5 Marks)

c) Determine whether or not $\mathbf{F}$ is a conservative vector field by evaluating $\text{curl } \mathbf{F}$. (15 Marks)

d) Find a scalar field φ such that $\text{grad } \varphi = \mathbf{F}$. Hence, show that

$$\int_{C_1} \mathbf{F} \cdot d\mathbf{r} = \varphi(1,1,3) - \varphi(0,0,0) \quad (10 \text{ Marks})$$

ii) Let $f(t) = \begin{cases} 0, & -\pi < t < 0 \\ t, & 0 < t < \pi \end{cases} \quad f(t + 2\pi) = f(t)$

a) Sketch a graph of $f(t)$ in the interval $-\pi < t < \pi$ (5 Marks)

b) Find the Fourier series representation of $f(t)$ (30 Marks)

c) How should $f(t)$ be defined at $t = 0$ in order that the Fourier series will converge to $f(t)$ for $-\pi < t < \pi$ (5 Marks)

4.

- i) Let X be a continuous random variable with the probability density function given by

$$f(x) = \begin{cases} kx^2 & 0 < x \leq 2 \\ 0 & \text{otherwise} \end{cases}$$

a) Find k (5 Marks)

b) Find $E(X)$ (10 Marks)

c) Find $P(X < 1.5 \mid X > 1)$. (Hint : $P(A|B) = \frac{P(A \cap B)}{P(B)}$) (10 Marks)

- ii) In a semiconductor manufacturing process, 90% of silicon wafers produced meet quality standards. A batch of 300 wafers is randomly selected for inspection.

a) Use the normal approximation to estimate the probability that exactly 290 wafers meet quality standards. (7 Marks)

b) Find the probability that fewer than 270 wafers meet quality standards. (8 Marks)

c) Given that the probability that at least n wafers meet quality standards is 0.2, find the value of n . (10 Marks)

- iii) The thicknesses of twenty 1 mm metal sheets are measured. The data are:

1.01, 0.98, 0.97, 0.97, 1.02, 0.99, 1.01, 1.01, 0.99, 1.02,
1.01, 1.01, 1.02, 0.98, 1.02, 1.00, 0.97, 1.00, 1.03, 1.01

a) Calculate the sum of the thicknesses of the metal sheets, (5 Marks)

b) Find a 95% confidence interval for the standard deviation σ . (15 Marks)

- iv) Two types of steel alloys are being evaluated to determine their effect on the tensile strength of a new bridge design. Currently, Alloy A is used; however, Alloy B is being considered due to its lower cost. Alloy B will be adopted if it does not affect the tensile strength of the bridge. A series of tests are conducted, and the following tensile strength measurements (in MPa) are obtained from samples of both alloys.

Observation Number	Alloy A	Alloy B
1	410	405
2	412	407
3	408	406
4	415	408
5	409	409
6	413	404
7	407	403
8	411	407
9	414	406
10	408	405
	$\sum_{i=1}^{10} x_i^2 = 1686813$	$\sum_{i=1}^{10} y_i^2 = 1648390$

Assuming the populations from which the samples are drawn have equal variances, is there any difference in the mean tensile strengths? Use a 5% level of significance.

(30 Marks)

Additional Information**Partial Derivatives**

$$D = f_{xx}f_{yy} - (f_{xy})^2$$

Vector Calculus

The gradient of the scalar field $\phi = f(x, y, z)$ is $\text{grad } \phi = \nabla \phi = \frac{\partial \phi}{\partial x} \underline{i} + \frac{\partial \phi}{\partial y} \underline{j} + \frac{\partial \phi}{\partial z} \underline{k}$

Consider the vector field $\underline{F} = F_1 \underline{i} + F_2 \underline{j} + F_3 \underline{k}$. $\text{div } \underline{F} = \frac{\partial F_1}{\partial x} + \frac{\partial F_2}{\partial y} + \frac{\partial F_3}{\partial z}$.

The curl of the vector field given by $\underline{F} = F_1 \underline{i} + F_2 \underline{j} + F_3 \underline{k}$ is defined as the vector field

$$\text{curl } \underline{F} = \nabla \times \underline{F} = \begin{vmatrix} \underline{i} & \underline{j} & \underline{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ F_1 & F_2 & F_3 \end{vmatrix}$$

Fourier Series

$$a_n = \frac{2}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} f(t) \cos\left(\frac{2n\pi t}{T}\right) dt \quad n = 0, 1, 2, \dots$$

$$b_n = \frac{2}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} f(t) \sin\left(\frac{2n\pi t}{T}\right) dt \quad n = 1, 2, \dots$$

These integrals give the Fourier coefficients for a function of period T whose Fourier series is

$$f(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \left\{ a_n \cos\left(\frac{2n\pi t}{T}\right) + b_n \sin\left(\frac{2n\pi t}{T}\right) \right\}$$

Continuous Random Variable

Let X be a continuous random variable with associated pdf $f(x)$. Then its expectation and variance denoted by $E(X)$ (or μ) and $V(X)$ (or σ^2) respectively are given by:

$$\mu = E(X) = \int_{-\infty}^{\infty} x f(x) dx$$

and

$$\sigma^2 = V(X) = \int_{-\infty}^{\infty} (x - \mu)^2 f(x) dx = \int_{-\infty}^{\infty} x^2 f(x) dx - \mu^2$$

Point Estimation

We estimate μ using the sample mean: $\bar{y} = \frac{\sum y_i}{n}$

We estimate σ^2 using the sample variance:

$$s^2 = \frac{1}{n-1} \sum (y_i - \bar{y})^2 = \frac{1}{n-1} \left\{ \sum y_i^2 - \frac{1}{n} \left[\sum y_i \right]^2 \right\}$$

Interval Estimation

It follows that if we do not know the population variance, we must use the estimate $\hat{\sigma}$ in place of σ . Our 95% and 99% confidence intervals (for large samples) become

$$\bar{x} - 1.96 \frac{\hat{\sigma}}{\sqrt{n}} \leq \mu \leq \bar{x} + 1.96 \frac{\hat{\sigma}}{\sqrt{n}} \quad \text{and} \quad \bar{x} - 2.58 \frac{\hat{\sigma}}{\sqrt{n}} \leq \mu \leq \bar{x} + 2.58 \frac{\hat{\sigma}}{\sqrt{n}}$$

where

$$\hat{\sigma}^2 = \frac{\sum (x - \bar{x})^2}{n-1}$$

If $x_1, x_2, x_3, \dots, x_n$ is a random sample with variance S^2 taken from a normal population with variance σ^2 then a $100(1 - \alpha)\%$ confidence interval for σ^2 is

$$\frac{(n-1)S^2}{\chi_{\alpha/2, n-1}^2} \leq \sigma^2 \leq \frac{(n-1)S^2}{\chi_{1-\alpha/2, n-1}^2}$$

where $\chi_{\alpha/2, n-1}^2$ and $\chi_{1-\alpha/2, n-1}^2$ are the appropriate right-hand and left-hand values respectively of a chi-squared distribution with $n-1$ degrees of freedom.

Test Concerning Two Samples (Unknown But Equal Variances)

$$T = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{S_c \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

will follow Student's t -distribution with $n_1 + n_2 - 2$ degrees of freedom.

$$S_c^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

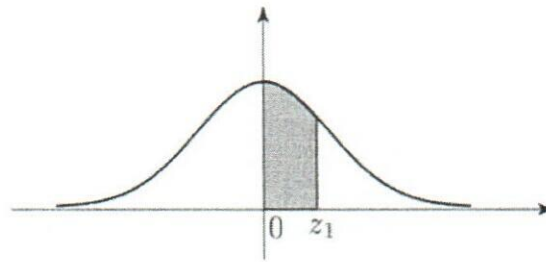
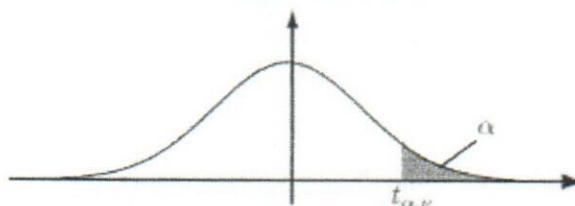


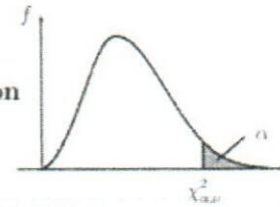
Figure 3

Table 1: The Standard Normal Probability Integral

$Z = \frac{x-\mu}{\sigma}$	0	1	2	3	4	5	6	7	8	9
0	0000	0040	0080	0120	0160	0199	0239	0279	0319	0359
.1	0398	0438	0478	0517	0577	0596	0636	0675	0714	0753
.2	0793	0832	0871	0909	0948	0987	1026	1064	1103	1141
.3	1179	1217	1255	1293	1331	1368	1406	1443	1480	1517
.4	1555	1591	1628	1664	1700	1736	1772	1808	1844	1879
.5	1915	1950	1985	2019	2054	2088	2123	2157	2190	2224
.6	2257	2291	2324	2357	2389	2422	2454	2486	2517	2549
.7	2580	2611	2642	2673	2703	2734	2764	2794	2822	2852
.8	2881	2910	2939	2967	2995	3023	3051	3078	3106	3133
.9	3159	3186	3212	3238	3264	3289	3315	3340	3365	3389
1.0	3413	3438	3461	3485	3508	3531	3554	3577	3599	3621
1.1	3643	3665	3686	3708	3729	3749	3770	3790	3810	3830
1.2	3849	3869	3888	3907	3925	3944	3962	3980	3997	4015
1.3	4032	4049	4066	4082	4099	4115	4131	4147	4162	4177
1.4	4192	4207	4222	4236	4251	4265	4279	4292	4306	4319
1.5	4332	4345	4357	4370	4382	4394	4406	4418	4429	4441
1.6	4452	4463	4474	4484	4495	4505	4515	4525	4535	4545
1.7	4554	4564	4573	4582	4591	4599	4608	4616	4625	4633
1.8	4641	4649	4656	4664	4671	4678	4686	4693	4699	4706
1.9	4713	4719	4726	4732	4738	4744	4750	4756	4761	4767
2.0	4772	4778	4783	4788	4793	4798	4803	4808	4812	4817
2.1	4821	4826	4830	4834	4838	4842	4846	4850	4854	4857
2.2	4861	4865	4868	4871	4875	4878	4881	4884	4887	4890
2.3	4893	4896	4898	4901	4904	4906	4909	4911	4913	4916
2.4	4918	4920	4922	4925	4927	4929	4931	4932	4934	4936
2.5	4938	4940	4941	4943	4946	4947	4948	4949	4951	4952
2.6	4953	4955	4956	4957	4959	4960	4961	4962	4963	4964
2.7	4965	4966	4967	4968	4969	4970	4971	4972	4973	4974
2.8	4974	4975	4976	4977	4977	4978	4979	4979	4980	4981
2.9	4981	4982	4982	4983	4984	4984	4985	4985	4986	4986
	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
	4987	4990	4993	4995	4997	4998	4998	4999	4999	4999

Table 2: Percentage Points of the Students t -distribution

α	.40	.25	.10	.05	.025	.01	.005	.0025	.001	.0005
ν										
1	.325	1.000	3.078	6.314	12.706	31.825	63.657	127.32	318.31	636.62
2	.289	.816	1.886	2.902	4.303	6.965	9.925	14.089	23.326	31.598
3	.277	.765	1.638	2.353	3.182	4.514	5.841	7.453	10.213	12.924
4	.271	.741	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	.267	.727	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	.265	.718	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	.263	.711	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	.262	.706	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	.261	.703	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	.260	.700	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.487
11	.260	.697	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	.259	.695	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	.259	.694	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	.258	.692	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	.258	.691	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	.258	.690	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	.257	.689	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	.257	.688	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	.257	.688	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	.257	.687	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	.257	.686	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	.256	.686	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	.256	.685	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	.256	.685	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	.256	.684	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	.256	.684	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	.256	.684	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	.256	.683	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	.256	.683	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	.256	.683	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	.255	.681	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
60	.254	.679	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
120	.254	.677	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	.253	.674	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

Table 3 : Percentage Points $\chi^2_{\alpha, \nu}$ of the χ^2 distribution

α	0.995	0.990	0.975	0.950	0.900	0.500	0.100	0.050	0.025	0.010	0.005
ν											
1	0.00	0.00	0.00	0.00	0.02	0.45	2.71	3.84	5.02	6.63	7.88
2	0.01	0.02	0.05	0.01	0.21	1.39	4.61	5.99	7.38	9.21	10.60
3	0.07	0.11	0.22	0.35	0.58	2.37	6.25	7.81	9.35	11.34	12.28
4	0.21	0.30	0.48	0.71	1.06	3.36	7.78	9.49	11.14	13.28	14.86
5	0.41	0.55	0.83	1.15	1.61	4.35	9.24	11.07	12.83	15.09	16.75
6	0.68	0.87	1.24	1.64	2.20	5.35	10.65	12.59	14.45	16.81	18.55
7	0.99	1.24	1.69	2.17	2.83	6.35	12.02	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	3.49	7.34	13.36	15.51	17.53	20.09	21.96
9	1.73	2.09	2.70	3.33	4.17	8.34	14.68	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	4.87	9.34	15.99	18.31	20.48	23.21	25.19
11	2.60	3.05	3.82	4.57	5.58	10.34	17.28	19.68	21.92	24.72	26.76
12	3.07	3.57	4.40	5.23	6.30	11.34	18.55	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	7.04	12.34	19.81	22.36	24.74	27.69	29.82
14	4.07	4.66	5.63	6.57	7.79	13.34	21.06	23.68	26.12	29.14	31.32
15	4.60	5.23	6.27	7.26	8.55	14.34	22.31	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	9.31	15.34	23.54	26.30	28.85	31.00	34.27
17	5.70	6.41	7.56	8.67	10.09	16.34	24.77	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	10.87	17.34	25.99	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	11.65	18.34	27.20	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	12.44	19.34	28.41	31.41	34.17	37.57	40.00
21	8.03	8.90	10.28	11.59	13.24	20.34	29.62	32.67	35.48	38.93	41.40
22	8.64	9.54	10.98	12.34	14.04	21.34	30.81	33.92	36.78	40.29	42.80
23	9.26	10.20	11.69	13.09	14.85	22.34	32.01	35.17	38.08	41.64	44.18
24	9.89	10.86	12.40	13.85	15.66	23.34	33.20	36.42	39.36	42.98	45.56
25	10.52	11.52	13.12	14.61	16.47	24.34	34.28	37.65	40.65	44.31	46.93
26	11.16	12.20	13.84	15.38	17.29	25.34	35.56	38.89	41.92	45.64	48.29
27	11.81	12.88	14.57	16.15	18.11	26.34	36.74	40.11	43.19	46.96	49.65
28	12.46	13.57	15.31	16.93	18.94	27.34	37.92	41.34	44.46	48.28	50.99
29	13.12	14.26	16.05	17.71	19.77	28.34	39.09	42.56	45.72	49.59	52.34
30	13.79	14.95	16.79	18.49	20.60	29.34	40.26	43.77	46.98	50.89	53.67
40	20.71	22.16	24.43	26.51	29.05	39.34	51.81	55.76	59.34	63.69	66.77
50	27.99	29.71	32.36	34.76	37.69	49.33	63.17	67.50	71.42	76.15	79.49
60	35.53	37.48	40.48	43.19	46.46	59.33	74.40	79.08	83.30	88.38	91.95
70	43.28	45.44	48.76	51.74	55.33	69.33	85.53	90.53	95.02	100.42	104.22
80	51.17	53.54	57.15	60.39	64.28	79.33	96.58	101.88	106.63	112.33	116.32
90	59.20	61.75	65.65	69.13	73.29	89.33	107.57	113.14	118.14	124.12	128.30
100	67.33	70.06	74.22	77.93	82.36	99.33	118.50	124.34	129.56	135.81	140.17

- End of Examination Paper -

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CINEC Campus
Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering



CE2326 SURVEYING 1

FINAL EXAMINATION PAPER – Semester 4

Date: 17th July 2024

Examiner: Ms. Luckshi Ranasinghe

Time Allowed: Three Hours

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **seven** questions in **six** pages.
- Answer **any five** questions.
- If you have answered more than five questions, either in part or in full, strike out the extra answers. Otherwise, only the first five answers appearing in the book will be evaluated.
- The allocated time for the paper is **3 hours**.
- Show all stages of your work, with diagrams where appropriate.
- Drawings and sketches should be clear, neat, and in approximate proportion.
- Do not use red or green ink.
- Maximum marks allocated for each section of questions are shown.
- Non-programmable calculators may be used.
- Start your answers to each question on a new page.
- Assume reasonable values for the data not given, but state the assumed values.
- Any indications of copied work will be scrutinized heavily and may even be subject to academic misconduct

Question 1

- a) Explain the differences between a ground survey and an aerial survey by describing the methods used, their applications, advantages, and disadvantages. (2 marks)
- b) Illustrate the differences between accuracy and precision (2 marks)
- c) A steel tape with a cross-sectional area of 0.020cm^2 , measured the distance of four spans in a traverse survey. Measurements taken for the survey conducted at a temperature of 25°C , are given in Table Q1.

Table Q1

Span	Measured length (m)	Pull Applied (N)	Level difference between ends (m)
1	29.440	80	0
2	29.365	80	2.20
3	29.652	85	0
4	12.140	80	3.05

Under standardized conditions of 20°C temperature and 100N pull, the tape measured 30.00m . Find the true length of the survey line.

Young's modulus of steel = $0.207 \times 10^6 \text{ N/mm}^2$

Coefficient of linear expansion of steel = $1.15 \times 10^{-5} \text{ m per } ^\circ\text{C}$

Weight per unit length = 0.020kg/m

[The effect of temperature, sag, slope and pull on the length are $(T_m - T_o)KL$, $\frac{w^2 L^3}{24P^2}$, $\frac{h^2}{2L}$, and $\frac{(P - P_o)L}{AE}$ respectively, in standard notation.]

(16 marks)

Question 2

- a) A rectangular plot of land measures 30cm x 50cm on a map drawn to a scale of 1cm: 50m. A new map must be drawn at a scale of 1cm:100m. What is the area of the same plot of land on the new map?

(4 marks)

- b) P, Q, R and S are four stations whose coordinates are as shown in Table Q2. Another station X is to be fixed at the intersection of the lines PR and QS. Calculate the coordinates of X.

Table Q2

Station	Easting (m)	Northing (m)
P	1000.00	1000.00
Q	1180.94	1075.18
R	1021.98	1215.62
S	939.70	1102.36

(8 marks)

- c) Figure Q2 shows a survey line OABC crossing a lake, where the chainage at O and A are 0.00m and 560.80m, respectively. A perpendicular to line OABC is drawn from B to the points P and Q located on opposite sides of the lake. If the distance from P to Q is 1000m, find the chainage at B.

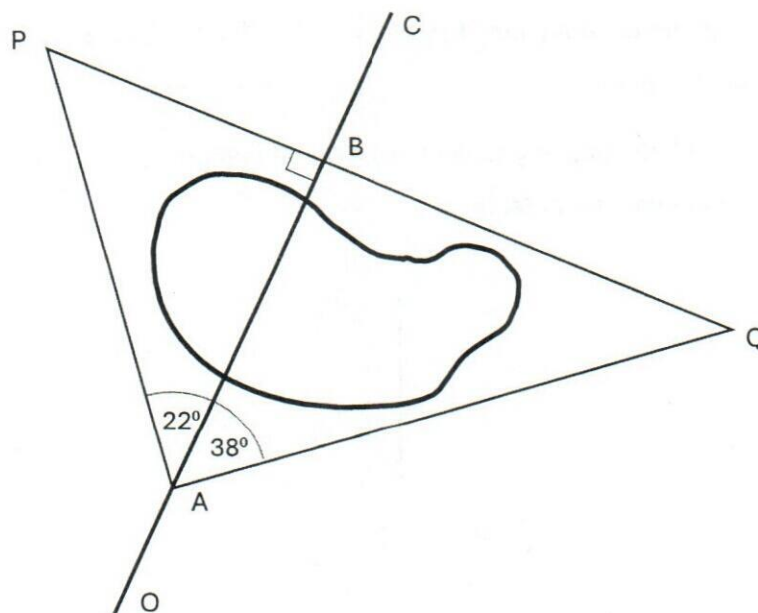


Figure Q2

(8 marks)

Question 3

a) What is the purpose of a flyback when conducting a levelling survey?

(5 marks)

b) The level sheet given by Table Q3 is missing several readings.

Table Q3

BS	IS	FS	Rise	Fall	RL	Remarks
A					X1	BM A
	B			1.305	X2	Curb 1
C		3.980		D	X3	CP 1
	1.250		1.623		X4	Lamp post
	2.854			E	97.401	Curb 2
F		1.533	G		98.722	CP 2
	2.580			1.300	X5	Curb 3
H		1.540	1.04		X6	CP 3
	3.060			0.945	X7	Curb 4
		I	2.475		X8	BM A
$\Sigma \text{BS} = 7.63$		$\Sigma \text{FS} = \text{X9}$	$\Sigma \text{Rise} = \text{X10}$	$\Sigma \text{Fall} = 6.467$		

(i) Fill in the gaps of the level sheet.

(12 marks)

(ii) Calculate and verify the obtained error using the relevant checks for the Rise and Fall method.

(3 marks)

Question 4

- a) How would you apply Bowditch's correction to a traverse conducted between two stations whose positions are known? (5 marks)
- b) The readings given by Table Q4 were obtained for a closed loop traverse run in a construction zone where local attraction is suspected.

Table Q4

Line	Whole Circle Bearing	Length (m)
AB	0°00'00"	50.60
BC	63°49'00"	91.08
CD	89°13'00"	67.06
DE	160°55'00"	61.57
EF	264°02'00"	41.15
FA	258°18'00"	121.62

- (i) Compute the interior angles at each control point.

(5 marks)

- (ii) Adjust the traverse using Bowditch rule and calculate the bearing of each line.

(10 marks)

Question 5

- a) There are several errors that occur when conducting a traverse. What is a parallax error and how can you avoid it when conducting a survey? (5 marks)
- b) A traverse survey is conducted between two known stations P and Q, with four control points A, B, C, and D. The readings obtained are given in Table Q5. The coordinates of P are given as (87.50mN, 110.00mE) and Q as (366.83mN, 64.28mE).

Table Q5

Line	Length (m)	Whole Circle Bearing		
		°	'	"
PA	82.56	31	25	00
AB	100.72	56	18	20
BC	93.85	08	50	00
CD	128.14	312	33	00
DQ	96.20	254	06	30

- (i) Find the distance between the two known points P and Q.

(5 marks)

- (ii) Calculate the coordinates of points A, B, C, and D.

(10 marks)

Question 6

a) Explain the advantages of using tacheometry when conducting a survey.

(5 marks)

b) A survey used tacheometry to identify the distance between two points X and Y. The instrument was leveled at a height of 1.38m at point A, which has an elevation of 45.60m. The readings obtained are given in Table Q6 and Figure Q6 shows a plan view of the site. [The multiplying constant of the instrument is 100]

Table Q6

Instrument Stn	Staff Stn	Horizontal Angle	Vertical Angle	Stadia Reading (m)
A	X	30°	$87^\circ 38' 53''$	3.240, 3.047, 2.853
A	Y	60°	$92^\circ 21' 36''$	2.458, 2.230, 2.002

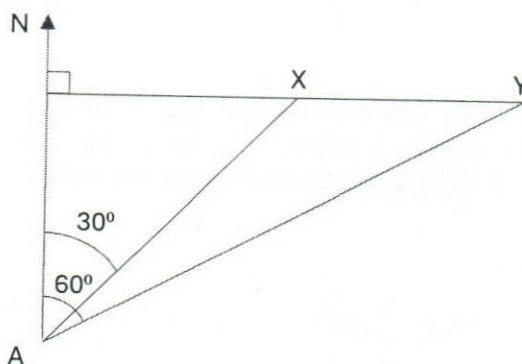


Figure Q6

(i) Find the reduced level at stations X and Y

(5 marks)

(ii) Find the horizontal distance from A to the two stations X and Y.

(5 marks)

(iii) Find the gradient of the slope from point X to Y

(5 marks)

Question 7

An embankment with a constant width (b), length (L), height (H), and side slope ($1:n$) must be reconstructed in an efficient manner.

- a) Derive an equation to identify the cross-sectional area (A) of the level section in filling using the notations given in Figure Q7-1.

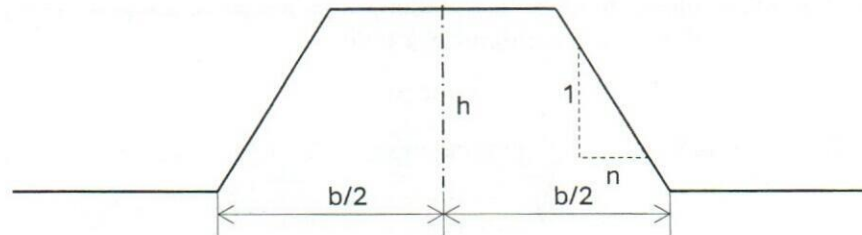


Figure Q7 - 1

(4 marks)

- b) Using the cross-section method, find the existing volume of soil in the embankment assuming $b = 6\text{m}$, $L = 25\text{m}$ and $n = 2$ using the trapezoidal rule. The height of the embankment (h) given by Figure Q7-2, is obtained at 5m intervals.

Existing level

CE1322

Mid Exam

Fluid Mechanics

**CINEC**
CAMPUS**Colombo International Nautical & Engineering College****Faculty of Engineering & Technology****Bachelor of Science Honours in Engineering****CE1322: Fluid Mechanics****Mid Exam (Semester-2)****(10% of Component 2 weighting)**

Date : 12th July 2024**Examiner : Nimali Sugandika****Time Allowed : 1.5 Hours**

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **ten** Questions.
- Answer **all** questions.
- Show **all stages** of your work, and marks **will not be given** only for answers.
- You should write legibly in black or blue ink.
- This is a close book online examination.
- All questions should be answered within 2 hours.
- Write your student number on all papers very clearly.

MATERIALS REQUIRED

- Answer booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination. Programmable calculators, PDAs and mobile phones are not permitted in the exam.

1. Open channel flow takes place _____
 - a) In a pump
 - b) On a free surface
 - c) Within a cylindrical depth
 - d) In the pipe
2. The viscous force the relative motion between the adjacent layers of a fluid in motion. Which of the following flowing fits best in the sentence?
 - a) never affects
 - b) may effect under certain conditions
 - c) opposes
 - d) facilitates
3. Pressure intensity or force due to pressure gradient for fluid at rest is considered as which of the following kind of force?
 - a) Body force
 - b) Force due to motion
 - c) None of the mentioned
 - d) Surface force
4. Which of the following principle is used for calculating the centre of pressure?
 - a) Principle of balancing of momentum
 - b) Principle of momentum
 - c) Principle of conservation of energy
 - d) None of the mentioned

5. Which of the following cannot be the value of absolute pressure of a fluid at any point?
- a) 0
 - b) 1.45 bar
 - c) - 1 bar
 - d) 24 bar
6. Which among the following does not depend on the friction factor?
- a) Pipe diameter
 - b) Fluid density
 - c) Viscosity
 - d) Weight
7. The formula for hydraulic diameter is _____
- a) $4A/P$
 - b) $4AP$
 - c) $4AV$
 - d) $4V$
8. What are the reasons for minor head losses in a pipe?
- a) Friction
 - b) Valves and bends
 - c) Heat
 - d) Temperature
9. Equal volume of two liquids of densities ρ_1 and ρ_2 are poured into two identical cuboidal beakers. The hydrostatic forces on the respective vertical face of the

beakers are F_1 and F_2 respectively. If $p_1 > p_2$, which one will be the correct relation between F_1 and F_2 ?

- a) $F_1 \leq F_2$
- b) $F_1 \geq F_2$
- c) $F_1 < F_2$
- d) $F_1 > F_2$

10. The discharge through a trapezoidal channel is $61 \text{ m}^3/\text{s}$ and the depth and widths of the channel are 4m and 5m respectively. The wetted perimeter of the channel is 13.16m, calculate the bed slope of the channel if the value of C (Chezy coefficient) is 45.

- a) 1 in 1000
- b) 1 in 1500
- c) 1 in 100
- d) 1 in 500

11. Which of the following is the basic principle of fluid mechanics?

- a) Momentum principle
- b) Energy equation
- c) Continuity equation
- d) All of the mentioned

12. What is fluid mechanics used for?

- a) Fluid mechanics enables to comprehend the behaviour of solid fluids under pressure
- b) Fluid mechanics enables to comprehend the behaviour of fluids under a variety of forces & atmospheric conditions

- c) Fluid mechanics enables to comprehend the behaviour of fluids under various temperatures only
 - d) None of the mentioned
13. When is a fluid called turbulent?
- a) High viscosity of fluid
 - b) Reynolds number is greater than 4000
 - c) Reynolds number is less than 4000
 - d) The density of the fluid is low
14. Stagnation point is the point in fluid mechanics where the velocity of the fluid at that point is _____
- a) unity
 - b) constant
 - c) infinite
 - d) zero
15. When a fluid is subjected to resistance, it undergoes a volumetric change due to _____
- a) Cohesion
 - b) Compressibility
 - c) Strain
 - d) Adhesion
16. The depth and widths of a rectangular channel section are y and B respectively, determine the economical perimeter of the section.

- a) y
- b) $2y$
- c) $3y$
- d) $4y$

17. A rectangular channel is having depth 2m and width 3m, bed slope of 1 in 700. The value of manning's roughness coefficient (n) is 0.06, estimate the discharge through the channel.

- a) $2.42\text{m}^3/\text{s}$
- b) $3.42\text{m}^3/\text{s}$
- c) $4.42\text{m}^3/\text{s}$
- d) $5.42\text{m}^3/\text{s}$

18. Estimate the discharge through a triangular channel having depth 7m and side slope 1H:5V in which the bed slope is 1 in 1000. Manning's coefficient = 0.03.

- a) $6.07\text{m}^3/\text{s}$
- b) $9.07\text{m}^3/\text{s}$
- c) $8.07\text{m}^3/\text{s}$
- d) $11.07\text{m}^3/\text{s}$

19. The base width and the depth of a trapezoidal channel is 9m and 5m respectively. Calculate the discharge through a channel if the side slope of the channel is 1H:4V and the bed slope is 1 in 500 ($n=0.04$).

- a) $112.73\text{m}^3/\text{s}$
- b) $110.73\text{m}^3/\text{s}$
- c) $108.73\text{m}^3/\text{s}$
- d) $109.73\text{m}^3/\text{s}$

20. A student wants to find the absolute pressure of water at a point below the surface of water. He has a barometer and a manometer pressure gauge. The barometer reads 1.3152 bar whereas the manometer pressure gauge reads 0.3152 bar. What is the absolute pressure? (Assume that pressure at one end of the manometer is atmospheric and 1bar is equal to 10^5 pa).

- a) 1.6304 bar
- b) 1.0000 bar
- c) 0.3152 bar
- d) 1.3152 bar

Equations

$$V = \frac{1}{N} R_h^{2/3} S_0^{1/2}$$

$$V = C \sqrt{R_h S_0}$$

- For turbulent and laminar flow in pipes
- $hf = \frac{4 \cdot f \cdot L \cdot v^2}{D \cdot 2g}$ or $hf = \frac{\lambda \cdot L \cdot v^2}{D \cdot 2g}$
- Where
 - hf is head losses due to viscous friction over length L
 - v is mean velocity
 - D is diameter of pipe
 - f is friction coefficient
 - λ is friction factor = $4f$

CE1322

Final Exam

Fluid Mechanics

**CINEC**
CAMPUS**Colombo International Nautical & Engineering College****Faculty of Engineering & Technology****Bachelor of Science Honours in Engineering****CE1322: Fluid Mechanics****Final Exam (Semester-2)****(70% of Component 2 weighting)**

Date : 12th July 2024**Examiner : Nimali Sugandika****Time Allowed : 3 Hours**

INSTRUCTIONS TO CANDIDATES

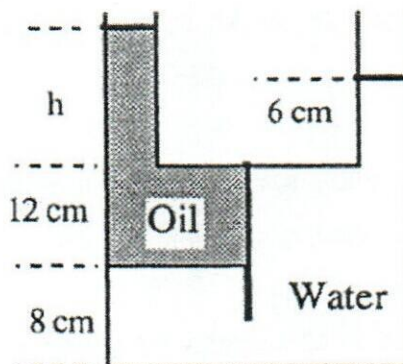
- This question paper consists of **three** Questions.
- Answer **all** questions.
- Show **all stages** of your work, and marks **will not be given** only for answers.
- You should write legibly in black or blue ink.
- This is a close book examination.
- Write your student number on all papers very clearly.

MATERIALS REQUIRED

- Answer booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination. Programmable calculators, PDAs and mobile phones are not permitted in the exam.

Question 1

- (a) Establish a relationship among absolute, gauge and atmospheric pressures with a simple sketch. [10%]
- (b) Define the terms, [10%]
1. The total pressure force
 2. The center of pressure
- (c) A differential U-tube manometer is used to measure the pressure difference between two points in a horizontal water pipeline. If the manometer shows a difference in the mercury level as 25 cm, find the pressure difference between two points (assume density mercury is 13600 kg/m^3). [10%]
- (d) The tank contains water and immiscible oil at 20°C . What is h if the density of the oil is 898 kg/m^3 ? [10%]

**Figure 1**

- (e) Gate AB in the given Figure 2 is 1.2 m long 0.8 m wide (into the paper). Neglecting the atmospheric pressure effects, compute the force F on the gate and its center of pressure position X . [60%]

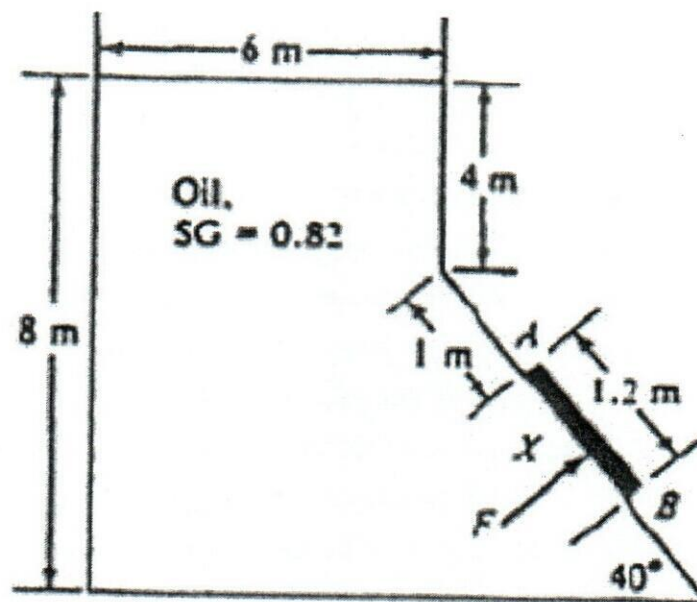


Figure 2

Question 2

- (a) Explain how velocity of flow at any point in a pipe or a channel can be measured, with a pitot tube. [10%]
- (b) Define the following terms and mention their SI units. [15%]
1. Specific weight
 2. Dynamic viscosity
 3. Kinematic viscosity
- (c) A pipeline carrying oil of specific gravity 0.8 changes in diameter from 300 mm at position A to 500 mm diameter at position B which is 5 m at a higher level. If the pressure at A and B are 20 N/cm² and 15 N/cm² respectively and discharge is 150 liters/s, determine the loss of head and direction of flow. [40%]
- (d) A horizontal venturimeter with inlet diameter 20 cm and throat diameter 10 cm is used to measure the flow of water. The pressure at the inlet is 17.658 N/cm² and the vacuum pressure at the throat is 30 cm of mercury (density of mercury is 13600 kg/m³). Find the discharge of water through the venturimeter (Assume $C_d=0.98$). [35%]

Question 3

- (a) What are the energy losses that occur in pipes? [10%]
- (b) Describe Hydraulic gradient and total energy lines. [10%]
- (c) The discharge through a rectangular channel is 50 m³/s, find out dimensions of the channel and the hydraulic radius when it is flowing under the optimum condition (for the best hydraulic section) and the velocity is 1 m/s. [10%]
- (d) In a 45° bend, a horizontal rectangular air duct of 1 m² cross sectional area is gradually reduced to 0.5 m² area. Find the magnitude and direction of the force required to hold the duct in position if the velocity of flow at 1 m² section is 10 m/s and pressure is 3 N/cm². Take specific weight of air as 11.38 N/m³. [50%]
- (e) A pipe of diameter 30 cm and length 1000 m connects two reservoirs having difference of water levels as 15 m. Determine the discharge through the pipe (take $f=0.02$ and neglect minor losses). [20%]

Equations

$$hf = \frac{4 \cdot f \cdot L \cdot v^2}{D \cdot 2g} \text{ or } hf = \frac{\lambda \cdot L \cdot v^2}{D \cdot 2g}$$

Where

- hf is head losses due to viscous friction over length L
- v is mean velocity
- D is diameter of pipe
- f is friction coefficient
- λ is friction factor = $4f$



**CINEC CAMPUS
FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING**

FE1321 Engineering Mathematics - II

In class Test - 2

Time allowed: 2 hours

18th June 2024

Answer All Questions.

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- Attempt **all questions**.
- Show all stages of your work.
- You should write legibly in black or blue ink.
- **Additional information is provided on page 4.**

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a scientific calculator. This must not be programmable. This must not be programmable and may be inspected during the examination.

1. a) Identify whether the following transformation is linear.

$$T \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 2x_1 + 3x_2 - x_3 \\ x_1 + 4x_2 \\ 2x_1 - x_2 + 2 \end{pmatrix}$$

(10 Marks)

b) Determine whether the vectors $V_1 = (1, 4, -3)$, $V_2 = (-2, 1, 5)$ and $V_3 = (4, 7, -11)$ span $\mathbb{R}^3$?

(10 Marks)

c) Let $S = \{V_1, V_2, V_3, V_4\}$ where

$$V_1 = \begin{pmatrix} -2 \\ 3 \\ 1 \end{pmatrix}, \quad V_2 = \begin{pmatrix} 0 \\ -1 \\ 4 \end{pmatrix}, \quad V_3 = \begin{pmatrix} 4 \\ 5 \\ -2 \end{pmatrix}, \quad V_4 = \begin{pmatrix} 1 \\ 3 \\ 0 \end{pmatrix}$$

i) Find a basis for S

ii) Find the dimension of the basis.

(15 Marks)

2.a) Find the limits of the following sequences and state whether they converge or diverge.

$$\text{i) } \lim_{n \rightarrow \infty} \left\{ \frac{\sqrt[4]{n^5+1} - \sqrt{8n^3-3n^2+2n^2}}{\sqrt[3]{n^6+4n^3} - \sqrt[5]{n^9-5n^4+7}} \right\}$$

$$\text{ii) } \lim_{n \rightarrow \infty} \left(\frac{n^2+2n}{n^2+3n} \right)^{6n+2}$$

$$\text{iii) } \lim_{n \rightarrow \infty} \sqrt{n^4 - 4n^2 + 3} - \sqrt{n^4 + 5n}$$

(25 Marks)

b) Determine whether the following series are convergent or divergent.

i) $\sum_{n=1}^{\infty} \frac{n-1}{2n^3+5n^2}$ using Limit comparison test

ii) $\sum_{n=1}^{\infty} ne^{-n^2}$ using Integral test.

iii) $\sum_{n=1}^{\infty} (-1)^n \frac{n^3}{n^4+1}$ using Alternating series.

(25 Marks)

c) Find the interval and radius of convergence.

$$\sum_{n=1}^{\infty} \frac{(-1)^n n(x+3)^n}{4^n}$$

(15 Marks)

**CINEC**
CAMPUS

Colombo International Nautical & Engineering College
Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering

CE3323: Advanced Hydraulics Design and Modelling

Mid Semester Examination-Resit (Semester-3)

(20% of Component 1 weighting)

Date : 9th June 2024

Examiner : Nimali Sugandika

Time Allowed : 2.5 Hours

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **ten** Questions.
- Answer **all ten** questions
- Show **all stages** of your work
- You should write legibly in black or blue ink.
- This is a closed book examination

MATERIALS REQUIRED

- Answer booklet.
- You may use a scientific calculator. This must not be programmable, and may be inspected during the examination. Programmable calculators, PDAs and mobile phones are not permitted in the exam.

1. Determine the dimensions of an optimum trapezoidal section for a discharge of $40 \text{ m}^3/\text{s}$ with a bed slope of 1:2500 and Manning's constant $N = 1/50$ and the side slope is 60° for the optimum condition, $\left(v = \frac{\alpha}{N} R_h^{2/3} S_0^{1/2}\right)$, $B = 2D(\sqrt{n^2 + 1} - n)$. [20%]
2. A rectangular channel with most economical cross-section carries 8000 l/s of water with an average velocity of 2 m/s . If Chezy constant is 65, determine its cross-section and slope $(V = C\sqrt{R_h S_0})$. [10%]
3. A vertical pipe of diameter of 30 cm carrying water is reduced to a diameter of 15 cm . The transition piece length is 6 m . The pressure at the bottom is 200 kPa and at the top it is 80 kPa . If frictional drop is 2 m of water head, determine the rate of flow. [10%]
4. A tank with water level of 12 m has a pipe of 200 mm dia connected from its bottom which extends over a length to a level of 2 m below the tank bottom. Calculate the pressure at this point if the flow rate is $0.178 \text{ m}^3/\text{s}$. The losses due to friction in the pipe length is accounted for by $4.5 V^2/2g$. [10%]
5. A liquid of specific gravity 1.3, flows in a pipe at a rate of 800 l/s , from point 1 to point 2 which is 1 m above point 1. The diameters at section 1 and 2 are 0.6 m and 0.3 m respectively. If the pressure at section 1 is 10 bar , determine the pressure at section 2 ($1 \text{ bar} = 10^5 \text{ Pa}$). [10%]
6. A pipe 75 mm diameter, and 33 m long is running full. Calculate the head loss along the pipe for a velocity of 2 m/s , using Darcy's formula ($f=0.011$) and using Manning formula ($n=0.0113$) $\left(v = \frac{\alpha}{n} R_h^{2/3} S_0^{1/2} \text{ and } h_f = \frac{4fL}{d} \frac{V^2}{2g}\right)$. [10%]
7. Water flows from a reservoir 240 m above the tip of a nozzle. The velocity at the nozzle outlet is 66 m/s . The flow rate is $0.13 \text{ m}^3/\text{s}$. Calculate the loss in head due to friction. [10%]
8. Describe what is meant by a hydraulic jump and explain where, how and why a hydraulic jump forms. [5%]
9. A rectangular channel 10 m wide forms part of a dam spillway. The discharge is $36.5 \text{ m}^3/\text{s}$ when the depth of flow is 0.43 m . At the foot of the spillway the channel is almost horizontal with a hydraulic jump. Calculate the depth of the flow after the jump and the energy loss at the jump. [10%]

$$d_1 = \frac{-d_2}{2} + \sqrt{\left(\frac{2V_2^2 d_2}{g} + \frac{d_2}{4}\right)}$$

$$d_2 = \frac{-d_1}{2} + \sqrt{\left(\frac{2V_1^2 d_1}{g} + \frac{d_1}{4}\right)}$$

10. Explain the total energy and the specific energy of the flow in an open channel. [5%]



CINEC CAMPUS
FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

EXAMINATION PAPER

Module Code	:	FE1321
Module Title	:	Engineering Mathematics II
Academic Year	:	Semester 2/2023
Date	:	8th July 2024
Examiner	:	B.S.Wijeratne
Time Allowed	:	3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You Should Answer all four questions. Each question carries equal marks.
- Each answer should start on a separate page.
- There are 6 pages. Additional information is provided on page 6

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a Scientific calculator. This must not be programmable and may be inspected during the examination

1.

a) Consider the following system of equations

$$x - 2y + 3z = 7$$

$$4x + 5 - z = -3$$

$$-2x + 4y - 6z = -14$$

- i) Find the ranks of the augmented matrix and coefficient matrix (15 marks)
- ii) Determine the nature of solutions for the above system. (6 marks)
- iii) Determine the solutions if it exists. (8 marks)

b) Consider the following matrix:

$$A = \begin{pmatrix} 2 & 2 & -2 \\ 1 & 3 & -1 \\ -1 & 1 & 1 \end{pmatrix}$$

- i) Find the characteristic polynomial of the above matrix. (12 marks)
- ii) Find the eigenvalues of A (10 marks)
- iii) Find the corresponding eigenvectors of A. (30 marks)
- iv) Find the normalized eigenvectors of A. (6 marks)
- v) Find eigenvalues of A^2 , $A + 3I$ and $2A$. (9 marks)
- vi) Does A^{-1} exist? Justify your answer. (4 marks)

2.

a) Find general/particular solutions for the following differential equations using a **suitable method** and keep your answers in the **most simplified form**.

i) $2t \left(t - \frac{d\theta}{dt} \right) = 5$ given $\theta = 2$ when $t = 1$ (10 marks)

ii) $\frac{d\theta}{dt} = 2e^{3t-2\theta}$ given $\theta = 0$ when $t = 0$ (15 marks)

iii) $\left(\frac{2y-x}{y+2x} \right) \frac{dy}{dx} = 1$ given $y = 3$ when $x = 2$ (20 marks)

iv) $\frac{dy}{dx} - 2(x+1)^3 = \frac{4}{(x+1)}y$ (15 marks)

v) $\frac{2ty}{t^2+1} - 2t - \left(2 - \ln(t^2+1) \right) \frac{dy}{dt} = 0$ given $y(5) = 0$ (15 marks)

b) The current i in an electric circuit containing resistance R and inductance L in series with a constant voltage source E is given by the differential equation ,

$$E - L \left(\frac{di}{dt} \right) = Ri$$

Show that the solution to the above differential equation is given by ,

$$i = \frac{E}{R} \left(1 - e^{-\frac{Rt}{L}} \right) \quad \text{if } t = 0 \text{ when } i = 0.$$

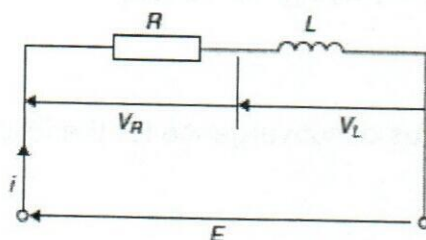


Figure 1: R-L circuit

(25 marks)

3.

a) Determine whether or not the transformation $T: \mathbb{R}^2 \rightarrow \mathbb{R}^3$ is a linear transformation where,

$$T \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} x_1^2 \\ 2x_1 \\ x_1x_2 \end{pmatrix} \text{ using } \bar{u} = \begin{pmatrix} 3 \\ -2 \end{pmatrix} \text{ and } \bar{v} = \begin{pmatrix} 1 \\ 5 \end{pmatrix}$$

(20 marks)

b) Find the limits of the following sequences and state whether they converge or diverge .

i) $\lim_{n \rightarrow \infty} (-1)^n \frac{3n^2+1}{n^2+n}$ (12 marks)

ii) $\lim_{n \rightarrow \infty} \left(\frac{3n+2}{4n+3} \right)^n$ (10 marks)

c) Determine whether the following series are convergent or divergent.

i) $\sum_{n=0}^{\infty} \frac{3ne^n}{n^2+1}$ using nth term test for divergence. (6 marks)

ii) $\sum_{n=0}^{\infty} \frac{(-1)^n}{n^3+4n+1}$ using alternating series test (12 marks)

d) Determine the interval and radius of convergence for the following power series.

$$\sum_{n=1}^{\infty} \frac{(-1)^n (x-4)^n}{n \cdot 9^n} \quad (20 \text{ marks})$$

e) If $e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!}$ Find the Maclaurin series of $f(x) = x^2 e^{-x}$. (20 marks)

4.

a) Consider the following set of vectors.

$$\begin{pmatrix} 2 \\ -1 \\ 1 \end{pmatrix}, \begin{pmatrix} 3 \\ 0 \\ 5 \end{pmatrix}, \begin{pmatrix} 1 \\ 4 \\ \alpha \end{pmatrix}$$

i) For what value of α are above vectors become linearly dependent.

(25 marks)

ii) If $\alpha = 2$ find the basis of the above three vectors and check whether they are orthogonal (an orthogonal basis).

(15 marks)

b) If, $V_1 = (1, 3, -5)$, $V_2 = (4, 2, 0)$ and $V_3 = (1, -2, \alpha)$ span $\mathbb{R}^3$, find the interval of the possible values of α .

(20 marks)

c) Let

$$A = \left\{ \begin{pmatrix} 1 \\ 3 \end{pmatrix}, \begin{pmatrix} 2 \\ 1 \end{pmatrix} \right\} \quad \text{and} \quad B = \left\{ \begin{pmatrix} -1 \\ 4 \end{pmatrix}, \begin{pmatrix} 3 \\ 2 \end{pmatrix} \right\}$$

A and B are bases for $\mathbb{R}^2$.i) Find the change of basis matrix from B to A. ($P_{B \rightarrow A}$)

(20 marks)

ii) If $X = 4a_1 + 5a_2$ (X is a vector w.r.t the basis A) find the coordinates of X w.r.t. basis B.

(20 marks)

Additional information

Inverse of a matrix:

$$A^{-1} = \frac{\text{adj}(A)}{|A|}$$

Characteristic polynomial $C(\lambda)$

$$c(\lambda) = |\lambda I - A| = 0$$

The normalized form of eigen vector:

$$\hat{e} = \frac{e}{|e|}$$

Where,

$$|e| = \sqrt{e_1^2 + e_2^2 + \dots + e_n^2}$$



CINEC Campus
Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering



CE2324 HYDROLOGY

FINAL EXAMINATION

Date : 12th June 2024
Examiner : Ms. Udayanga Edirisooriya
Time Allowed : 3 hours

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **FIVE** questions.
- Answer **All** questions.
- Show all stages of your work.
- You should write legibly in **BLACK** or **BLUE** ink.
- All the answers should be given with respective units.

MATERIALS REQUIRED

- Answer booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination. Programmable calculators, PDAs and mobile phones are not permitted in the exam.

Question 01**(Total -100 marks)**

- i. Hydrology means the science of water. It is the science that deals with the occurrence, circulation and distribution of water of the earth and earth's atmosphere. It is developed based on the Hydrological cycle.
- a) Draw the hydrological cycle indicating all the important processes
 - b) Select two processes and describe each process giving a definition, factors affecting the process and methods available to measure it.
- (35 marks)**
- ii. A catchment area receives an average annual precipitation of 1200 mm. The annual evapotranspiration is estimated to be 500 mm, and the annual runoff is measured to be 400 mm. The catchment feeds into a reservoir with an initial water level of 10 meters. Assume that the change in groundwater storage is negligible.
- a) Calculate the annual water inflow to the reservoir from the catchment area.
 - b) If the catchment area is 150 square kilometers and the surface area of the reservoir is 2 square kilometers, estimate the change in the reservoir water level over the year.
- (35 marks)**
- iii. The normal annual precipitation of five rain gauge stations P, Q, R, S and T are respectively 125 cm, 102 cm, 76 cm, 113 cm, and 137 cm. During a particular storm the precipitation recorded by stations P, Q, R and S are 13.2 cm, 9.2 cm, 6.8 cm and 10.2 cm respectively. The instrument at station T was inoperative during that storm. Estimate the rainfall at station T during that storm.

(30 marks)**Question 02****(Total -100 marks)**

Data given in Table 1 were collected during a stream gauging operation in a river. Calculate the discharge from the river.

Draw a neat sketch and mark the dimensions clearly. Indicate the calculation steps of important parameters.

Distance from left water edge (m)	Depth (m)	Velocity (m/s)		
		At 0.2d	At 0.6d	At 0.8d
0.0	0.0	0.0	-	0.0
1.5	1.5	-	0.4	-
3.5	2.8	1.0	-	0.5
5.5	1.7	-	0.6	-
7.5	1.3	0.7	-	0.3
9.5	0.5	0.5	-	0.2
11.0	0.0	0.0	-	0.0

Table 1: stream gauging details

Question 03**(Total -100 marks)**

Using the 6 hr unit hydrograph given in Table 2, derive the flood hydrograph due to the storm given in Table 3. The ϕ index for the storm can be assumed to be 0.1667 cm/h. Assume the base flow to be 20 m³/s constant throughout.

Time (hr)	0	6	12	18	24	30	36	42	48	54	60	66
6hr UH ordinates (m ³ /s)	0	20	60	150	120	90	66	50	32	20	10	0

Table 2: 6 hr UH ordinates

Time from beginning of the storm (hr)	0	6	12	18
Accumulated rainfall (cm)	0	4	5	10

Table 3: storm details

Question 04**(Total -100 marks)**

A reservoir has the elevation, discharge and storage relationship given in Figure 1. When the reservoir level was at 100.5 m the flood hydrograph given in Table 4, entered the reservoir.

- Strating from the basic Equation, Derive the equation for Modified Pul's method.

(25 marks)

- Obtain the ordinates of the outflow and the reservoir elevation as a result of the passage of flood hydrograph across the reservoir. (Attach the given graph with your answers)

(75 marks)

Time (hr)	0	6	12	18	24	30	36	42	48	54	60	66	72
inflow (m ³ /s)	10	20	55	80	73	58	46	36	27.5	20	15	13	11

Table 4: Flood Hydrograph

Question 05**(Total -100 marks)**

- i. A 30 cm well completely penetrates an unconfined aquifer of saturated depth of 40 m. After a long period of pumping at a steady rate of 1500 lpm (liters per minute), the drawdown in two observation wells 25 m and 75 m from the pumping well were found to be 3.5m and 2.0 m respectively.
 - a. Mark the details in a clear diagram.
 - b. Determine the transmissivity of the aquifer.
 - c. What is the drawdown at the pumping well?
- ii. Differentiate the terms aquifer, aquitard, aquiclude and aquifuge based on its porosity and permeability.

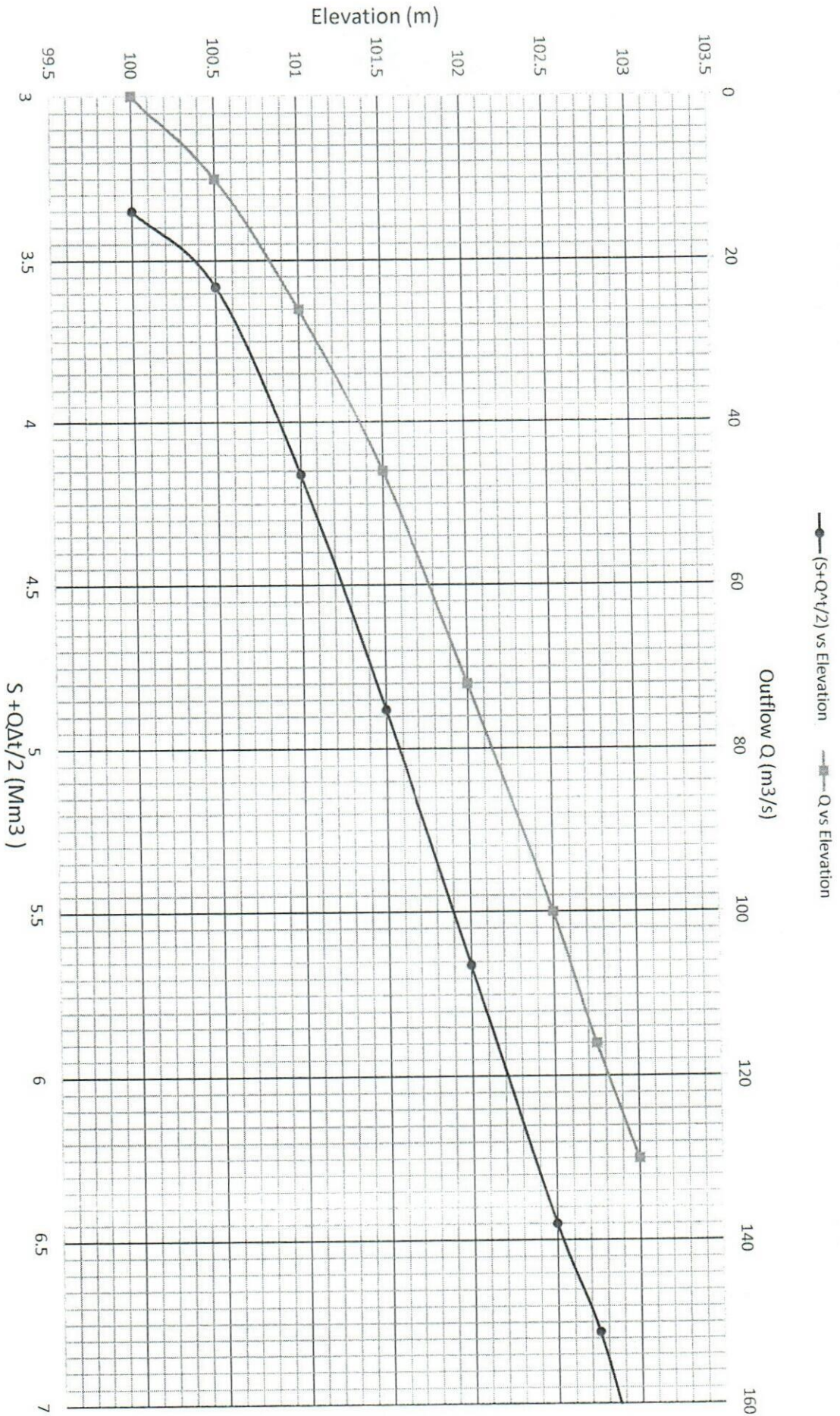


Figure 1



FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

Inclass Test - 2

Module Code	:	FE2321
Module Title	:	Engineering Mathematics IV
Academic Year	:	Semester 4/2024
Date	:	16th May 2024
Examiner	:	M.T.M.Ramees
Time Allowed	:	1 Hour

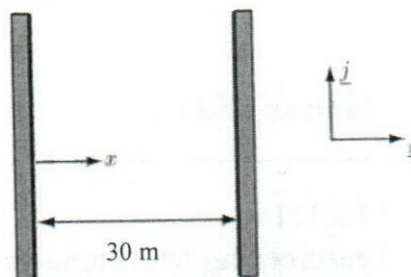
INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all three questions.
- Each answer should start on a separate page.
- This paper contains 3 pages.
- Additional information is provided on page 3

MATERIALS REQUIRED

- An answer booklet
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.

1. The surface water velocity on a straight uniform river 30 meters wide is modelled by the vector $\underline{v} = \frac{2}{15}x(30 - x)\underline{j}$ where x is the distance from the west bank (see diagram).



- i. Find the velocity $\underline{v}$ at each bank and at midstream. [5 Marks]
 - ii. Find $\nabla \times \underline{v}$ at each bank and at midstream. [15 Marks]
2. Let $\underline{F} = 2x\underline{i} + (xz - 2)\underline{j} + xy\underline{k}$, $\phi = x^2y^3z$ and the curve C between $(0,0,0)$ and $(1,-1,2)$ defined by
- $$C : x = t^2, \quad y = -t, \quad z = 2t \quad \text{for } 0 \leq t \leq 1$$
- i. Find $\int_C \underline{F} \cdot d\underline{r}$ [15 Marks]
 - ii. Is $\nabla\phi$ a conservative vector field? Justify your answer. [15 Marks]
 - iii. Determine $\int_C \phi d\underline{r}$ [15 Marks]
3. Consider the following periodic function,
- $$f(t) = \begin{cases} 0 & -\pi < t < 0 \\ t & 0 < t < \pi \end{cases}$$
- $$f(t + 2\pi) = f(t)$$
- i. Sketch the given function over a few periods. [5 Marks]
 - ii. Find the Fourier series of the function f . [30 Marks]

Additional Information

$$a_n = \frac{2}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} f(t) \cos\left(\frac{2n\pi t}{T}\right) dt \quad n = 0, 1, 2, \dots$$

$$b_n = \frac{2}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} f(t) \sin\left(\frac{2n\pi t}{T}\right) dt \quad n = 1, 2, \dots$$

These integrals give the Fourier coefficients for a function of period T whose Fourier series is

$$f(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \left\{ a_n \cos\left(\frac{2n\pi t}{T}\right) + b_n \sin\left(\frac{2n\pi t}{T}\right) \right\}$$



Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering

ME3315 – Finite Element Analysis
RE-SIT EXAMINATION PAPER (Semester 6)

Date : 12/05/2024

Examiner : Mr. R.Y. Sampath

Time Allowed : 3 h

Instructions to Candidates

- This is a closed-book examination.
- This paper consists of five (5) questions.
- Answer all questions.
- All questions carry equal marks as indicated against each question or part thereof.
- Do not use red ink in answering the questions.
- All drawings or sketches, if any, should be produced clearly.
- Assume reasonable values for any data not given with the question paper. Clearly state any assumptions.
- An electronic non-programmable calculator approved by the faculty may be used.
- All examinations are conducted in accordance with the Rules & Regulations currently in force at the University.

Q1

(20 marks)

- a) What is the difference between Finite Difference Method (FDM) and Finite Element Analysis (FEA)? (05 marks)
- b) Briefly explain the basic steps for FDM with an engineering application. (05 marks)
- c) What is meant by discretization and explain the purpose of having discretization in FEA? (05 marks)
- d) Briefly explain the followings terms in relation to FDM and FEA. (05 marks)
- i) Consistency
 - ii) Convergence
 - iii) Explicit and Implicit Methods
 - iv) Round-off
 - v) Finite Difference Operators

Q2

(20 marks)

A stiffness matrix is a square matrix, derived from the material properties and geometry of the system in finite element analysis.

- a) Briefly explain what stiffness matrix is for different engineering systems such as structural and non-structural. (05 marks)
- b) Obtain the stiffness matrix for a spring element with two nodes using a schematic diagram of the system. (05 marks)
- c) What are the properties of this stiffness matrix? (05 marks)
- d) What will be the stiffness matrix if you extended this to a two-spring system? (05 marks)

Q3

(20 marks)

Consider a bar with a variable cross-section supporting a load P , as shown in Figure Q3. The bar is fixed at one end and carries the load P at the other end. The width of the bar at the top is w_1 , at the bottom is w_2 , its thickness by t , and its length by L . The bar's modulus of elasticity is E . Assume the applied load is considerably higher than the weight of the bar.

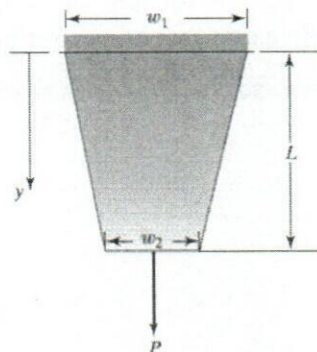


Figure Q3: The bar under axial Loading

- Write down the force-displacement equations (Hook's law) for each node dividing this system into three finite elements and considering them equivalent to spring elements. What is the analogous value for the spring constant k ? (03 marks)
- Construct the global stiffness matrix based on the equations obtained in a). (04 marks)
- What do you mean by boundary conditions in FEA? What are the boundary conditions you must apply in the above system? (05 marks)
- Find the displacement values at each node if $E = 70 \text{ GPa}$, $w_1 = 50 \text{ mm}$, $w_2 = 25 \text{ mm}$, $t = 3 \text{ mm}$, $L = 30 \text{ cm}$, and $P = 550 \text{ kg}$. (08 marks)

Q4**(20 marks)**

Direct formulation, minimum total potential energy approach, and weighted residual formulations are three different formulation methods used in finite element analysis.

- Explain what the minimum total potential energy approach is in FEA formulation. (02 marks)
- A 25 cm slender rod weighing 5.0 kg is supported by a spring with a stiffness $k = 8 \text{ kN/m}$. A force $P = 220 \text{ N}$ is applied to the rod at the location shown in Figure Q4 b). (04 marks)

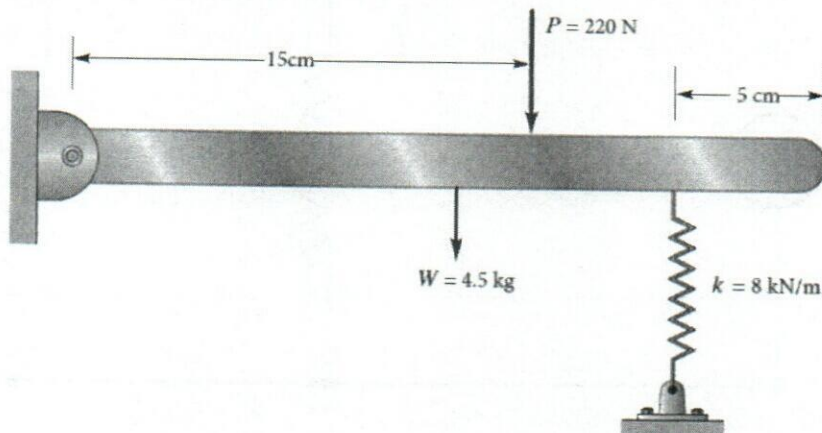


Figure Q4 b): Slender rod with Load

Determine the deflection of the spring,

- By drawing a free-body diagram of the rod.
 - By applying the minimum total potential energy concept.
- In a DC electrical circuit, Ohm's law relates the voltage drop $V_2 - V_1$ across a resistor to a current flowing through the element and the resistance R as in Figure Q3 c) according to the equation $V_2 - V_1 = RI$. (06 marks)

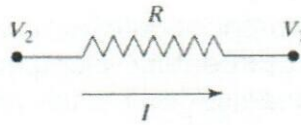


Figure Q3 c): Resistance Element

Using direct formulation, show that for a resistance element comprising two nodes, the conductance matrix, the voltage drop, and the currents are related according to the following equation.

$$\frac{1}{R} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{Bmatrix} V_1 \\ V_2 \end{Bmatrix} = \begin{Bmatrix} I_1 \\ I_2 \end{Bmatrix}$$

- d) Find the voltage drop in each branch of the circuit shown in Figure Q4 d) using the results of part c) (08 marks)

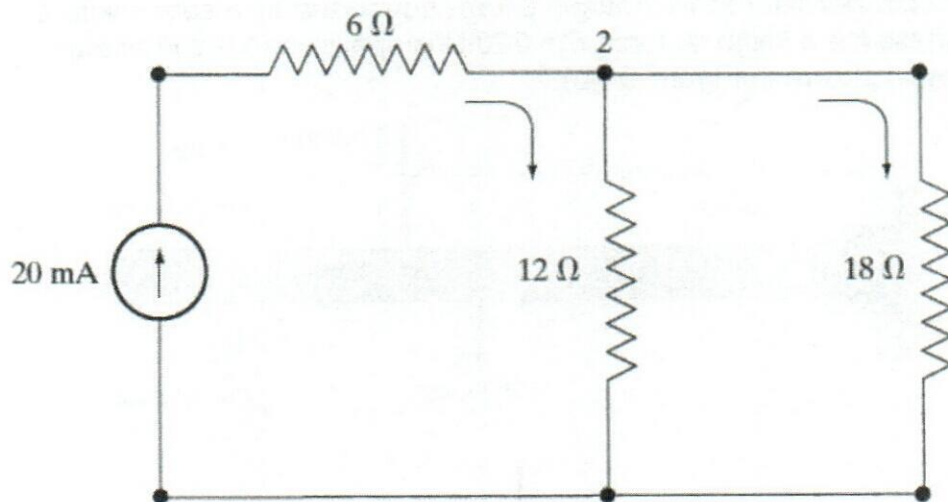


Figure Q4 d): Circuit Diagram

Q5

(20 marks)

- a) A thin steel plate with the profile shown in the accompanying figure is subjected to an axial load. Approximate the deflection and the average normal stresses along the plate using the model shown in Figure Q5 a). The plate has a thickness of 0.4 cm and a modulus of elasticity $E = 200 \text{ MPa}$. (06 marks)

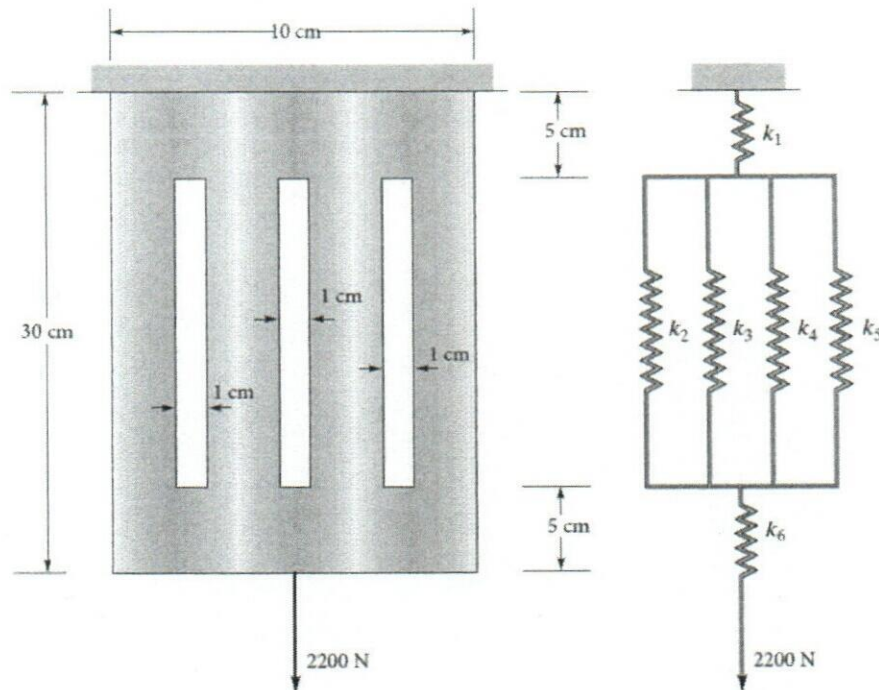


Figure Q5 a): Steel plate with applied force and spring model

- b) Discuss the advantages of using ANSYS software to analyze this type of system. (06 marks)
- c) Explain the step-by-step procedure of finite element analysis of the above steel plate using ANSYS software. Discuss the importance of the size of elements on your results. (08 marks)

Library

CINEC Campus
Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering

**CE2324 HYDROLOGY****MID EXAMINATION**

Date : 08th May 2024
Examiner : Ms. Udayanga Edirisooriya
Time Allowed : 2 hours

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **THREE** questions.
- Answer **All** questions.
- For Question 02, you could use a graph paper if required.
- For Question 03, mark the most suitable answer from the given answers on the **EXAM PAPER ITSELF**.
- **SHOW ALL STAGES OF YOUR WORK IN THE GIVEN ADDITIONAL PAPERS.**
- You should write legibly in **BLACK** or **BLUE** ink.
- All the answers should be given with respective units.
- **Attach the question paper with the answer sheet.**

MATERIALS REQUIRED

- The answer booklet.
- Graph papers.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination. Programmable calculators, PDAs and mobile phones are not permitted in the exam.

Question 01**(100 marks)****Provide short answers for the below questions**

- a) Distinguish the methods available to record the rainfall. (10 marks)
- b) Indicate the factors affecting evaporation and explain how each factor contribute towards the rate of evaporation. (10 marks)
- c) There are three separate methods available to estimate evaporation. Summarize them. (10 marks)
- d) It is important to reduce the reservoir evaporation. Indicate different methods available to reduce reservoir evaporation. (10 marks)
- e) Categorize the methods available to estimate the evapotranspiration. (10 marks)
- f) Interpret the initial loss and explain how water is lost in this process. (10 marks)
- g) List the methods available to measure infiltration. (10 marks)
- h) Distinguish the available streamflow measurement techniques. (10 marks)
- i) Assemble the methods available to measure water depth of a stream. (10 marks)
- j) Indicate the methods available to measure the velocity of a stream. (10 marks)

Question 02**(100 marks)**

A boundary of a catchment area can be identified as ABCDF, of which the coordinates are given in Table 1. There are six rain gauges located at points A, B, C, D, E and F. The annual precipitation of each rain gauge are also given in Table 1. Determine the average precipitation for the catchment using Thiessen Polygon method. Clearly draw the catchment area to a scale and clearly draw the thiessen polygons. Compare the answer with arithmetic average of the precipitation.

Table 1

Location	X coordinate (km)	Y coordinate (km)	Annual precipitation (cm)
A	8.66	10	46
B	18.66	10	65
C	18.66	0	76
D	8.66	0	80
E	13.66	5	70
F	0	5	60

Question 03

(100 marks)

Select the most suitable answer for the following multiple choice questions

- a) A catchment has an area of 120ha and a runoff/rainfall ratio of 0.50. If due to a 10 cm rainfall over the catchment, a stream flow at the catchment outlet lasts for 10 hours, the average streamflow in the period is,

(10 marks)

- a) $1.33 \text{ m}^3/\text{s}$
 b) $16.7 \text{ m}^3/\text{s}$
 c) $100 \text{ m}^3/\text{min}$
 d) $6 \times 10^4 \text{ m}^3/\text{hour}$
- b) A catchment has five rain gauge stations. In a year, the annual rainfall recorded by the gauges are as follows.

Station	A	B	C	D	E
Rainfall (cm)	103.9	178.5	112.4	99.5	121.7

For a 10% error in the estimation of the mean rainfall, what is the alteration required for the catchment.

(10 marks)

- a) Need to add one more station.
 b) Already available stations are adequate.
 c) Need to remove one station.
 d) Need to add two stations.
- c) Normal annual rainfall at stations A, B, C and D in a basin are 84.93 cm, 88.51 cm, 91.21 cm and 95.96 cm respectively. In the year 2018, the station C was inoperative. The stations A, B and D recorded annual precipitations of 78.23 cm, 92.11 cm, 86.68 cm respectively. Estimate the rainfall at station C in that year.

(10 marks)

- a) 85.67 cm
 b) 87.11 cm
 c) 95.88 cm
 d) 86.57 cm
- d) A 5-hr storm had 7 cm of rainfall and the resulting runoff was 3 cm. If the ϕ index remains at the same value, the runoff due to 11 cm of rainfall in 7 hrs in the same catchment is,

(10 marks)

- a) 9 cm
 b) 6 cm
 c) 5.4 cm
 d) 4.5 cm

- e) A reservoir has an average area of 50 km^2 over a year. The normal annual rainfall at the place is 140 cm and the class A pan evaporation is 250 cm. Assuming a pan coefficient of 0.7 and a runoff coefficient of 0.3 for the land flooded by the reservoir. What can you suggest regarding the reservoir?

(10 marks)

- a) Volume of the reservoir will reduce by 38.5 Mm^3
- b) Volume of the reservoir will increase by 38.5 Mm^3
- c) Volume of the reservoir will reduce by 66.5 Mm^3
- d) None of above

- f) What is the stream discharge for the stream given below?

(10 marks)

Distance from the left bank (m)	Depth (m)	Velocity at 0.6d (m/s)
0.0	0.0	0.00
6.0	3.0	0.40
14.0	5.0	0.60
22.0	4.0	0.42
28.0	0.0	0.00

- a) $59 \text{ m}^3/\text{s}$
- b) $48 \text{ m}^3/\text{s}$
- c) $53 \text{ m}^3/\text{s}$
- d) $57 \text{ m}^3/\text{s}$

- g) The surface velocity at any vertical section of a stream is,

(10 marks)

- a) Not of any use in stream flow measurement
- b) Smaller than the mean velocity in that vertical
- c) Larger than the mean velocity in that vertical
- d) Equal to the velocity in that vertical at 0.6 times the depth

Questions h), i) and j) are based on the following information.

A triangular DRH due to a storm has a time base of 60 hrs and a peak flow of $60 \text{ m}^3/\text{s}$ occurring at 25 hrs from the start. The catchment area is 120 km^2 .

- h) The rainfall excess of the storm is

(10 marks)

- a) 5.4 cm
- b) 2.3 cm
- c) 1.5 cm
- d) 4.5 cm

i) If this rainfall is due to a 6-hr storm, the peak discharge of a 6 hr UH is,

(10 marks)

- a) $10.11 \text{ m}^3/\text{s}$
- b) $12.66 \text{ m}^3/\text{s}$
- c) $13.33 \text{ m}^3/\text{s}$
- d) $11.11 \text{ m}^3/\text{s}$

j) If baseflow is $12 \text{ m}^3/\text{s}$, the peak discharge of flood hydrograph is,

(10 marks)

- a) $24.66 \text{ m}^3/\text{s}$
- b) $48.00 \text{ m}^3/\text{s}$
- c) $72.00 \text{ m}^3/\text{s}$
- d) $22.11 \text{ m}^3/\text{s}$



FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

Inclass Test - 1

Module Code	:	FE2321
Module Title	:	Engineering Mathematics IV
Academic Year	:	Semester 4/2024
Date	:	30th April 2024
Examiner	:	M.T.M.Ramees
Time Allowed	:	1 Hour

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all three questions.
- Each answer should start on a separate page.
- This paper contains 3 pages.
- Additional information is provided on page 3

MATERIALS REQUIRED

- An answer booklet
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.

1. Let $f(x, y) = 6x^2 + 8y^2 - 2x^3 + 2024$

- Find f_x and f_y
- Is $(-2, 0)$ a stationary point? Justify your answer.
- Find all the stationary points of f
- Determine the nature of each stationary point.

[10 Marks]

[5 Marks]

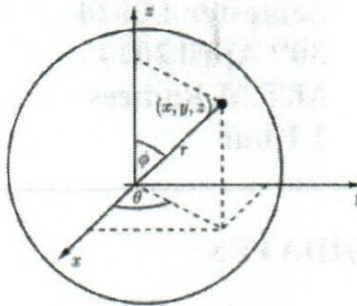
[10 Marks]

[15 Marks]

2.

- Evaluate the double integral $\int_0^{\pi/2} \int_0^1 (y \cos x) dy dx$
- Use spherical coordinates to find the volume of a sphere of radius R

[10 Marks]



[20 Marks]

3.

- Find the vector equation of the line passing through $(9, 1, 2)$ and which is parallel to the vector $\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$.

[5 Marks]

- Find the value of a for which

$$\mathbf{v} = (2x^2y + z^2)\mathbf{i} + (xy^2 - x^2z)\mathbf{j} + (axyz - 2x^2y^2)\mathbf{k}$$

is the vector field of an incompressible fluid.

[15 Marks]

- If $\mathbf{F} = x^2y\mathbf{i} - 2xz\mathbf{j} + 2yz\mathbf{k}$, find $\nabla \cdot (\nabla \times \mathbf{F})$

[10 Marks]

Additional Information

$$D \equiv \frac{\partial^2 f}{\partial x^2} \times \frac{\partial^2 f}{\partial y^2} - \left(\frac{\partial^2 f}{\partial x \partial y} \right)^2, \text{ which is also expressible as } D \equiv f_{xx}f_{yy} - (f_{xy})^2$$

The volume is given by the triple integral $\iiint dV$

The vector equation of the line through points A and B with position vectors $\underline{a}$ and $\underline{b}$ is

$$\underline{r} = \underline{a} + t(\underline{b} - \underline{a})$$



**CINEC CAMPUS
FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING**

FE1321 Engineering Mathematics - II

In class Test - 1

Time allowed: 2 hours

22nd April 2024

Answer All Questions.

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- Attempt **all questions**.
- Show all stages of your work.
- You should write legibly in black or blue ink.
- **Additional information is provided on page 4.**

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a scientific calculator. This must not be programmable. This must not be programmable and may be inspected during the examination.

1. Apply the **rank test** to determine the nature of solutions for the following system of equations and determine the solution if it exists.

$$x - 2y + 3z = 4$$

$$2x + 4y - 2z = 3$$

$$-3x + 6y - 9z = -12$$

(16 Marks)

2. Consider the following matrix.

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

- i) Find the characteristic polynomial of the above matrix.
- ii) Find the eigenvalues and the corresponding eigenvectors of A.
- iii) Find the normalized eigenvectors of A.
- iv) Find the eigenvalues of A^2

(20 Marks)

3.a) Find general/particular solutions for the following differential equations using a suitable method.

$$\text{i. } 2x^2y \frac{dy}{dx} = y^2 - 4$$

(6 Marks)

$$\text{ii. } \frac{dy}{dx} = \frac{-(3xy + y^2)}{x^2 + xy} \text{ given that } y = 2 \text{ when } x = 1$$

(16 marks)

$$\text{iii. } \sin x \frac{dy}{dx} + y \tan x = \sec x - \tan x$$

(10 marks)

$$\text{iv. } (x - 2xy + e^y) + (y - x^2 + xe^y) \frac{dy}{dx} = 0$$

(14 marks)

b) There's a large water tank in the chemical manufacturing department of a company which is used to store water required for the manufacturing process as given below (figure 1). Tank has a diameter of 2 m and water is leaking through a hole which has a diameter of 1 cm. Initial height of the water when the hole is open is 2.25 m.

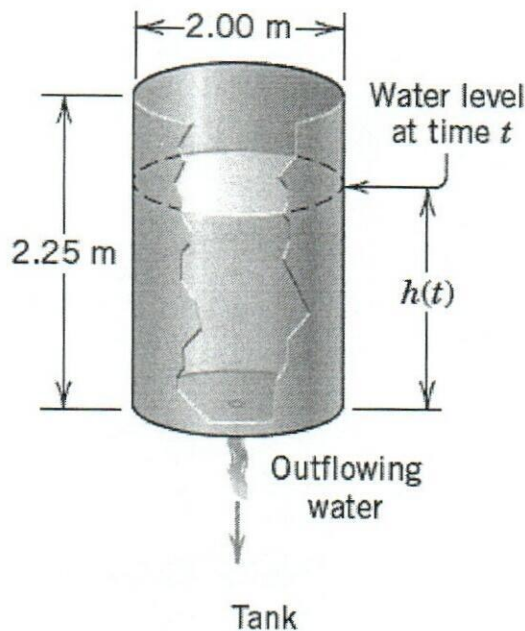


Figure 1: Leaking tank

Under the influence of gravity the outflowing water has velocity,

$$v(t) = 0.600 \sqrt{2gh(t)} \quad (\text{Torricelli's law})$$

where $h(t)$ is the height of the water above the hole at time t , and $g = 980 \text{ cm/sec}^2$ is the acceleration of gravity at the surface of the earth.

The volume ΔV of the outflow during a short time Δt is given by ,

$$\Delta V = AV\Delta t$$

A = Area of the hole

V = Velocity of the water outflow

i) If Δh is the change in water level and if cross sectional area of the tank is B , form an equation to find the change in volume (decrease) of the tank (ΔV^*)

ii) Show that $\frac{dh}{dt} = -26.56 \frac{A}{B} \sqrt{h}$, assuming $\Delta V = \Delta V^*$ and using Torricelli's law.

iii) Find the general solution to the above ODE.

iv) Find the particular solution.

(18 Marks)

Additional informationInverse of a matrix:

$$A^{-1} = \frac{\text{adj}(A)}{|A|}$$

Characteristic polynomial C (λ)

$$c(\lambda) = |\lambda I - A| = 0$$

The normalized form of eigen vector:Where, $\hat{e} = \frac{e}{|e|}$

$$|e| = \sqrt{(e_1^2 + e_2^2 + \dots + e_n^2)}$$

Table of Integrals

$$\int uv' dx = uv - \int u'v dx \text{ (by parts)}$$

$$\int x^n dx = \frac{x^{n+1}}{n+1} + c \quad (n \neq -1)$$

$$\int \frac{1}{x} dx = \ln |x| + c$$

$$\int e^{ax} dx = \frac{1}{a} e^{ax} + c$$

$$\int \sin x dx = -\cos x + c$$

$$\int \cos x dx = \sin x + c$$

$$\int \tan x dx = -\ln |\cos x| + c$$

$$\int \cot x dx = \ln |\sin x| + c$$

$$\int \sec x dx = \ln |\sec x + \tan x| + c$$

$$\int \csc x dx = \ln |\csc x - \cot x| + c$$



Faculty of Engineering & Technology
Department of Mechanical & Automotive Engineering
Bachelor of Science Honours in Engineering

ME4328 – Condition Monitoring

FINAL EXAMINATION PAPER (Semester 8)

Academic year 2024 (Repeat Paper)

Time Allowed: 3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- The question paper consists of **five** questions.
- **Answer all questions.**
- You may use a Scientific calculator. This must not be programmable and may be inspected during the examination.

- 1 (a) Discuss the most common maintenance approaches including advantages and disadvantages of each. 75%
- (b) Although vibration is the most common parameter measured for monitoring the condition of a machine, there are other methods available. Discuss a minimum of three other methods. 25%
- 2 (a) Discuss the use of accelerometers for monitoring the condition of machinery, with reference to selection of a suitable accelerometer, its sensitivity, orientation, mounting location and mounting method. 45%
- (b) Discuss the problems associated with frequency analysis of time domain data from machinery with reference to quantization, aliasing, sample frequency, frequency resolution, windowing, and averaging. Include sketches to illustrate your answer. 55%
- 3 (a) The vibration spectrum from a rotating machine can exhibit a range of frequency peaks dependent on many factors. Discuss the most likely sources of vibration in a rotating machine. 60%
- (b) Vibration measurements have been taken on an air washer consisting of a horizontal 50 kW motor driving an overhung fan via a belt drive. 40%
- Motor speed: 1778 RPM (1XM)
- Motor bearing data: Ball diameter 6.09 mm
- Cage set diameter 26.2 mm
- Number of balls 8
- Contact angle 0 degrees
- Motor sheave diameter: 163 mm
- Fan sheave diameter: 329 mm
- Distance between centres: 1194 mm
- Belt length: 3164 mm
- Fan has 16 blades
- Fan bearing data: Ball diameter 6.09 mm
- Cage set diameter 26.2 mm
- Number of balls 8
- Contact angle 0 degrees

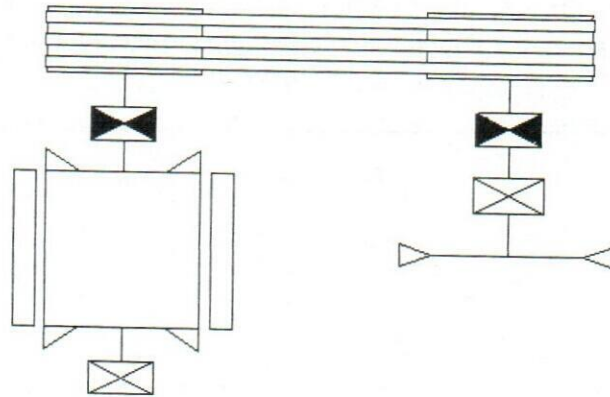


Figure Q3

(4).

(a) Figures Q4b.1 and Q4b.2 show two spectra from the vertical transducer mounted on the motor inboard bearing housing, one over a low frequency range up to 10 times the rotational frequency of the motor and one over a high frequency range up to 100 times the rotational frequency of the motor. These spectra exhibit peaks at 3.06XM and its higher harmonics. What is the most likely cause of these peaks? Explain your reasoning.

30%

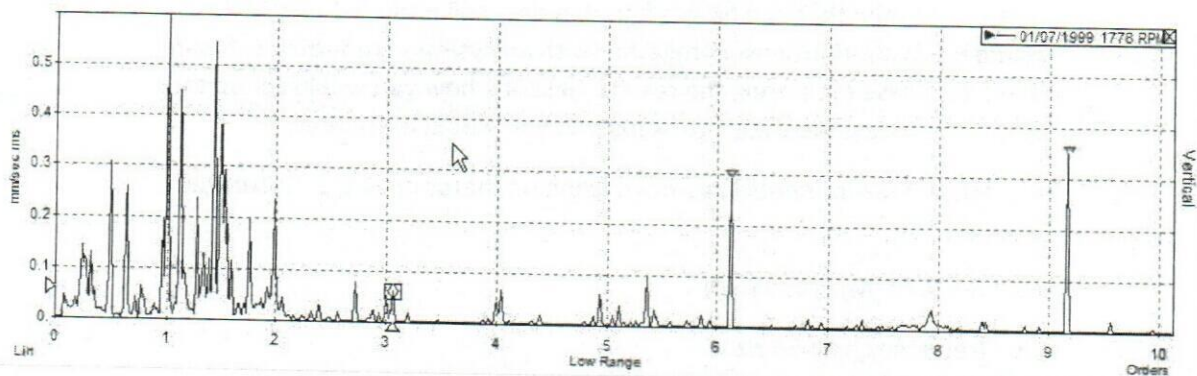


Figure Q4b.1: Vertical velocity spectrum on inboard motor bearing housing up to 10XM

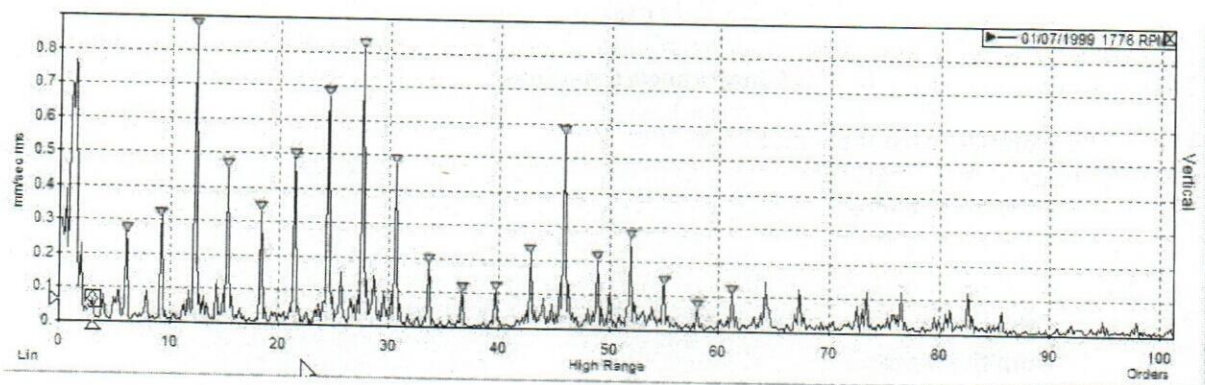


Figure Q4b.2: Vertical velocity spectrum on inboard motor bearing housing up to 100XM

- (b) Figure Q4c.1 shows a spectrum from the vertical transducer on the fan outboard bearing housing which exhibits a strong peak at 7.932XM. What is the most likely cause of this peak? Explain your reasoning.

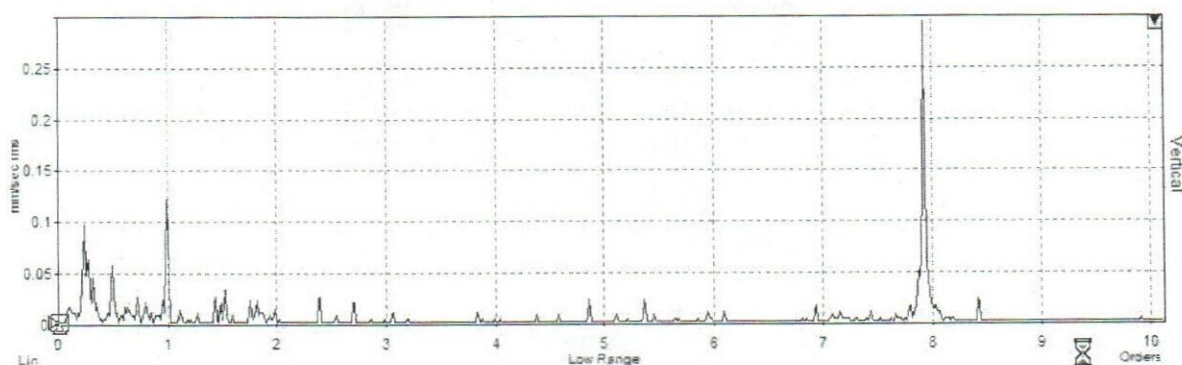


Figure Q3c.1: Vertical velocity spectrum on outboard fan bearing housing up to 10XM

- (d) Explain the advice you would give to management concerning this air washer.

- 5 (a) You have been asked to carry out a pilot study for a condition monitoring system. Assume that you have a portable data collector and a limited number of vibration sensors together with analysis and reporting software and a database for storing the results. Describe how you would set up the study, discussing the likely problems that you would encounter.

- (b) Vibration measurements have been taken on motor driving a centrifugal pump.

Motor speed (M): 1420 RPM

Line frequency (LF): 50 Hz

Motor bearing data: Ball diameter 9.09 mm

Cage set diameter 42.2 mm

Number of balls 9

Contact angle 0 degrees

Number of rotor bars: 32

Number of poles: 4

Calculate the frequencies in Hz of the peaks that could arise in the spectrum from the motor.

Data Sheet

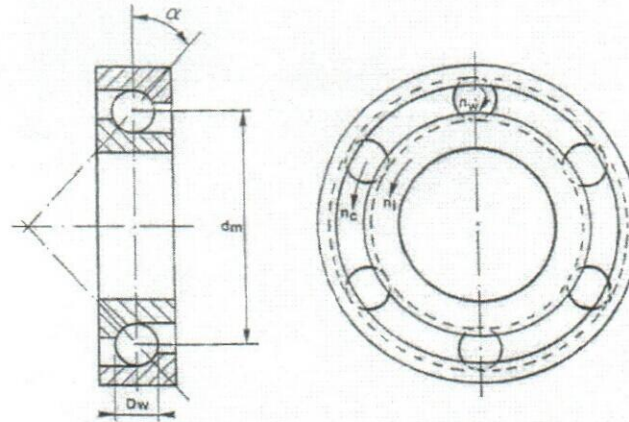


Figure A1: Geometry of an angular contact ball bearing with stationary outer ring and rotating inner ring

d_m = pitch diameter for rolling element set

D_w = diameter of rolling elements

f_i = rotational speed of inner ring (Hz)

f_c = rotational speed of cage set (Hz)

f_w = rotational speed of rolling element about its own centre, about an axis parallel to the bearing axis (Hz)

α = contact angle

f_{ORD} = vibration frequencies caused by outer ring local defect

f_{IRD} = vibration frequencies caused by inner ring local defect

f_{BD} = vibration frequencies caused by rolling element local defect

l = any positive integer

k = any positive integer

z = number of rolling elements

$$f_c = \frac{f_i}{2} \left(1 - \frac{D_w}{d_m} \cos \alpha \right)$$

$$f_w = \frac{f_i}{2} \left(\frac{d_m}{D_w} - \frac{D_w}{d_m} \cos^2 \alpha \right)$$

$$f_{ORD} = lz f_c$$

$$f_{IRD} = lz(f_i - f_c) \pm k f_i$$

$$f_{BD} = 2l f_w \pm k f_c$$

□

$$\frac{1}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}} = \frac{\text{Measured value}}{\text{True value}}$$



Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering

ME4322 – Maintenance & Reliability Engineering

RE SIT EXAMINATION PAPER (Semester 8)

Time Allowed: 3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- The question paper consists of **five** questions in **three** pages.
- **Answer all questions.**
- You may use a Scientific calculator. This must not be programmable and may be inspected during the examination.

Question 1

- (i) Discuss the difference between reactive and preventive maintenance with suitable examples. **(20 marks)**
- (ii) Draw a flow chart to decide whether reactive or preventive maintenance has to be chosen in a system. **(40 marks)**
- (iii) Discuss the preventive maintenance tasks which are generally performed. **(20 marks)**
- (iv) Discuss common causes of unreliability of equipment that come under your supervision. **(20 marks)**

Question 2

- (i) Discuss the difference between Warm Standby and Hot Standby systems with suitable examples **(20 marks)**
- (ii) A welding machine has three components in series with component reliabilities of 0.6, 0.75 and 0.85.
 - (a) Determine the net reliability of the system. **(20 marks)**
 - (b) In order to improve the system reliability what similar component should added to the system and the reliability of the system with this redundant component. **(20 marks)**
 - (c) If the cost of failure is LKR 30,000 and the cost of the redundant component that you have selected to introduce to the system in (b) is LKR 3,000, how many redundant components are required to minimize the cost. **(40 marks)**

Question 3

- (i) Discuss the steps that you are going to introduce to improve the reliability of your maintenance system. **(20 marks)**
- (ii) One of the major issues that the maintenance engineer is facing is to ensure the maintenance budget to implement prepared maintenance activities. Do you agree? Justify your answer. **(20 marks)**
- (iii) If a component has a failure rate of 3×10^{-6} failures/hour, what is its reliability for operating period of 1000 hrs. **(20 marks)**
- (iv) If there are 3000 similar items in the test, how many failures are expected in 1000 hours. Assume constant failure rate and no premature failures during the test. **(20 marks)**
- (v) If the Mean Time between Failure for the component is 200,000 hours, what is the reliability if the operating time is equal to 100,000 hours? **(20 marks)**

Question 4

- (i) Discuss the meanings of Availability, Reliability and Maintainability from maintenance engineer's point of view **(20 marks)**
- (ii) Discuss the difference between Mean Time Between Failures (MTBF) and Mean Time To Fail (MTTF) **(20 marks)**

- (iii) One of the important machines used in the production process is required to operate 300 days (24 hours per day) a year. Over the last year, its performances are given below.

Scheduled operation time	300 days
Number of breakdowns	6
Time to correct breakdowns	180 hours
Preventive maintenance time	80 hours
Waiting time for preparation	120 hours

Find,

- Availability of the machine **(20 marks)**
- Mean Time Between Failures **(20 marks)**
- Mean Down Time **(20 marks)**

Question 5

Power supply system of a hospital is consisting with utility system (national supply) and diesel engine driven standby generator to ensure uninterrupted power supply throughout. There is a Voltage Monitor to identify the utility power failure and give necessary signals to start the generator as soon as national power system fails.

- Are there any suggestions to improve the reliability of the power supply system further? **(15 marks)**
- Draw the Reliability Block Diagram of the system. **(15 marks)**
- Draw the Event Tree diagram for the power failure. **(30 marks)**
- Draw the Fault Tree Diagram for the top event of total blackout. **(40 marks)**

Colombo International Nautical & Engineering College
Faculty of Engineering & Technology
Bachelor of Science Honours in Engineering



ME1312 – Engineering Drawing

EXAMINATION PAPER (Semester 1)

Date : 2024 February
Examiners : Virantha E.A.I
Time Allowed : 3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- The question paper consists of **one** question in two pages.
- Answer all questions.
- Any data which is not given assume.

MATERIALS REQUIRED

- A2 size drawing sheet (Will be provided)
- Drawing tools including compass set and triangles
- You may use a Scientific calculator. This must not be programmable and may be inspected during the examination.

Q1. The pictorial view of an object shown in Figure: 01. Draw the following views in THIRD ANGLE PROJECTION.

1. Sectional Front elevation on **AB**, viewing in the direction of arrow **X**
2. End elevation viewing in the direction of arrow **Y**
3. Plan view

Use suitable scale

Complete the drawing by adding title Dimensions and projection symbol.

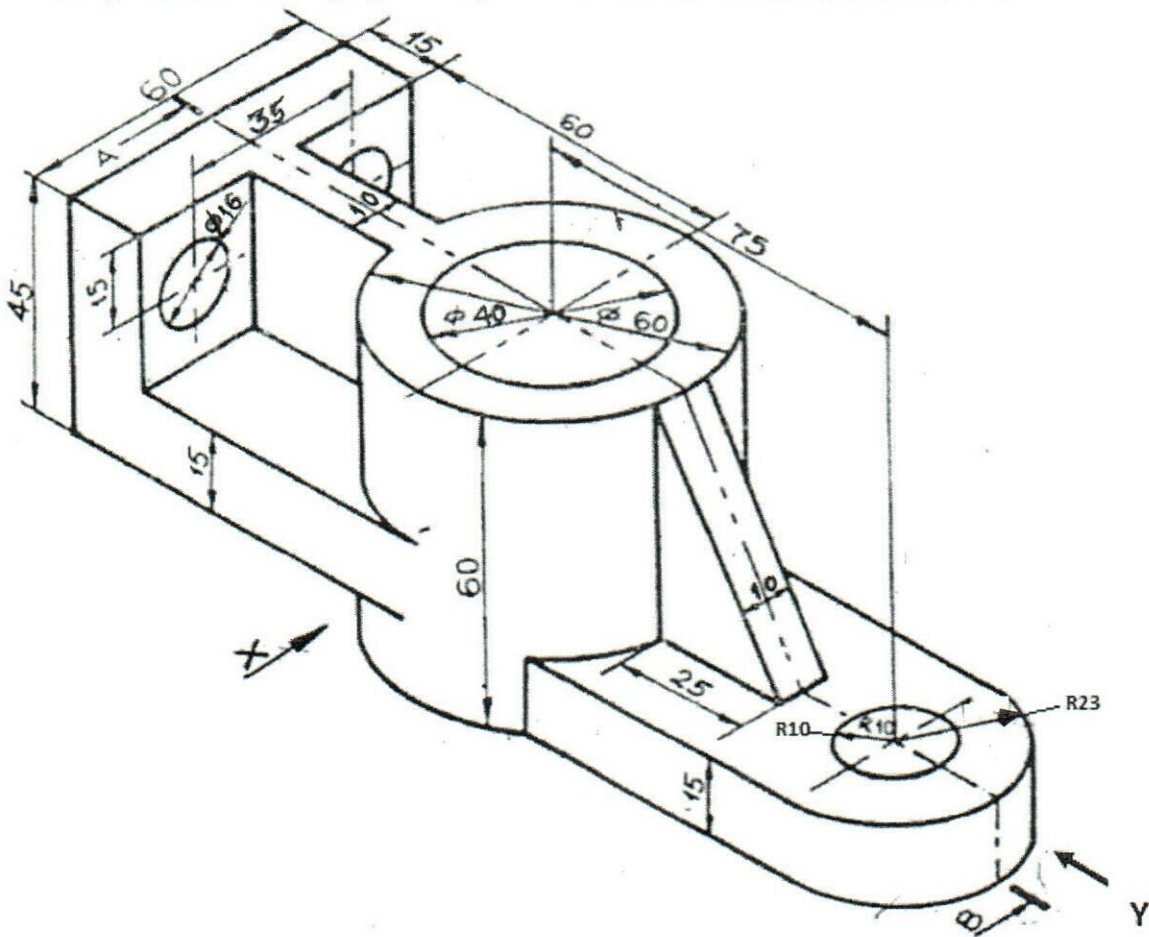


Figure: 01

Marking Scheme

1. Accuracy of view (a)	20 Marks
2. Accuracy of view (b)	20 Marks
3. Accuracy of view (c)	25 Marks
4. Alignment of views	10 Marks
5. Spacing	10 Marks
6. Title block, Projection symbol, Lettering	05 Marks
7. Dimensioning	05 Marks
8. Final Appearance	05 Marks

Faculty of Engineering & Technology
Bachelor of Science (Honours) in Engineering



FE2312 Economics and Accounting for Engineers

First sit Examination

Semester-3 2024 (Batch – 5)

Time allowed: 3 hours for the exam 8th February 2024 from 01:30 p.m. to 04:30 pm

Note:

- Answer all **FIVE** questions and all carry equal marks.
- This is a closed book examination
- Some useful formulas and data are given at the end of the question paper

01.

a) Due to the increased demand, the management of company X is considering to purchase a new machine to increase the production and revenues. The useful life of the machine is 9 years and the company's maximum desired payback period is 4 years. The inflow and outflow of cash associated with the new machine is given below:

Description	Cost (\$)
Initial cost of equipment	39,000
Annual cash inflows:	
Sales	76,000
Annual cash Outflows	
Cost of ingredients	43,000
Salaries expenses	14,000
Maintenance expenses	1,400
Non cash expenses:	
Depreciation expense	4,900

Required:

- I. Calculate the payback period and state whether the company X can purchase the new machine as to the results of the payback method
(08 marks)
- II. Give your explanations for the answer given above.
(04 marks)

b) Akbar & Company purchased a factory machine of Rs. 180,000 on January 1, 2012. The machine is expected to have a salvage value of Rs. 20,000 at the end of its 4th year useful life. During the useful life, the machine is expected to be used for 160,000 hours. The machine was used as under:

Year	Hours Used
2012	40,000
2013	60,000
2014	35,000
2015	25,000

Required:

Prepare the schedule of Depreciation on the basis of Straight-Line Method for the machine

(08

marks)

02.

A company makes a single product which it sells at Rs.102 per unit. Its variable cost is Rs 58 per unit. Fixed costs are Rs.550,000 per annum.

Required;

- I. The number of units to break even
- II. Sales value at break even point
- III. c/s ratio
- IV. The number of units that must be sold to achieve a profit of Rs.190,000 per annum
- V. The level of sales to achieve a profit of Rs.190,000 per annum.

(4*5=20

marks)

03. An inexperienced book-keeper has drawn up an Incorrect and Unadjusted Trial Balance, as shown below .

XYZ Company
Trial Balance
31st Nov.2021

S.No	Descriptions	Amount(Rs)	
		Debit	Credit
1	Purchase return	13,000	
2	Machinery	34,000	
3	Salaries		17,200
4	Creditors		33,000
5	Cash in hand	40,000	
6	Carriage Inward	6,000	
7	Rent Received		3,000
8	Discount Allowed		2,000
9	Purchases	100,000	
10	Bill Payable		20,000
11	Debtors	15,000	
12	Carriage Outward		5,000
13	Owner Equity	53,200	
14	Building		18,000
15	Sales Return	3,000	
16	Discount Received		14,000
17	Insurance Expenses	6,000	
18	Sales		130,000
19	Furniture		20,000
20	Suspense Account		8,000
	Total	Rs.270,200	Rs.270,200

Adjustments:

- a. Salary Payable on December 31, 2016 is Rs. 1,500
- b. Depreciation on Furniture charged to 10% by cost method
- c. Inventory on hand on December is Rs. 60,000
- d. 30,000 of Sales Account is unearned

Required;

- I. Correct the Trial Balance (04 marks)
- II. Prepare Adjusted Trial Balance: (16 marks)

04. ABC company started business by 1st of May and the owner of the business has planned to prepare a monthly financial statement and has completed below transactions.

- May 1. Owner invested Rs. 500,000 cash along with computer equipment that had a market value of Rs.120,000 two years ago but was now worth Rs. 100,000 only.
- May 2. Paid Rs. 15,000 cash for the rent of office space for the month.
- May 4. Purchased Rs. 12,000 of additional equipment on credit (due within 30 days).
- May 8. Completed a work for a client and immediately collected Rs. 32,000 cash.
- May 10. Completed work for a client and sent a bill for Rs. 27,000 to be paid within 30 days.
- May 12. Purchased additional equipment for Rs. 8,000 in cash.
- May 15. Paid an assistant Rs. 6,200 cash as wages for 15 days.
- May 18. Collected Rs. 15,000 on the amount owed by the client.
- May 25. Paid Rs. 12,000 cash to settle the liability on the equipment purchased.
- May 28. Owner withdrew Rs. 500 cash for personal use.
- May 30. Completed work for another client who paid only Rs. 40,000 for 50% of the system design.
- May 31. Paid salary of assistant Rs. 700.
- May 31. Received PLDT bill, Rs. 1,800 and Meralco bill Rs. 3,800.

Required:

Prepare T accounts and trial balance for this business.

Note; You may Combine salaries and wages into one account

(20 marks)

05.

- a) Define the Net Present Value(NPV) and Internal Rate of Return (IRR) (02 marks)
- b) ABC Ltd has the opportunity to invest in a project with the following forecasted annual cash flows:

c)

Year	0	1	2	3	4
Cash Flow(\$)	2,000,000	600,000	800,000	700,000	650,000

The Financial Manager of ABC Ltd has to determine the appropriate cost of capital (COC) to apply as the discount rate to the project's cash flows p.a.

Required;

- I. The NPV of the project for 12% and 17% Discounting rates (08 marks)
- II. State in which rate the project is viable (04 marks)
- III. IRR of the project (08 marks)

Useful formula & Data:

Current ratio = Current assets/Current liabilities

Quick asset Ratio = Current assets less stocks/Current liabilities

Debt to equity Ratio = Borrowings (long term plus short term)×100 /Total equity

DCF formula for Net Present Value; $NPV = \sum_{t=0}^n Ct/(1+i)^n$

Where;

Ct – the net cash flow in a period

t - the period number

i – the discount rate

- Sales Revenue or Sales (S)=Variable Cost(V)+Fixed Cost (F) + Profit (P)
- Brake Even point (units to be sold to cover total cost) $n_B = F / c = \text{Fixed cost/contribution per unit}$
- Number of units required to provide the expected profit = (Fixed cost + Expected profit)/contribution per unit
- Contribution per unit (C) = Selling price per unit -Variable cost per unit

Discounting factors at 12% required rate of return of the project

Year	1	2	3	4
Discounting factor 12%	0.8929	0.7972	0.7118	0.6355
Discounting factor 17%	0.8547	0.7305	0.6244	0.5337



CINEC CAMPUS
FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

FINAL EXAMINATION

Module Code	:	FE1311
Module Title	:	Engineering Mathematics I
Academic Year	:	Semester 1- 2023/2024
Date	:	7th February 2024
Examiner	:	B.S Wijeratne
Time Allowed	:	3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all four questions. Each question carries equal marks.
- Each answer should start on a separate page.
- This paper contains 8 pages.
- Additional information is provided on page 6 -8

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a Scientific calculator. This must not be programmable

1. a) Find the following limits.

i) $\lim_{x \rightarrow \infty} x^{1/x}$ [16 Marks]

ii) $\lim_{x \rightarrow 1} \frac{\sqrt{x+3}-2}{x-1}$ [5 Marks]

iii) $\lim_{x \rightarrow \infty} x(1 - e^{3/x})$ [9 Marks]

b) i) A d.c circuit comprises three closed loops. Applying Kirchhoff's laws to the closed loops gives the following equations for current flow in milliamperes,

$$\begin{aligned} 2I_1 + 3I_2 - 4I_3 &= 26 \\ I_1 - 5I_2 - 3I_3 &= -87 \\ -7I_1 + 2I_2 + 6I_3 &= 12 \end{aligned}$$
 [35Marks]

Use Cramer's rule to solve for I_1 , I_2 and I_3 .

ii) In a mass-spring damper system, the acceleration $a \text{ ms}^{-2}$, velocity $v \text{ ms}^{-1}$ and displacement $x \text{ m}$ are related by the following simultaneous equations.

$$\begin{aligned} 3a - 2v + x &= -3 \\ 6a + v - 2x &= 17/2 \\ a + 4v + x &= -2/3 \end{aligned}$$
 [35 Marks]

By using Gaussian elimination method determine acceleration, velocity, and displacement for the system.

2. a) The path of a satellite moving around the earth is given by the equation $|z + 1| + |z - 1| = 4$. Show that the locus is an ellipse and find the coordinates of its foci and sketch the ellipse. [40 Marks]
- b) Find all the third roots of $8 + 8\sqrt{3}i$, and display them on an Argand diagram (You should display all three points in the same complex plane). [25 Marks]
- c) A cycloid has parametric equations $x = 2(\theta - \sin\theta)$ and $y = 2(1 - \cos\theta)$. Evaluate radius of curvature at $\theta = 0.62$ rad correct to 4 significant figures [35 marks]
3. a) The time of oscillation t of a pendulum is given by, $t = 2\pi\sqrt{\frac{l}{g}}$. Determine the approximate change in t when l has an error of 0.2% increase and g 0.1% decrease. [25 Marks]
- b) The total surface area S of a cone of base radius r and perpendicular height h is given by ,
- $$S = \pi r^2 + \pi r\sqrt{r^2 + h^2}$$
- If r and h are each increasing at the rate of 0.25 cm s^{-1} , find the rate at which S is increasing at the instant when $r = 6 \text{ cm}$ and $h = 8 \text{ cm}$ [30 Marks]
- c)i) The maximum and minimum distances of the Earth from the Sun respectively are $152 \times 10^6 \text{ km}$ and $94.5 \times 10^6 \text{ km}$. The Sun is at one focus of the elliptical orbit. Find the distance from the Sun to the other focus and sketch the positions of sun and earth on the ellipse. [30 Marks]
- ii) A person in a whispering gallery standing at one focus of the ellipse can whisper and be heard by another person standing at the other focus because all the sound waves that reach the ceiling are reflected to other person (figure 1). If you have been asked to build a whispering gallery with a length 314 m where foci are 85m from the center, calculate the height of the ceiling at the center.

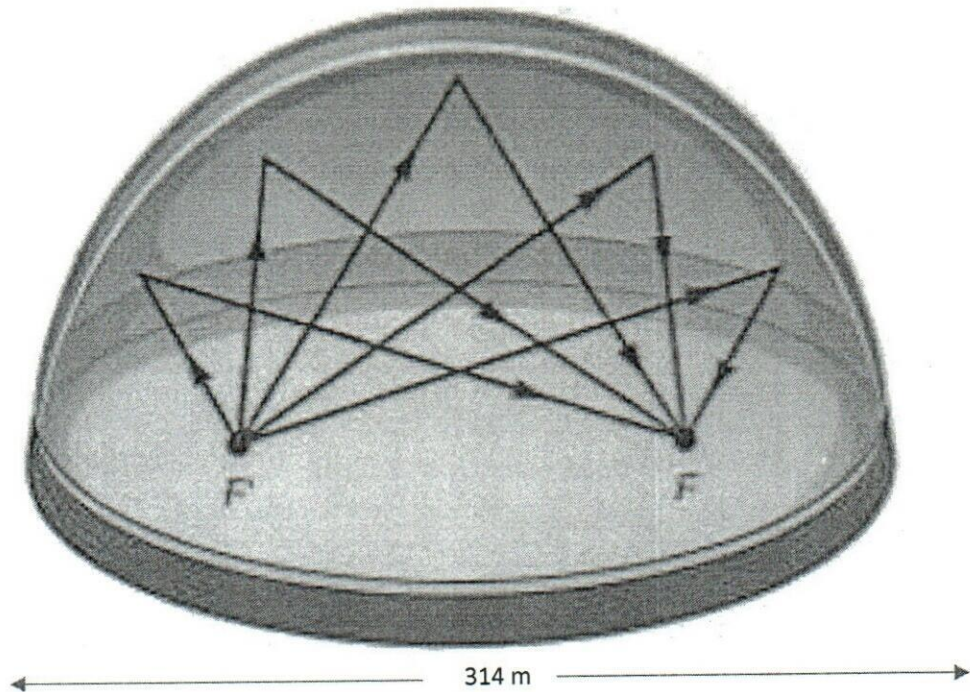


Figure 1: Whispering Gallery

[15 Marks]

4.a) Let, $\vec{a} = 4\vec{j} + \vec{k}$, $\vec{b} = 2\vec{j} + 4\vec{k}$ and $\vec{c} = 3\vec{i} + 2\vec{j} - \vec{k}$,

i) Find the area of the parallelogram formed by the vectors $\vec{a}$ and $\vec{b}$ [10 Marks]

ii) If a parallelepiped is formed with $\vec{a}$, $\vec{b}$ and $\vec{c}$ as edge vectors find its volume [10 Marks]

b) Radar uses radio waves to detect the location of objects. A device called a magnetron generates high powered radio waves. An antenna focuses these waves into a narrow beam and continually shoots them into the sky. The radio waves travel at the speed of light until they hit an object. The waves bounce off the airplane and travel back towards the earth (figure 2). Some of the return waves are captured by antenna. Based on strength and travel time of the radio waves, location of the airplane can be determined.

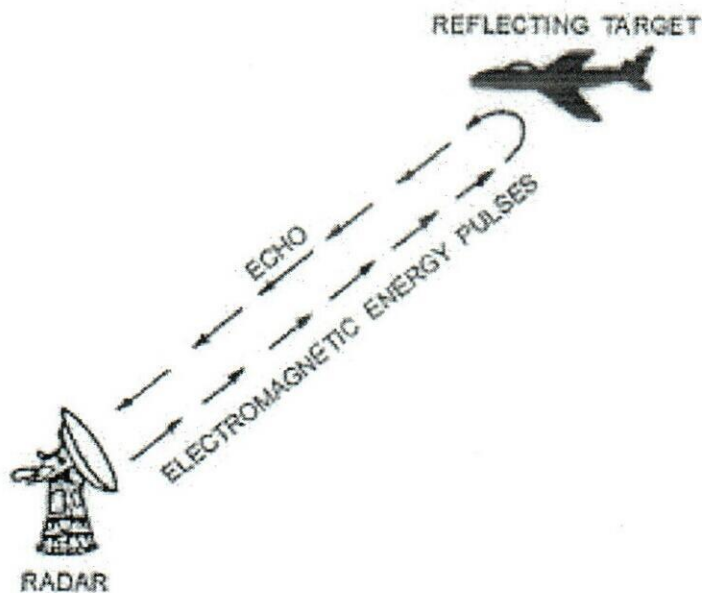


Figure 2: Radar antenna

A radar is stationary at $S(1, -2, 4)$. The radio waves travelling at speed of light hits an airplane moving in a straight line passing through $A(1, 3, 6)$ and $B(5, -1, 4)$. If the shortest distance between a point P and a line through the points A and B is given by $\frac{|\overrightarrow{AP} \times \overrightarrow{AB}|}{|\overrightarrow{AB}|}$. Find the time elapsed (t) between the moment of transmission of waves and reception of reflected waves assuming that the airplane is receiving the radio waves at the time of closest point to the radar.

[speed of light (c) = $3 \times 10^8 \text{ ms}^{-1}$, The distance (d) between the radar distance sensor and the target surface = $\frac{ct}{2}$]

[30 Marks]

c) Evaluate the following integrals using a suitable method.

i) $\int \frac{\sqrt{x^2-4}}{x} dx$

[14 Marks]

ii) $\int \frac{8x^3+5x}{(x^2+3)^2} dx$

[14 Marks]

iii) $\int \frac{\tan x}{\sec^4 x} dx$

[12 Marks]

iv) $\int t^7 \sin(2t^4) dt$

[10 Marks]

Additional Information

Partial Derivatives:

- 1 Small increments (Total differentials of z)

$$z = f(x, y) \quad \delta z = \frac{\partial z}{\partial x} \delta x + \frac{\partial z}{\partial y} \delta y \quad (a)$$

- 2 Rates of change (Simple Chain Rule)

$$\frac{dz}{dt} = \frac{\partial z}{\partial x} \cdot \frac{dx}{dt} + \frac{\partial z}{\partial y} \cdot \frac{dy}{dt} \quad (b)$$

- 3 Implicit functions

$$\frac{dz}{dx} = \frac{\partial z}{\partial x} + \frac{\partial z}{\partial y} \cdot \frac{dy}{dx} \quad (c)$$

- 4 Change of variables (Chain Rule for Two Sets of Independent Variables,

$$\begin{aligned} \frac{\partial z}{\partial u} &= \frac{\partial z}{\partial x} \cdot \frac{\partial x}{\partial u} + \frac{\partial z}{\partial y} \cdot \frac{\partial y}{\partial u} \\ \frac{\partial z}{\partial v} &= \frac{\partial z}{\partial x} \cdot \frac{\partial x}{\partial v} + \frac{\partial z}{\partial y} \cdot \frac{\partial y}{\partial v} \end{aligned} \quad (d)$$

Standard derivatives:

$F(x)$	$\frac{df(x)}{dx}$
x^n	nx^{n-1}
$\sin ax$	$a \cos ax$
$\cos ax$	$-a \sin ax$
$\tan ax$	$a \sec^2 ax$
$\sec ax$	$a \sec ax \cdot \tan ax$
e^{ax}	ae^{ax}
$\ln ax$	$\frac{a}{x}$

Standard Integrals:

$f(x)$	$\int f(x)dx$
x^n	$\frac{x^{n+1}}{n+1}$, for $x \neq -1$
e^x	e^x
e^{ax}	$\frac{1}{a} e^{ax}$
$\frac{1}{x}$	$\ln x$
$\sin ax$	$-\frac{1}{a} \cos ax$
$\cos ax$	$\frac{1}{a} \sin ax$

Rules of differentiation	$\frac{d}{dx}(uv) = u \frac{dv}{dx} + v \frac{du}{dx}$ $\frac{d}{dx} \left(\frac{u}{v} \right) = \frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2}$ $\frac{dy}{dx} = \frac{dy}{du} \frac{du}{dx}$
Integration by parts equation	$\int u \frac{dv}{dx} dx = uv - \int v \frac{du}{dx} dx$

Radius of Curvature:

$$R = \frac{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}}{\left|\frac{d^2y}{dx^2}\right|}$$

TRIGONOMETRIC IDENTITIES**RECIPROCAL IDENTITIES**

$$\cot x = \frac{1}{\tan x} = \frac{\cos x}{\sin x}$$

$$\csc x = \frac{1}{\sin x}$$

$$\sec x = \frac{1}{\cos x}$$

PYTHAGOREAN IDENTITIES

$$\sin^2 x + \cos^2 x = 1$$

$$\sin^2 x = 1 - \cos^2 x$$

$$\cos^2 x = 1 - \sin^2 x$$

$$1 + \tan^2 x = \sec^2 x$$

$$1 + \cot^2 x = \csc^2 x$$

SUM AND DIFFERENCE IDENTITIES

$$\sin(x \pm y) = \sin x \cos y \pm \cos x \sin y$$

$$\cos(x \pm y) = \cos x \cos y \mp \sin x \sin y$$

$$\tan(x \pm y) = \frac{\tan x \pm \tan y}{1 \mp \tan x \tan y}$$

DOUBLE-ANGLE IDENTITIES

$$\sin 2x = 2 \sin x \cos x = \frac{2 \tan x}{1 + \tan^2 x}$$

$$\cos 2x = \cos^2 x - \sin^2 x$$

$$= 2 \cos^2 x - 1$$

$$= 1 - 2 \sin^2 x = \frac{1 - \tan^2 x}{1 + \tan^2 x}$$

$$\tan 2x = \frac{2 \tan x}{1 - \tan^2 x}$$

$$\cot 2x = \frac{\cot^2 x - 1}{2 \cot x}$$

HALF-ANGLE IDENTITIES

$$\sin \frac{x}{2} = \pm \sqrt{\frac{1 - \cos x}{2}}$$

$$\cos \frac{x}{2} = \pm \sqrt{\frac{1 + \cos x}{2}}$$

$$\tan \frac{x}{2} = \pm \sqrt{\frac{1 - \cos x}{1 + \cos x}} = \frac{\sin x}{1 + \cos x} = \frac{1 - \cos x}{\sin x}$$

Nth roots of a complex number:

If $z = r(\cos \theta + i \sin \theta)$,

then the n distinct complex numbers

$$\sqrt[n]{r} \left(\cos \frac{\theta + 2\pi k}{n} + i \sin \frac{\theta + 2\pi k}{n} \right)$$

Where $k = 0, 1, 2, \dots, (n-1)$ are the n th roots of a complex number Z .



FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

FINAL EXAMINATION

Module Code	:	FE2311
Module Title	:	Engineering Mathematics III
Academic Year	:	Semester 3 - 2023/2024
Date	:	06th February 2024
Examiner	:	M.T.M.Ramees
Time Allowed	:	3 Hours

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all four questions. Each question carries equal marks.
- Each answer should start on a separate page.
- This paper contains 8 pages.
- Additional information is provided on pages 6,7 and 8.

MATERIALS REQUIRED

- Two eight-page answer booklets
- You may use a Scientific calculator. This must not be programmable and may be inspected during the examination.

1.

- i) Determine the particular solution of $\frac{dy}{dt} + 3t^2y = t^2$ using the integrating factor, given that $y = 0.2$ when $t = 0$

[15 Marks]

- ii) The displacement s of a body in a damped mechanical system, with no external forces, satisfies the following differential equation

$$\frac{d^2s}{dt^2} + 14\frac{ds}{dt} + 49s = 0$$

Solve the equation for s given that $s = 2$ and $\frac{ds}{dt} = -3$ when $t = 0$

[20 Marks]

- iii) Determine the particular solution of the differential equation

$$\frac{d^2y}{dx^2} - 9y = -6 \cos 3x$$

When $x = 0$, $y = \frac{dy}{dx} = 1$

[40 Marks]

iv)

- a) Find the domain and range of function,

$$z = f(x, y) = 25 - x^2 - y^2 \text{ and then sketch the graph.}$$

[15 Marks]

- b) Determine whether the limit, $\lim_{(x,y) \rightarrow (0,0)} \frac{x^4 + y^3}{x^5 y^3 + y^2}$ exists or not.

[10 Marks]

2.

- i) Find the 2024th derivative of $y = xe^{-x}$ using the Leibnitz's theorem.

[10 Marks]

- ii) Show that the power series solution of the differential equation

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

Using the Leibnitz – Maclaurin method, is given by

$$y = 2 + 4x - e^x$$

Given the boundary conditions that at $x = 0$, $y = 1$ and $\frac{dy}{dx} = 3$.

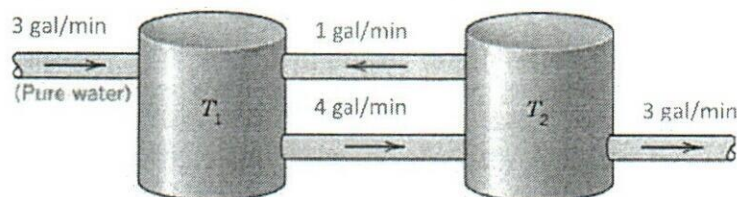
(Note that $e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \dots$)

[45 Marks]

- iii) Let $\frac{dy}{dx} = y + x$, $y(0) = a$
- If $y(0.1) = 3.32$ using the Improved Euler (Euler-Cauchy) method with a step size of $h = 0.1$ then find the value of a . [10 Marks]
 - Apply the Improved Euler method to find $y(0.3)$. (Consider the step size in a)) [20 Marks]
 - Solve the differential equation using integrating factor method. [10 Marks]
 - Hence, find the percentage error with Improved Euler method for $x = 0.3$. [5 Marks]

3.

- Find the Laplace transform of $f(t) = 2t + 1$ by integration. ($\mathcal{L}\{f(t)\} = \int_0^\infty f(t)e^{-st} dt$). Show the details of your work. [15 Marks]
- Solve the following shifted data IVP by the Laplace transform. Show the details of your work.
 $y'' + 5y' + 4y = 3e^{t-2}$, $y(2) = -2$ and $y'(2) = 5$ [30 Marks]
- Tank T_1 in the figure initially contains 100 gal of water in which 100 lb of salt are dissolved. Tank T_2 initially contains 100 gal of pure water. Liquid is pumped through the system as indicated, and the mixtures are kept uniform by stirring. Find the amounts of salt $y_1(t)$ and $y_2(t)$ in T_1 and T_2 , respectively.



[25 Marks]

- Find the real general solution and sketch or graph some of the trajectories in the phase plane for the following system of equation and determine the type of the critical point.

$$y_1' = -4y_1 + 6y_2$$

$$y_2' = -3y_1 + 5y_2$$

[30 Marks]

4.

- i) The probability that an eagle kills a rabbit in a day of hunting is 15%. Assume that results are independent for each day.
- a) What is the probability that the first successful hunt occurs on day five? [6 Marks]
 - b) What is the expected number of days until a successful hunt? [3 Marks]
 - c) What is the probability that the second successful hunt occurs on day five? [6 Marks]
 - d) If the eagle can survive up to 10 days without food (it requires a successful hunt on the 10th day), what is the probability that the eagle is still alive 10 days from now? [5 Marks]
- ii) Traffic flow is traditionally modeled as a Poisson distribution. A traffic engineer monitors the traffic flowing through an intersection with an average of four cars per minute. Determine the following probabilities.
- a) What is the probability that no cars pass through the intersection within 30 seconds? [6 Marks]
 - b) What is the probability that more than two cars pass through the intersection within 2 minutes? [14 Marks]
 - c) Calculate the minimum number of cars such that the probability of this number or fewer cars pass through the intersection within 30 seconds is at least 90%. [8 Marks]
 - d) If the variance of the number of cars through the intersection per minute is 15, is the Poisson distribution appropriate? Explain. [2 Marks]

- iii) In a company of 1000 employees, there are 650 developers, 230 sales & marketing and the remaining QA engineers. The company selects 30 employees randomly (without replacement).
- a) What is the probability that exactly two of the selected employees are QA engineers? [5 Marks]
 - b) What is the probability that at least two of the selected employees are QA engineers? [10 Marks]
 - c) What is the probability that more than 90% of the selected employees are QA engineers? [10 Marks]
 - d) What is the probability that exactly two of the selected employees are developers? [5 Marks]
- iv) A company produces widgets. 45% of the widgets are manufactured in China, 30% of the widgets are manufactured in German, and 25% of the widgets are produced in Korea. In the sample of 10 widgets,
- a) What is the probability that exactly 4, 4 and 2 widgets are manufactured in China, German and Korea, respectively? [6 Marks]
 - b) What is the probability that at least one of the widgets made in China and exactly one of the widgets made in Korea? [8 Marks]
 - c) What is the conditional probability that exactly three widgets made in China given that exactly 2 widgets made in German? [6 Marks]

Table 1 Form of particular integral for different functions

Type	Straightforward cases Try as particular integral:	'Snag' cases Try as particular integral:
(a) $f(x) = a$ constant	$v = k$	$v = kx$ (used when C.F. contains a constant)
(b) $f(x) = \text{polynomial}$ (i.e. $f(x) = L + Mx + Nx^2 + \dots$ where any of the coefficients may be zero)	$v = a + bx + cx^2 + \dots$	
(c) $f(x) = \text{an exponential function}$ (i.e. $f(x) = Ae^{ax}$)	$v = ke^{ax}$	(i) $v = kxe^{ax}$ (used when e^{ax} appears in the C.F.) (ii) $v = kx^2e^{ax}$ (used when e^{ax} and $x e^{ax}$ both appear in the C.F.)
(d) $f(x) = \text{a sine or cosine function}$ (i.e. $f(x) = a \sin px + b \cos px$, where a or b may be zero)	$v = A \sin px + B \cos px$	$v = x(A \sin px + B \cos px)$ (used when $\sin px$ and/or $\cos px$ appears in the C.F.)
(e) $f(x) = \text{a sum e.g.}$ (i) $f(x) = 4x^2 - 3 \sin 2x$ (ii) $f(x) = 2 - x + e^{3x}$	(i) $v = ax^2 + bx + c + d \sin 2x + e \cos 2x$ (ii) $v = ax + b + ce^{3x}$	
(f) $f(x) = \text{a product e.g.}$ $f(x) = 2e^x \cos 2x$	$v = e^x (A \sin 2x + B \cos 2x)$	

Leibnitz's theorem:

$$y^{(n)} = (uv)^{(n)} = u^{(n)}v + nu^{(n-1)}v^{(1)} + \frac{n(n-1)}{2!}u^{(n-2)}v^{(2)} + \frac{n(n-1)(n-2)}{3!}u^{(n-3)}v^{(3)} + \dots$$

Maclaurin's Series:

$$f(x) = f(0) + xf'(0) + \frac{x^2}{2!}f''(0) + \frac{x^3}{3!}f'''(0) + \dots$$

Formulae for Euler-Cauchy Method:

$$y_{p_1} = y_0 + hy'_0$$

$$y_{c_1} = y_0 + \frac{1}{2}h[y'_0 + f(x_1, y_{p_1})]$$

Laplace Transform:

$$F(s) = \mathcal{L}(f) = \int_0^\infty e^{-st}f(t) dt.$$

Laplace Transform of Derivatives:

$$\mathcal{L}(f') = s\mathcal{L}(f) - f(0)$$

$$\mathcal{L}(f'') = s^2\mathcal{L}(f) - sf(0) - f'(0).$$

$$\mathcal{L}(f^{(n)}) = s^n\mathcal{L}(f) - s^{n-1}f(0) - s^{n-2}f'(0) - \dots - f^{(n-1)}(0).$$

Some Functions $f(t)$ and Their Laplace Transforms $\mathcal{L}(f)$

	$f(t)$	$\mathcal{L}(f)$		$f(t)$	$\mathcal{L}(f)$
1	1	$1/s$	7	$\cos \omega t$	$\frac{s}{s^2 + \omega^2}$
2	t	$1/s^2$	8	$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$
3	t^2	$2!/s^3$	9	$\cosh at$	$\frac{s}{s^2 - a^2}$
4	t^n ($n = 0, 1, \dots$)	$\frac{n!}{s^{n+1}}$	10	$\sinh at$	$\frac{a}{s^2 - a^2}$
5	t^a (a positive)	$\frac{\Gamma(a+1)}{s^{a+1}}$	11	$e^{at} \cos \omega t$	$\frac{s-a}{(s-a)^2 + \omega^2}$
6	e^{at}	$\frac{1}{s-a}$	12	$e^{at} \sin \omega t$	$\frac{\omega}{(s-a)^2 + \omega^2}$

The Probability Mass Function of Hypergeometric Random Variable X :

$$f(x) = \frac{\binom{K}{x} \binom{N-K}{n-x}}{\binom{N}{n}} \quad x = \max\{0, n+K-N\} \text{ to } \min\{K, n\}$$

A set of N objects contains

K objects classified as successes

$N - K$ objects classified as failures

A sample of size n objects is selected randomly (without replacement) from the N objects where $K \leq N$ and $n \leq N$.

If X is a Hypergeometric Random Variable with parameters N, K and n , then

$$\mu = E(X) = np \quad \text{and} \quad \sigma^2 = V(X) = np(1-p) \left(\frac{N-n}{N-1} \right)$$

where $p = K/N$.

The Probability Mass Function of Poisson Random Variable X :

$$f(x) = \frac{e^{-\lambda T} (\lambda T)^x}{x!} \quad x = 0, 1, 2, \dots$$

The Joint Probability Mass Function of Random Variables $X_1, X_2, \dots, X_k$ which have a Multinomial Distribution:

$$P(X_1 = x_1, X_2 = x_2, \dots, X_k = x_k) = \frac{n!}{x_1! x_2! \dots x_k!} p_1^{x_1} p_2^{x_2} \dots p_k^{x_k}$$

for $x_1 + x_2 + \dots + x_k = n$ and $p_1 + p_2 + \dots + p_k = 1$.

The Probability Mass Function of Negative Binomial Random Variable X :

In a series of Bernoulli trials (independent trials with constant probability p of a success), the random variable X that equals the number of trials until r successes occur is a negative binomial random variable with parameters $0 < p < 1$ and $r = 1, 2, 3, \dots$, and

$$f(x) = \binom{x-1}{r-1} (1-p)^{x-r} p^r \quad x = r, r+1, r+2, \dots$$

If X is a negative binomial random variable with parameters p and r ,

$$\mu = E(X) = r/p \quad \text{and} \quad \sigma^2 = V(X) = r(1-p)/p^2$$

The Probability Mass Function of Geometric Random Variable X :

$$f(x) = (1-p)^{x-1} p \quad x = 1, 2, \dots$$

If X is a Geometric Random Variable with parameters p ,

$$\mu = E(X) = 1/p \quad \text{and} \quad \sigma^2 = V(X) = (1-p)/p^2$$



Faculty of Engineering & Technology
Department of Civil Engineering
Bachelor of Science Honours in Engineering
Year 1 Semester 1 In-Class Examination 2024

Module Code	:	CE1313
Module Title	:	Properties of Materials
Date/Time	:	17 th January 2024 / 01.30 pm – 02.30 pm
Examiner	:	P.W Gavithra Udayakumara
Time Allowed	:	One hour

INSTRUCTIONS TO CANDIDATES

- This is a **closed book** examination.
- You should attempt **ALL** questions.
- Show all stages of your work.
- This paper contains 4 pages.
- **Attempt all 08 questions.**
- **One hour will be allocated to answer all the 08 questions.**

MATERIALS REQUIRED

- Answer Booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.
- Extra answer papers (if required)
- Equations are mentioned at the 4th page

Student Number

1. The sports car is expected to face high temperatures during prolonged use. What type of composite material would be suitable for components requiring heat resistance and thermal stability?
 - a) Glass fiber-reinforced polymer (GFRP)
 - b) Carbon fiber-reinforced polymer (CFRP)
 - c) Ceramic matrix composite (CMC)
 - d) Aramid fiber-reinforced polymer (AFRP)
 - e) Hybrid Composite
2. An engineering team is working on designing a critical component for an aircraft that will be subjected to cyclic loading during its operational life. The team is concerned about the potential for fatigue failure and is exploring various materials and design strategies to mitigate this risk. What is the significance of conducting fatigue testing during the design phase of the component?
 - a) To determine the hardness of the material
 - b) To identify the yield strength of the material
 - c) To assess the material's response to cyclic loading and predict fatigue life
 - d) To measure the material's thermal conductivity
 - e) To determine the Ultimate Tensile Strength and Yield Strength of the material
3. An engineering team is designing a bridge structure. The team is designing a bridge that needs to withstand heavy loads and potential earthquakes. Which type of failure, ductile or brittle, is more desirable for this application, and why?
 - a) Ductile failure because it allows for deformation and energy absorption before complete failure, which is crucial for withstanding dynamic loads.
 - b) Brittle failure because it provides early warning signs through visible deformations, allowing for timely maintenance.
 - c) Ductile failure because it results in sudden, catastrophic failure, reducing the chances of progressive collapse.
 - d) Brittle failure because it ensures better load distribution across the structure
4. Fiber Reinforced composites become a vital material in many manufacturing operations.
 - a) Mention 3 types of fiber reinforced composites and give brief description of each (applications)
 - b) Mention 3 methods of processing "Fiber Reinforced Composites" and briefly explain one of those methods with the aid of diagram.
5. A relatively large plate of glass is subjected to a tensile stress of 70MPa. If the specific surface energy and modulus of elasticity for this glass are 0.6J/m^2 and 88GPa, respectively, determine the maximum length of a surface flaw that is possible without fracture.

6. Estimate the theoretical fracture strength of a brittle material if it is known that fracture occurs by propagation of an elliptically shaped surface crack length of .8mm and having a tip radius of curvature of 7×10^{-3} mm when a stress of 1080MPa is applied.
7. Below mentioned the details of a bridge to happen a failure with respect to the type of moving vehicles

Type of vehicle s_i (MPa)	No. Applied Cycles by 1 vehicle, N_i	Number of vehicles moving on the bridge	No. Cycles to Failure, N_f
Prime mover	500	X	10,000
bus	50	5	500
car	40	2	320

- What will be the minimum number of prime movers(X) that can be moved to fail the bridge?
 - Briefly explain the importance of considering the fatigue behavior of materials when selecting those for engineering applications.
8. A continuous and aligned fibrous reinforced composite having a cross sectional area of 970 mm^2 is subjected to an external tensile load. If the stresses sustained by the fiber and matrix phases are 215 MPa and 5.38 MPa, Respectively, the force sustained by the fiber phase is 76,800N, and the total longitudinal composite strain is 1.56×10^{-3} , then determine
- The force sustained by the matrix phase
 - The modulus of elasticity of the composite material in longitudinal direction
 - The moduli of elasticity for fiber and matrix phases.

$$\sigma_c = \left(\frac{2E\gamma_s}{\pi a} \right)^{1/2}$$

$$\sum_i n_i / N_{fi} \leq 1$$

$$\sigma_m = 2\sigma_0 (a/p_t)^{1/2}$$

$$N(S)_a^m = c$$

$$E_c(u) = E_m V_m + E_p V_p$$

$$E_c(l) = E_m E_p / (E_m V_p + E_p V_m)$$

$$F_c = F_m + F_f$$

$$\sigma_c A_c = \sigma_m A_m + \sigma_f A_f$$

$$\sigma_c = \sigma_m V_m + \sigma_f V_f$$

$$\sigma_c / \epsilon_c = (\sigma_m / \epsilon_m) V_m + (\sigma_f / \epsilon_f) V_f$$

$$E_c = E_m V_m + E_f V_f$$

$$E_c = E_m (1 - V_f) + E_f V_f$$



FACULTY OF ENGINEERING & TECHNOLOGY
BACHELOR OF SCIENCE HONOURS IN ENGINEERING

Continuous Assessment - 3

Module Code	:	FE2311
Module Title	:	Engineering Mathematics III
Academic Year	:	Semester 3/2023
Date	:	24th January 2024
Examiner	:	M.T.M.Ramees
Time Allowed	:	1 Hour

INSTRUCTIONS TO CANDIDATES

- This is a closed book examination.
- You should answer all three questions.
- Each answer should start on a separate page.
- This paper contains 3 pages.
- Additional information is provided on page 3

MATERIALS REQUIRED

- An answer booklet
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination.

1. Each sample of water has 15% chance of containing a particular organic pollutant. Assume that the samples are independent with regard to the presence of the pollutant. In the next 20 samples,
- Find the probability that exactly two samples contain the pollutant. [10 Marks]
 - Find the probability that at least one sample contain the pollutant. [10 Marks]
 - Find the probability that at least 18 samples do not contain the pollutant. [15 Marks]
 - Find the expected value of the random variable defined in (i). [5 Marks]
2. The following table shows the joint probability distribution of random variables X and Y .

	X		
Y	1	2	3
1	0.01	0.02	0.25
2	0.02	0.03	$2c$
3	0.02	c	0.05
4	0.15	0.1	0.05

- Find the value of c . [5 Marks]
 - Obtain the marginal probability distribution of X . [10 Marks]
 - Calculate the conditional probability, $P(Y = 3 | X = 1)$. [10 Marks]
 - Determine the value of $E(X)$ and $V(X)$. [10 Marks]
3. Determine the covariance and correlation for the following joint probability distribution.

x	1	1	2	4
y	3	4	5	6
$f_{XY}(x, y)$	1/8	1/4	1/2	1/8

[25 Marks]

Additional Information

The random variable X that equals the number of trials that result in a success is a **binomial random variable** with parameters $0 < p < 1$ and $n = 1, 2, \dots$. The probability mass function of X is

$$f(x) = \binom{n}{x} p^x (1-p)^{n-x} \quad x = 0, 1, \dots, n$$

If X is a binomial random variable with parameters p and n ,

$$\mu = E(X) = np \quad \text{and} \quad \sigma^2 = V(X) = np(1-p)$$

The **covariance** between the random variables X and Y , denoted as $\text{cov}(X, Y)$ or σ_{XY} , is

$$\sigma_{XY} = E[(X - \mu_X)(Y - \mu_Y)] = E(XY) - \mu_X \mu_Y$$

The **correlation** between random variables X and Y , denoted as ρ_{XY} , is

$$\rho_{XY} = \frac{\text{cov}(X, Y)}{\sqrt{V(X)V(Y)}} = \frac{\sigma_{XY}}{\sigma_X \sigma_Y}$$

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CE2315 STRUCTURAL ANALYSIS I

FINAL EXAMINATION

Date : 14th February 2024
Examiner : Ms. Udayanga Edirisooriya
Time Allowed : 3 hours

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **SIX** questions in 4 pages.
- Answer **All** questions.
- Show all stages of your work
- You should write legibly in **BLACK** or **BLUE** ink.
- All the answers should be given with respective units.

MATERIALS REQUIRED

- Answer booklet.
- You may use a scientific calculator. This must not be programmable and may be inspected during the examination. Programmable calculators, PDAs and mobile phones are not permitted in the exam.

- 1) The simply supported beam ABCDEF given in Figure 1, is pinned at B and E is on a roller support. The beam is subjected to two, point loads of 40 kN and 20 kN at A and C, a uniformly distributed load of 12 kN/m on segment DE, and a concentrated moment of 20 kNm at F. The flexural rigidity EI is a constant.

- Find the reactions at supports B and E
(10 marks)
- Use Macaulay's method to write the Bending moment equation for the beam.
(20 marks)
- Derive the equations of slope and deflection.
(30 marks)
- Determine the deflection at A and F
(20 marks)
- Find the location and the value of the maximum deflection in span BE.
(20 marks)

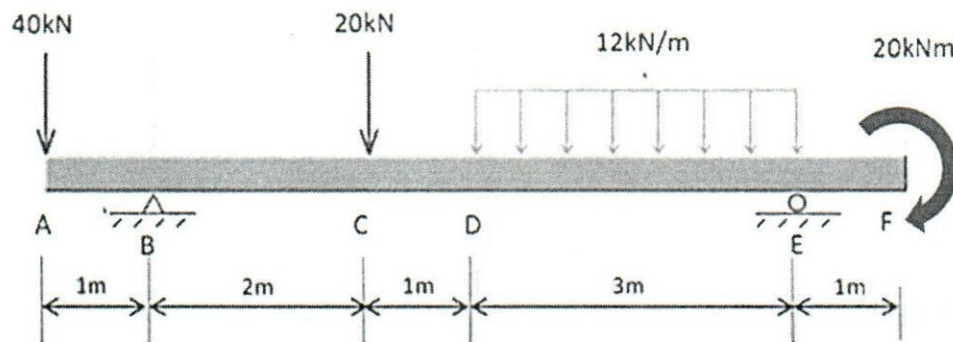


Figure 1

- 2) The statically indeterminate uniform beam ABCD given in Figure 2, is fixed at A, and B and C are on roller supports. The beam is subjected to a point load and a uniformly distributed load as given in the figure and there is a 20 mm support settlement at B. Take $E = 70 \text{ GPa}$ and $I = 50 \times 10^6 \text{ mm}^4$. Equations are given in the last page.

- Determine the Bending moments at points A, B and C
(50 marks)
- Draw the Bending Moment diagram for the beam.
(30 marks)
- Draw the Shear Force diagram for the beam.
(20 marks)

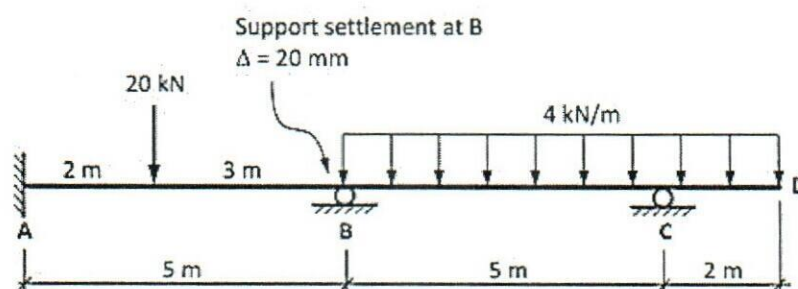


Figure 2

- 3) The three-pinned parabolic arch given in Figure 3 is subjected to a uniformly distributed load and two concentrated loads as given.
- Determine the support reactions at A and C. (40 marks)
 - Calculate the radial shear and the normal thrust at a section 50 m away from A. (60 marks)

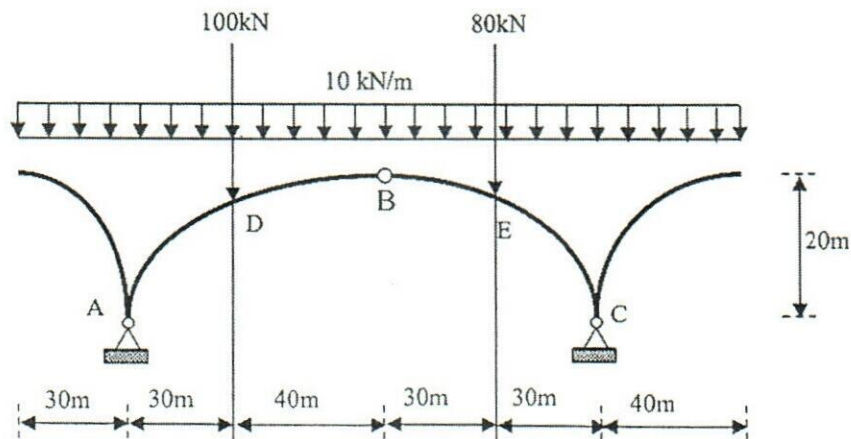


Figure 3

- 4) The moving truck load system given in Figure 4 consists of 3-point loads. The load system is moving from right to left.
- Draw the influence line diagrams for shear force at point C and bending moment at point C. (20 marks)
 - Determine the maximum positive shear force that can be generated at point C when the truck passes through the beam. (40 marks)
 - Determine the maximum positive Bending moment that can be generated at point C when the truck passes through the beam. (40 marks)

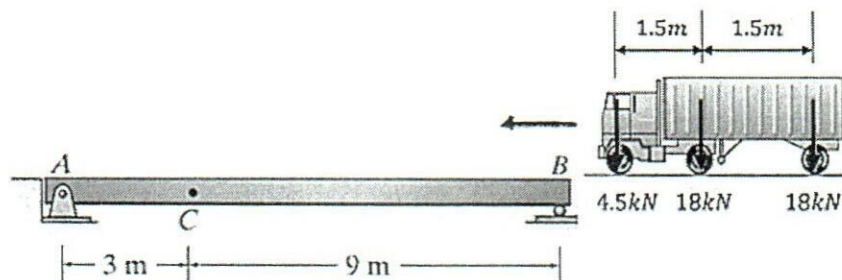


Figure 4

- 5) The cable ABCDE given in Figure 5, is pinned at A and E. Three-point loads are applied at B, C, and D.

i. Determine the forces P_1 and P_2 needed to hold the cable in the position, so that segment CD remains horizontal.

(80 marks)

ii. Determine the maximum diameter required for the cable if the allowable stress is 400 MPa.

(20 marks)

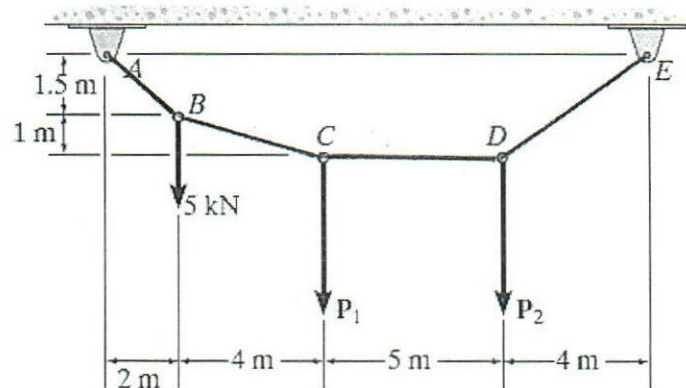


Figure 5

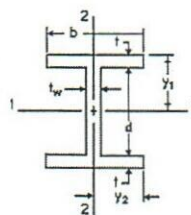
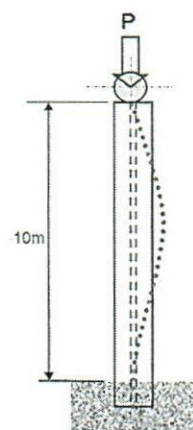
- 6) Consider the universal steel column 203mm x 203mm x 46.1 kg/m with a flange thickness of 11mm and web thickness of 7.2mm given in Figure 6. The height of the column is 10m and has load applied on to a pinned joint on top and is fixed in concrete at its base.

i. Calculate the Second moment of area of the column section.

(50 marks)

ii. Determine the Euler buckling load of the column. Take Young's modulus of steel as 210 GPa.

(50 marks)



Length of flange

Length of web

Flange thickness

Web thickness

Column in Buckling

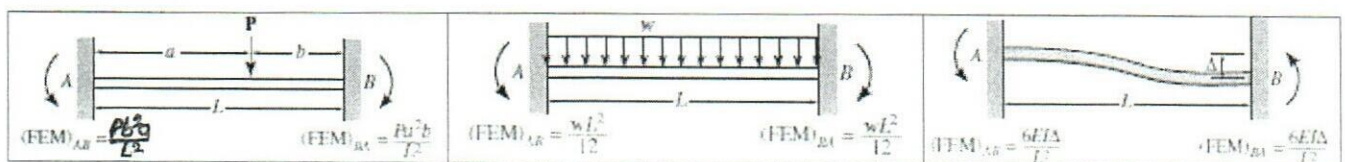
$b = 203\text{ mm}$

$d = 181\text{ mm}$

$t = 11\text{ mm}$

$t_w = 7.2\text{ mm}$

Figure 6



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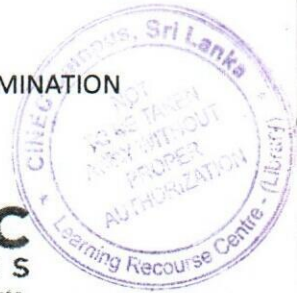
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FE3311

INDUSTRIAL LAW

Re-Sit EXAMINATION

Faculty of Engineering & Technology
Bachelor of Science (Honours) in Engineering



FE3311 INDUSTRIAL LAW

Semester-5 2023 (Batch -4) Re-sit Examination

Time allowed: 3 hours 25th November 2023 from 09:00 a.m. to 12:00 noon.

Note:

- Attempt **all five (05) questions** and all carry equal marks.
- Write answers on A4 size booklet.
- Write your name and student number on each sheet.

01.

- a) Discuss the scope and application of the 'Kandyan (Sinhala) Law' in Sri Lanka.
- b) Briefly discuss the hierarchy of courts and their limitations (powers).

02.

- a) What are the legal requirements that should be fulfilled to make a valid offer?
- b) Distinguish the terms *justa causa* and *consideration*.
- c) Briefly explain the terms *dolus* and *culpa*.

03.

Sujith employed Nishshanka on a monthly salary to do the odd jobs as a carpenter's assistant on his building site. Sujith's neighbour Sirisoma wanted Nishshanka to work for him during the weekend for a period of two months, to attend to repairs on Sirisoma's roof. Sujith had instructed Nishshanka not to work outside his own work site. While working at Sirisoma's weekend, Nishshanka dropped plank (timber) carelessly, seriously injured Sirisoma's sister. Is it possible to get sue for the damage either from Sujith or Nishshanka?

04.

Gorge has established a small-scale sulphuric acid manufacturing plant on his own land. Kate a neighbour of Gorge who is running a tutorial at her residence wants to take legal action against Gorge on the grounds that the noxious sulphur dioxide fumes emitted by the factory cause respiratory problems, headaches and faintness among her students and therefore she had to close down the tutorial.

Comment about the legal aspect in this regard.

05.

Write notes on followings.

- a) Fixed term employment and Casual employment
- b) Difference between a probationer and an apprentice