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PAST PAPERS

Faculty	Department / Section/Division
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Past Papers

Faculty of Engineering and Technology

Bachelor of Science Honours in Engineering

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CINEC CAMPUS

FACULTY OF ENGINEERING & TECHNOLOGY

BACHELOR OF SCIENCE HONOURS IN ENGINEERING

ME3315 FINITE ELEMENT ANALYSIS

FINAL EXAMINATION PAPER (semester 05)

Date	:	**31st January 2025**
Examiner	:	**Hasitha Wipulaguna**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **6 questions.**
- Answer **5** questions out of **6**.
- You should write legibly in **black or blue ink pens**.
- Do not remove the question paper or part of it, out of the examination hall.
- Graph papers, blank answer books and separate blank sheets will be provided.
- Non programmable calculators are allowed.
- This is a closed book exam.
- Any data which is not given in the question paper should be reasonably assumed and clearly state such assumptions.

QUESTION 01 **[20 marks]**

a) Describe with flow charts, the major steps of in the use of Finite element Method software.
b) Describe the difference between FDM, FEM and FVM.
c) Describe the major steps of a "Static Structural" component in ANSYS Workbench.

QUESTION 02 **[20 marks]**

The members of the truss shown in Figure Q2 have a cross-sectional area of 0.001483 mm^2 and are made of aluminum alloy (E = 209 GPa).

Determine

a) the deflection of joint A,
b) the stress in each member, and
c) the reaction forces.

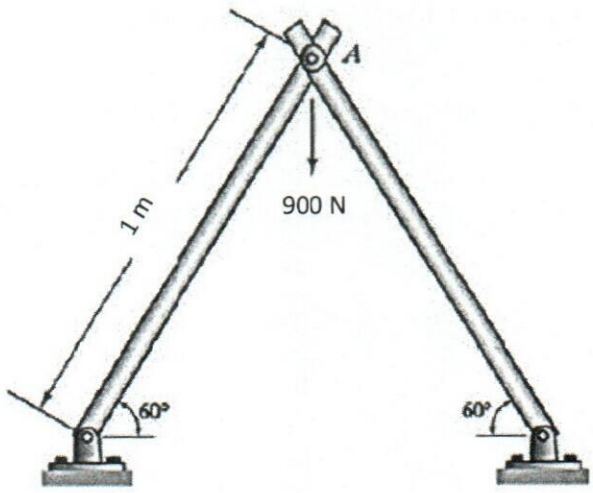


Figure Q2

QUESTION 03 **[20 marks]**

The plane truss shown in Figure Q3 consists of three trusses 1-2, 2-3 and 3-1.

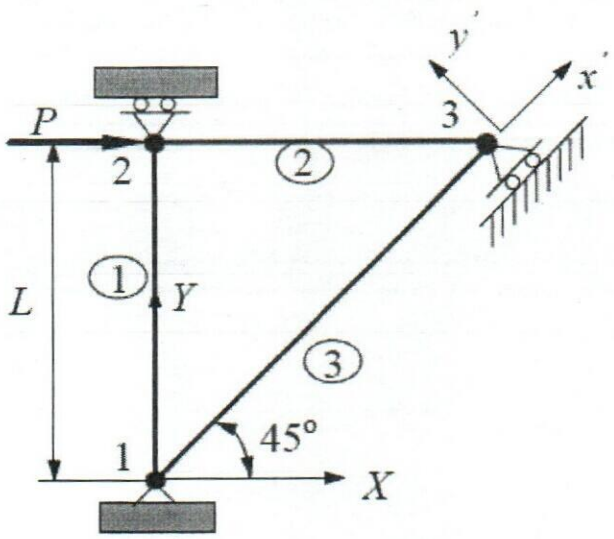


Figure Q3

For the plane truss shown above,

$P = 1000$ kN, $L = 1m$, $E = 210\,GPa$,

$A = 6.0 \times 10^{-4} m^2$ for elements 1 and 2,

$A = 6\sqrt{2} \times 10^{-4} m^2$ for element 3.

Using direct stiffness approach, find the displacements and the reaction forces of the system.

Hint: Use the following approach,

$$\frac{EA}{L}\begin{bmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix}$$

QUESTION 04 **[20 marks]**

The beam 1-3 shown in Figure Q4 is rigidly clamped at the two ends, and the moment M and downward force P are applied at midpoint 2.

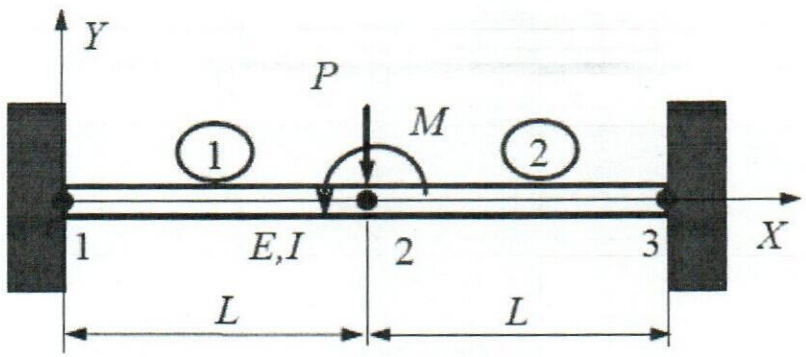


Figure Q4

Determine the deflection and rotation at the center node and the reaction forces and moments at the two ends.

Hint: Use the beam bending matrix,

$$\mathbf{k}_1 = \frac{EI}{L^3}\begin{bmatrix} v_1 & \theta_1 & v_2 & \theta_2 \\ 12 & 6L & -12 & 6L \\ 6L & 4L^2 & -6L & 2L^2 \\ -12 & -6L & 12 & -6L \\ 6L & 2L^2 & -6L & 4L^2 \end{bmatrix}$$

QUESTION 05 **[20 marks]**

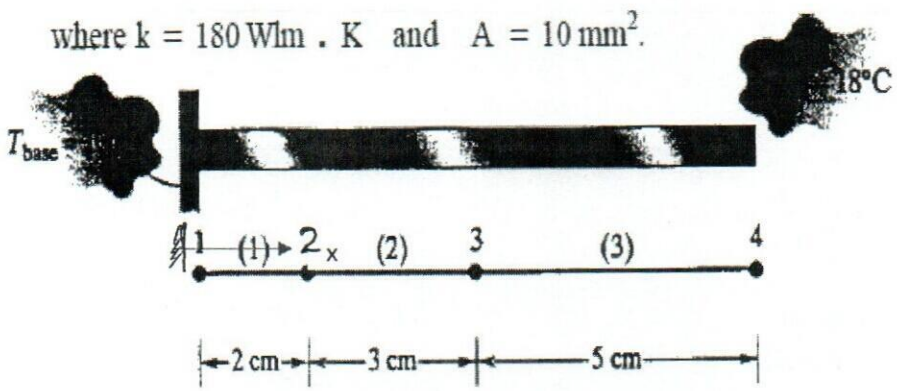
Figure Q5 illustrates a fin with linear one-dimensional elements to approximate temperature distribution over its length. The nodal temperatures at corresponding nodes and other necessary parameters and information are also given with the figure.

(a) What is the temperature of the fin at x = 7 cm?

(b) Evaluate the heat loss from the fin using the relationship

$$Q = -kA\frac{dT}{dX}\Big|_{X=0}$$

where k = 180 Wlm . K and A = 10 mm^2.



$$\begin{Bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \end{Bmatrix} = \begin{Bmatrix} 100 \\ 80 \\ 64 \\ 41 \end{Bmatrix} °C$$

Figure Q5

QUESTION 06 **[20 marks]**

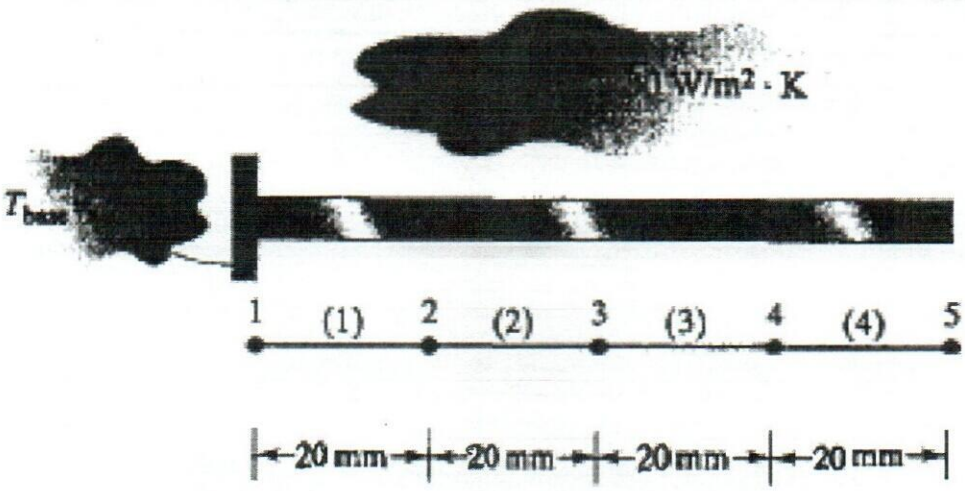


Figure Q6

Aluminum fins of a rectangular profile, shown in Figure Q6, are used to remove heat from a surface whose surface temperature is 100°C. The temperature of the ambient air is 20°C.

The thermal conductivity of Aluminum is 168 $W/m^2.K$ ($W/m^2.^0C$). The natural convective heat transfer coefficient associated with the surrounding air is $30W/m^2.^0C$). The fins are 80 mm long, 5 mm wide, and 1 mm thick.

(a) Determine the temperature distribution along the fin using the finite element model shown in the figure.

(b) Compute the heat loss per fin.

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CINEC CAMPUS

FACULTY OF ENGINEERING & TECHNOLOGY

BACHELOR OF SCIENCE HONOURS IN ENGINEERING

ME3312 Heat Engines &Heat Transfer Devices

FINAL EXAMINATION PAPER (semester 05)

Date	:	**24th January 2025**
Examiner	:	**Hasitha Wipulaguna**
Time Allowed	:	**3 Hours**

INSTRUCTIONS TO CANDIDATES

- This question paper consists of **5 questions.**
- Answer **4** questions out of **5**.
- You should write legibly in **black or blue ink**.
- Do not take the exam paper or part of it, out of the examination hall.
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Q-1

(a) The second law of thermodynamics has been stated in different ways, all of which are equivalent.

(i) Write two statements which are applicable to heat engines and refrigerators with the name of statement. (20 marks)

(ii) Prove that these two statement are equivalent with the aid of schematics. (30 marks)

(b) Coal fired steam power plant produces net power of 300 MW. Overall efficiency of fuel combustion is 32%. The actual gravimetric air / fuel ratio is 12. Calorific value of coal is 28000 KJ/kg.

Determine;

(i) The amount of Coal consumed during 24 hrs period. (30 marks)

(ii) Rate of air flowing through furnace. (20 marks)

Q- 2

(a) The Otto and the Diesel cycles can be identified as special cases of the dual cycle. Discuss this statement with the aid of P-V diagrams of each of these cycles. (30 marks)

(b) An IC engine takes in air at 1.01 bar, 20^0 C and maximum cycle pressure is 69 bar. The compression ratio is 18/1. Assume that the heat added at constant volume is equal to the heat added at constant pressure.

(i) Draw P-V diagram for the above case. (10 marks)

(ii) Calculate the temperatures in Kelvins of each state point on the dual cycle drawn. (30 marks)

(iii) Calculate the air standard thermal efficiency based on the dual combustion cycle. (30 marks)

Q-3

(a) Sketch a diagram representing a reversed heat engine system operating on Carnot Cycle. (10 marks)

(b) Sketch T-S diagram for this cycle, showing network and heat absorbed to the system at the evaporator. (10 marks)

(c) Describe each process and develop equations for COP_{ref} and COP_{hp}. (50 marks)

(d) A refrigerator has working temperatures in the evaporator and condenser coils of -30^0C and 32^0C respectively.

(i) What is the maximum COP possible? (20 marks)

(j) If the actual refrigerator has a COP of 0.75 of the maximum, calculate the required power input for a refrigerating effect of 5KW. (10 marks)

Q-4 Consider steady heat transfer between two large parallel plates at constant temperatures of $T_1 = 300$ K and $T_2 = 200$ K that are $L = 1$ cm apart, as shown in Figure Q-4. Assuming the surfaces to be black (emissivity $\varepsilon = 1$), determine the rate of heat transfer between the plates per unit surface area assuming the gap between the plates is;

(*a*) filled with atmospheric air, (40 marks)

(*b*) evacuated, (20 marks)

(*c*) filled with urethane insulation, and (20 marks)

(*d*) filled with superinsulation that has an apparent thermal conductivity of 0.00002 W/m·K. (20 marks)

Use the following K valves taken from the tables of Properties

The thermal conductivity at the average temperature of 250 K is;

$k = 0.0219$ W/m·K for air,

$k = 0.026$ W/m·K for urethane insulation,

k =0.00002 W/m·K for the superinsulation.

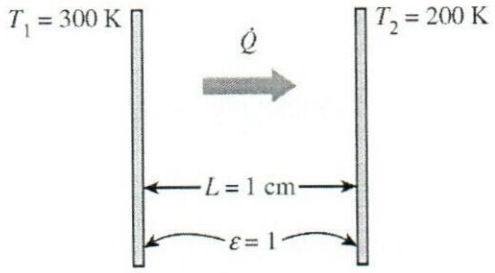

Figure Q-4

Q-5 A test is conducted to determine the overall heat transfer coefficient in an automotive radiator that is a compact cross-flow water-to-air heat exchanger with both fluids (air and water) unmixed (Figure Q-5). The radiator has 40 tubes of internal diameter 0.5 cm and length 65 cm in a closely spaced plate-finned matrix. Hot water enters the tubes at 90^0C at a rate of 0.6 kg/s and leaves at 65^0C. Air flows across the radiator through the inter fin spaces and is heated from 20^8C to 40^0C.

Take correction factor F = 0.97 and heat capacity Cp = 4.195 KJ/kgK for the water at applied average temperatures.

Determine the overall heat transfer coefficient *Ui* of this radiator based on the inner surface area of the tubes.

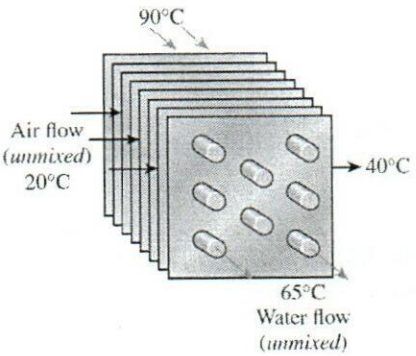

Figure Q-5 (100 marks)

FORMULAE SHEET

$$T_2 = T_1 \cdot r^{(\gamma-1)}$$

$$COP_{\max} = \frac{T_L}{T_H - T_L}$$

$$COP_{\text{actual}} = \frac{Q_L}{W_{\text{in}}}$$

$$\eta_{\text{th}} = 1 - \frac{r^{1-\gamma}}{(\gamma-1)\cdot r^{\gamma} - (\gamma-1)}$$

$$\dot{Q}_{\text{emit}} = \varepsilon\sigma A_s T_s^4$$

----------END OF EXAMINATION PAPER ----------