2012-13
B.TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGG
MANUFACTURING ENGINEERING
ME 404

Maximum Marks: 60
Credits: 05
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) Explain the steps involved in the 'Numerical Control' manufacturing. [03]
1(b) Why flexible manufacturing system is also known as mini CIM? [03]
1(c) Write a part programme using G-M codes for the component shown in figure 1. The machining parameters are given below:
   Cutting Speed=1500 rpm
   Feed=250 mm/min
   Depth of cut= 2 mm

![Figure 1](image)

1(a') Describe the work envelope of a robot? How does it differ from one robot to another. [03]

Contd. . . . . . . . . 2
1'(b) State various types of manufacturing flexibilities. Explain any two types briefly. [03]

1'(c) What are the fixed cycles? Discuss how a fixed cycle can be useful in writing a part program. [06]

2(a) A profile milling operation is to be performed to generate the outline of the part. One hole is also to be drilled on the part as shown in the figure below. The part is ½ inch thick. Write the complete APT part programme to perform the profile milling and drilling operations. [08]

2(b) Define a robot. Identify manufacturing situations which are suitable for robot applications. Give your reasons. [04]

3(a) Distinguish clearly with the help of an example between accuracy and repeatability of a robot. [03]

3(b) Discuss how position and velocity feedback is obtained in CNC machines. [03]

Contd......3
3(c) Write notes on the following:

(i) Systems approach to human factors engineering

(ii) Gravin's 8 dimensions of quality

4(a) What do you understand by acceptance sampling? What are the advantages of sampling inspection over 100% inspection?

4(b) What are control charts and where are they used?

Draw the control charts for Mean $\bar{X}$ and range $R$ from the following data relating to 15 samples of size 5 each and comment whether it is in statistical control or not.

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For the sample size $n = 5$, $D_3 = 0.000$, $D_4 = 2.115$ and $A_2 = 0.577$

4(b) Name the major environmental factors that have an effect on human performance?

Discuss any ONE of them in detail.

5(a) Explain with neat sketches the cutting action a blanking and piercing die. How is clearance and shear provided on punches and dies? How do the clearance and shear affect the size and shape of the cut blank?

5(b) With the help of a neat sketch explain the working of a diamond pin locator?

OR

5'(a) What are the basic principles of Jig and Fixture design?

5'(b) How are drill bushes classified? Also explain the uses of the different types.

5'(c) Why should punches of diameter less than the stock diameter be designed carefully?

What precautions are to be taken if such a punch is to be designed?
B.TECH (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
PROCESSING OF PLASTICS, POLYMERS & CERAMICS (DE)
ME-407
CREDITS: 04
DURATION: THREE HOURS

Maximum Marks: 60

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

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<td>1. (a)</td>
<td>Differentiate between the following: I. Addition polymerization and Condensation polymerization  II. Plasticizers and Fillers  III. Flame retardants and Stabilizers</td>
<td>[06]</td>
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<td>(b)</td>
<td>Discuss the composition and properties of:  I. High density polyethylene  II. Polyimide  III. Polyacetal</td>
<td>[06]</td>
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<td>2.</td>
<td>Write a detailed description on application of polymeric materials in the areas given below particularly emphasizing on recent trends:  I. Automobile applications  II. Aerospace applications  III. Medical applications  IV. Corrosion prevention and control</td>
<td>[12]</td>
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<td>2'.</td>
<td>Explain the following:  I. Biodegradable plastics  II. Retorting  III. Controlled atmosphere packaging  IV. Asceptic packaging</td>
<td>[12]</td>
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<td>3.</td>
<td>Write detailed notes on:  I. Fabrication techniques for glasses  II. Machining of Ceramics</td>
<td>[12]</td>
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Contd......2
3'. (a) What are different types of reflectories?

(b) What are cermets? What properties or combination of properties do they offer?

(c) Why most ceramic products are designed to be single piece structures rather than multi part assemblies?

(d) Explain chemical, physical and mechanical properties of ceramics. [12]

4. (a) Choose and write the correct answer/answers of the following: [06]

I. Manufacturing of synthetic rubbers involve the process of

Addition polymerization / Copolymerization / Condensation
polymerization / Ring opening polymerization

II. The monomers of CH₂O and C₆H₅OH, when cross-linked, produce by-product as

Alcohol / Oxygen / Water / H₂O₂

III. Deformation in plastics occurs by -Twin / Yield / Slip / Cross-linking

IV. The table-tennis ball is made of

Bismalemides / Nitrocellulose / Polycarbonate / Polypropylene

V. Which of the following is not a thermoplastic?

PVC / Nylon / Phenolic / Acrylic

VI. Highly oriented (rod like) that increase directional strength in polymers is

Liquid-crystal polymers / Linear polymers / Amorphous polymers / Branched polymers

(b) In casting of plastic the material must have a low enough viscosity. Why? Suggests various methods to achieve the same. [06]

5. (a) Briefly describe the phenomenon of crazing. [06]

(b) A screw extruder has D = 75 mm screw with h = 5 mm- high flight of 17.5° pitch angle in the metering section. The screw rotates at 100 rpm. The plastic has a density of a 1 g/cm³. Calculate (a) the output for zero back pressure, (b) the output to be expected for typical conditions, (c) the approximate power requirement, and (d) the temperature rise attainable with polypropylene. [06]
1(a) In Fig 1, find the equivalent mass of the rocker arm assembly with respect to the $x$ coordinate.

1(b) Find the Fourier series expansion of the periodic function shown in Fig 2.

1(c) A mass of 20 kg is suspended from a spring of stiffness 10,000 N/m. The vertical motion of the mass is subjected to Coulomb friction of magnitude 50 N. If the spring is initially displaced downward by 5 cm from its static equilibrium position,
determine (i) the number of half cycles elapsed before the mass comes to rest, (ii) the time elapsed before the mass comes to rest, and (iii) the final extension of the spring.

OR

1'(a) An automobile moving over a rough road as shown in Fig. 3, can be modeled considering (i) weight of the car body, passengers, seats, front wheels, and rear wheels; (ii) elasticity of the tires(suspension), main springs, and seats; and (iii) damping of the seats, shock absorbers and tires. Develop three mathematical models of the system using a gradual refinement in the modeling process.

![Image](Fig3)

1'(b) Find the Fourier series expansion of the periodic function shown in Fig. 4.

![Image](Fig4)

1'(c) The system shown in Fig. 5 has a natural frequency of 5 Hz for the following data: \( m = 10 \text{ kg}, J_0 = 5 \text{ kg-m}^2, r_1 = 10 \text{ cm}, r_2 = 25 \text{ cm} \). When the system is disturbed by giving it an initial displacement, the amplitude of free vibration is reduced by 80 percent in 10 cycles. Determine the values of \( k \) and \( c \).

![Image](Fig5)
2(a) A counter rotating eccentric mass exciter shown in Fig. 6 is used to determine the vibrational characteristic of a structure of mass 180 kg. At a speed of 1000 rpm a stroboscope shows the eccentric masses to be at the top at the instant the structure is moving upwards through the static equilibrium position and the corresponding amplitude is 20 mm. If the unbalance of each wheel of exciter is 0.1 Kg-m, determine (i) the natural frequency of the structure (ii) the damping factor of the structure (iii) the amplitude at 1200 rpm (iv) the angular position of the eccentrics at the instant the structure is moving upward through its equilibrium position.

![Fig 6](image)

2(b) For the system shown in Fig. 7, \( x \) and \( y \) denote respectively the absolute displacements of the mass \( m \) and the end \( Q \) of the dashpot \( c1 \) (i) derive the equation of motion of the mass \( m \) (ii) find the steady state displacement of the mass \( m \) (iii) find the force transmitted to the support at \( P \), when the end \( Q \) is subjected to the harmonic motion \( y(t) = Y \cos \omega t \).

![Fig 7](image)
3(a) For the system shown in Fig. 8, \( m_1 = 1 \text{ kg}, \ m_2 = 2 \text{ kg}, \ k_1 = 2000 \text{ N/m}, \ k_2 = 1000 \text{ N/m}, \ k_3 = 3000 \text{ N/m}, \) and an initial velocity of 20 m/s is imparted to the mass \( m_1. \) Find the resulting motion of the two masses.

3(b) A diesel engine, weighing 3000 N, is supported on a pedestal mount. It has been observed that the engine induces vibration into the surrounding area through its pedestal mount at an operating speed of 6000 rpm. Determine the parameters of the vibration absorber that will reduce the vibration when mounted on the pedestal. The magnitude of the exciting force is 250N, and the amplitude of motion of the auxiliary mass is to be limited to 2 mm.

4. Find the stiffness and flexibility influence coefficients for the system shown in Fig. 9. Also determine the first three natural frequencies and the first mode shape. Take \( k_1 = k, \ k_2 = k_3 = 2k, \ k_4 = k, \) and \( m_1 = m_2 = m_3 = m.\)

4'. The largest eigenvalue of the matrix

\[
[D] = \begin{pmatrix}
2.5 & -1 & 0 \\
-1 & 5 & -\sqrt{2} \\
0 & -\sqrt{2} & 10
\end{pmatrix}
\]

Contd......5
is given by $\lambda_i = 10.38068$. Find the other eigenvalues and all the eigenvectors of the matrix, using matrix iteration method. Assume $[m] = [J]$.

5(a) Derive the free longitudinal vibration equation of a uniform bar. Further determine the natural frequencies and the free vibration solution of the bar fixed at one end and free at the other.

5(b) Using Lagrange Equation derive the equation of motion of the system shown in Fig. 10. Take generalised coordinates as $x_1, x_2, x_3$.

![Diagram of a mechanical system with pulley, mass, and springs](image)

**Fig 10**

**OR**

5(b') Derive the Dunkerley's formula for obtaining the fundamental frequency of a general $n$ degree of freedom system using characteristic equation. State the assumptions made.
2(a) Differentiate (with the help of examples) between:

(i) Elementary and global reactions

(ii) Order and molecularity of reaction.

2(b) For the second order reaction of the type: \( A + B \rightarrow C + D \), show that:

\[ k_t = \ln \left( \frac{AB_0}{A_0B_0} \right) \frac{1}{(A_0-B_0)} \] ; assume, after time \( t \), initial concentrations \( A_0 \) and \( B_0 \) reduce by the same amount.

3(a) Discuss chain initiating, chain propagating, chain branching and chain termination reactions with the help of examples.
3(b) A closed chamber initially contains \(8.126 \times 10^{-3} \text{gmol/m}^3\) of CO. Concentration of \(O_2\) is 30 times that of CO and the remainder is \(N_2\). The pressure and temperature are 1 atm and 1500 K. Determine the time required for 90% CO to react, assuming elementary reaction \(\text{CO+O}_2 \rightarrow \text{CO}_2+\text{O}\). Take \(k = 2.5 \times 10^6 \text{exp}(-24060/T)\) in \(\text{m}^3/\text{gmol.s}\). Treat molar concentration of \(O_2\) as constant.

4(a) Draw species variation for a diffusion flame at a fixed height above the fuel jet tube. What is the significance of Damkohler number (Da) in premixed/non-premixed flames?

4(b) For a stoichiometric \(\text{CH}_4\)-Air mixture at 0.1 MPa and 298 K, considering a single step global kinetic scheme for which the average reaction rate (RR) expression is:

\[
RR(\text{kg/m}^3\text{s}) = -M_{\text{CH}_4} \times 1.44 \times 10^{11} \exp(-15000/T_{av}) \times \rho_{av}^{-0.12} \times \left(\frac{y_{\text{CH}_4}}{M_{\text{CH}_4}}\right)^{0.5} \times \left(\frac{y_{\text{O}_2}}{M_{\text{O}_2}}\right)^{0.5}
\]

Calculate the RR and the laminar burning velocity in cm/s using the relation:

\[S_l = \left[\frac{32\alpha_k}{9\rho_{av}}(v+1) \times RR\right]^{1/2}\]

Take \(T_{av} = 1724.5\text{K}, \alpha_k = 7.65 \times 10^{-5} \text{m}^2/\text{s}\); here \(y_{\text{CH}_4}\) and \(y_{\text{O}_2}\) are the average mass fractions; \(\rho_{av}\) is the average mixture density at \(T_{av}\), \(\rho_{av}\) is the air density at 298 K; \(v\) is the \((A/F)_{	ext{stoichiometric mass basis}}\)

Section-B

5 Differentiate between explosion, deflagration and detonation. Derive the Rankine-Hugoniot relation, given as:

\[q = \left[\frac{\gamma}{\gamma-1}\right] \left(\frac{P_2}{P_1} - \frac{P_1}{\rho_1}\right)^{1/2} \left(\frac{1}{\rho_1} + \frac{1}{\rho_2}\right)
\]

6 A 50 \(\mu\text{m}\) n-octane droplet burns in air at 0.1 MPa, 300 K. Calculate the relevant temperature dependent properties and estimate the transfer number \(B_T\), burning constant \(K_b\), mass burning rate, life time and flame stand off ratio for:

(i) Steady state combustion and (ii) combustion with droplet heating.

7(a) A gaseous mixture of 70% CO and 30% \(C_2H_4\) is maintained at 300 K and 100 bar. Calculate the mixture density using ideal gas equations and Kay's rule.

7(b) Write brief notes on formation and control of emissions in SI, CI and gas turbine engines.
Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Use of tables and charts are allowed

Q.No.  Question  M.M.
1(a)  Give the performance analysis of the single stage theoretical as well as actual 
vapour compression cycle.  [04]

1(b)  A vapour compression plant uses R-134a and has a suction saturation temperature 
-5 °C and a condenser saturation temperature of 45 °C. The vapour is dry saturated 
on entering the compressor and there is no under cooling of the condensate. The 
compression is carried out isentropically in two stages and a flash chamber is 
employed at an inter stage saturation temperature of 15 °C. Calculate:

i.  the amount of vapour bled off at the flash chamber;

ii.  the state of the vapour at inlet to the second stage of compression,

iii.  the refrigerating effect per unit mass of refrigerant in the condenser,

iv.  the work done per unit mass of refrigerant in the condenser,

v.  the coefficient of performance.

[ Table-1, some properties of R-134a may be used]

OR

1'(a)  Explain the simple air refrigeration cycle with evaporative cooling.  [04]

1'(b)  An air refrigeration plant of 20 ton capacity comprises a centrifugal compressor and 
air turbine. The compressor is coupled directly to the air turbine. The compressor 
also receives power from another prime mover. The processes in the compressor 
and turbine are adiabatic but not isentropic. Air at temperature 21 °C and 0.85 bar 
enters the compressor. It leaves the compressor at 90 °C, the same air enters the 
turbine at 30 °C and 1.5 bar. The turbine exit is at 0 °C, assuming no pressure drop 
in the cooler and refrigerator (evaporator) section, and constant specific heat 
C_p = 1.004 kJ/kgK and C_v = 0.712 kJ/kgK. Determine:

i.  the compressor efficiency  ii.  turbine efficiency,

iii.  flow rate of air  iv.  power input to the plant and COP

Contd......2
2(a) Explain the working principle of Vapour Absorption System and derive the expression for COP of the system. [05]

2(b) Discuss the detailed comparison between Vapour Absorption System and Vapour Compression System with the help of suitable diagrams. [04]

2(c) Compare the ammonia-water system with Lithium-Bromide-water system giving simplified flow diagrams for both. [03]

OR

2'(a) With the help of schematic diagram explain the working of an Ammonia-Water Vapour Absorption System with an analyzer, rectifier, pre-heater and pre-cooler. [06]

2'(b) In an aqua-ammonia absorption refrigerator, heat is supplied to the generator by condensing steam at 0.2 MPa, 90% quality. The temperature to be maintained in the refrigerator is -10°C, and the ambient temperature is 30°C. Estimate the COP of the refrigerator. If the actual COP is 40% of the maximum COP and the refrigeration load is 20 tonnes, what will be the required steam flow rate?

Values from steam table at 0.2 MPa: \( t_g = 120.2^\circ C \), \( h_g = 2201.9 \text{kJ/kgK} \) [06]

3(a) Discuss the thermodynamic properties of the refrigerants. Explain Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) of CFC refrigerants. [04]

3(b) What are Transitional refrigerants? Discuss in detail the substitutes for CFC refrigerants. [04]

3(c) Explain the use of secondary refrigerants and anti-freeze solutions. Also discuss the role of Normal Boiling Point (NBP) in selecting different alternative refrigerants. [04]

4 Explain the working principle of any three systems giving schematic diagram: [3 x 4]

i. Capillary tube
ii. Thermostatic expansion valve
iii. Automatic expansion valve
iv. Pulse tube refrigerator
v. Vortex tube refrigerator
vi. Direct expansion coil evaporator

5(a) Explain the areas involving cryogenic engineering. [04]

5(b) What are the limitations of vapour compression system for low temperature production? [03]

5(c) Explain Linde-Pre-cooled System for liquefaction of gases, giving schematic and T-S diagrams. Obtain expression for liquid yield and show that the work required per unit mass of compressed gas is reduced below that of the Simple Linde-Hampson system. [05]

TABLE ENCLOSED

Contd......3
Table 1: Some properties of R134a

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2012 - 2013
B.TECH. WINTER (VIII SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
FLUID MACHINERY
(ME - 433)
Credits: 04

Maximum Marks : 60
Duration : Three Hours

Note: (i) Answer all the questions.
      (ii) All question carry equal marks.
      (iii) Draw the neat sketches / diagrams where needed.
      (iv) Velocity triangles are must where needed.
      (v) Mention clearly any assumption made.

1. (a) Show with the help of diagram that effective head 'H' of a centrifugal pump may be expressed as
       \[ H = H_s + H_d + H_f + H_f' + \frac{V_d^2}{2g} \]
       All terms have usual meaning. [04]

       (b) A centrifugal pump impeller is 25 cm in diameter and the passage width at outlet is 2 cm. The blade angle at outlet is 45°, running at 1000 rpm. The discharge is 45 litre/s. Calculate the fraction of KE of discharge which is subsequently recovered in the casing. Neglect hydraulic friction and other losses. The pump is delivering against a head of 10m. [08]

2. (a) Explain the phenomena of surging, choking and stalling. [04]

       (b) A turbo compressor consumes 220 KW when pumping 1 kg/s of air from 1 kgf/cm² abs to 5 kgf/cm² abs. In the inlet duct, the air has temp of 25°C and in the exit duct the velocity is 150 m/s calculate
           (i) static and total temp in exit duct,
           (ii) change of entropy and
           (iii) Isentropic efficiency based on static values
       Assume negligible velocity at inlet and also negligible mech. losses. [08]

OR

(b') Derive an expression for degree of reaction for an axial flow compressor and show that for reaction equal to 0.5, stationary and moving are symmetrical. [08]

3. (a) A hydraulic lift raises the load of 8.75 tonnes at a speed of 0.50 m/s through a height of 13.5 m once in 96 sec, being worked from a accumulator which is fed by a pump of efficiency 80%. If pressure of water is 70 Kgf/cm² and efficiency of lift is 70%, find power input of pump and min. capacity of accumulator. Neglect the other losses. [06]
3(b) A single acting reciprocating pump has a plunger diameter of 200mm and stroke of 300mm. The suction pipe is 100mm diameter and 8m long. The water surface in the sump from which the pump draws the water is 4m below the cylinder axis. If pump is working at 30 rpm, find the pressure head on the piston at the beginning, middle and end of the suction stroke. Take \( \lambda = 4f = 0.04 \). (6)

Or

3(b') Derive an expression for acceleration head impressed on the flow in case of reciprocating pump. Assume that the piston has simple harmonic motion. (6)

4(a) (i) Why draft tube is not provided in Pelton Turbine? (1)

(ii) Why Pelton Turbine is tested on constant head? (1)

4(b) A Pelton turbine is 2.5 m diameter operates under the following conditions:

Net available head = 300m, speed = 300rpm, coefficient of velocity of jet = 0.98, Blade friction coefficient = 0.95, Blade angle = 165°, diameter of the jet = 20cm, Mechanical efficiency = 0.95

Determine: (i) the power developed (ii) hydraulic efficiency and (iii) specific speed. (10)

5(a) what are the functions of blades of Kaplan Turbine? (2)

5(b) A Kaplan Turbine develops 15,000 kW power at a head of 30m. The diameter of the boss is 0.35 times a diameter of the runner. Assuming a speed ratio of 2, a flow ratio of 0.65 and an overall efficiency 90%. Calculate: (i) diameter of the runner (ii) rotational speed and (iii) specific speed. (10)

Or

5'(a) (i) define the specific speed of the turbine. (1)

(ii) What is the approximate angle of divergence of draft tube? (1)

5'(b) An inward flow reaction turbine is required to develop 294Kw at 220 rpm. The effective head on the turbine is 20m. Determine the inside and outside diameter, inlet and exit angles of the vanes and the guide blade angle. Assume inlet diameter is twice the outlet diameter; hydraulic efficiency is 82% and constant velocity of flow 3.5m/s. Ratio of width of wheel at inlet to its diameter is 0.1. Assume radial discharge. (10)
2012-13
B.TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
GAS DYNAMICS
(ME-438)

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. | Question | M.M.
--- | --- | ---
1(a) | Mention the applications in which weak and strong oblique shock waves occur? | 03
1(b) | A jet plane uses a diverging passage as a diffuser. For a flight Mach number of 1.92, determine the range of back pressures over which a normal shock will appear in the diffuser. The inlet pressure and temperature are 70 KPa and 270 K. Find the mass flow rates handled by the diffuser for the determined back pressure ranges, with inlet area = 100cm² and exit area = 200cm². Assume isentropic flow except for the shocks. | 09

OR

1'(a) | Why are two-shock spike diffusers preferred over a ordinary diffuser? Explain the phenomenon using figures. | 4
1'(b) | Compute the lift and drag coefficients $C_L$ and $C_D$ for a flat plate airfoil with free-stream $M=3$, chord length $c=1$ m and angle of attack $=10^\circ$. | 8

2(a) | What happens to the Fanno flow once it reaches $M=1$ and yet there is additional duct length of the insulated constant-area pipe? | 03
2(b) | Flow enters a constant area, insulated duct with a Mach number of 0.6, static pressure of 150 KPa and static temperature of 300 K. Assume a duct length of 45 cm, duct diameter of 3cm, and a friction coefficient of 0.02. Determine the Mach number, static pressure, and static temperature at the duct outlet. | 09
3(a) | Explain briefly how following a Rayleigh line you can convert a subsonic flow to a supersonic flow? | 3

Contd......2
3(b) Air enters a turbofan combustion chamber at 400 K and 200 KPa, with a temperature after combustion of 1100 K. If the heating value of the fuel is 48000 KJ/Kg, determine the required fuel-air ratio. Assume Rayleigh line flow in the combustion chamber. What fuel-air-ratio would be required to choke the combustion chamber? Inlet velocity is 35 m/s.

4. Using finite disturbances theory, derive the momentum equation for a forward running wave. Further, discuss the progression of finite-amplitude disturbance.

5. Show that for a weak waves, Reimann invariants are

\[ \frac{u}{a_o} + \frac{1}{\gamma \rho_o} \frac{p}{\rho} = \text{constant along } x = a_o t = \text{constant} \]

\[ \frac{u}{a_o} - \frac{1}{\gamma \rho_o} \frac{p}{\rho} = \text{constant along } x + a_o t = \text{constant} \]

Also, discuss operation of shock tube using Reimann invariants.

OR

5' The low speed lift coefficient for a NACA 2412 aerofoil at an angle of attack of 3° is 0.5. Using the Prandtl-Glauert rule, calculate the lift coefficient for a free stream Mach number \((M_x) = 0.7\). Using linearized theory, derive the equations used.
Discuss Interactive Computer Graphics. How is it different from Non-Interactive
Computer Graphics?

Locate the new position of the triangle [(5, 4), (8, 3), (8, 8)] after its rotation by 90°
clockwise about its centroid.

Prove that 2D rotation and scaling commute if \( S_x = S_y \) or if \( \theta = n \pi \) for integer \( n \),
where \( S_x, S_y \) are the scaling factors in \( x, y \) directions respectively and \( \theta \) is the angle
of rotation.

OR

Write down the sequence of transformations required to reflect an object about an
arbitrary line \( ax + by + c = 0 \). Derive the concatenated transformation matrix for the
same in terms of the constants \( a, b \) and \( c \).

Show that \( R_\alpha \cdot R_\beta = R_\beta \cdot R_\alpha = R_\alpha \beta \), Where \( R \) is the transformation matrix for
rotation of an object about the origin and the subscripts \( \alpha, \beta \) and \( \alpha + \beta \) are the angles
of rotation.

Determine the proportions of a four bar mechanism ABCD, by using three precision
points, to generate \( y = x^{1.5} \), where \( x \) varies between 1 and 4. Assume 30° starting
position and 120° finishing position for the input link and 90° starting position and
180° finishing position for the output link. Take length of the fixed link AD as 25
mm.
3(a) What is the basic idea behind Finite Element Method? Discuss the steps used in FEM modeling.

3(b) What do you mean by Natural Coordinates? Why it is preferred? Obtain shape functions for a quadratic element in Natural Coordinates.

OR

3' For the bar shown in Fig. 1, an axial load \( P = 100 \, \text{kN} \) is applied at node 2. Using two linear elements with single degree of freedom at each node, determine the nodal displacements, the stresses in each element and the reaction forces.

The area of cross section and Young's modulus for element 1 are \( 2400 \, \text{mm}^2, 70 \, \text{GPa} \) and for element 2 are \( 600 \, \text{mm}^2, 200 \, \text{GPa} \) respectively.

![Diagram of a bar with dimensions](image)

(All dimensions in mm)

Fig. 1

4(a) Why optimisation algorithms are becoming popular in Engineering Design activities? Draw a flow chart of the optimal design procedure.

4(b) A seven member truss structure having area of cross section \( A_1 \) to \( A_7 \) is shown in Fig. 2. Considering the symmetry of the truss structure and loading, formulate the optimization problem with constraints. The tensile and compressive stresses generated must not be more than the corresponding allowable strength of the material i.e. \( S_u = S_y = 500 \, \text{MPa} \) and the maximum vertical deflection at \( C \) is 2 mm. The variable bounds \( A_1 \) to \( A_4 \) are between 10 mm\(^2\) and 500 mm\(^2\). Take \( l = 1 \text{m} \).

Contd......3
5(a) Define Artificial intelligence (AI). What are the important fields where AI techniques are used? Discuss Turing’s Method of testing the artificial intelligence.

5(b) Enumerate various knowledge representation techniques.

OR

5(b') Define knowledge net with the help of a suitable example. Also discuss different type of nodes pertaining to knowledge net.
1(a) The air-handling unit of an air conditioning plant supplies a total of 4500 cmm of dry air which comprises by weight 20% fresh air at 40°C dbt and 27°C wbt, and 80% recirculated room air at 25°C dbt and 50% RH. The air leaves the cooling coil at 13°C saturated. Calculate the total cooling load and room heat gain.

(b) Draw neat and labelled sketches of the following:

(i) Constant air volume dual duct central A. C. System.

(ii) Window type unit air conditioner

OR

1' The design conditions for a space are: inside 25°C dbt and 50% RH; outside 40°C dbt and 25°C wbt. Space sensible heat gain is 24.5 kW. The supply air is saturated at 10°C. The equipment consists of an air washer. The air entering the air washer comprises of 25% outside air, the remainder being recirculated room air. Calculate: (i) cmm of air supplied to space; (ii) RLH and (iii) cooling load of air washer.

2(a) Discuss briefly the internal heat gains considered for cooling load.

(b) Calculate the total heat gain of a restaurant at its peak occupancy load at about 1.00 p.m. When 100 diners and 15 employees are present. Given:

Heat gain through walls and roof = 2500 kJ/h; Heat gain through glass areas = 500 kJ/h;
No. of fluorescent tube lights = 60 of 40 W each; Rating of toaster inside space = 2650 W; Sensible heat gain per diner = 250 kJ/h; Latent heat gain per diner = 260 kJ/h; Sensible heat gain per employee = 305 kJ/h; Latent heat gain per employee = 545 kJ/h; Inside design conditions = 25°C dbt, 19°C wbt; Outside design conditions = 40°C dbt, 27°C wbt;
Ventilation requirement = 0.4 cmm/person

3(a) What are equal friction and static regain methods of duct sizing?

(b) Draw the air distribution patterns in a room for any three locations of supply outlets used for cooling.

OR

Contd……..2
3' Determine, using equal friction method, the duct sizes of all the sections of the duct system shown in figure, also determine the total pressure at fan outlet.

4(a) What are radiators and convectors in a hot water or steam heating system? Sketch neatly two pipe and four pipe water heating systems.

(b) Draw neat sketches of ventilation systems.

5(a) Giving neat sketches briefly explain a bi-metallic element used as thermostat.

(b) Sketch a block diagram of basic elements of a control unit.

OR

5' An air conditioning plant with face and bypass control by a room thermostat is designed to maintain the conditioned space at 25°C dbt and 50% RH, when the outside conditions are 43°C dbt and 24°C wbt. The room sensible and latent heat gains are 80 and 20 kW respectively. The ventilation air is 75 cmm. Calculate the static and rate of supply air and design duty of cooling coil. Assume coil bypass factor as zero.

If the room total heat is reduced to half when the outside conditions change to 34°C dbt and 24°C wbt, determine the amount of mixture of the recirculated room air and ventilation air bypassed and relative humidity maintained in the conditioned space.