MECHANICAL ENGINEERING PAPER I

Time allowed: 3 hours **Maximum marks: 300**

INSTRUCTIONS

Each question is printed both in Hindi and in English.
Answers must be written in the, medium specified in the Admission.
Certificate issued to you, which must be stated clearly on the cover of the answer-book in the space provided for the purpose.
No credit will be given for the answers written in a medium other than that specified in the Admission Certificate.
Candidates should attempt Questions **1** *and* **5** *which are compulsory and any* ***THREE*** *of the remaining questions selecting at least* ***ONE*** *question from each Section.*
All questions carry equal marks.
Symbols/notations carry their usual meanings, unless otherwise indicated.
Newton may be converted to kg using the equality 1 kilonewton (1 kN) = 100 kg, if found necessary.

Section A

1.(a) The state of stress at a given point in a loaded component is given by σ_x, σ_y and τ_{xy} and the principal stresses at the point are σ_1 and σ_2. If the new axes at the point are changed to *x*' and *y*' such that state of stress w.r.t. the new axes are $\sigma_{x'}$, $\sigma_{y'}$ and $\tau_{x'y'}$.

(i) Show that $\sigma_x + \sigma_y = \sigma_{x'} + \sigma_{y'} - \sigma_1 + \sigma_2$. 6

(ii) Sketch the Mohr's stress circle for pure shear stress state and hydrostatic state of stress. 3

(iii) A cast iron bar of 30 mm diameter and 1 m length is subjected to equal and opposite torque T applied at its ends. If tensile strength of cast iron is 80 MPa, what is the maximum value of torque T? Show the plane of failure for the applied sense of torque T. 3

(b) (i) A hollow shaft whose internal diameter is half of the external diameter is subjected to maximum bending moment of 2 kN-m at a section and constant torque of 4 kN-m all along its length. If yield stress of the shaft material is 280 MPa and factor of safety is 3.0, what should be the minimum safe diameters of the shaft? 9

(ii) What is the difference between centrifugal and inertia type of governors? Which one is more sensitive? Why is the former preferred to the latter? 3

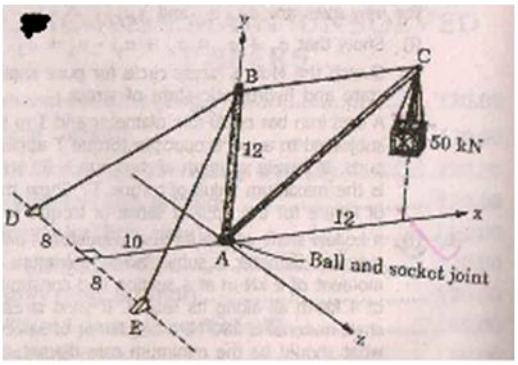
(c) (i) Distinguish between the pressure angle of a radial cam and that of a spur gear, with the help of a sketch. 8

(ii) What type of motion is performed by a point on the surface of a football rolling on the ground and a point on the surface of a nut moving over a threaded bolt? 4

(d) Distinguish between Eutectoid and Eutectic, in the case of Fe - C system. Give the composition and the maximum temperature at which eutectoid and eutectic are formed. 12.

(e) (i) A solid cylinder of mass m and radius *r* starts rolling down an inclined plane. What will be the velocity of mass after it has come down by 3 m vertically? (Assume g = 9.81 m/s^2) 4

(ii) The crane shown in Figure above is supported by cables BD and BE. The distance marked are in m. What are the tensions in the cables BC, BD and HI, when BC is parallel to the *x*-axis? 8



2.(a) A hollow shaft is subjected to a steady bending moment of 40 N-m and twisting moment of 50 N-m. Outer diameter of the shaft is twice the inside diameter. Calculate the diameters of the shaft using ASME Code for transmission shafting on the basis of maximum shearing stress theory of failure. Take:
Yield point stress in tension of shaft material = 280 MPa
Factor of safety = 2.0
Combined bending and fatigue shock factor =1.5
Combined shock and fatigue factor for twisting = 1.0 30

(b) (i) What is a quick-return mechanism? Give its types and applications. How is the ratio of time of cutting stroke to return stroke calculated for a slotted lever and crank type of quick-return mechanism? Explain with the help of a neat sketch. 15

(ii) Which type of epicyclic gear train is used for rear wheel drive of automotive trucks? Show that rpm of the propeller shaft is arithmetical mean of rpm of two rear wheels, while negotiating a road curve. 15

3.(a) (i) Figure 1 shows a polyspast lifting a weight Q equaling 1000 N by another weight of P equaling 300 N. Neglecting friction and the masses of the pulleys and cables and the inclinations of cables, determine the distance moved by Q in 2 seconds from start. 18

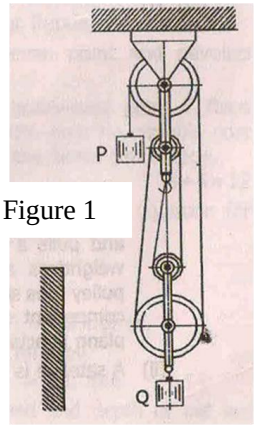


Figure 1

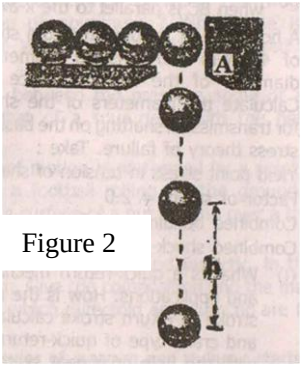
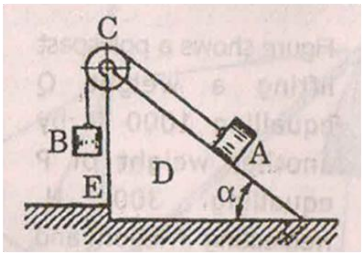


Figure 2

(ii) Small steel balls fall from rest through the opening at A at a steady rate of two per second. Find the vertical separation h of two consecutive balls when the lower one has dropped 5 m from A. 12

(b) (i) A body A weighing P1descends down an inclined plane D which makes an angle α with the horizontal and pulls a load B that weighs P2 by means of a weightless and inextensible string passing over a pulley C as shown in Figure. Determine the horizontal component of the pressure with which the inclined plane D acts on the floor rib E. 20



(ii) A satellite is orbitting around the Earth at an altitude of 320 km. Assuming the Earth radius as 6500 km and both the orbit and the Earth as circular, determine the speed of the satellite. 10

4.(a) What is Tin Babbitt? What is the composition and major application of this alloy? How is it different from other Babbitts? 20

(b) What is the application of glass fibre reinforced plastic (epoxy)? How do these composite compare with carbon reinforced plastics (epoxy)? 20

(c) Explain the transformation of iron from BCC to FCC. What properties change when iron changes from BCC structure to FCC structure? 20

Section – B

5.(a) Compare 'Work Sampling' with 'Time Study'. When are they used for calculating standard time of performing short cycle jobs? Give respective areas of application. 12

(b) XYZ Corporation has a production (and sales) capacity of Rs 10,00,000 per month. Its fixed costs are Rs 3,50,000 per month and the variable costs over a considerable range of volume are Rs 0.50 per Rupee of sales.

(i) Determine annual break-even point and develop break-even graph.

(ii) Determine the effect on break-even point if fixed cost were decreased by 10% and the variable cost per unit are increased by the same percentage. 8+4=12

(c) In a metal cutting operating, the following equation for tool-life was obtained for H.S.S. tool:

$$VT^{0.13}f^{0.6}t^{0.3} = C$$

Given that: tool-life (T) = 60 min,

Cutting speed (V) = 40 m/min,

Feed (f) = 0.25 mm/rev,

Depth of cut (t) = 2.0 mm.

Compute tool-life, if speed, feed and depth of cut are together increased by 25% and also if they are increased individually by 25%. 12

(d) What is the difference between hole basis system and shaft basis system? Why is hole basis system the more extensive in use?

What are the differences between interchangeability and selective assembly? 12

(e) Why is Total Quality Management (TQM) important? What are the benefits that can be obtained by applying TQM in the software industries? What are the principles of TQM in such applications? 12

6.(a) What are the various five fuel gases used for gas welding? Give their chemical composition, formula and specific heat content. Indicate also the maximum temperature reached in the respective flames. What percentage of oxygen is supplied by the torch in any one of the fuel gases? Give the chemical reactions in the various zones of the neutral flame. 30

(b) How are metal tooth-paste tubes made commercially? Draw the tools configuration with the help of a heat sketch? 30

7.(a) (i) Illustrate with the help of neat sketches the differences between open-loop and closed-loop control in NC system. Why is feedback not possible in open-loop control system? 22

(ii) In open-loop NC system the shaft of a stepping motor is connected directly to the lead screw *x*-axis of the machine table. The pitch of the lead screw is 3.0 mm. The number of step angles on the stepping motor is 200. Determine how closely the position of the table can be controlled, assuming that there are no mechanical errors in the positioning system. Also, what is the required frequency of the pulse train and the corresponding rotational speed of the stepping motor in order to drive the table at a travel rate of 100 mm/min? 8

(b) (i) Determine the trial central line and control limits for a p-chart using the following data, which are for the payment of dental insurance claims. Plot the values on graph paper and determine if the process is stable. If there are any out-of-control points, assume an assignable cause and determine the revised central line and control limits. 15

Subgroup Number	Number Inspected	Number Noncon-forming	Subgroup Number	Number Inspected	Number Noncon-forming
1	300	3	14	300	6
2	300	6	15	300	7
3	300	4	16	300	4
4	300	6	17	300	5
5	300	20	18	300	**7**
6	300	2	19	300	5
7	300	6	20	300	0
8	300	7	21	300	2
9	300	3	22	300	3
10	300	0	23	300	6
11	300	6	24	300	1
12	300	9	25	300	8
13	300	5			

(ii) Determine the trial limits and revised control limits for a u-chart using the data in the table for the surface finish of rolls of white paper. Assume any out-of-control points have assignable causes.

Lot Number	Sample Size	Total Noncon-formities	Lot Number	Sample Size	Total Noncon-formities
1	10	45	15	10	48
2	10	51	16	11	35
3	10	36	17	10	39
4	9	48	18	10	29
5	10	42	19	10	37
6	10	5	20	10	33
7	10	33	21	10	15
8	8	27	22	10	33
9	8	31	23	11	27
10	8	22	24	10	23
11	12	25	25	10	25
12	12	35	26	10	41
13	12	32	27	9	37
14	10	43	28	10	28

In both cases assume 3o limit. 15

8.(a) JIT, Toyota Production System (TPS) and lean operations sustain competitive advantage. Distinguish among the three. Secondly, discuss how effective JIT contributes to competitive advantage. Thirdly, identify three core components of TPS.

5+20 + 5 = 30

(b) A cost matrix is provided; here amount available exceeds the amount required.

	D1	D2	D3	D4	Available
S1	8	9	3	7	130
S2	3	6	8	4	180
S3	7	5	4	5	240
S4	8	7	2	6	160
S5	5	4	2	9	90
S6	8	4	4	3	120
Required	300	100	150	200	

(i) Using Vogel's Approximation determine initial feasible solution. Give all assumptions and provide clear steps

(ii) What is total transportation cost? How can this be checked for optimality? Show one step only. 20 + 10 = 30

MECHANICAL ENGINEERING PAPER II

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All questions carry equal marks.
If any data is considered insufficient, assume suitable value.
Psychometric chart is attached with this question paper.
Wherever coordinate diagrams/graphs are to be drawn, these are to be plotted only on the answer book and not on a separate graph sheets.

Section A

1. Answer any THREE of the following:

(a) (i) 0.5 m^3 of gas at 10 kPa and 130°C expands adiabatically to 1 kPa. It is then isothermally compressed to its original volume.
C_p = 1.005 kJ/kg-K and C_v = 0.718 kJ/kg-K.
Represent these processes on P-V diagram. Find final temperature and pressure of gas.

(ii) For compression work to be minimum, what should be process of compression? Is it used in practice? 20

(b) (i) For normal shock wave derive the following expression:

$$\frac{P_{ay}}{P_x} = \left[1 + \frac{\gamma - 1}{2} M_x^2\right]^{\frac{\gamma}{(\gamma-1)}} \left[\frac{2\gamma}{\gamma + 1} M_x^2 - \frac{\gamma - 1}{\gamma + 1}\right]$$

where *x* and *y* are the conditions before and after the shock wave.

(ii) Show Fanno line in adiabatic flow with friction on h-s diagram & explain the physical significance. 20

(c) A decorative plastic film on a copper sphere having 10 mm diameter is cured in an oven at 75°C. Upon removal from the oven, the copper sphere is subjected to an air stream at a pressure, temperature and velocity of 1 bar, 23°C and 10 m/s respectively. How long it will take for the sphere to cool down to 35°C? State the assumptions made and justify the method of analysis used. For copper, the density, specific heat and thermal conductivity are, respectively, 8933 kg/m^3, 388 J/kg-K and 350 W/m-K. The following correlation for forced convection may be used:

$$Nu_d = 2 + \left[0.4 Re_d^{1/2} + 0.6 Re_d^{2/3}\right] Pr^{0.4}$$

For air, kinematic viscosity, thermal conductivity and Prandtl number at the mean film temperature under consideration are 15.53 x 10^{-6} m^2/s, 0.025 W/m-K and 0.708 respectively. 20

(d) (i) Derive the following expression for lift (C_L) and drag (C_D) coefficients for flow with friction through a compressor (axial flow type) cascades:

$$C_L = 2\frac{S}{C}(\tan\alpha_1 - \tan\alpha_2)\cos\alpha_m - C_D \tan\alpha_m$$

$$C_D = \xi \frac{S}{C} . \frac{Cos^3 \alpha_m}{Cos^2 \alpha_1}$$

where S, C, α_1, α_2, α_m and ξ denote pitch, chord, inlet flow angle, outlet flow angle, average flow angle and total pressure loss coefficient.

(ii) Show the variation of C_L and C_D with incidence and discuss physical significance. 20

2.(a) A Carnot engine operates between source temperature of 500 K and sink temperature of 300 K. It produces work utilizing the heat of 10 kJ from the source at 500 K. The work produced by this engine is utilized by a Carnot refrigerator operating between refrigerator temperature of 200 K and sink temperature of 300 K. Represent schematically these engine and refrigerator operations. Find out:

(i) Work produced by the Carnot engine.

(ii) Refrigerating effect produced at 200 K by the Carnot refrigerator.

(iii) Total heat rejected to the sink at 300 K.

(iv) By how much the refrigerator temperature be increased to get double the refrigerating effect as per (ii) above?

(v) Total heat rejected to the sink at 300 K when the refrigerator operates as per the temperature for (iv) above. 20

(b) The velocity distribution in the fully developed flow region of steady incompressible laminar flow of a fluid in a horizontal pipe is given by

$$\frac{u}{u_m} = 1 - \left(\frac{r}{R}\right)^2$$

where u and u_m are respectively the velocities of any radial distance, r, from the axis and at the axis of the pipe and R is the radius. Show that the kinetic energy correction factor, α and momentum correction factor, β are respectively equal to 2 and 1.33. 20

(c) Air at the rate of 35 kg/s flows through a nozzle in which a normal shock occurs in the diverging section down- stream of the throat. The nozzle has an area of cross- section equal to 40 cm^2 at the section of shock. The pressure and velocity of fluid just before the shock are 2.5 bar and 480 m/s respectively. Find the Mach number, pressure and temperature after the shock.

Comment on the results. 20

Normal shock table:

M_1	M_2	P_2/P_1	T_2/T_1	ρ_2/ρ_1	P_{20}/P_{10}
1.42	0.7314	2.1858	1.2676	1.7243	0.9531
1.43	0.7274	2.2190	1.2742	1.7416	0.9503

3.(a) The temperature of product of combustion in a boiler decreases from 1100°C to 550°C while the pressure remains constant at 0.1 MPa. Water at 0.8 MPa, 150°C is converted into steam at 0.8 MPa, 250°C with the surroundings is at 100 kPa and 25°C. Sketch the control volume depicting the terminal and process conditions and show on a T-s diagram the processes. Calculate the following:

(i) Change in availability of water on unit mass of water basis.

(ii) Change in availability of product of combustion per kg of water.

(iii) Process irreversibility per unit mass of water.

(iv) second law efficiency, and

(v) Entropy generated per kg of water.

Take average specific heat of product of combustion as 1.09 kJ/kg-K. Specify enthalpy and specific entropy of water at 0.8 MPa, 150°C are, respectively, at 632.2 kJ/kg and 1.8418 kJ/kg-K and that of steam at 0.8 MPa, 250°C are respectively at 2950 kJ/kg and 7.0389 kJ/kg-K. 20

(b) A heat transfer equipment utilizes 5 mm diameter, 10 cm long smooth circular cross-sectioned conduits drilled horizontally in a plate longitudinally on which a constant heat flux is imposed uniformly. Air enters each conduit at 27°C with a mean velocity of 3.0 m/s and leaves at 77°C. If 20 conduits are arranged in the plate, calculate the following:

(i) total rate of heat removed from the plate,

(ii) exit conduit wall temperature, and

(iii) local heat transfer coefficient at the exit of each conduit.

Sketch the variation in local heat transfer coefficient along the length of conduit.

The following correlations are known for convection heat transfer:

$Nu_d = 4.364$, for fully developed laminar flow,

$Nu_d = 0.023\ Re_d^{0.8}\ Pr^{0.4}$, for turbulent flow,

$$Nu_z = 1.3\left[\frac{Re_d.Pr}{(z/d)}\right]^{1/3}, \text{developing flow with } \left[\frac{Re_d.Pr}{(z/d)}\right] > 10$$

'z' is the axial location from the inlet along the length of conduit.

Properties of air at 52°C: C = 1006 J/kg-K, ρ = 1.1774 kg/m^3, ν = 18.22 x 10^{-6} m^2/s, k = 0.028 W/m- K. Pr = 0.703. 20

(c) A 0.5 m diameter disc heater is horizontally placed and enclosed concentrically in a hemispherical shaped surface. The surface of the enclosure having an emissivity of 0.7, is maintained at 500 K. The disc heater, having emissivity of 0.8 is maintained at 1200 K. The diameter of the hemisphere is 2 m and the remaining base area enclosed is open to surroundings at 300 K and may be considered as black with reference to radiation exchange.

Sketch the schematic and thermal radiation network.

Using thermal network method, calculate the heat exchange between heater and hemispherical enclosure and that between heater and surroundings.

Neglect convection heat transfer.

Assume heater and hemispherical surface are opaque, diffuse and gray. 20

4.(a) An open cycle gas turbine takes in air at 300 K and 1 bar and develops a pressure ratio of 20. The turbine inlet temperature is 1650 K. The polytropic efficiency of compressor and turbine each is 90%. The pressure loss in the combustor is 3% and the alternator efficiency is 97%. Take c_{Pa} = 1.005 kJ/kg-K and c_{Pg} = 1.128 kJ/kg-K for air and gas respectively. The calorific value of fuel is 42 MJ/kg. Work out the following:

(i) Sketch the system and show the process on T-s diagram.

(ii) The overall efficiency.

(iii) The specific power output.

(iv) The fuel to air ratio.

(v) The specific fuel consumption

(vi) Show in general the variation of gas turbine thermal efficiency with compressor ratio for various turbine inlet temperatures.

(vii) What is the reason that thermal efficiency of gas turbine plant increases with decrease in compressor inlet temperature? 20

(b) During a test on a two stroke engine on full load, the following observations were recorded:

Speed = 350 rpm
Net brake load = 590 N
Mean effective pressure = 2.8 bar
Fuel oil consumption = 4.3 kg/h
Cooling water required = 500 kg/h
Rise in cooling water temperature = 25°C
Air used per kg of fuel = 33 kg
Room temperature = 25°C
Exhaust gas temperature = 400°C
Cylinder diameter = 220 mm
Stroke length = 280 mm
Effective brake diameter = 1 m
C.V. of fuel oil = 43900 kJ/kg
Proportion of hydrogen in fuel = 15%
Mean specific heat of exhaust gases =1.0 kJ/kg-K
Specific heat of steam = 2.09 kJ/kg-K
Calculate the following:

(i) Indicated power
(ii) Brake power
(iii) Draw heat balance sheet on the basis of kJ/min. 20

(c) A cross flow heat exchanger consists of a bundle of 32 straight 0.6 m long tubes in a rectangular duct of cross-sectional area of 0.6 m^2. Hot water at 150°C and a mean velocity of 0.5 m/s enters each tube having inner and outer diameters of 10.2 mm and 12.5 mm respectively. Atmospheric air at 10°C enters the heat exchanger with a volumetric flow rate of 1 m^3/s. The mean convective heat transfer coefficient on the outside air flow is 400 W/m^2-K. Assume tube side flow is fully developed and negligible thermal resistance due to tube wall. Heat transfer is only between air and water. Calculate exit temperatures of water and air and the total heat transfer rate. The following properties are known:

For air: at 10°C, ρ = 1.2407 kg/m^3, at 40°C, ρ = 1.1181 kg/m^3, C_p = 1007 J/kg-K.
For water: ρ = 922 kg/m^3, C_p = 42 97 J/kg-K, k = 0.688 W/m-K, $\mu = 188 \times 10^{-6}$ N-s/m^2, Pr = 1.18.

Take cross flow correction factor as 0.8. Heat transfer correlations:

(1) $Nu_d = 4.364$, for fully developed laminar tube flow,
(2) $Nu_d = 0.023\ Re_d^{0.8}\ Pr^{0.3}$, for turbulent flow, in tube
(3) Minimum fluid mixed and other unmixed in cross flow exchanger

$$\varepsilon = \frac{1 - e^{\{-CR[1-e^{-N}]\}}}{CR}$$

Minimum fluid unmixed and other mixed in cross flow exchanger

$$= 1 - e^{-\left\{[1-e^{-CR.N}].\frac{1}{CR}\right\}}$$

where ε: effectiveness, CR : capacity ratio, N : Number of Transfer Units.
Symbols have the usual meaning. 20

Section 'B'

5. Answer any THREE of the following:

(a) Two identical petrol engines having the following specifications are used in vehicles:

Engine 1: Swept volume = 3300 cc, Normally aspirated, bmep = 9.3 bar, rpm = 4500, Compression ratio = 8.2, Efficiency ratio = 0.5, Mechanical efficiency = 0.9, Mass of the engine = 200 kg.

Engine 2: Super charged, Swept volume = 3300 cc, bmep = 12.0 bar, rpm = 4500, Compression ratio = 5.5, Efficiency ratio = 0.5, Mechanical efficiency = 0.92, Engine mass = 220 kg.

If both the engines are supplied with just adequate quantity of petrol for the test run, determine the duration of test run so that the specific mass per kW of brake power is same for both the engines. Calorific value of petrol = 44000 kJ/kg,

Assume both the engines operate on four stroke cycle.

Also compare two engines and suggest their applications with reasoning. 20

(b) (i) With the help of a sketch discuss the working principle of a high pressure Benson boiler with advantages.

(ii) Discuss the purpose of drum used in boiler and show internal details for mechanism of separation of moisture in drum. 20

(c) (i) Derive the expression for optimum ratio for blade velocity to steam velocity in the case of Parson's reaction steam turbine with the sketch of blade shape of a stage and velocity triangles,

(ii) Give a cylinder layout of a 500 MW steam turbine and explain the reasons of double flow cylinder used. 20

(d) Comment on the following (Be brief) with the help of schematic diagram, if required:

(i) In the reciprocating compressors used in vapour compression system, the mass of refrigerant discharged by the compressor reduces as the pressure ratio is increased.

(ii) Thermostatic expansion valve is preferred over automatic expansion valve as throttling device.

(iii) COP of refrigeration system increases when water cooled condenser is used in place of air cooled condenser.

(iv) Vapour at suction to the hermetically sealed compressor is always superheated vapour.

(v) For low sensible heat factor applications, reheat is necessary. 20

6.(a) (i) Discuss the requirements of an injection system of a diesel engine.

(ii) With the help of a sketch discuss the working of common rail injection system.

(iii) Show the performance curves of a S.I. engine on constant speed and constant load tests. 20

(b) A saturated vapour compression refrigeration system is extracting heat from a thermal reservoir at -10°C and rejecting heat to another thermal reservoir at 36°C. The saturation temperature of evaporator is -20°C and that of condenser is 46°C. The mass flow rate of refrigerant (R- 134 a) is 0.1 kg/s. Assume environment temperature equal to 36°C. Find:

(i) Refrigerating capacity in Tons

(ii) Power input in kW

(iii) COP

(iv) COP of Carnot refrigeration cycle

(v) Second law efficiency of the cycle.

Compare with the help of T-s diagram, the vapour compression cycle and Carnot refrigeration cycle and show the deviation between the two cycles by shaded areas. 20

Properties of refrigerant (Saturated)

Temp (°C)	Saturation Pressure MPa	Enthalpy (kJ/kg)		Entropy (kJ/kg-K)	
		Sat liquid	Sat vapour	Sat liquid	Sat vapour
		h_f	h_g	s_f	s_g
-20	0.13273	173.64	386.55	0.9002	1.7413
-10	0.20060	186.70	392.66	0.9506	1.7334
36	0.91185	250.48	417.65	1.1717	1.7124
46	1.1903	265.47	421.92	1.2186	1.7089

Super heated

Pressure(MPa)	h_g(kJ/kg)	s_g(kJ/kg-K)
1	428.9	1.741
1.2	436.12	1.7413

(c) (i) Derive the following expression for the critical pressure ratio (r_c) in a steam nozzle where steam enters with initial velocity and the flow is accompanied with friction:

$$r_c = \left[\frac{z}{n'+1}\right]^{n'/(n'-1)} \left[1 + \frac{{C_1}^2}{2\eta n' P_1 v_1}\right]$$

where

C_1 = initial steam velocity

P_1 = initial steam pressure

η = small stage expansion efficiency

n'= actual exponent of expansion

v_1 = initial steam specific volume.

(ii) Show the effect of variation of back pressure on distribution of pressure and velocity all along in a convergent-divergent nozzle. 20

7.(a) In a steam power plant, the steam generator generates steam at the rate of 120 t/h at a pressure of 100 bar and temperature of 500°C. The calorific value of fuel used by steam generator is 41 MJ/kg with an overall efficiency of 85%. In order to have efficient combustion, 17 kg of air per kg of fuel is used for which a draught of 25 mm of water gauge is required at the base of stack. The flue gases leave the steam generator at 240°C. The average temperature of gases in the stack may be taken as 200°C and the atmospheric temperature is 30°C. Work out the following:

(i) The height of stack required.

(ii) The diameter of stack at its base.

(iii) Draw the draught distribution considering balanced draught system in a steam generator and mention the advantages of balanced draught.

Take the following steam properties for solution:

h = 3375 kJ/kg, h_f = 632.2 kJ/kg. 20

(b) Draw a neat sketch of aqua-ammonia vapour absorption system. On this sketch:

(i) Indicate thermodynamic state points with (1) at the inlet of pump.

(ii) Show the direction of the following energy transfers to various components:

e_A - energy transfer to absorber

e_p - energy transfer to pump

e_g - energy transfer to generator

e_D - energy transfer to dephlegmator

e_c - energy transfer to condenser

e_e - energy transfer to evaporator

(iii) Mention for each of the energy transfers in (ii) above whether it is in the form of work or heat.

(iv) With heat sink temperature of 27°C, heat source temperature of 127°C and refrigeration temperature of -13°C, find max COP of the vapour absorption system and mention the assumptions made. 20

(c) (i) With the help of a neat sketch show a steam/gas combined cycle with two pressures heat recovery steam generator (HRSG).

(ii) Show the processes of topping and bottoming cycle on one T-s diagram and also show T-Q diagram for process in HRSG.

(iii) Discuss the advantages of combined cycles. 20

8.(a) (i) Discuss the objectives of supercharging and show the process on p-v diagram.

(ii) Give sketches of two common types of supercharging and turbo-charging configurations.

(iii) Discuss parameters affecting engine heat transfer. 20

(b) (i) Give a practical feed heating arrangement of a 660 MW steam power plant by showing steam and feed flow paths. Mention its special features.

(ii) In low pressure steam turbine, steam is wet. With the help of velocity diagrams show the direction of flow of steam and water particles on moving blades and guide vanes so that the causes of erosion of blades get established. 20

(c) Illustrate the following processes on psychometric chart with initial state of moist air as dry bulb temperature equal to 20°C and relative humidity of 50%:

(i) Cooling and humidification

(ii) Heating and humidification

(iii) Humidification at constant dry bulb temperature.

Mention one application each for above humidification processes. If the moist air leaves the system for the case (iii) above, at 90% relative humidity, determines per unit mass of dry air:

(i) increase in humidity ratio, AW

(ii) increase in enthalpy, Ah

(iii) increase in dry bulb temperature, At

(iv) Determine Sensible Heat Factor (SHF) for this process. 20