MECHANICAL ENGINEERING

PAPER - I

SECTION A

1. Answer any four of the following (each answer should confirm to a limit of around 150 words)

(a) Explain how several eccentric masses rotating in different planes are balanced. (10)

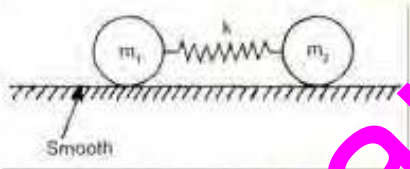
(b) What is meant by buckling of columns? Show how end fixation affects the buckling load. (5 + 5)

(c) What is hardening? Why should hardening be followed by tempering? (5 + 5)

(d) Discuss briefly a power pressing technique as applied to ceramic materials. (10)

(e) Give one method for the heat treatment of high speed tool steel. (10)

2. (a)



Determine the natural frequency of oscillation of spring mass system as shown above. (15)

(b) Determine the addendum of two equal involutes spur gears in mesh with the following specification:

Number of teeth = 60
Pressure angle = 20°
Module = 6 mm, and
Arc of contact = 1.75 × circular pitch. (10)

(c) What is meant by friction circle? Show that the radius of friction circle depends only on the radius of the journal and coefficient of friction. (10)

(d) Give the field of application of chain drives. State the advantages and disadvantages of chain drives. (5)

3. (a) A steel bar of diameter 60 mm and length 300 mm is subjected to an axial compressive load of 50 kN. To what diameter the middle one-third length of the bar be reduced in order to increase the stored energy by 50%? (10)

(b) A cantilever of length 1.2 m carries a udl of 4 kN/m run and a concentrated load of 10 kN at the free end. The cross-section of the cantilever is rectangular and having a width of 40 mm and a depth of 100 mm.

(i) Draw S.F. and B.M. diagrams for the cantilever and obtain the value of S.F. and B.M. at a section 1m from the free end.

(ii) Obtain normal stress and shear stress distribution on a section 1m from the free end, and

(iii) Calculate the maximum deflection of the cantilever and indicate the location where it occurs.

(10 + 15 + 5)

4. (a) The fluctuation of energy of a flywheel with mass 7500 kg and radius of gyration 2 m is 60 kN-m. Mean speed is 120 rpm. Determine the maximum and minimum speeds.

(10)

(b) A crank and slotted lever quick return motion mechanism has the following specifications
Distance between fixed centers = 200 mm
Length of the driving crank = 100 mm
Sketch the mechanism. Determine the inclination of the slotted bar with the vertical in the extreme position and the ratio of cutting stroke to return stroke.

(10)

(c) A rectangular plate of thickness 10 mm carries tensile normal stresses of $\sigma_1 = 600$ MPa and 2 $\sigma_2 = 200$ MPa on two perpendicular planes on which there are no shear stresses. Obtain the change in thickness of the plate. Take E = 200 x 10^9 Pa and G = 80 x 10^9 Pa.

(20)

SECTION B

5. Answer any four of the following (each answer should conform to a limit of around 150 words)

(a) What is meant by Built-Up-Edge (BUE) chip? Comment on its effect during metal cutting action.

(4 + 6)

(b) With block diagram, explain the electroforming process and its application.

(4 + 4 + 2)

(c) List out the steps required in "Morphology of Design" for product development and manufacturing.

(10)

(d) (i) What is meant by job design?

(ii) How will you prepare the job structures to meet the job requirements?

(iii) Summaries the decisions involved.

(2 + 4 = 4)

(e) Write down the characteristics of 'C' arrays for engineering applications.

(10)

6. (a) What is the purpose of parity check in NC program preparation?

(10)

(b) What are the assumptions made in ultrasonic machining process and also write the process parameters for the same?

(5 +5)

(c) By deriving the equations, determine the power required to draw wire from 15.5 mm to 13.25 mm in diameter at 125 m/min speed. Where $\mu = 0.15$, $\alpha = 5°$, $S = 2k = 39$ Kg/mm^2

(10 + 10)

7 (a) An automobile instrument manufacturer has identified the following options for obtaining a machined component. They can out-source component at Rs. 220/- per unit (including materials). They can manufacture the component on a semiautomatic lathe at Rs. 80/- per component (including material); or they can manufacture the components on a CNC turning centre at Rs. 18/- per component including materials. There is negligible fixed if the items are outsourced, a semi-automatic lathe costs Rs. 3.5 Lacs and CNC turning centre costs Rs. 9.5 Lacs. Suggest your optimal choices for minimizing cost and maximizing profit if the component is sold at Rs. 310/- each.

(15)

(b) In the past, an 'MNC industries' has used a fixed time period inventory system that involved taking a complete inventory count of all items each month. However, increasing labour costs are forcing the industry to examine alternative ways to reduce the amount of labour involved in inventory stock- rooms, yet without increasing other costs, such as shortage costs. Here is a random sample of 10 items.

(10)

Item No.	1	2	3	4	5	6	7	8	9	10
Annual Use (Units)	1500	12000	2200	50000	9[illegible]	7[illegible]	2000	11000	800	15000
Unit Cost Rs.	42.00	345.00	0.70	26.2[illegible]	0.[illegible]	[illegible].50	109.00	0.50	2.00	492.00

(i) What is your recommendation to cut the costs by using A-B-C analysis ?

(ii) If the item 7 is critical to continued operations, how will you recommend for items classification?

(10 + 5)

(c) Discuss about frequent versus infrequent capacity expansion of a manufacturing system.

(10)

8 (a) Describe a queuing model with KENDALL's notation incorporating the priority rules.

(5)

(b) A company manufactures groundnuts (packeted) through a chain of food stores. It has been experiencing over-and-underproduction because of forecasting errors. The following data are in demand in packets for the past 5 weeks. Groundnut packets are made for the following day For example, Sunday's production is for Monday's sales. Monday's production is for Tuesday's sales, and so forth. The company is closed on Saturday, so Friday's production must satisfy demand for both Saturday and Sunday.

DAYS	5 Weeks Ago	4 Weeks Ago	3 Weeks Ago	2 Weeks Ago	Last Week
MON	2900	2300	2500	2300	2500
TUE	3000	2100	2200	2100	2200
WED	3800	2400	2500	2200	2700
THU	5000	2200	2100	1900	2000
FRI	3700	2700	1900	2000	2100
SAT	—	—	—	—	—
SUN	2800	2900	2900	3200	2900

Make a forecast for this week on the following basis

(i) Daily, using a simple five-week moving average.

(ii) Daily using a weighted average of 0.3, 0.25, 0.2, 0.15, 0.10 for the past five weeks.

(5 + 5)

(c) The following table shows the data for a PERT Programme:

ACTIVITY		A	B	C	D	E	F	G	H	I	J	K	L
Time Estimate (Days)	Oppo-Site	1	1	1	3	2	3	4	6	2	4	1	3
	Most Likely	2	2	3	4	3	5	5	7	4	6	2	5
	Pesti-mistic	3	3	5	5	4	7	6	8	6	8	3	7

A and B are start activities. A controls C, D and E; B controls F and J; G depends on C; H depends on D; E and F control I and L; K depends on J; L is also controlled by K; G, H, I and L are the ending activities.

(i) Construct the network.

(ii) Find the critical path.

(iii) What is the probability of completing the project in 18 days?

(10 + 10 + 5)

MECHANICAL ENGINEERING

PAPER - II

SECTION A

1. Answer any four parts

(a) A salesman reports that he has a steam turbine available that delivers 3 MW. The steam enters the turbine at a pressure of 6 bar and leaves at 0.15 bar and the required rate of steam consumption is 12000 kg/hour.

(i) How do you evaluate his claim?

(ii) Next he changed his statement and said that the required steam flow was 20,000 kg/hour, how do you evaluate his claim now?

(10)

(b) Derive Clausius-Clapeyron equation and calculate the change in freezing temperature per bar change in pressure for water. Given that specific volume of water at 0°C is 10^{-3} m^3/kg and that of ice is 1.09×10^{-3} m^3/kg. Latent heat of ice = 33 kJ/kg.

(10)

(c) Using the Maxwell relation, derive the following equation for dh

$$dh = C_p dT + \left[V - T\left(\frac{\partial V}{\partial T}\right)_p \right] dP$$

(10)

(d) Discuss the various fuels used in compression ignition engines and spark ignition engines. What are the desirable properties of fuels used in these two types of engines? How are the fuels used in C.I. and S.I. engines rated?

(10)

(e) A steam pipe 75 mm OD and 30 m long conveys 1000 kg of steam/hour at a pressure of 2 MN/m^2. The steam enters the pipe with a dryness fraction of 0.98 and is to leave the other end of the pipe with a minimum dryness fraction of 0.96. This is to be accomplished by suitable insulation of the pipe, the thermal conductivity of insulating material being 0.19 W/m K. Neglecting the temperature drop along the stem pipe, determine the minimum thickness of insulation required to meet the necessary conditions. Take the temperature of outside surface of insulation as 27°C. For steam at 2 MN/m^2, t = 212.4°C and h_{fg} = 1888.6 kJ/kg.

(10)

2. (a) In a parallel flow heat exchanger water enters at 90°C and leaves at 110°C, while oil of specific gravity 0.8 enters the exchanger at 280°C and leaves at 200°C. The specific heat of oil is 2 kJ/kg-K. Determine the loss in availability of the system for 1 kg/s of oil flow rate. Environment is at 300 K.

(20)

(b) In a closed system, dry saturated steam at 100 bar expands isothermally and reversibly to a pressure of 10 bar. Calculate the heat supplied and work done per kg of steam during the process

(20)

3. (a) The following observations were made during a 30-minute trial of a single-cylinder, four-stroke gas engine having cylinder diameter of 18 cm and stroke 24 cm, running at 300 rpm.

Indicated mean effective pressure = 5 bar, total number of explosions = 4425, total gas consumption = 2.4 m^3, calorific value of gas = 19000 kJ/m^3, density of gas = 1.275 kg/m^3, air

consumption = 32.1 m^3, density of air = 1.29 kg/m^3, temperature of exhaust gases = 350°C, specific heat of gases = 1.0 kJ/kg-K, mass of cooling water circulated = 120 kg, rise in temperature of cooling water = 30°C. Net load on the brake drum is 38 kg and the effective diameter of the brake drum is 1 m.

Assuming room temperature of 27°C, calculate

(i) Indicated power,

(ii) Brake power,

(iii) Indicated thermal efficiency,

(iv) Mechanical efficiency, and

(v) Brake thermal efficiency.

Also draw up a heat balance sheet on per minute basis as well as percentage basis.

(25)

(b) The venturi of a simple carburettor has a throat diameter of 20 mm and the fuel orifice has a diameter of 1.12 mm. The petrol surface in the float chamber is 6 mm below the throat of venturi. Coefficient of discharge for venturi and fuel orifice are 0.85 and 0.78 respectively. Density of petrol is 750 kg/m^3. Calculate

(i) The air-fuel ratio for a pressure drop of 0.08 bar,

(ii) The minimum air velocity at which petrol starts flowing in the venturi throat, and

(iii) Petrol consumption in kg/hr.

Intake air condition is 1 bar and 17°C. For air take C_p = 1.005 kJ/kg-K and C = 0.718 kJ/kg-K.

(15)

4. (a) What is the main difference in the construction of the two-stroke and four-stroke engines? What is scavenging in two- stroke engines and how is it carried out? Explain with neat sketches various methods of scavenging in two-stroke engines. Give also their comparative merits and demerits.

(15)

(b) A 1 meter long, 6 m diameter cylinder placed in an atmosphere of 30°C is provided with 10 longitudinal straight fins. (The material conductivity k 150 W/m K). The fins are 0.80 mm thick and extend 2.5 cm from the cylinder surface. The heat transfer coefficient between the cylinder and the atmospheric air is 25 W/m^2K. The surface temperature of the cylinder is 160°C. Calculate

(i) the rate of heat transfer from cylinder to air,

(ii) the percentage increase in heat transfer by providing fins in comparison to cylinder without fins,

(iii) the temperature at the end of fins, and

(iv) the efficiency of fins.

(25)

SECTION - B

5. Answer any four parts

(a) The air at condition 17° C and relative humidity 60% is passed over a cooling coil at the rate of 0.5 m^3/sec. The temperature of cooling coil is 6°C. Calculate the rate of water vapour condensed. Assume that the barometric pressure is 1.01325 bar and the air leaving the coil is at 9°C and 90% relative humidity. Determine also its by-pass factor.

(10)

(b) Explain the phenomena of equimolar counter diffusion. Derive an expression of equimolar counter diffusion between two gases.

(10)

(c) Distinguish with the help of simple sketches the difference between natural circulation and forced circulation steam generators. State advantages and disadvantages of each. Also compare them with on be through boilers.

(10)

(d) With the help of a neat sketch, explain the working of an absorption refrigeration system based on solar heating. Give the function of each component.

What is the maximum possible thermal coefficient of performance of an absorption refrigeration system if heat is supplied at 90°C, heat rejection is at 40°C and refrigeration effect is to be obtained at 5°C?

(10)

(e) In a hydroelectric generating plant, there are four similar turbines of total output 200 MW. Each turbine is 90% efficient and runs at 100 rpm under a head of 60 m. It is proposed to test the model of the above turbines in the laboratory where the water available is 300 lit/sec under a head of 5 m. Calculate (i) the scale ratio and (ii) the power and speed of the model. Take efficiency of model = 87%.

Give also the specific speed of turbines and specify the type of turbine runner.

(10)

6. (a) A hemispherical cavity of 60 cm radius is covered by a plate with a hole of 20 cm diameter drilled in its centre. The inner surface of the plate is maintained at 250°C by a heater embedded in the surface. The surfaces may be assumed to be black and the hemisphere is well insulated. Assuming that the energy entering the hole from outside is negligible, calculate the temperature of the surface of the hemisphere and the power input to the heater.

(20)

(b) Explain the effect of area change in subsonic and supersonic flows.

A stream of air flows in a duct of 600 mm diameter at the rate of 60 kg/mm. The stagnation temperature is 47°C. At one section of the duct the static pressure is 40 kPa. Calculate the mach number, velocity and stagnation pressure at this section. Take γ = 1.4 and R = 0.287 kJ/kg-K.

(20)

7. (a) A vapour compression system uses R-22 as a refrigerant and works between condenser pressure and evaporator pressure corresponding to saturation temperatures of 44°C and -20°C respectively. It uses a single acting reciprocating compressor having bore equal to 10 cm and stroke equal to 12 cm. Speed of the compressor is 2800 rpm. the clearance factor for compressor is 0.04. Assume the process of compression to be isentropic. Refrigerant vapour at the outlet of the evaporator is dry and saturated and liquid at the outlet of the condenser is sub cooled to a temperature of 35°C. Assume the behaviour of the superheated vapour to be that of an ideal gas at constant pressure.

Determine

(i) temperature of the superheated vapour at the exit of compressor,
(ii) volumetric efficiency of the compressor,
(iii) mass flow rate of the refrigerant,
(iv) cooling capacity of refrigeration system in tons of refrigeration,
(v) power needed to drive the compressor,
(vi) COP of the system,
(vii) Draw the cycle on T - & and p -h diagram.

Use following properties of R-22:

Saturation temperature (°C)	–20	44
Pressure (bar)	2.448	16.885
Enthalpy of sat. liquid (kJ/kg)	177.21	254.30
Enthalpy of sat. vapour (kJ/kg)	397.53	416.43
Entropy of sat. liquid (kJ/kg-K)	0.9139	1.1831
Entropy of sat. vapour (kJ/kg-K)	1.7841	1.5943
Sp. volume of sat. vapour (m^3/kg)	0.0928	0.0136

Assume average specific heat of superheated vapour and subcooled liquid at 16.885 bar to be equal to 0.95 and 1.30 kJ/kg °C respectively.

(20)

(b) Dry bulb temperature, t_d and wet bulb temperature, t_w of moist air measured by a sling type psychrometer are 40°C and 26°C respectively. Total pressure p of moist air is 1.02 bar.

For a sling type psychrometer

$$p_w = p_{ws} - pA\,(t_d - t_w)$$

where t_d — dry bulb temperature, t_w — measured wet-bulb temperature, p — total pressure,

A is a constant = 7×10^{-4} (1/°C),

P_w — partial pressure of water vapour in moist air

P^{ws} — partial pressure of water vapour in saturated air at measured wet bulb temperature t_w.

Assume gas constant for water vapour 461 J/kg-K.

Determine using only steam tables and properties of dry air

(i) specific humidity,

(ii) relative humidity,

(iii) dew point temperature,

(iv) specific enthalpy,

(v) degree of saturation,

(vi) specific volume, and

(vii) define thermodynamic wet bulb temperature and discuss the procedure for determining the thermodynamic wet bulb temperature in the present case.

(20)

8. (a) A centrifugal compressor running at 10,000 rpm delivers 800 m^3/min of free air. The air is compressed from 100 kPa and 17°C to a compression ratio of 4 with an isentropic efficiency of 82%. Impeller has radial blades at outlet and flow velocity of 60 m/sec may be assumed constant throughout. The outer radius of impeller is twice the inner. The slip factor is 0.9. At inlet blade area coefficient is 0.85. Calculate

(i) final temperature of air,

(ii) theoretical power required,

(iii) diameter of impeller at inlet and

(v) blade angle of impeller at inlet, and

(vi) blade angle of diffuser at inlet, outlet,

(iv) breadth of impeller at inlet.

Take for air

C_p = 1.005 kJ/kg-K,
C_v = 0.718 kJ/kg-K.

(20)

(b) The load has annual duration characteristics as tinder

Load in kW	5000	4000	2000	1000	500
Hours at load	200	4000	2000	1000	1560

Two plants, a steam turbine plant and a diesel engine plant are being considered. For the steam plant, coal at Rs. 4000 per ton with a calorific value of 25,000 kJ/kg is available whereas for the diesel plant, oil at Rs. 8000 per ton with a calorific value of 40,000 kJ/kg is available.

The performance characteristics of the two plants are

Steam : $I = 2.5 \times 10^4 (6 + 8L + 0.10 L^2)$

Diesel : $I = 2.5 \times 10^4 (9 + 4L + 0.50 L^2)$

Where I is input in kJ/hour and L is load in MW. The steam plant would require more men at a total salary of Rs. 4,00,000 per annum for operation than the diesel plant. Which plant would be selected if the steam plant cost is Rs. 4000 per kW and diesel plant cost is Rs. 6000 per kW and no reserve capacity is required? The fixed charges are 12% of each plant.

(20)