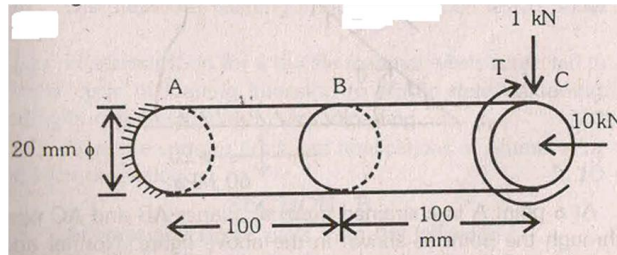


MECHANICAL ENGINEERING PAPER I**Time allowed: 3 hours****Maximum marks: 300****INSTRUCTIONS***Each question is printed both in Hindi and in English.**Answers must be written in the, medium specified in the Admission.**Certificate issued to you, which must be stated clearly on the cover of the answer-book 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.**If any data is considered insufficient, assume suitable value.**Newton may be converted to kg using the equality 1 kilonewton (1 kN) = 100 kg, if found necessary.***Section A****1. Answer any three of the following: (Each answer should not exceed 200 words):****20 x 3 = 60**

- (a) What do you understand by inversions of a mechanism? Show two inversions of a slider crank mechanism with the help of neat sketches.
- (b) A stepped shaft ABC, is 0.8 m long. For a length AB = 0.4 m, shaft diameter is 40 mm and for length BC = 0.4 m, shaft diameter is 20 mm. Shaft is fixed at both the ends A and C. At the Section B, a torque T is applied which causes a maximum shear stress of 100 MPa in stepped shaft. Determine the magnitude of torque T.
- (c) A cantilever ABC, 200 mm long and 20 mm diameter is fixed at end A as shown in the figure. A horizontal axial load 10kN, a vertical load of 1 kN acts at end C. Torque T applied at a section C produces a maximum shear stress of intensity 50 MPa in cantilever. Determine principal stresses at point B of cantilever.



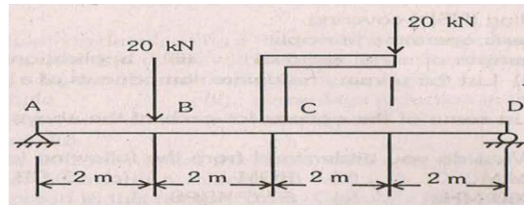
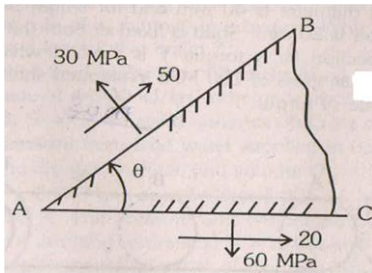
- (d) Give the composition and applications of following alloys:

(i) Mavaging steel (ii) Invar (iii) Beryllium bronze (iv) Aluminum bronze

- 2.(a)** In a spring controlled governor, mass of each governor ball is 7 kg and moves radially under the action of a controlling force F. If the speed range is 420 RPM to 440 RPM with range of ball path radius r equal to 12.4 cm to 13.2 cm, determine the linear relationship between ball path radius and controlling force. Sketch the graph between F and r . What is the equilibrium speed at $r = 12.8$ cm? 30

- (b)** What do you understand by primary balancing and secondary balancing of multi-cylinder in line engines. Consider a six cylinder in line engine and show that it is fully balanced. 20

- 3.(a) At a point A in a strained material, planes AB and AC pass through the point as shown in the above figure. Normal and shear stresses on plane AB are 30 MPa and 50 MPa respectively as shown. Normal and shear stresses on plane AC are 60 MPa and 20 MPa respectively as shown. By graphical or analytical method, determine angle between the planes AB and AC. 30



- (b) A beam ABCD, 8 m long, hinged at end A and roller supported at end D carries the transverse loads as shown in the above figure. Determine the support reactions and draw the BM diagram for the beam. 30

- 4.(a) With the help of neat sketches, differentiate clearly between interstitial and substitutional solid solutions. Comment on F - C and Au - Ag solid solutions. 30
- (b) What do you understand by atomic packing factor? Determine atomic packing factor for BCC structure. 10
- (c) Explain the mechanisms of
- Discontinuous yielding in mild steel when tested under tension
 - Hysteresis loop for a ductile material when subjected to a stress cycle of loading intension to plastic state unloading, loading in compression and then unloading. 20
- (d) Give the compositions and applications of Alumel alloy and Nichrome alloy. 10

SECTION B

5. Attempt any three parts from the following:

- (a) What is a Master Production Schedule? Explain its relationship with Material Planning (MRP), capacity planning and control activities. 20
- (b) Explain with a neat sketch the salient features of Ultrasonic drilling (USD) covering
- the basic operating principle
 - mechanism of metal removal
 - applications 20
- (c) (i) List the primary hardware components of a personal computer.
(ii) List some of the options for each of the above components.
(iii) What do you understand from the following terms?
(a) RAM (b) ROM (c) 5 GB (d) 860 MHz (e) 57.6 KBPS 20
- (d) Write a FORTRAN programme to accept data of heights of up to 100 students of a college. The programme should be able to calculate the mean, variance, and standard deviation of heights and print
- the number of students
 - the serial number and heights of individual students
 - the mean, variance and standard deviation of heights. 20

- 6.(a) (i) Explain the difference between the following two types of motion controls used in CNC machines:
- Point to point or position control
 - Contouring or continuous path control Give an example each of their application.

- (ii) A stepper motor is used in a CNC positioning system, for driving the table through a lead screw of pitch = 3 mm. The control resolution for the table movement is specified as 0.01 mm. Determine
- The number of pulses which the motor should give per revolution
 - The size of step angle of the motor.
 - The linear travel rate of the table.

The motor works at a pulse rate of 200/s.

20

- (b) (i) List three high energy rate forming processes.
 (ii) What are the important reasons behind the use of these processes.
 (iii) Explain in detail, using a diagram the process of explosive forming of a spherical dome with a flange from sheet steel.

30

7.(a) Define the following terms in rolling

- bite angle
- percentage reduction in thickness
- elongation coefficient
- neutral point
- forward slip.

A slab of 300 mm initial thickness, 600 mm wide is given a reduction of 50 mm in a rolling mill with rolls 1000 mm diameter. The spread in this pass is 5 mm. Calculate the values of the bite angle, percentage reduction in thickness and elongation coefficient.

How is forward slip determined experimentally?

40

(b) Solve the following linear programming problem graphically or otherwise:

$$\text{Maximize } Z = 4x_1 + 10x_2$$

$$\text{subject to } 2x_1 + x_2 \leq 50$$

$$2x_1 + 5x_2 \leq 50$$

$$2x_1 + 3x_2 \leq 50$$

$$x_1, x_2 \geq 0.$$

20

8.(a) (i) What is an inventory? Explain the salient features of the following inventory models:

Deterministic models Probabilistic models

Models under uncertainty.

- (ii) In a deterministic model the ordering cost is Rs. 4500/ order. The cost of each item is Rs. 2500 and carrying cost is 10% per year. If the annual requirement is 10,000 units determine Economic Ordering Quantity (EOQ). If the inventory carrying cost decreases by 10% and ordering cost increases by 10% determine the % change in EOQ. What do you infer?

30

(b) (i) List four of the most common priority decision rules applicable to jobs to be completed on one single machine,

- (ii) Six jobs are to be processes through the preparation and paint shops. The operation times are as follow:

Job	Preparation time HRS	Paint shop time HRS
A	10	5
B	7	4
C	5	7
D	3	8
E	2	6
F	4	3

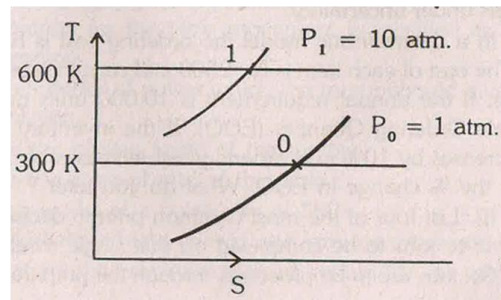
Determine a sequence that will minimize the total completion time. Find the make span time.

MECHANICAL ENGINEERING PAPER II**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.**If any data is considered insufficient, assume suitable value.**Use of Psychometric chart is permitted.***Section A****1.** Answer any three of the following (Answers to each of the parts (a), (b) and (c) should be in about 200 words only): **20 X 3 = 60**

- (a) The ratio of heat transfer to work transfer in the process of an air compressor reciprocating type is $1/4$. If the compression follows $pv^n = \text{constant}$, what is the value of n ? Derive the equation that you use.

In such a compression process the work required is 200 kJ/kg and the specific heat at constant volume is 0.75 kJ/kg K. What rise of temperature is expected at the end of compression process?

- (b) What is the available energy i.e., the maximum amount of work that can be obtained from 1 kg of air at state point 1 in the figure. The dead state is also marked '0' in the figure?



- (c) What are the fan laws? Discuss at least three methods which are used to control fan output (Q) in a power plant.
- (d) Show that in a 50% reaction turbine stage, the maximum stage efficiency is given by,

$$\frac{2\cos^2\alpha}{1 + \cos^2\alpha}$$

where, α is the nozzle angle.

2.(a) A power generating station has a maximum demand of 20 MW. The daily load on the station is as follows:

Time	Load, MW
6 AM to 8 AM	7
8 AM to 12 NOON	16
12 NOON to 1 PM	6
1 PM to 5 PM	15

5 PM to 7 PM	17
7 PM to 9 PM	20
9 PM to 11 PM	9
11 PM to 6 AM	4

- (i) Draw the load curve and load duration curve for the plant.
- (ii) Decide the capacity and number of units.
- (iii) Prepare the operating schedule of the units.
- (iv) Determine the load factor, plant capacity factor and plant use factor of the station.

30

- (b) Develop the Clapeyron equation for the pure substance changing the phase. Hence find the enthalpy of evaporation for R-22 at -10°C and compare the same with the tabulated value. What is the percentage error involved?

30

Properties of R-22

T_s	P_s	v_f	v_g	h_{fg}
$^{\circ}\text{C}$	kPa	liters/kg	m ³ /kg	kJ/kg
20	244.72	0.7409	0.0929	220.331
-10	354.16	0.7587	0.0654	213.136
0	497.41	0.7783	0.0472	205.369

- 3.(a) A four cylinder engine of a truck has been converted to run on propane fuel. A dry analysis of the engine exhaust gives the following volumetric percentages:

$\text{CO}_2 = 4.90$; $\text{CO} = 9.79$ and $\text{O}_2 = 2.45$.

Calculate the equivalence ratio at which the engine is operating.

30

- (b) Explain the following:

- (i) Rich mixture is used during idling.
- (ii) As the engine speed increases, the ignition timing should be advanced.
- (iii) S.I. engines are generally not supercharged.
- (iv) Two stroke C.I. engines find wide applications in marine propulsion.

30

- 4.(a) A three liter V 6 S.I. engine operates on a four stroke cycle at 3600 rpm. The compression ratio is 9.5, the length of the connecting rod is 16.6 cm and the engine is square (bore = stroke). At this speed, the combustion ends at 20°ATDC . Calculate:

- (i) cylinder bore and stroke length
- (ii) average piston speed
- (iii) clearance volume of one cylinder
- (iv) piston speed at the end of combustion
- (v) distance the piston has travelled from TDC at the end of combustion.
- (vi) volume in the combustion chamber at the end of combustion.

30

- (b) Derive an expression for the air-fuel ratio delivered by a simple carburetor. Discuss its limitations. What are the systems incorporated to overcome the limitations of a simple carburetor?

SECTION B

5. Answer any three of the following parts (Answer to each part should not exceed 200 words):

- (a) Show that volumetric clearance efficiency of a reciprocating compressor is given by:

$$\eta_w = 1 + c_l - [c_l(p_d/p_s)^{1/n}]$$

where c_l is clearance ratio and suffix d & s refer to discharge and suction pressures.

- 20
- (b) Discuss and show on the skeleton psychometric chart, the process for the air passing through air washers with three types of spray (i) re-circulated (ii) chilled and (iii) heated water. 20
- (c) How, in a refrigeration system using ammonia, the compressor could be replaced by another suitable set of equipments? 20
- (d) Show that : $Nu (Pr)^{-1/3} = \{ St(Pr)^{2/3} \} Re.$ 20
- 6.(a)** Calculate the (i) c.o.p. (ii) power requirement and (iii) cooling capacity of a CO₂ compressor working between 22.68 bar and 64.32 bar pressures. The liquid in the condenser gets cooled, by another system, to 15°C before entering the expansion valve. The system is assumed to work on wet-compression with $x = 0.9$. The compressor data: stroke volume = 500 c.c; rpm = 500 and $\eta_{vol} = 0.85$. Property values are: sp. heat of CO₂ vapour = 2.4 kJ/kg°C. 30
- | P
bar | Enthalpy (KJ/kg) | | v (m ³ /kg) | | S (KJ/kg°C) | | t
°C |
|----------|------------------|--------|--------------------------|--------|-------------|--------|-----------|
| | Liq. | Vap. | Liq. | Vap. | Liq. | Vap. | |
| 22.68 | 49.62 | 322.86 | 0.00101 | 0.0166 | 0.1976 | 1.2567 | -15 |
| 50.92 | 127.75 | 308.08 | 0.00130 | 0.0066 | 0.4697 | 1.0959 | 15 |
| 64.32 | 164.17 | 283.63 | 0.00147 | 0.0042 | 0.5903 | 0.9912 | 25 |
- (b) In an air-conditioning plant equipment exists for reheating the air before supply to a room to be maintained at 25° dbt with 55% R.H. The RSHL= 150,000 W and RLHL = 122,000 W.
The discharge from cooling coil is 12°C dbt, 95% R.H. Calculate:
(i) the supply air state and rate
(ii) reheating, if any. 30
- 7.(a)** A 3 m long 25 mm dia tube is held at 100 °C by steam jacketing. Water flows through the tube @ 180 kg/hr at 20°C. Calculate the rate of heat transfer from the tube to water. For water (60°C): $C_p = 4.178$ kJ/kg K; $k = 0.66$ (W/mK); $\rho = 983$ kg/m³ and $\mu = 0.47 \times 10^{-3}$ kg/ms. 30
- (b) The surface of two circular discs parallel to each other, each with 1 m² area, are exchanging thermal radiation with each other and with the surrounding walls. The temperatures of disc 1 disc 2 and the walls are 800 K, 500 K and 300 K respectively. The shape factor between discs is 0.5. Compute with help of network analysis the net radiative heat transfer between the two discs. 30
- 8.(a)** The velocity of steam entering a simple impulse turbine is 1000 m/s and the nozzle angle is 20°. The mean peripheral velocity of blades is 400 m/s. The blades are asymmetrical. If the steam is to enter the blades without shock, that will be the blade angles? Neglecting the friction effects on the blades, calculate the tangential force on the blades and the diagram power for a mass flow of 0.75 kg/s. Calculate the axial thrust and diagram efficiency. 30
- (b) Clearly explain as to how the circulation is maintained in modern boilers having operating pressures 100 bar, 180 bar and 240 bar respectively? What is circulation ratio? What is the normal range of circulation ratio in case of utility boilers and industrial boilers? 30