



AERTM
MECHANICAL ENGINEERING
PAPER – II
SUBJECT CODE : 09

Full Marks : 200

Time : 3 Hours

Instructions For Candidates :

Please read each of the following instructions carefully before attempting questions.

- (1) *Answers must be written in **ENGLISH** only.*
- (2) *The question paper contains a total of 8 questions in **TWO** Sections : Section-A and Section-B. (**FOUR** questions in each section)*
- (3) *Question No. 1 of Section 'A' and Question No. 5 of Section 'B' are **compulsory**.*
- (4) *Candidates have to attempt another **THREE** questions from remaining **SIX** questions choosing atleast **ONE** question from each section.*
- (5) *Assume suitable data if found necessary.*
- (6) *Wherever any assumption be made for answering a question, they must be clearly indicated.*
- (7) *Marks carried by a question / section is indicated against it.*
- (8) *Unless struck off, attempt of question shall be counted even if attempted partly.*
- (9) *Any page or portion of the page left blank in the Answer Booklet must be clearly struck off.*

Marks

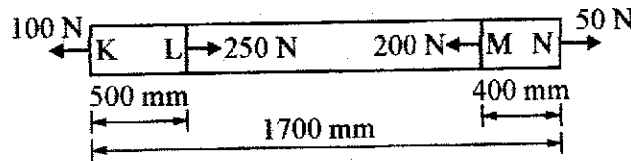
SECTION – A

5 × 8 = 40

1. (i) A clutch has outer and inner diameters 100 mm and 40 mm respectively. Assuming a uniform pressure of 2 MPa and coefficient of friction of liner material as 0.4, calculate the torque carrying capacity of the clutch.
- (ii) Two crossed helical gears are used for speed reduction. Gear 1 has pitch circle diameter (PCD) of 80 mm and helix angle of 30°, while gear 2 has PCD of 120 mm and helix angle of 22.5°. If the input speed is 1440 rpm, calculate the output speed in rpm.
- (iii) A flywheel connected to a punching machine has to supply energy of 400 Nm, while running at a mean angular speed of 20 rad/s. If the total fluctuation of speed is not to exceed ±2%, calculate the mass moment of inertia of the flywheel in Kg-m².



- (iv) A hollow shaft ($d_o = 2d_i$ where d_o and d_i are the outer and inner diameters, respectively) needs to transmit 20 kW power at 3000 rpm. If the maximum permissible shear stress is 30 MPa, calculate the value of outer diameter of hollow shaft.
- (v) The figure below shows a steel rod of 25 mm^2 cross sectional area. It is loaded at four points K, L, M and N, Assume $E_{\text{steel}} = 200 \text{ GPa}$. Determine the total change in the length of the rod due to loading.

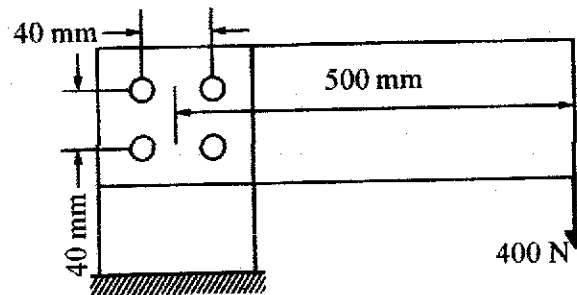


2. (i) A lightly loaded full journal bearing has journal diameter of 50 mm, bush bore of 50.05 mm and bush length of 20 mm. If the rotation speed of the journal bearing is 1200 rpm and average viscosity of the liquid lubricant is 0.03 Pa.s, calculate the power loss (in W).

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- (ii) A horizontal plate has been joined to a vertical post using four rivet arrangement shown in figure. Calculate the magnitude of the load (in N) on the worst loaded rivet.

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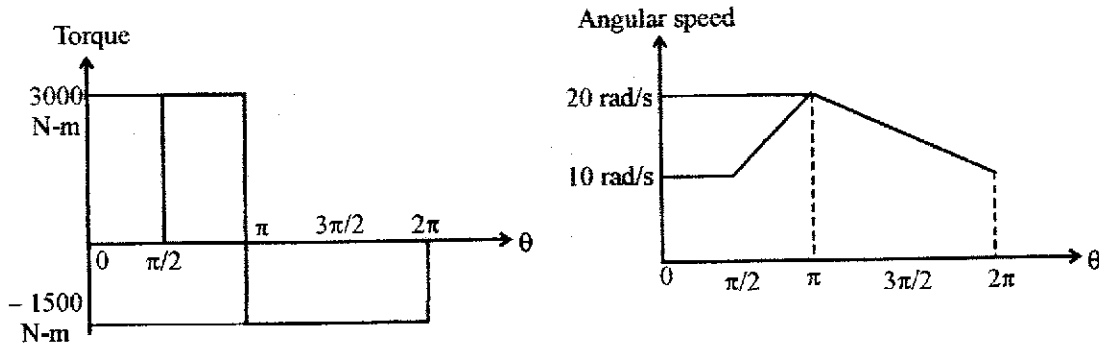


- (iii) A Spur Gear with 20° full depth is transmitting 20 kW at 200 rad/s. The pitch circle diameter of gear is 100 mm. Calculate the magnitude of the force applied on the gear in the radial direction.

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3. (i) Torque and angular speed data over one cycle for a shaft carrying a flywheel are shown in figures. Determine the Moment of Inertia of the flywheel (in kg.m^2). 20



- (ii) Explain the Iron-Carbon equilibrium diagram with the help of a neat sketch. What is the distinction between hypoeutectoid and hypereutectoid steels ? 20

4. (i) A steel beam of rectangular section has a span of 8 m and is simply supported at its ends. It is required to carry a total load of 60 kN uniformly distributed over the whole span. Find the minimum values of breadth and depth if the maximum bending stress is not to exceed 50 MPa and the maximum deflection is limited to 10 mm. $E = 210 \text{ GPa}$. 20

- (ii) A cylindrical shell has the following dimensions :

Length = 3 m, Inside diameter = 1 m, Thickness of metal = 10 mm, Internal pressure = 1.5 MPa. Calculate the change in dimensions of the shell and the maximum intensity of shear stress induced. Take $E = 200 \text{ GPa}$ and Poisson's ratio = 0.3. 20

**SECTION – B**

5. (i) A manufacturer produces mustard oil in small and family-sized plastic bottles, with the demand forecast given in Table 1.

Table 1.

Sizes	Demand per year
Small	1,50,000
Family	1,15,000

The capacity available with the manufacturer and other details are given in Table 2.

Table 2.

Size of the bottle	No. of machines	Production per year per machine	No. of operators required
Small	3	100,000	2
Family	2	120,000	3

Calculate the % of machine capacity used for the production of small and family sized bottles, respectively.

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- (ii) In a project, tasks A, B, C, D, E, F, G, H, I and J are to performed. The precedence relationships and the time required (in days) to complete the tasks are given in the table.

Tasks	A	B	C	D	E	F	G	H	I	J
Time (Days)	8	10	8	10	16	17	18	14	9	4
Preceding tasks	-	-	-	A	A	B, D	C	C	F, G	E, I, H

Determine the time required (in days) to complete the project along the critical path.

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- (iii) In a calendar year, the demand forecast of microwaves for the month of June is 250. The actual demand of microwaves for the month of June and July are 300 and 350, respectively. If single exponential smoothing method with smoothing constant 0.7 is used, determine the demand forecast for the month of August.

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- (iv) Briefly explain the grinding wheel designation/specification with example.

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- (v) Distinguish between Up milling and Down milling with the help of suitable diagrams.

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6. A machine centre in a job shop of a local fabrication company has five unprocessed jobs remaining at a particular point in time. The jobs are labelled 1, 2, 3, 4 and 5 in the order that they entered the shop. The respective processing times (in hours) and due times (in hours) for delivery are given in the Table.

Job number	Processing time (hours)	Due time for delivery (hours)
1	11	61
2	29	45
3	31	31
4	1	33
5	2	32

- (i) Sequence the 5 jobs using Shortest Processing Time (SPT) rule and calculate the mean flow time, average tardiness, and number of tardy jobs, respectively. 20
- (ii) Sequence the 5 jobs using First Come First Serve (FCFS) rule and calculate the mean flow time, average tardiness, and number of tardy jobs, respectively. 20
7. (i) Explain the various types of chips encountered in metal cutting. List the conditions leading to formation of different types of chips. Derive the expression for the chip thickness ratio. 7 + 7 + 6
- (ii) In a limit system, the following limits are specified to give a clearance fit between a shaft and a hole :

$$\text{Shaft } 30 \begin{matrix} -0.005 \\ -0.018 \end{matrix} \text{ mm } \Phi$$

$$\text{Hole } 30 \begin{matrix} +0.020 \\ -0.000 \end{matrix} \text{ mm } \Phi$$

Determine : (a) Basic size (b) shaft and hole tolerances (c) the shaft and hole limits (d) the maximum and minimum clearance. 10

- (iii) During orthogonal machining with a cutting tool having a 10° rake angle, the chip thickness is measured to be 0.4 mm, the uncut thickness being 0.15 mm. Determine the shear plane angle and also the magnitude of the shear strain. 10



8. (i) A municipal corporation is having three water treatment plants. The volume of water treated daily from Plant 1, Plant 2 and Plant 3 are 6 million litres, 1 million litres and 10 million litres respectively. Water is distributed at four distribution centres and the demand at first, second, third and fourth distribution centres are 7 million litres, 5 million litres, 3 million litres and 2 million litres respectively. Cost of transporting 1 million litres of water from treatment plants to distribution centres are given in the following table, in hundreds of rupees. Find the initial basic solution using Least Cost Method and calculate the total transportation cost.

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		Distribution centres			
		1	2	3	4
Water treatment plant	1	2	3	11	7
	2	1	0	6	1
	3	5	8	15	9

- (ii) Solve using simplex method :

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$$\text{Max } Z = X_1 + X_2 + 3X_3$$

Subject to,

$$3X_1 + 2X_2 + X_3 \leq 3$$

$$2X_1 + X_2 + 2X_3 \leq 2$$

$$X_1, X_2, X_3 \geq 0$$

- (iii) Solve the following assignment problem and compute the total time (in hours).

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Machines (time in hours)

Jobs	X	Y	Z
A	11	16	21
B	20	13	17
C	13	15	12



(iv) A self-service store employs 1 cashier at its counter. 9 customers arrive on an average every 5 minutes while the cashier can serve 10 customers in 5 minutes. Assuming Poisson distribution for arrival rate and exponential distribution for service time, find

- (1) Average number of customers in the system.
- (2) Average number of customers in the queue or average queue length.
- (3) Average time a customer spends in the system.
- (4) Average time a customer waits before being served.

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