

AKR/41/16

2016-17

MECHANICAL ENGINEERING

FIRST PAPER

Full Marks : 200

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

Answer any ten questions

1. (a) In a flat belt drive, find the expression

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

where T_1 = tension in the tight side of the belt, T_2 = tension in the slack side of the belt, θ = angle of lap and μ = coefficient of friction between belt and pulley.

8

- (b) The crank of a slider crank mechanism rotates at a constant speed of 300 r.p.m. The lengths of the crank and connecting rod are 150 mm and 600 mm respectively. Determine—

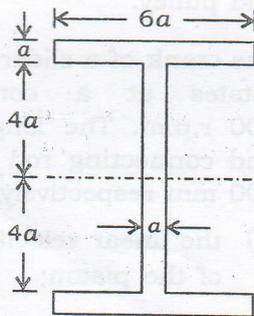
- (i) the linear velocity and acceleration of the piston;

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(Turn Over)

(2)

- (ii) the angular velocity of the connecting rod at a crank angle of 45° from inner dead centre position. 12
2. (a) How does a Porter governor differ from a Watt governor? 5
- (b) In a Porter governor, each of the four arms is 400 mm long. The upper arms are pivoted on the axis of the sleeve, whereas the lower arms are attached to the sleeve at a distance of 45 mm from the axis of rotation. Each ball has a mass of 10 kg and the load on the sleeve is 60 kg. What will be the equilibrium speeds for the two extreme radii of 250 mm and 300 mm of rotation of governor balls? 15
3. (a) Find the moment of inertia of a rolled steel joist girder of symmetrical I section shown in the figure below : 10



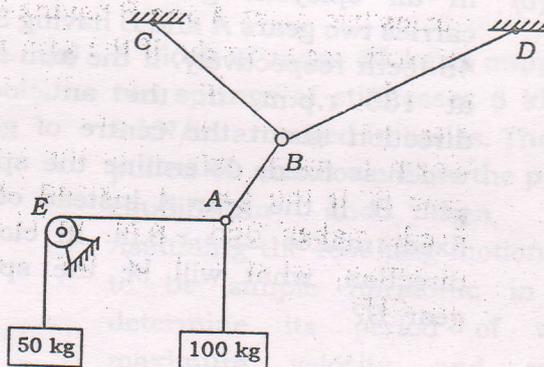
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(Continued)

(3)

- (b) Find the tensions in the three cables connected to B (shown below). The entire system of cables is coplanar. The roller at E is free to turn without resistance :

10



4. (a) For the given state of stress, determine the principal stresses and their directions :

10

$$[\tau_{ij}] = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

- (b) The displacement field for a body is given by

$$u = (x^2 + y)i + (3 + z)j + (x^2 + 2y)k$$

Find the rectangular components of strain at point $(2, 1, -3)$.

10

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(Turn Over)

5. (a) Describe with the help of sketch, a pair of external gearing and a pair of internal gearing. 5
- (b) In an epicyclic gear train, an arm carries two gears A and B having 36 and 45 teeth respectively. If the arm rotates at 150 r.p.m. in the anticlockwise direction about the centre of gear A, which is fixed, determine the speed of gear B. If the gear A instead of being fixed, makes 250 r.p.m. in clockwise direction, what will be the speed of gear B? 15
6. (a) In a cold rolling operation, a flat steel plate of thickness 40 mm is to be reduced to 20 mm. The roll diameter is 600 mm. The coefficient of friction between work material and the roll is 0.1. Determine the minimum number of passes required and the draft per pass. 8
- (b) Explain the different sand defects observed in sand castings. Mention the remedial measures to eliminate each defect. 12
7. (a) Explain the wire drawing process. How does the tube drawing differ from wire drawing? 6

(b) What is meant by the term 'forgeability' of metals and alloys as applied to forging process? On what factors does forgeability of metals and alloys depend? Briefly explain a test to determine the forgeability. 4+4+6

8. (a) A block of mass 60 kg is supported by two springs of stiffnesses 6 kN/m and 8 kN/m arranged in series. The block is pulled 40 mm down from the position of equilibrium and then released. Assuming the resulting motion of block to be simple harmonic in nature, determine its period of vibration, maximum velocity and maximum acceleration. 8

(b) A steel rod, 15 cm long and 8 cm in diameter fits radially between two rigid walls 15 cm apart at room temperature. Young's modulus of elasticity and coefficient of linear expansion of steel are 200 GPa and $12 \times 10^{-6} \text{ K}^{-1}$ respectively. Determine the stress developed in the rod due to a temperature rise of 100 °C. 8

(c) Differentiate between couple and moment. 4

9. (a) A flexible rotor-shaft system comprises of a 10 kg rotor disc placed in the middle of a massless shaft of diameter 30 mm and length 500 mm between bearings mounted at the ends. The bearings are assumed to simulate simply supported boundary conditions. The shaft is made of steel for which the value of E is 2.1×10^{11} Pa. What is the critical frequency of rotation of the shaft? 8
- (b) A thick cylinder of 150 mm outside and 100 mm inside radii is subjected to an external pressure of 30 MN/m^2 . Find the hoop stress at the inner surface. 8
- (c) Differentiate a thick cylinder from a thin cylinder. State the types of stress induced in both types of cylinder. 4
10. (a) What is the function of flywheel in a prime mover? 4
- (b) The turning moment diagram for a petrol engine is drawn to a vertical scale of $1 \text{ mm} = 500 \text{ Nm}$ and a horizontal scale of $1 \text{ mm} = 3^\circ$. The turning moment diagram repeats itself after every half revolution of the crank shaft. The areas above and below the mean torque line are 260 mm^2 , -580 mm^2 , 80 mm^2 , -380 mm^2 , 870 mm^2 and -250 mm^2 .

The rotating parts have a mass of 55 kg and the radius of gyration is 2.1 m. If the engine speed is 160 r.p.m., determine the coefficient of performance of speed. 16

11. (a) A charge of RDX of mass 9 kg is used in an explosive forming operation. Plot the peak pressure generated over the work surface with the stand-off distance. Take the value of constant of proportionality as 4450. 8

(b) With a suitable machine setup, explain a surface finishing method for automobile engine cylinder. 12

12. (a) Calculate the maximum deflection in a fixed beam when loaded centrally with point load. 15

(b) Briefly explain Castigliano's theorem. 5

13. (a) A manufacturer produces two types of products 1 and 2 at production levels of X_1 and X_2 respectively. The profit is given as $2X_1 + 5X_2$. The production constraints are—

$$X_1 + 3X_2 \leq 40; \quad 3X_1 + X_2 \leq 24$$

$$X_1 + X_2 \leq 0; \quad X_1 > 0; \quad X_2 > 0$$

Find the maximum profit which can meet the constraints. 8

- (b) A company has sold 250000 packets of toothpaste for which the variable cost of manufacture was ₹ 4.20 per packet. Each packet contributes to 30% of its revenue to fixed costs and profit. The company has decided a price reduction of 5% in the coming year. How many additional packets of toothpaste must the company sell at the new scheme in order to earn the same profit as before? 12
14. (a) A single bay car wash with a Poisson arrival rate and exponential service time has cars arriving at an average rate of 10 min apart and an average service time of 4 minutes. What is the system utilisation? 6
- (b) What is meant by 'group technology'? How does this concept affect the process and product layout techniques? 14
15. (a) Four jobs are to be processed on a machine as per data listed in the table given below :

Job	Processing time (in days)	Due date
1	4	6
2	7	9
3	2	19
4	8	17

If the earliest due date rule is used to sequence the jobs, find the number of jobs delayed. Using the shortest possible time rule, find the total tardiness.

6

(b) Draw the arrow diagram for the following project and determine the float for the activities :

14

Activity	a	b	c	d	e	f	g	h	i	j
Immediate predecessor	—	a	a	b	b, c	e	e	d, f	d, f	g, h
Duration (in days)	3	4	5	5	6	8	7	5	3	4
