

MECHANICAL ENGINEERING

FIRST PAPER

2016

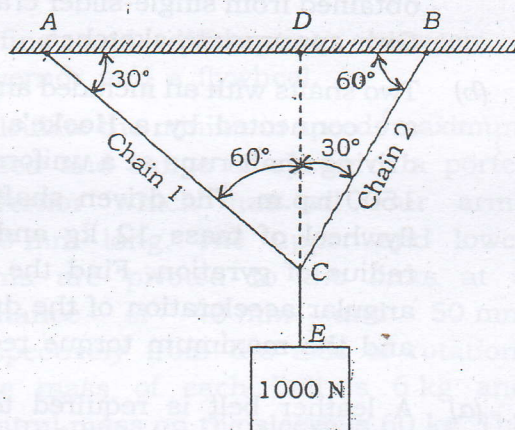
Full Marks : 200

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer any ten questions

1. (a) A weight of 1000 N is supported by two chains as shown in figure below. Determine the tension in each chain. 10



- (b) Prove that the shape of the cable having uniformly distributed load and suspended from two points at the same horizontal level is parabolic. 10

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(Turn Over)

2. (a) The acceleration of a particle is expressed as $a = 10 - x$. The particle starts with no initial velocity at the position $x = 0$. Determine the velocity of the particle when $x = 8$ m. 8
- (b) Two adjacent guns having the muzzle velocity of 400 m/s fire simultaneously at angles α_1 and α_2 for the same target at a range 4800 m. Calculate the time difference between the hits. Assume the gravitational acceleration $g = 9.80 \text{ m/s}^2$. 12
3. (a) What are the different inversions obtained from single-slider crank chain? Give appropriate sketches. 10
- (b) Two shafts with an included angle of 160° are connected by a Hooke's joint. The driving shaft runs at a uniform speed of 1500 r.p.m. The driven shaft carries a flywheel of mass 12 kg and 100 mm radius of gyration. Find the maximum angular acceleration of the driven shaft and the maximum torque required. 10
4. (a) A leather belt is required to transmit 7.5 kW from a pulley 1.2 m in diameter and running at 250 r.p.m. The angle embraced is 165° and the coefficient of friction between the belt and pulley is 0.3. If the safe working stress for the leather belt is 1.5 MPa, density

of leather is 1.5 mg/m^3 and the thickness of the belt is 10 mm, determine the width of the belt taking centrifugal tension into account. 10

(b) Four masses are attached to a shaft at planes A, B, C and D at equal radii. The distances of the planes B, C and D from A are 40 cm, 50 cm and 120 cm respectively. The masses at A, B and C are 60 kg, 45 kg and 70 kg respectively. If the system is in complete balance, determine the mass at D and the position of masses B, C and D with respect to A. 10

5. (a) Define and differentiate between a governor and a flywheel. 8

(b) Calculate the minimum speed, maximum speed and range of speed of a porter governor which has all four arms 250 mm long. The upper and lower arms are pivoted to the links at a distance of 40 mm and 50 mm respectively from the axis of rotation. The mass of each ball is 6 kg and central mass on the sleeve is 60 kg. The force of friction on the sleeve is 48 N. The radius of rotation of the ball is 125 mm when the governor begins to lift and 150 mm when the governor is at the maximum speed. 12

6. (a) Discuss the turning moment diagram of a multi-cylinder engine. 10
- (b) Distinguish between brakes and dynamometers. 5
- (c) Write short notes on cams and followers. $2\frac{1}{2} \times 2 = 5$
7. (a) State the Taylor's tool-life equation and explain the significance of the exponent and the constant term. 5
- (b) Discuss the tool-life criteria commonly adopted. 5
- (c) During straight turning of a 25 mm diameter steel bar at 300 r.p.m. with an HSS tool, a tool life of 10 min was obtained. When the same bar was turned at 250 r.p.m., the tool life increased to 52.5 min. What will be the tool-life at 275 r.p.m.? 10
8. (a) Explain the mechanism of metal removal in EDM and ECM. 10
- (b) Explain the process of ultrasonic machining. 10
9. (a) Explain the following : $4 \times 3 = 12$
- (i) ABC analysis
 - (ii) Break-even analysis
 - (iii) Economic order quantity

- (b) Write the salient aspects of queing theory. 4
- (c) Discuss your concept on value engineering. 4
10. (a) Discuss and differentiate between jigs and fixtures with necessary sketches. 5
- (b) Derive the blank diameter (D) if the cup diameter (d) and cup height (h) are given in deep drawing process. 5
- (c) A 5 mm thick aluminium alloy strip is rolled to a thickness of 4 mm using steel rollers of radius 100 mm. The tensile yield stress of aluminium is 0.28 kN/mm^2 . Determine (i) the angle subtended by the contact zone at the roll centre and (ii) the minimum coefficient of friction μ_{\min} between the workpiece and the rolls for an unaided bite to be possible. 10
11. (a) A maximum allowable shear stress in a hollow shaft of external diameter equal to twice the internal diameter is 80 N/mm^2 . Determine the diameter of the shaft if it is subjected to a torque of $4 \times 10^6 \text{ N-mm}$ and a bending moment of $3 \times 10^6 \text{ N-mm}$. 8

(b) A simply supported beam of length 4 m is subjected to a uniformly distributed load of 30 kN/m over the whole span and deflects 15 mm at the centre. Determine the crippling loads when this beam is used as a column with the condition of 'one-end fixed and other-end is hinged'.

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12. (a) Annual demand for window frames is 10000. Each frame costs ₹ 200 and ordering cost is ₹ 300 per order. Inventory holding cost is ₹ 40 per frame per year. The supplier is willing to offer 2% discount if the order quantity is 1000 or more, and 4% discount if the order quantity is 2000 or more. If the total cost is to be minimized, what will be the discount percentage acceptable by the retailer?

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(b) Time estimates of an activity in a PERT network are :

optimistic time = 9 days

pessimistic time = 21 days

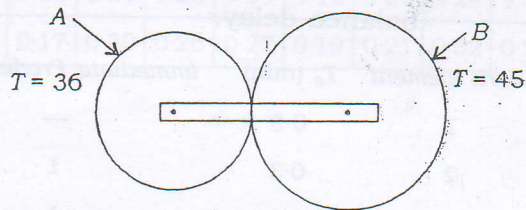
most likely time = 15 days

Determine the approximate probability of completion of this activity in 13 days. 10

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(Continued)

13. (a) The arm of an epicyclic gear train rotates at 100 r.p.m. in the anti-clockwise direction. The arm carries two wheels *A* and *B* having 36 and 45 teeth respectively. The wheel *A* is fixed and the arm rotates about the centre of wheel *A*. Find the speed of wheel *B*. What will be the speed of *B*, if the wheel *A* instead of being fixed, makes 200 r.p.m. clockwise? 10



- (b) An elemental cube is subjected to tensile stresses of 30 N/mm^2 and 10 N/mm^2 acting on two mutually perpendicular planes and a shear stress of 10 N/mm^2 on these planes. Draw the Mohr's circle of stresses and hence or otherwise determine the magnitudes and directions of principal stresses and also the greatest shear stress. 10
14. (a) What is assembly line balancing? Name three methods/algorithms for line balancing. 8

(b) The table below defines the precedence relationships and element times for a new model toy

(i) Construct the precedence diagram for this job.

(ii) If the ideal cycle time = 1.1 min (repositioning time = 0.1 min, uptime = 1.0 min), find the number of workstations using any one of the methods.

(iii) Also find the balance efficiency and balance delay.

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Work element	T_e (min)	Immediate Predecessors
1	0.5	—
2	0.3	1
3	0.8	1
4	0.2	2
5	0.1	2
6	0.6	3
7	0.4	4, 5
8	0.5	3, 5
9	0.3	7, 8
10	0.6	6, 9

15. (a) What is sampling inspection? Explain Type-I and Type-II statistical error in sampling.

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(Continued)

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(b) For constructing \bar{X} and R charts, 10 samples of size 5 are collected and the dimension of interest has been measured for each part. The calculated values of \bar{X} and R for each sample are as given below (measured values are in mm). Draw the charts showing control limits :

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S	1	2	3	4	5	6	7	8	9	10
\bar{X}	9.22	9.15	9.20	9.28	9.19	9.12	9.20	9.24	9.17	9.23
R	0.24	0.17	0.30	0.26	0.27	0.19	0.21	0.32	0.21	0.23
