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Question Paper Code : 81655

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2025.

Fourth Semester

Mechanical Engineering

ME 3491 — THEORY OF MACHINES

(Common to : Mechanical Engineering (Sandwich)/Mechanical and Automation Engineering)

(Regulations 2021)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define Kinematic chain.
2. Determine the mobility of the mechanism shown in figure-1 by using Kutzbach mobility criterion.

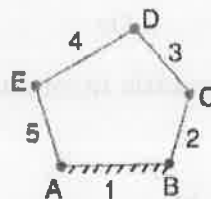


Figure-1

3. List out the function of idle gear.
4. The gearing of a machine tool is shown in below figure-2

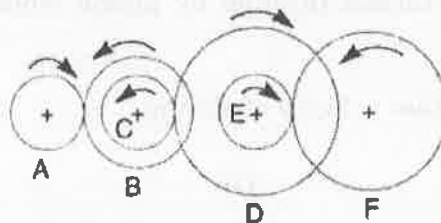


Figure-2

The motor shaft is connected to gear A and rotates at 975 r.p.m. The gear wheels B, C, D and E are fixed to parallel shafts rotating together. The final gear F is fixed on the output shaft. What is the speed of gear F? The number of teeth on each gear are as given below :

Gear	A	B	C	D	E	F
Number of teeth	20	50	25	75	26	65

5. State the law of coefficient of friction.
6. Infer about the effect of friction in vehicle propulsion.
7. Differentiate between applied and constrained forces.
8. How superposition principle is applied in force analysis?
9. Define logarithmic decrement.
10. Write the formula to calculate frequency of torsional vibration.

PART B — ($5 \times 13 = 65$ marks)

11. (a) Explain the working principle of following inversions of single slider crank mechanisms with its sketch.
 - (i) Oscillating cylinder engine (6)
 - (ii) Whitworth quick return motion mechanism. (7)

Or

- (b) Illustrate any three kinematic inversions of four bar chain with its neat sketch.
12. (a) Two involute gears of 20° pressure angle are in mesh. The number of teeth on pinion is 20 and the gear ratio is 2. If the pitch expressed in module is 5 mm and the pitch line speed is 1.2 m/s, assuming addendum as standard and equal to one module, find :
 - (i) The angle turned through by pinion when one pair of teeth is in mesh and (7)
 - (ii) The maximum velocity of sliding. (6)

Or

- (b) In an epicyclic gear train, the internal wheels A and B and compound wheels C and D rotate independently about axis O. The wheels E and F rotate on pins fixed to the arm G. E gears with A and C and F gears with B and D. All the wheels have the same module and the number of teeth are : $T_C = 28$; $T_D = 26$; $T_E = T_F = 18$.
- Sketch the arrangement. (2)
 - Find the number of teeth on A and B, (3)
 - If the arm G makes 100 r.p.m. clockwise and A is fixed, find the speed of B and (4)
 - If the arm G makes 100 r.p.m. clockwise and wheel A makes 10 r.p.m. counter clockwise; find the speed of wheel B. (4)
13. (a) A thrust shaft of a ship has 6 collars of 600 mm external diameter and 300 mm internal diameter. The total thrust from the propeller is 100 kN. If the coefficient of friction is 0.12 and speed of the engine 90 r.p.m., find the power absorbed in friction at the thrust block, assuming
- Uniform pressure and
 - Uniform wear. (6+7)

Or

- (b) A casting weighing 9 kN hangs freely from a rope which makes 2.5 turns round a drum of 300 mm diameter revolving at 20 r.p.m. The other end of the rope is pulled by a man. The coefficient of friction is 0.25. Determine :
- The force required by the man, and
 - The power to raise the casting. (6+7)
14. (a) The length of crank and connecting rod of a horizontal reciprocating engine are 100 mm and 500 mm respectively. The crank is rotating at 400 rpm when the crank has turned 30° from the inner dead centre, find analytically,
- Acceleration of the piston, (2)
 - Velocity of the piston, (3)
 - Angular velocity of the connecting rod, and (4)
 - Angular acceleration of the connecting rod. (4)

Or

- (b) The slider crank mechanism of a single cylinder diesel engine is shown in figure-3. A gas force $P = 17800 \text{ N}$ acts to the left through piston pin C. The crank rotates counter-clockwise at a constant speed of 1800 rpm. Determine (6+7)

- (i) the force F_{14} and F_{12} and the torque T_2 exerted by the crankshaft on the crank for equilibrium and
- (ii) the magnitude and direction of the shaking force and its location from point O_2 .

Take, $O_2B = 75 \text{ mm}$, $O_2G_2 = 50 \text{ mm}$, $BC = 280 \text{ mm}$, $BG_3 = 125 \text{ mm}$, $m_2 = 2.25 \text{ kg}$, $m_3 = 3.65 \text{ kg}$, $m_4 = 2.75 \text{ kg}$, $I_2 = 0.0055 \text{ kgm}^2$, $I_3 = 0.041 \text{ kgm}^2$.

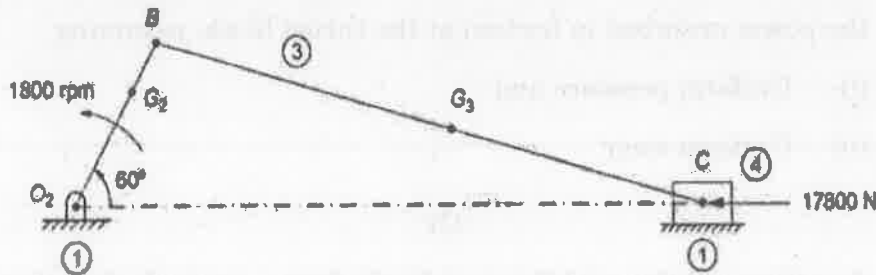


Figure-3

15. (a) A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45° , B to C 70° and C to D 120° . The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions.

Or

- (b) The mass of an electric motor is 120 kg and it runs at 1500 r.p.m. The armature mass is 35 kg and its C.G. lies 0.5 mm from the axis of rotation. The motor is mounted on five springs of negligible damping so that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the five springs.

Determine the following:

- (i) Stiffness of each spring; (5)
- (ii) Dynamic force transmitted to the base at the operating speed; and (4)
- (iii) Natural frequency of the system. (4)

PART C — (1 × 15 = 15 marks)

16. (a) In the mechanism, as shown in below figure-4, the crank OA rotates at 20 r.p.m. anticlockwise and gives motion to be sliding blocks B and D. The dimensions of the various links are OA = 300 mm; AB = 1200 mm; BC = 450 mm and CD = 450 mm.

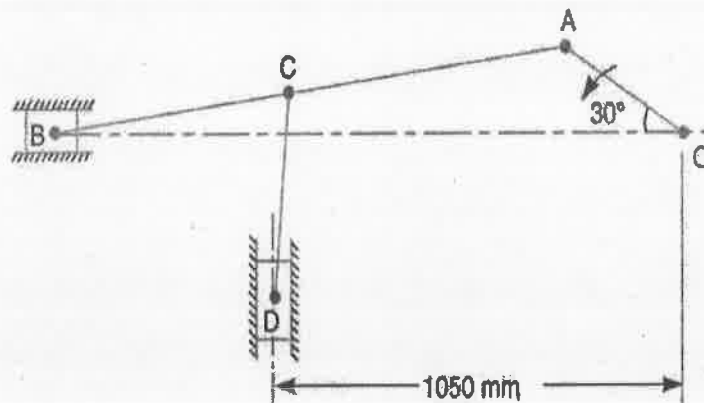


Figure-4

For the given configuration. Determine the following,

- (i) Velocities of sliding at B and D, (3)
- (ii) Angular velocity of CD, (4)
- (iii) Linear acceleration of D, and (4)
- (iv) Angular acceleration of CD. (4)

Or

(b) It is required to set out the profile of a cam to give the following motion to the reciprocating follower with a flat contact face :

- (i) Follower to have a stroke of 20 mm during 120° of cam rotation;
- (ii) Follower to dwell for 30° of cam rotation
- (iii) Follower to return to its initial position during 120° of cam rotation; and
- (iv) Follower to dwell for remaining 90° of cam rotation.

The minimum radius of the cam is 25 mm. The out stroke of the follower is performed with simple harmonic motion and the return stroke with equal uniform acceleration and retardation.



Figure 2

The cam is to be designed to give the following motion to the follower:

- (i) Follower to have a stroke of 20 mm during 120° of cam rotation;
- (ii) Follower to dwell for 30° of cam rotation
- (iii) Follower to return to its initial position during 120° of cam rotation; and
- (iv) Follower to dwell for remaining 90° of cam rotation.