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NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech

SEM: V - THEORY EXAMINATION (2025-2026)

Subject Theory of Machines

Time: 3 Hours

Max. Marks:100

General Instructions:**IMP:** Verify that you have received question paper with correct course, code, branch etc.

1. This Question paper comprises of three Sections -A, B, & C. It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.
2. Maximum marks for each question are indicated on right hand side of each question.
3. Illustrate your answers with neat sketches wherever necessary.
4. Assume suitable data if necessary.
5. Preferably, write the answers in sequential order.
6. No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.

SECTION – A

20

1. Attempt all parts:-

- 1-a. For a planar mechanism with 6 links and 7 lower pairs (single-degree) and 0 higher pairs, the degree of freedom by Gruebler's equation is: (CO1, K2) 1
- (a) 1
 - (b) 2
 - (c) 0
 - (d) 3
- 1-b. A kinematic chain is known as a mechanism when (CO1, K2) 1
- (a) None of the links is fixed
 - (b) One of the links is fixed
 - (c) Two of the links are fixed
 - (d) All of the links are fixed
- 1-c. In a radial cam, the follower moves (CO2, K2) 1
- (a) in a direction perpendicular to the cam axis
 - (b) in a direction parallel to the cam axis
 - (c) in any direction irrespective of the cam axis
 - (d) along the cam axis
- 1-d. The size of a gear is usually specified by (CO2, K2) 1
- (a) Pressure angle
 - (b) Circular pitch
 - (c) Diametral pitch
 - (d) Pitch circle diameter

1-e.	D'Alembert's principle transforms dynamic equilibrium into: (CO3, K2)	1
	(a) Static equilibrium by introducing inertia forces	
	(b) Thermal equilibrium	
	(c) Harmonic motion	
	(d) Rigid body motion only	
1-f.	The ratio of the maximum fluctuation of speed to the mean speed is called (CO3, K2)	1
	(a) Fluctuation of speed	
	(b) Maximum fluctuation of speed	
	(c) Coefficient of fluctuation of speed	
	(d) None of these	
1-g.	When the sleeve of a Porter governor moves upwards, the governor speed (CO4, K2)	1
	(a) Increases	
	(b) Decreases	
	(c) Remains unaffected	
	(d) None of the above	
1-h.	The partial balancing means (CO4, K2)	1
	(a) Balancing partially the revolving masses	
	(b) Balancing partially the reciprocating masses	
	(c) BEST balancing of engines	
	(d) All of the above	
1-i.	The gyroscopic couple C for a wheel of mass moment of inertia I rotating with spin ω and precessing at rate ω_p is: (CO5, K2)	1
	(a) $C = I \omega \omega_p$ (direction given by right hand rule)	
	(b) $C = I \omega^2 \omega_p$	
	(c) $C = I (\omega + \omega_p)$	
	(d) $C = I \omega / \omega_p$	
1-j.	The torque measured by a Prony brake is obtained from: (CO5, K2)	1
	(a) $T = (T_1 - T_2) \times \text{radius of drum} \times \text{belt tension distribution}$	
	(b) $T = \text{mean speed} \times \text{friction coefficient}$	
	(c) $T = \text{power} / \text{angular speed only}$	
	(d) $T = \text{engine RPM only}$	
2.	Attempt all parts:-	
2.a.	Explain the classification of kinematic pairs with suitable examples. (CO1, K2)	2
2.b.	State and explain the law of gearing with neat sketches. (CO2, K2)	2
2.c.	Define piston effort and crank effort. (CO3, K2)	2
2.d.	Differentiate between static and dynamic balancing. (CO4, K2)	2
2.e.	Explain the application of gyroscopic principles to aircrafts and ship. (CO5, K2)	2
	SECTION – B	30

3. Attempt all parts:-

3.a. Answer any one of the following-

3-a.i Derive Gruebler's equation for the degree of freedom of a planar mechanism. (CO1, K3) 6

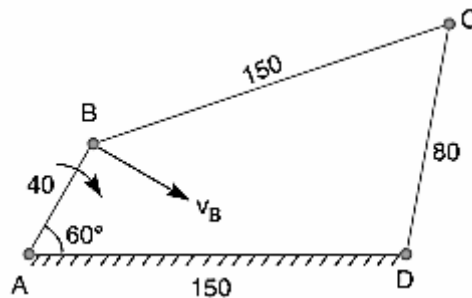
3-a.ii Explain the inversion of a single slider crank chain and discuss any two industrial applications. (CO1, K3) 6

3.b. Answer any one of the following-

- 3-b.i Define the following terms as applied to cam with a neat sketch: (CO2, K2) 6
 (a) Base circle, (b) Pitch circle, (c) Pressure angle, and (d) Stroke of the follower.
- 3-b.ii Derive an expression for the length of the arc of contact in a pair of meshed spur gears. (CO2, K3) 6
- 3.c. Answer any one of the following-
- 3-c.i Define the turning moment diagram. Draw and explain the turning moment diagram ($T - \theta$) for a 4 stroke I.C. engine during one cycle. (CO3, K2) 6
- 3-c.ii Define and derive an expression for fluctuation of energy and coefficient of fluctuation of speed for a flywheel. (CO3, K3) 6
- 3.d. Answer any one of the following-
- 3-d.i Explain the analytical method for balancing rotating masses placed in different planes. (CO4, K3) 6
- 3-d.ii Define and explain the following terms relating to governors: (CO4, K2) 6
 1. Stability, 2. Sensitiveness, 3. Isochronism, and 4. Hunting.
- 3.e. Answer any one of the following-
- 3-e.i Describe the working principle of a rope brake dynamometer. (CO5, K3) 6
- 3-e.ii What do you understand by gyroscopic couple? Derive a formula for its magnitude. (CO5, K3) 6

SECTION – C

4. Answer any one of the following- 50
- 4-a. In a four bar chain ABCD, AD is fixed and is 150 mm long. The crank AB is 40 mm long and rotates at 120 r.p.m. clockwise, while the link CD = 80 mm oscillates about D. BC and AD are of equal length. Find the angular velocity of link CD when angle BAD = 60°. (CO1, K4) 10



- 4-b. In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres is 240 mm and the length of the driving crank is 120 mm. Find the inclination of the slotted bar with the vertical in the extreme position and the time ratio of cutting stroke to the return stroke. If the length of the slotted bar is 450 mm, find the length of the stroke if the line of stroke passes through the extreme positions of the free end of the lever. (CO1, K3) 10
5. Answer any one of the following-
- 5-a. A cam is to be designed for a knife edge follower with the following data: 10
 1. Cam lift = 40 mm during 90° of cam rotation with simple harmonic motion.
 2. Dwell for the next 30°.
 3. During the next 60° of cam rotation, the follower returns to its original position with simple harmonic motion.
 4. Dwell during the remaining 180°.
 Draw the profile of the cam when the line of stroke of the follower passes through the axis of the cam shaft with a minimum radius of cam 25mm. (CO2, K4)
- 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 10

the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed, makes 300 r.p.m. in the clockwise direction, what will be the speed of gear B? (CO2, K3)

6. Answer any one of the following-

6-a. A single cylinder, single acting, four stroke gas engine develops 20 kW at 300 r.p.m. The work done by the gases during the expansion stroke is three times the work done on the gases during the compression stroke, the work done during the suction and exhaust strokes being negligible. If the total fluctuation of speed is not to exceed ± 2 per cent of the mean speed and the turning moment diagram during compression and expansion is assumed to be triangular in shape, find the moment of inertia of the flywheel. (CO3, K3) 10

6-b. The crank and connecting rod of a steam engine are 0.3 m and 1.5 m in length. The crank rotates at 180 r.p.m. clockwise. Determine the velocity and acceleration of the piston when the crank is at 40 degrees from the inner dead centre position. Also determine the position of the crank for zero acceleration of the piston. (CO3, K3) 10

7. Answer any one of the following-

7-a. Four masses m_1 , m_2 , m_3 and m_4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45° , 75° and 135° . Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m. (CO4, K3) 10

7-b. The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. The mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine the speed range of the governor. If the friction at the sleeve is equivalent of 20 N of load at the sleeve, determine how the speed range is modified. (CO4, K3) 10

8. Answer any one of the following-

8-a. The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 r.p.m. clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship when the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h. Also, explain the effect of gyroscopic couple. (CO5, K3) 10

8-b. Design a rope brake dynamometer for an engine that delivers 120 Nm at 1500 rpm for testing. Specify drum diameter, number of rope turns, brake arm length and calibration method. Compute the braking torque and the required spring/weight to hold equilibrium if single rope wrap is used. Discuss measurement errors and how to minimize them. (CO5, K4) 10