USN

21ME51

Fifth Semester B.E./B.Tech. Degree Examination, June/July 2025
Theory of Machines

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. What do you understand by inversion of kinematic chain? Explain with neat sketch inversion of single slider crank chain giving their practical application. **(10 Marks)**

b. A four bar chain has a fixed link AD = 1 m, driving crank AB = 0.3 m, follower link CD = 0.6 m and connecting link BC = 1.2 m. The crank AB rotates at a speed of 300 rpm clockwise with angular acceleration of 200 rad/sec^2 in anticlockwise direction. When the angle made by the crank with the fixed link is 135° in anticlockwise direction, determine

(i) Angular velocity of link BC and CD.

(ii) Acceleration of B and C. **(10 Marks)**

OR

2 a. Determine mobility of the mechanism shown in the Fig. Q2 (a) – (i) and Fig. Q2 (a) – (ii). **(04 Marks)**

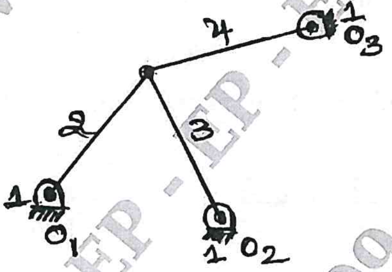

Fig. Q2 (a) – (i)

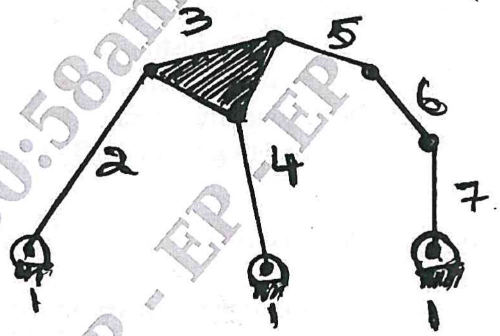

Fig. Q2 (a) – (ii)

b. State Grashoff's law. Classify kinematic pair based on nature of relative motion with neat sketches. **(06 Marks)**

c. A four bar mechanism shown in the Fig.Q2 (c) , determine the acceleration of link 3, when crank 2 rotates at 20 m/sec, $O_2O_4 = 200$ mm, $O_2A = 150$ mm, $AB = 450$mm, $O_4B = 300$mm, $O_4C = 200$ mm. **(10 Marks)**

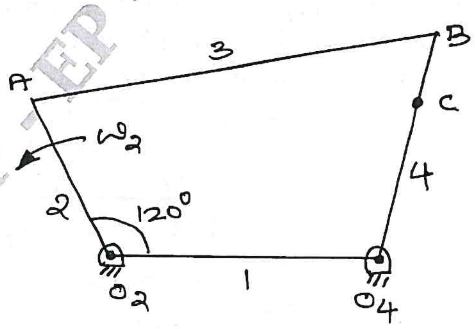

Fig. Q2 (c)

Module-2

3 a. A slider crank mechanism is shown in Fig. Q3 (a) . The force applied to the piston is 1000 N. When the crank is at 60° from TDC, calculate the driving torque T. **(10 Marks)**

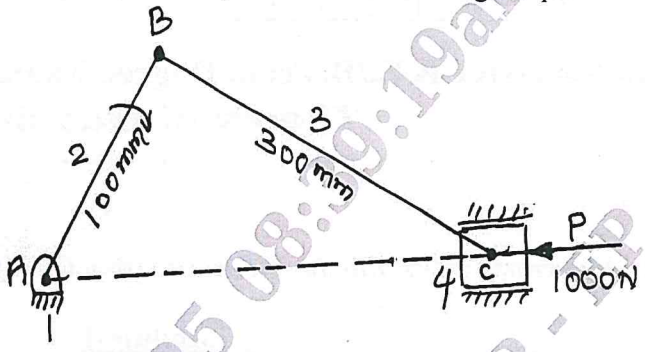

Fig. Q3 (a)

b. What is free body diagram? List any two advantages of free body diagram. **(04 Marks)**

c. State the condition for link to be in equilibrium,
   (i) When two forces act.
   (ii) When three forces act.
   (iii) When two forces and torque act. **(06 Marks)**

OR

4 a. State D'Alembert's principle. Describe application of D'Alembert's principle. **(04 Marks)**

b. What is basic principle of fly wheel? Describe application of fly wheel? **(06 Marks)**

c. When the crank is 45° from the inner dead centre on the down stroke, the effective steam pressure on the piston of a vertical steam engine is 2.5 bar. The diameter of the cylinder = 0.75 m, Stroke of the piston = 0.50 m and Length of connecting rod = 1 m. Determine the torque on the crank shaft, if engine runs at 350 rpm and mass of the reciprocating part is 200 kg. **(10 Marks)**

Module-3

5 a. Describe Addendum, Dedundum, Force flank, Pitch point, Circular pitch on a spur gear with neat sketch. **(05 Marks)**

b. List differences between involute and cycloidal tooth profile. **(05 Marks)**

c. Derive an expression to find length of path of contact with a neat sketch. **(10 Marks)**

OR

6 a. A pair of gears having 40 and 30 teeth respectively are of 25° involute form. Addendum = 5 mm, module = 2.5 mm. If the smaller wheel is the driver and rotates at 1500 rpm, find velocity of sliding at point of engagement, at pitch point and at point of dis-engagement, length of path of contact and Arc of contact. **(10 Marks)**

b. Fig. Q6 (b) shows an epicyclic gear train wheel E is fixed and wheels C and D are integrally cast and mounted on the same pin, if arm A makes one revolution per second (CCW) . Determine the speed and direction of rotation of wheel B and F. **(10 Marks)**

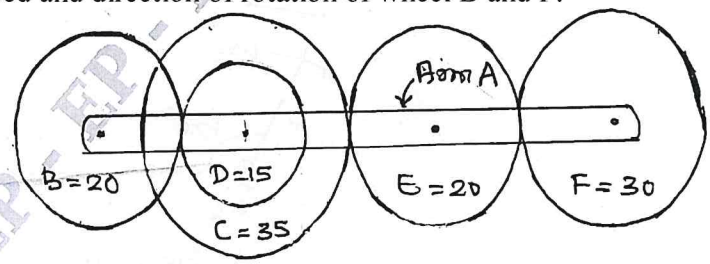

Fig. Q6 (b)

Module-4

7 a. Four masses rotating in different planes are to be arranged to give complete balance. Planes containing 'Q' and 'R' are 450 mm apart. The masses 'Q' and 'R' are at right angles to each other. 'S' makes 140° and 230° respectively with respect to 'Q' and 'R' in same sense. Find where the planes containing 'P' and 'S' should be placed and also the magnitude and angular position of mass 'P'.

Plane	Mass (kg)	Radius (m)
P	M_P	0.3
Q	200	0.5
R	300	0.2
S	225	0.4

(10 Marks)

b. Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses i.e. when $C = \frac{\ell}{2}$. **(10 Marks)**

OR

8 a. The pistons of a four cylinder vertical inline engine reach their upper most position at 90° interval in order of their axial position pitch of cylinder = 0.35 m. Crank radius = 0.12 m, Length of connecting rod = 0.42 m. The engine runs at 600 rpm. If the reciprocating parts of each engine has a mass of 2.5 kg. Find the unbalanced primary and secondary forces and couples. Take central plane of Engine as reference. **(10 Marks)**

b. Each arm of a portor governor is 300 mm long and is pivoted on the axis of the governor. Each ball has a mass of 6 kg and mass of sleeve is 18 kg. The radius of rotation of the ball is 200 mm when the governor begins to lift and 250 mm when the speed is maximum. Determine the maximum and the minimum speed and range of speed of governor. **(10 Marks)**

Module-5

9 a. Describe (i) Frequency (ii) Resonance (iii) Simple Harmonic Motion. **(06 Marks)**

b. Describe free vibration and classify free vibration. **(04 Marks)**

c. Add the following harmonic motions and check solution graphically,

$x_1 = 2\cos(\omega t + 0.5)$

$x_2 = 5\cos(\omega t + 1.0)$ **(10 Marks)**

OR

10 a. Split the harmonic motion $x = 5\sin\left(\omega t + \frac{\pi}{4}\right)$ into two harmonic motions one having phase of zero and the other of 60°. **(10 Marks)**

b. A mass of 10 kg suspended from one end of Helical spring, the other end is fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease $\frac{1}{10}^{th}$ of initial value in four complete oscillations. If a periodic force of 150cos50t N is applied at the mass with vertical direction. Find the amplitude of forced vibration. What is the value at resonance? **(10 Marks)**

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