CBCS SCHEME

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21ME51

# Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024
## 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. Define the following terms :
(i) Kinematic pair. (ii) Kinematic chain.
(iii) Mechanism (iv) Degree of freedom.
(iv) Inversion. **(05 Marks)**

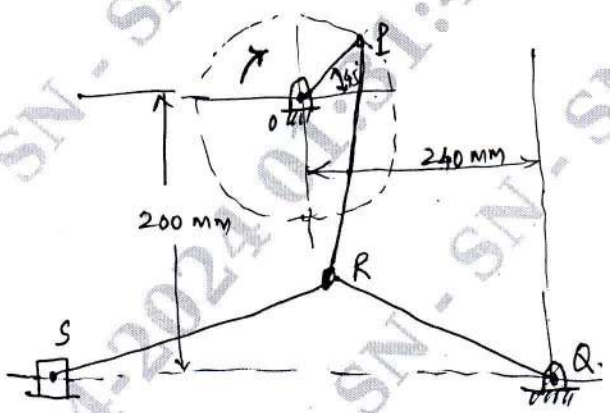
b. With neat sketch, explain any three inversions of four-bar kinematic chain. **(09 Marks)**

c. A four bar chain mechanism ABCD is made up of four links, pin jointed at the ends. AD is fixed line which is 120 mm long. The links AB, BC and CD are 60 mm, 80 mm and 80 mm respectively. At a certain instant, the link AB makes an angle of 60° with the link AD. If the link AB rotates at a uniform speed of 10 rpm clockwise, determine angular velocity of the link BC and CD. **(06 Marks)**

**OR**

2 a. Distinguish between machine and structure. (Any four) **(04 Marks)**

b. The Fig. Q2 (b) shows a toggle mechanism, Crank OP rotates at a uniform speed of 120 rpm in clockwise direction. Determine the velocity and acceleration of the slider S. The length of the various links are OP = 80 mm, PR = 180 mm, QR = 240 mm and SR = 270 mm. **(08 Marks)**




OP = 80 mm
PR = 180 mm
QR = 240 mm
SR = 270 mm

Fig. Q2 (b)

c. Using complex algebra, determine the velocity and acceleration of the piston, angular acceleration of the connecting rod of a reciprocating engine. If the crank length is 50 mm, connecting rod 200 mm, crank speed is constant at 3000 rpm and crank angle is 30°. **(08 Marks)**

### Module-2

3 a. Explain the static equilibrium of two forces, three forces and member with two forces and a torque. **(06 Marks)**

b. State D'Alemberts principle. When a crank 45° from 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 the length of the connecting rod = 1 m. Determine the torque on the crank shaft, if the engine runs at 350 rpm and the mass of reciprocating parts is 200 kg. **(06 Marks)**

c. What is fly wheel? The turning moment diagram for a multicylinder engine has been drawn to a scale of 1 mm = 600 N-m vertically and 1 mm = 3° horizontally. The intercepted areas between the output torque curve and the mean resistance line taken in order from one end are as follows : +52, −124, +92, −140, +85, −72 and +107 $mm^2$.
When the engine is running at a speed of 600 rpm, if the total fluctuation of speed is not to exceed +1.5% of the mean. Find the necessary mass of the flywheel of radius 0.5 m. **(08 Marks)**

**OR**

4 a. For the mechanism shown in Fig. Q4 (a), find the required input torque for static equilibrium. The lengths OA and AB are 250 mm and 650 mm respectively. F = 500 N.

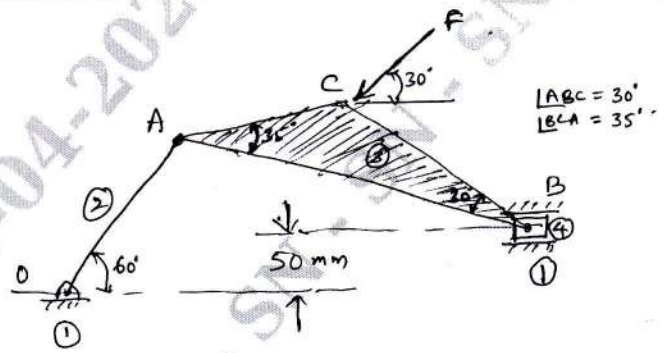



Fig. Q4 (a) **(10 Marks)**

b. The crank pin circle radius of a horizontal engine is 300 mm. The mass of reciprocating parts is 250 kg. when the crank has travelled 60° for IDC. The difference between the driving and the back pressure is 0.35 $N/mm^2$. The connecting rod length between centres is 1.2 m and the cylinder bore is 0.5 m. If the engine runs at 250 rpm and if the effect of piston rod diameter is neglected, calculate : (i) Pressure on the slide bars (ii) Thrust in the connecting rod (iii) Tangential force on the crank pin and (iv) Turning moment on the crank shaft. **(10 Marks)**

## Module-3

5 a. State law of gearing. Derive an expression for the minimum number of teeth on the pinion in order to avoid interference in involute gear teeth when it meshed with wheel. **(08 Marks)**

b. Two mating gears with module pitch 6 mm have 20 and 50 teeth of pressure angle 30° and addendum 6 mm. Determine the number of pairs of teeth in contact. **(05 Marks)**

c. What is a Gear Train? With neat sketch, explain different types of gear trains. **(07 Marks)**

**OR**

6 a. With neat sketch, explain spur gear terminology. **(06 Marks)**

b. Two 20° involute spur gears mesh externally to give a velocity ratio of 3. Module is 3 mm and the addendum is equal to 1.1 times the module. If the pinion rotates at 120 rpm ; determine ; Minimum number of teeth on each wheel to avoid interference. **(04 Marks)**

c. An epicyclic gear train consists of a sun wheel (s) a stationary internal gear (E) and the three identical planet wheel (P) carried on a star shaped planet carrier (C). The sizes of different toothed wheels are such that the planet carrier C rotates at $\frac{1}{5}$ of the speed of the sun wheel.

The minimum number of teeth on any wheel is 16. The driving torque on the sun wheel is 100 N-m. Determine :

(i) Number of teeth on different wheels of train.

(ii) Torque necessary to keep the internal gear stationary. **(10 Marks)**

## Module-4

7 a. Three masses of 8 kg, 12 kg and 15 kg attached at radial distance of 80 mm, 100 mm and 60 mm respectively to a disc on a shaft are in static balance. Determine the angular positions of masses 12 kg and 15 kg relative to 8 kg mass. **(06 Marks)**

b. Explain why only part of unbalanced forces due to reciprocating masses is balanced by revolving masses. **(06 Marks)**

c. What is a governor? Derive an expression for the equilibrium speed of a porter governor. **(08 Marks)**

**OR**

8 a. A rotating shaft carries four masses 1, 2, 3 and 4 which are radially attached to it. The mass centers are 30 mm, 38 mm, 40 mm and 35 mm respectively from the axis of rotation. The masses 1, 3 and 4 are 7.5, 5 and 4 kg respectively. The axial distance between the planes 1 and 2 is 400 mm and between 2 and 3 is 500 mm. The masses 1 and 3 are at right angles to each other. Find for complete balance

(i) Angle between 1, 2 and 1, 4
(ii) Axial distance between 3 and 4.
(iii) Magnitude of mass 2. **(10 Marks)**

b. The radius of rotation of the balls of a Hartnell Governor in 8 cm at the minimum speed of 300 rpm. Neglecting gravity effect determine the speed after the sleeve is lifted by 6 cm ; also determine the initial compression of the spring, governor effort and power. The particulars of the governor are, length of ball arm = 15 cm, Length of sleeve arm = 10 cm, Mass of each ball = 4 kg and stiffness = 25000 N/m. **(10 Marks)**

## Module-5

9 a. Define the terms : (i) Damping (ii) Damping ratio (iii) Stiffness of the spring (iv) Logarithmic decrement. **(06 Marks)**

b. Determine the natural frequency of the simple pendulum by using Newton's method. Neglecting the mass of rod. **(04 Marks)**

c. Determine the critical speed when an automobile trailer is travelling over a road with sinusoidal profile of wavelength 15 meter as shown in Fig. Q9 (c) and amplitude of 75 mm. The spring of the automobile are compressed 0.125 m under its own weight. Also determine the amplitude of vibration at 50 kmph.

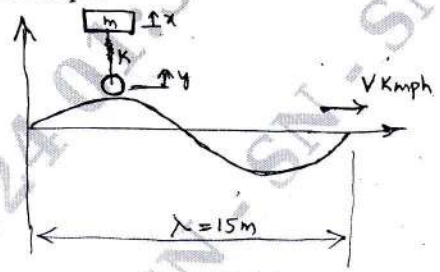



Fig. Q9 (c) **(10 Marks)**

**OR**

10 a. Derive an expression for steady state solution with viscous damping due to harmonic force. **(10 Marks)**

b. Determine the damped natural frequency for the system shown in Fig. Q10 (b). Also if m = 1.5 kg, K = 4900 N/m, a = 10 cm and b = 13 cm, determine the critical damping co-efficient 'C' for the system. **(10 Marks)**

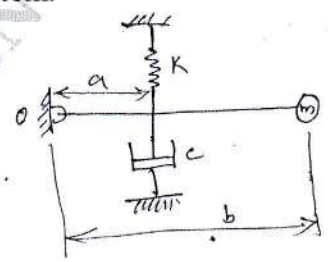



Fig. Q10 (b)