Ref. No.: Ex/ME/5/T/221/2023

BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING) SECOND YEAR SECOND SEMESTER – 2023

Subject: KINEMATIC ANALYSIS AND SYNTHESIS

Time: 3 Hrs **Full Marks: 100**

(A) Multiple Choice Questions (Answer any TEN) **10 x 1 = 10**

i. A kinematic chain is known as a mechanism when

(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

ii. According to Aronhold Kennedy's theorem, if three bodies move relatively to each other, their instantaneous centres will lie on a

(a) straight line (b) parabolic curve

(c) ellipse (d) none of these

iii. The direction of linear velocity of any point on a link with respect to another point on the same link is

(a) parallel to the link joining the points (b) perpendicular to the link joining the points

(c) at 45° to the link joining the points (d) none of these

iv. The component of the acceleration, parallel to the velocity of the particle, at the given instant is called

(a) radial component (b) tangential component

(c) coriolis component (d) none of these

v. An imaginary circle which by pure rolling action, gives the same motion as the actual gear, is called

(a) addendum circle (b) dedendum circle

(c) pitch circle (d) clearance circle

vi. Mitre gears are used for

(a) great speed reduction (b) equal speed

(c) minimum axial thrust (d) minimum backlash

vii. Involute profile is preferred to cycloidal because

(a) the profile is easy to cut

(b) only one curve is required to cut

(c) the rack has straight line profile and hence can be cut accurately

(d) none of the above

9. Draw the displacement, velocity and acceleration diagrams for a follower when it moves with simple harmonic motion. Derive the expression for velocity and acceleration during outstroke and return stroke of the follower.

(C) Answer the following questions. (Answer any THREE) **3 x 20 = 60**

10. A cam, with a minimum radius of 25 mm, rotating clockwise at a uniform speed is to be designed to give a roller follower, at the end of a valve rod, motion described below

1. To raise the valve through 50 mm during 120° rotation of the cam;
2. To keep the valve fully raised through next 30°;
3. To lower the valve during next 60°; and
4. To keep the valve closed during rest of the revolution i.e. 150°;

The diameter of the roller is 20 mm and the diameter of the cam shaft is 25 mm.

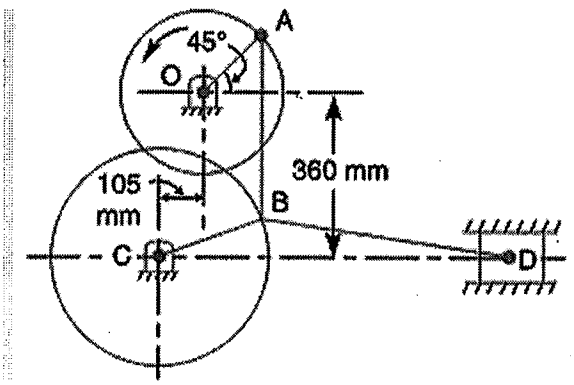
Draw the profile of the cam when

(a) the line of stroke of the valve rod passes through the axis of the cam shaft, and

(b) the line of the stroke is offset 15 mm from the axis of the cam shaft.

The displacement of the valve, while being raised and lowered, is to take place with simple harmonic motion. Draw the displacement, the velocity and the acceleration diagrams for one complete revolution of the cam. Determine the maximum acceleration of the valve rod when the cam shaft rotates at 100 r.p.m

11. In the toggle mechanism, as shown in Fig., the slider D is constrained to move on a horizontal path. The crank OA is rotating in the counter-clockwise direction at a speed of180 r.p.m. The dimensions of various links are as follows: OA = 180 mm; CB = 240 mm; AB = 360 mm; and BD = 540 mm. For the given configuration, find: 1. Velocity of slider D, 2. Angular velocity of links AB, CB and BD; 3. Velocities of rubbing on the pins of diameter 30 mm at A and D, and 4. Torque applied to the crank OA, for a force of 2 kN at D.



12. A four bar mechanism has the following dimensions:

DA =300 mm; CB = AB = 360 mm; DC = 600 mm. The link DC is fixed and the angle ADC is 60°. The driving link DA rotates uniformly at a speed of100 r.p.m. clockwise and the constant driving torque has the magnitude of 50 N-m. Determine the velocity of the point B and angular velocity of the driven link CB. Also find the actual mechanical advantage and the resisting torque if the efficiency of the mechanism is 70per cent

viii. In a simple gear train, if the number of idle gears is odd, then the motion of driven gear will

(a) be same as that of driving gear

(b) be opposite as that of driving gear

(c) depend upon the number of teeth on the driving gear

(d) none of the above

ix. A differential gear in an automobile is a

(a) simple gear train (b) epicyclic gear train

(c) compound gear train (d) none of these

x. The angle between the direction of the follower motion and a normal to the pitch curve is called

(a) pitch angle (b) prime angle

(c) base angle (d) pressure angle

xi. In a radial cam, the follower moves

(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

xii. For high speed engines, the cam follower should move with

(a) uniform velocity (b) simple harmonic motion

(c) uniform acceleration and retardation (d) cycloidal motion

(B) Short Answer Type Questions (Answer any SIX) **6 x 5 = 30**

1. Sketch and explain the various inversions of a slider crank chain.

2. Sketch and explain any two inversions of a double slider crank chain

3. State and prove the 'Aronhold Kennedy's Theorem' of three instantaneous centres.

4. Explain how the velocities of a slider and the connecting rod are obtained in a slider crank mechanism.

5. Draw the acceleration diagram of a slider crank mechanism

6. Explain briefly the differences between simple, compound, and epicyclic gear trains. What are the special advantages of epicyclic gear trains?

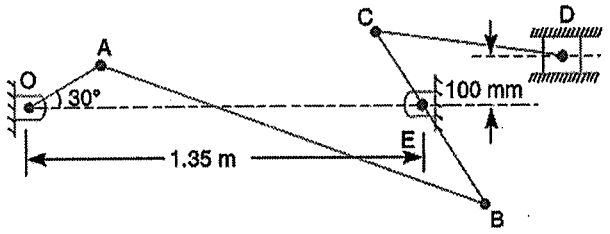
7. Explain the terms for Gear: (i) Module, (ii) Pressure angle, and (iii) Addendum

8. Define the following terms as applied to cam with a neat sketch: -

(a) Base circle, (b) Pitch circle, (c) Pressure angle, and (d) Stroke of the follower.

13. A mechanism, as shown in Fig. 6.15, has the following dimensions: OA = 200 mm; AB = 1.5 m; BC = 600 mm; CD = 500 mm and BE = 400 mm. Locate all the instantaneous centres.

If crank OA rotates uniformly at 120 r.p.m. clockwise, find 1. the velocity of B, C and D, 2. the angular velocity of the links AB, BC and CD.



14. A pair of gears, having 40 and 20 teeth respectively, are rotating in mesh, the speed of the smaller being 2000 r.p.m. Determine the velocity of sliding between the gear teeth faces at the point of engagement, at the pitch point, and at the point of disengagement if the smaller gear is the driver. Assume that the gear teeth are 20° involute form, addendum length is 5 mm and the module is 5 mm. Also find the angle through which the pinion turns while any pairs of teeth are in contact.

15. Fig. shows a Whitworth quick C return motion mechanism. The various dimension's in the mechanism are as follows: OQ = 100 mm; OA = 200 mm; QC = 150 mm; and CD = 500 mm. The crank OA makes an angle of 60° with the vertical and rotates at 120 r.p.m. in the clockwise direction.

Locate all the instantaneous centres and find the velocity of ram D.