BACHELOR IN PRODUCTION ENGINEERING SECOND YEAR FIRST SEMESTER - 2025

SUBJECT: ANALYSIS AND SYNTHESIS OF MECHANISMS

Time: 3 Hours Full Marks: 100

[*Answer any **five** taking at least **two** from each group*]

GROUP-A

(Note: All the notations used in any formula should be specified clearly to get full credit)

1. *(a) Show that the slider-crank mechanism is a modification of the basic four bar mechanism.*

(b) Sketch and explain the various inversions of a Slider-Crank mechanism.

(c) Explain with neat sketch an Elliptical-Trammel mechanism.

(d) Determine the degree of freedom of the given mechanisms as shown in Figure-1(a & b).

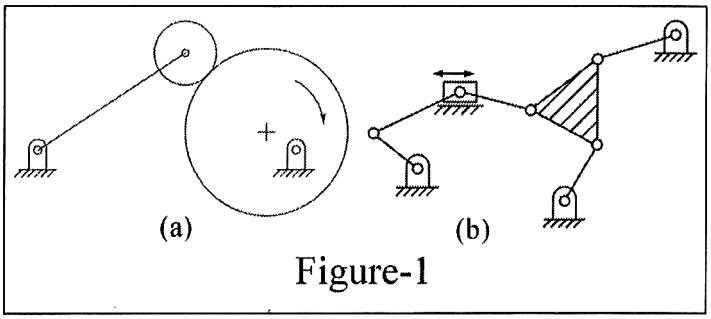

Figure-1

[3+6+5+(3+3) = 20]

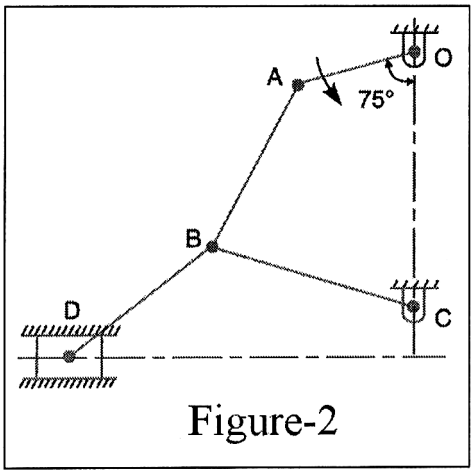

Figure-2

2. *(a) State and prove the 'Aronhold Kennedy's Theorem' of three instantaneous centres.*

(b) In the Figure-2, the angular velocity of the crank OA is 600 rpm. Determine the linear velocity of the slider D, and angular velocity of the link BD, when the crank is inclined at an angle of 75° to the vertical. The dimensions of the various links are: OA = 28 mm; AB = 44 mm; BC = 49 mm; and BD = 46 mm respectively. The centre distance between the centres of rotation O and C is 65 mm. the path of travel of the slider is 11 mm below the fixed point C. The slider moves along a horizontal path and OC is vertical.

(c) A Whitworth quick-return mechanism has been shown in Figure-3. The dimensions of the links are OP (Crank) = 240 mm, OA = 150 mm, AR = 165 mm and RS = 430 mm. The crank rotates at an angular velocity of 2.5 rad/sec counter clockwise direction. At the moment when the crank makes an angle of 45° with the vertical. Calculate-

(i) Velocity of the ram S, (ii) Velocity of the slider P on the Slotted-Lever, and (iii) Angular velocity of the link RS.

(Take convenient scale to draw the configuration diagram).

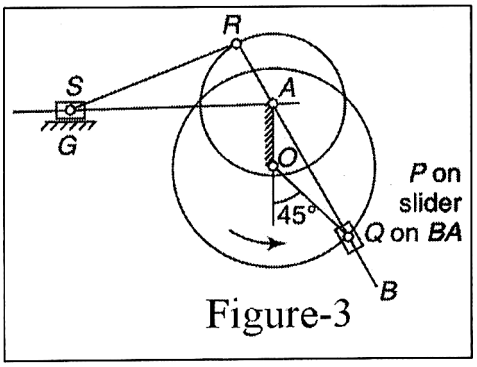

Figure-3

[5+7+8 = 20]

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3. *(a) What are centripetal and tangential components of acceleration?*

(b) In the given mechanism as shown in Figure-4, the crank OA rotates at 20 rpm counter-clockwise and gives motion to the sliding blocks B and D. The dimensions of the various links are OA = 300 mm, AB = 1200 mm, BC = CD = 450 mm. For the given configuration, determine-

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

(Take convenient scale to draw the configuration diagram).

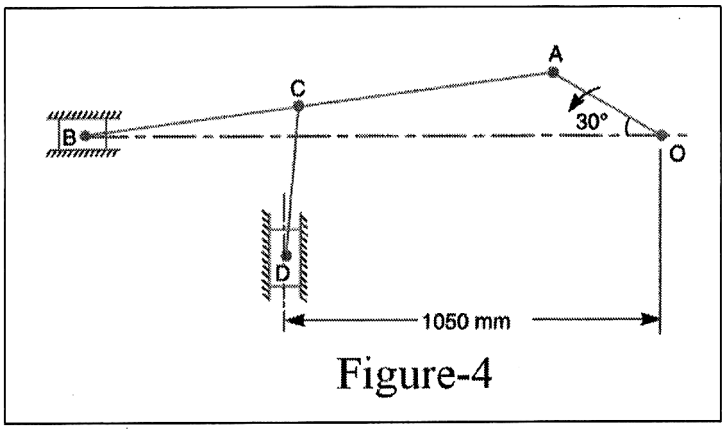

Figure-4

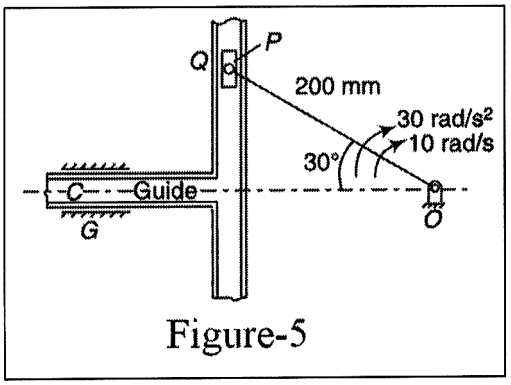

Figure-5

(c) Figure-5 shows the Scotch yoke mechanism. At the instant shown in the figure, the crank OP has an angular velocity of 10 rad/sec and an angular acceleration of 30 rad/sec^2 in the clockwise direction. Determine the acceleration of the slider P in the guide and the horizontal acceleration of the guide. (Take convenient scale to draw the configuration diagram).

[2+10+8 = 20]

4. *(a) Explain the term: Function generation and Path generation.*

(b) Describe the procedure to design a four-link mechanism by relative pole method when three positions of the input link $(\theta_1, \theta_2, \theta_3)$ *and the output link* $(\varphi_1, \varphi_2, \varphi_3)$ *are known.*

(c) Design a four-link mechanism if the motions of the input and the output links are governed by a function $y = x^{1.5}$, *and* x *varies from 1 to 4. Assume* θ *to very from* 30^0 *to* 120^0 *and* φ *from* 60^0 *to* 130^0. *The length of the fixed link is 30 mm. Use Chebychev spacing of accuracy points.*

[4+8+8 = 20]

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BACHELOR IN PRODUCTION ENGINEERING SECOND YEAR FIRST SEMESTER - 2025

SUBJECT: ANALYSIS AND SYNTHESIS OF MECHANISM

GROUP-B

(Note: All the notations used in any formula should be specified clearly to get full credit)

5. *(a) Define base circle, pitch circle, trace point, pitch curve and pressure angle in cam.*

(b) A cam with a minimum radius of 25 mm is to be designed for a knife edge follower with the following data:

i. To raise the follower through 35 mm during 60^0 *rotation of the cam,*

ii. Dwell for next 40^0 *of the cam rotation,*

iii. Descending of the follower during the next 90^0 *of the cam rotation,*

iv. Dwell during the rest of the cam rotation.

Draw the profile of the cam if the ascending and descending of the cam is with simple harmonic motion and the line of stroke of the follower is offset 10 mm from the axis of the cam shaft towards right. What is the maximum velocity and acceleration of the follower during the ascent and the descent if the cam rotates at 150 rpm? **[5+15 = 20]**

6. *(a) Derive the expression for velocity of sliding in a gear drive.*

(b) Find the minimum number of teeth on a pinion of standard addendum and 20^0 *pressure angle to avoid interference between a rack and pinion.*

(c) 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) Length of the arc of contact,

(ii) The maximum velocity of sliding. **[6+6+8 = 20]**

7. *(a) Explain with a neat sketch the 'Sun and Planet wheel'*

(b) Figure-6 shows a port indicator for a twin-screw ship. It is found that the pointer P remains stationary if the propellers runs at the same speed and drive the gears C and D in the same direction through equal gears A and B. If the number of teeth on G and F are 24 and 50 respectively, find the ratio of the number of teeth on C to that on D.

What will be the speed of the pointer if B runs at 5% faster than A and if the speed of C is 100 rpm.

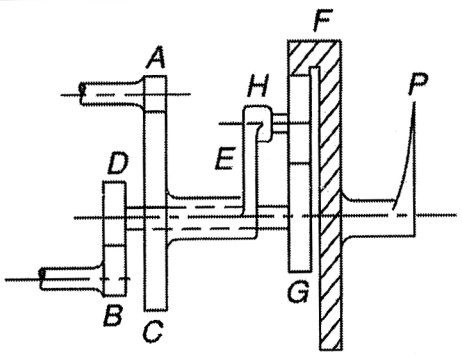

Figure-6

BACHELOR IN PRODUCTION ENGINEERING SECOND YEAR FIRST SEMESTER - 2025

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(c) Two shafts A and B are co-axial. A gear C (50 teeth) is rigidly mounted on shaft A. A compound gear D-E gears with C and an internal gear G. D has 20 teeth and gears with C and E has 35 teeth and gears with an internal gear G. The gear G is fixed and is concentric with the shaft axis. The compound gear D-E is mounted on a pin which projects from an arm keyed to the shaft B. Sketch the arrangement and finds the number of teeth on internal gear G assuming that all gears have the same module. If the shaft A rotates at 110 rpm, find the speed of shaft B. **[5+7+8 = 20]**

8. *(a) Derive an expression for the ratio of tight and slack side tensions in case of a V-belt drive.*

(b) Two pulleys, one 510 mm diameter and the other 260 mm diameter are on parallel shafts 2.15 meter apart and are connected by a crossed belt. Find the length of the belt required and the angle of contact between the belt and each pulley.

What power can be transmitted by the belt when the larger pulley rotates at 150 rpm, if the maximum permissible tension in the belt is 1 kN, and the coefficient of friction between the belt and pulley is 0.25?

(c) Two parallel shafts, connected by a crossed belt, are provided with pulleys 440 mm and 680 mm in diameters. The distance between the centre lines of the shaft is 2500 mm. Find by how much the length of the belt should be changed if it is desired to alter the direction of rotation of the driven shaft and also find the angle of lap. **[6+7+7 = 20]**

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