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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION (ONLINE) SEMESTER I SESSION 2020/2021

COURSE NAME	:	KINEMATICS MECHANISM
COURSE CODE	:	BDC 40303
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JANUARY / FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **FOUR (4)** QUESTIONS **ONLY**

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THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

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Q1 (a) You are asked to designed a compound gear for a specific purpose. The train ratio of the gear is 1:1a0 and the diametral pitch is 8. The value of a is the last digit of your matrix number. For example, a student with the matrix number CD170987 will have the value of 1a0 = 170.

(i) Specify pitch diameters and number of teeth

(12 marks)

(ii) Sketch the train to scale

(3 marks)

(b) **Figure Q1** shows a casement window opening mechanism. The gears have the following properties:

d1 = 0.7b5 in
N2 = 48 teeth and P_d = 32
N3 = 16 teeth and P_d = 32
d4 = 4.c in.

where:

b = fifth digit of your matrix number
c = forth digit of your matrix number

For example, a student with the matrix number CD170987 will have the values of 0.7b5 = 0.785 and 4.c = 4.9. Starting at the configuration shown, with $\beta = 20°$, the gear 1 rotates at a constant rate of 20 rpm to open the window.

(i) Determine the rotational velocity of gear 4 as gear 1 drives at constant rate of 20 rpm.

(7 marks)

(ii) Evaluate the distance range between the center of gear 1 and gear 4.

(3 marks)

Q2 A cam drive is used for a mechanism incorporated in a sewing machining. The cam follower must rise outward 2a mm with cycloidal motion in 0.2b s, dwell for 0.3c s, fall 10 mm with cycloidal motion in 0.3 s, dwell for 0.2 s, fall 2a - 10 mm with cycloidal motion in 0.2 s, and then repeat the sequence, where:

a = last digit of your matrix number
b = fifth digit of your matrix number
c = forth digit of your matrix number

For example, a student with the matrix number CD170987 will have the values of 2a = 27, 0.2b = 0.28 and 0.3c=0.39.

(a) Determine the required speed of the cam.

(10 marks)

(b) Graphically plot a follower displacement diagram.

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(8 marks)

(c) Evaluate the maximum velocity and acceleration of the follower.

(7 marks)

Q3 A four bar mechanism is shown in **Figure Q3**. The link AB is rotating at constant rate of 3 rad/s counterclockwise. Given the length of link AB = 0.1a m, BC = 0.19b m, CD = 0.2c m and AD = 0.3d m, where:

a = last digit of your matrix number
b = fifth digit of your matrix number
c = forth digit of your matrix number
d = second digit of your matrix number

For example, a student with the matrix number CD170987 will have the values of 0.1a = 0.17, 0.19b = 0.198, 0.2c = 0.29 and 0.3d=0.37.

(a) At the instant $\theta = 75°$,

(i) Analyze the mechanism to determine the number of instant center. Sketch the Instant center diagram.

(5 marks)

(ii) Locate all the coordinates (x,y) of instant centers of linkage. Take point A as a reference point, and

(7 marks)

(iii) Evaluate the velocity of point C, V_C.

(5 marks)

(b) If the link AB is then rotated 15° counterclockwise,

(i) Graphically reposition the links, and

(4 marks)

(ii) Evaluate the resulting angular displacement of the link BC and link CD.

(4 marks)

Q4 **Figure Q4** shows a compound planetary gear train (not to scale). Gear 6 (40 teeth) serves as the input to the train and Gear 2 (50 teeth) serves as the output. The teeth of Gear 3, 4 and 5 are 25, 45 and 30 respectively. Gear 6 rotates 2a rpm counter-clockwise and the arm rotates 5b rpm clockwise, where:

a = last digit of your matrix number
b = fifth digit of your matrix number

For example, a student with the matrix number CD170987 will have the values of 2a = 27 and 5b = 58.

(a) Propose solution steps based on superposition method. The steps should be explained briefly.

(3 marks)

(b) Analyze the rotational velocity of all members of this gear train.

(16 marks)

(c) Besides gears, cams are an extremely common component used in many machines. Evaluate the function of both components and state an example of each one.

(6 marks)

Q5 A in-line slider-crank mechanism is designed for a pick-and-place operation. Specification for the design are set as follow:

Time ratio of $Q = 1$,

Stroke of $(\Delta R_4)_{max} = 4a$ mm, and

Time per cycle of $t = 1.b$ s.

where:

a = last digit of your matrix number

b = fifth digit of your matrix number

For example, a student with the matrix number CD170987 will have the values of $4a = 47$ and $1.b = 1.8$.

(a) Construct the design based on the specification. Specify the link lengths and crank speed.

(10 marks)

(b) If the in-line slider-crank then changed to offset slider-crank mechanism since the cutting only on the forward stroke with time of ratio $Q = 1.2$. Design the offset slider-crank mechanism for the saw by maintaining the remaining specification. Specify the link lengths, offset distance and crank speed.

(12 marks)

(c) Evaluate your answer in **Q5 (a)** and **(b)**.

(3 marks)

-END OF QUESTIONS –

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SEMESTER / SESSION : SEM I / 2020/2021
COURSE NAME: KINEMATICS MECHANISM

PROGRAMME CODE : BDD
COURSE CODE : BDC 40303

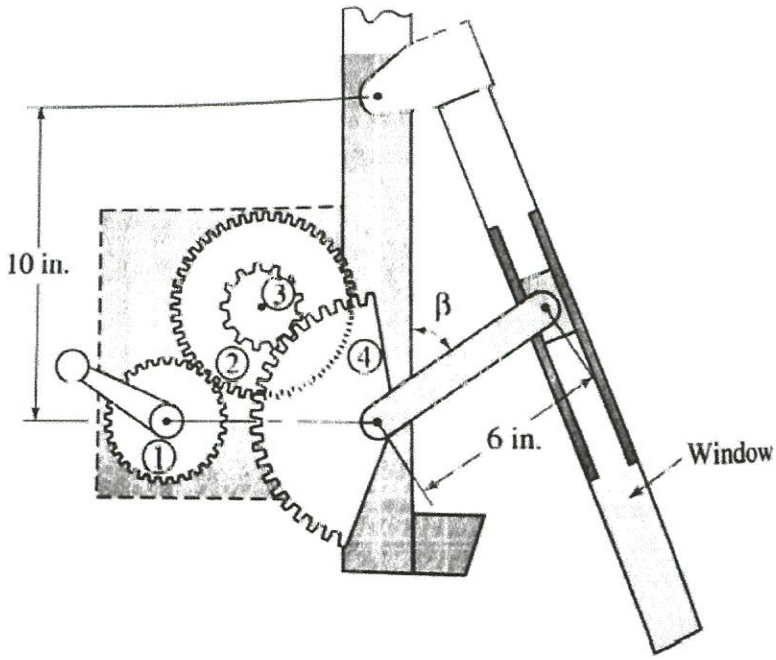

Figure Q1

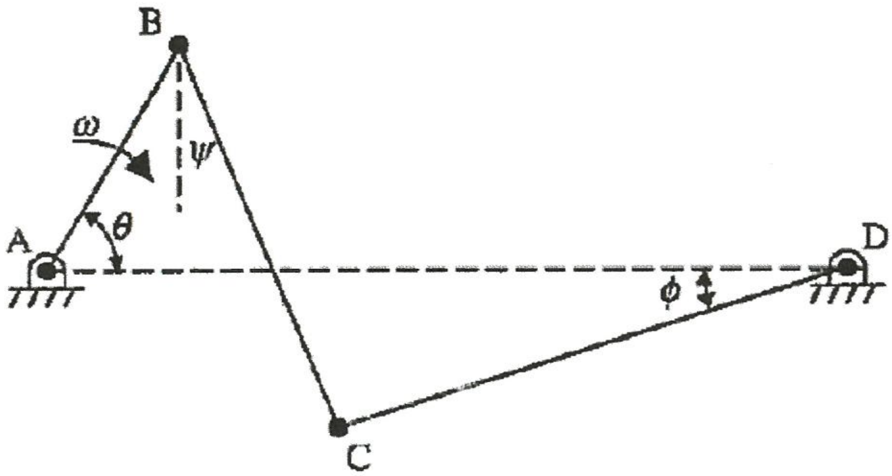

Figure Q3

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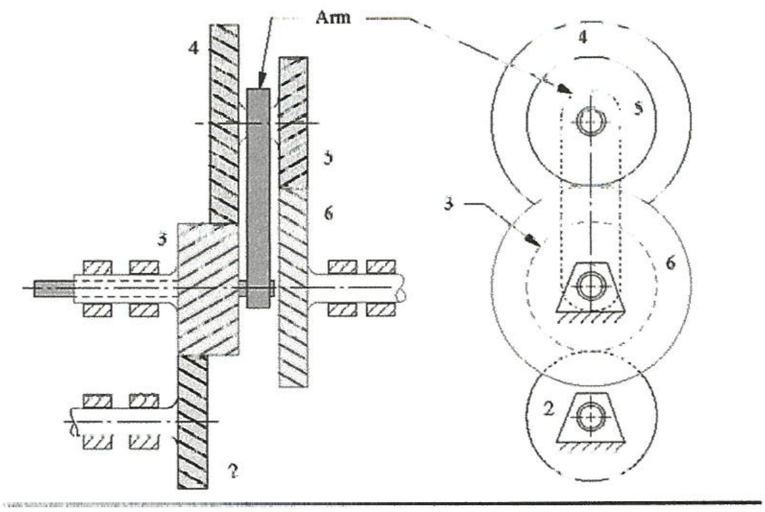

Figure Q4

Appendix for Q2: Cam Follower Kinematics for Cycloidal Motion

(Rise)

Displacement:

$$\Delta R_i = H_0 + H_i\left[\frac{t_i}{T_i} - \frac{1}{2\pi}\sin\left(\frac{2\pi t_i}{T_i}\right)\right]$$
$$= H_0 + H_i\left[\frac{\phi_i}{\beta_i} - \frac{1}{2\pi}\sin\left(\frac{2\pi\phi_i}{\beta_i}\right)\right]$$

Velocity:

$$v_i = \frac{H_i}{T_i}\left[1 - \cos\left(\frac{2\pi t_i}{T_i}\right)\right] = \frac{H_i\omega}{\beta_i}\left[1 - \cos\left(\frac{2\pi\phi_i}{\beta_i}\right)\right]$$

Acceleration:

$$a_i = \frac{2\pi H_i}{T_i^2}\left[\sin\left(\frac{2\pi t_i}{T_i}\right)\right] = \frac{2\pi H_i\omega^2}{\beta_i^2}\left[\sin\left(\frac{2\pi\phi_i}{\beta_i}\right)\right]$$

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Appendix for Q2: Cam Follower Kinematics for Cycloidal Motion

(Drop)

Displacement:

$$\Delta R_j = H_F + H_j\left[1 - \frac{t_j}{T_j} + \frac{1}{2\pi}\sin\left(\frac{2\pi t_j}{T_j}\right)\right]$$

$$= H_F + H_j\left[\frac{\phi_j}{\beta_j} - \frac{1}{2\pi}\sin\left(\frac{2\pi\phi_j}{\beta_j}\right)\right]$$

Velocity:

$$v_j = \frac{H_j}{T_j}\left[1 - \cos\left(\frac{2\pi t_j}{T_j}\right)\right] = \frac{H_j\omega}{\beta_j}\left[1 - \cos\left(\frac{2\pi\phi_j}{\beta_j}\right)\right]$$

Acceleration:

$$a_j = \frac{-2\pi H_j}{T_j^2}\left[\sin\left(\frac{2\pi t_j}{T_j}\right)\right] = \frac{-2\pi H_j\omega^2}{\beta_j^2}\left[\sin\left(\frac{2\pi\phi_j}{\beta_j}\right)\right]$$