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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

TERBUKA

COURSE NAME	:	KINEMATICS MECHANISM
COURSE CODE	:	BDC 40303
PROGRAMME	:	BDD
DATE	:	DECEMBER 2016/JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTIONS	:	PART A: ANSWER **ALL** QUESTIONS PART B: ANSWER **ONE** QUESTION **ONLY**

THIS PAPER CONSIST OF **SEVEN (7)** PAGES

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PART A: Answer **ALL** questions.

Q1 **Figure Q1** shows a James Watt's sun and planet drive that he used in his steam engine.

(a) Draw the kinematic diagram of the mechanism. Label clearly all the links and joints on the mechanism.

(5 marks)

(b) Identify number of links and joints exist in the mechanism.

(5 marks)

(c) Determine the degree of freedoms of the mechanism.

(3 marks)

(d) If you are asked to replace the sun and planet drive with a link, what kind of link will you propose? Why. Support your answer with some calculation and sketch.

(7 marks)

Q2 A kinematics diagram for a stamping mechanism is shown in **Figure Q2**. The link 2 is rotating at constant rate of 2 rad/s counterclockwise.

(a) At the instant $\theta_2 = 75°$,

(i) Find all the coordinates (x,y) of all points. Take point A as a reference point, and

(ii) Determine the velocity of point C, V_C.

(10 marks)

(b) If link 2 is rotated 10° counterclockwise,

(i) Graphically reposition the links, and

(ii) Determine the resulting angular displacement of the link 3 and link 4.

(10 marks)

Q3 Slider-crank mechnism is mainly used to convert rotary motion to a reciprocating motion or vice versa. There are mainly **two (2)** types of slider-crank mechanisms.

(a) State and sketch the **two (2) types** of slider crank mechanism.

(2 marks)

(b) Sketch the full motion of the two types of mechanisms in **Q3(a)** (use an approriate dimensions for each link). Give the relationship between the crank angle and position limits of slider. Specify the appropriate use for each type of mechanism.

(8 marks)

(c) Refer to **Figure Q3**, known that the slider constraint is vertical direction and the crank rotates point A with a constant angular velocity $\omega = 15$ rad/s clockwise.

(i) Determine the vertical displacement of the slider between two limiting positions.

(ii) When the $\theta = 0°$, determine the center of instantaneous velocity and angular velocity of the coupler.

(10 marks)

Q4 The parameters to define the follower motions according to Sine Constant Cossine Acceleration (SCCA) are b, c, d and c_a as tabulated in **Table 4**. The rising function has been coded in SMath, as shown in **Figure Q4** that can be used to plot the SCCA function.

(a) If you want to investigate several functions as listed in the **Table 4** below:

Table Q4: SCCA parameter values

Function	b	c	d	Ca
Constant acceleration	0.00	1.00	0.00	4.0000
Modified trapezoid	0.25	0.50	0.25	4.8881
Simple harmonic	0.00	0.00	1.00	4.9348
Modified sine	0.25	0.00	0.75	5.5280
Cycloidal displacement	0.50	0.00	0.50	6.2832

Propose the SMath plot employing the SMath code to compare the follower motions of different functions in a single plot.

(10 marks)

(b) By looking at the codes, explain the displacement zones of SCCA function.

(5 marks)

(c) Explain in brief how to modify the codes for falling motion of SCCA function. Give an example for the first zone only.

(5 marks)

PART B : Answer **ONE** question **ONLY.**
(Q5 and Q6 use the same Figure Q5)

Q5 The horizontal component velocity of the connecting rod (point 2) of an engine are recorded and presented in **Figure Q5**.

(a) The force acting on the bearing of the connecting rod will be investigated. You are required to propose a methodology to do the investigation of the force related to the acceleration. Explain your proposal to do the investigation, write down the equation involved for the force investigation.

(5 marks)

(b) Based on the velocity data, predict the positive and negative **zones** of acceleration.

(5 marks)

(c) Based on your proposed methodology in (a), calculate the acceleration when time 1s, 10s and 35s. Briefly explain how you can verify the calculation results related to the positive/negative zones of the acceleration.

(8 marks)

(d) In **tabular method** of gear analysis, propose three steps approach to find the rotational direction and the values of all gears.

(2 marks)

Q6 The horizontal component velocity of the connecting rod (point 2) of an engine are recorded and presented in **Figure Q5**. The crank engine rotates at 3.316 RPM constant.

(a) If you want to simulate the mechanism using SAM, what is the values in the input motion for the parameters: ***Motion***, ***Time*** and ***Interval***. Plot also the angle, angular velocity and angular acceleration. Make sure you mention the units.

(5 marks)

(b) Based on the engine illustration as shown in **Figure Q5**, draw an kinematics illustration of crank slider mechanism.

(5 marks)

(c) If the length of crank is L1 and the connecting rod is L2, propose an equation to calculate the velocity of the piston based on floating link analysis. The crank rotates ω counter clock wise direction. Assume all angles are variables.

(8 marks)

(d) In **tabular method** of gear analysis, propose three steps approach to find the rotational direction and the values of all gears.

(2 marks)

- END OF QUESTION -

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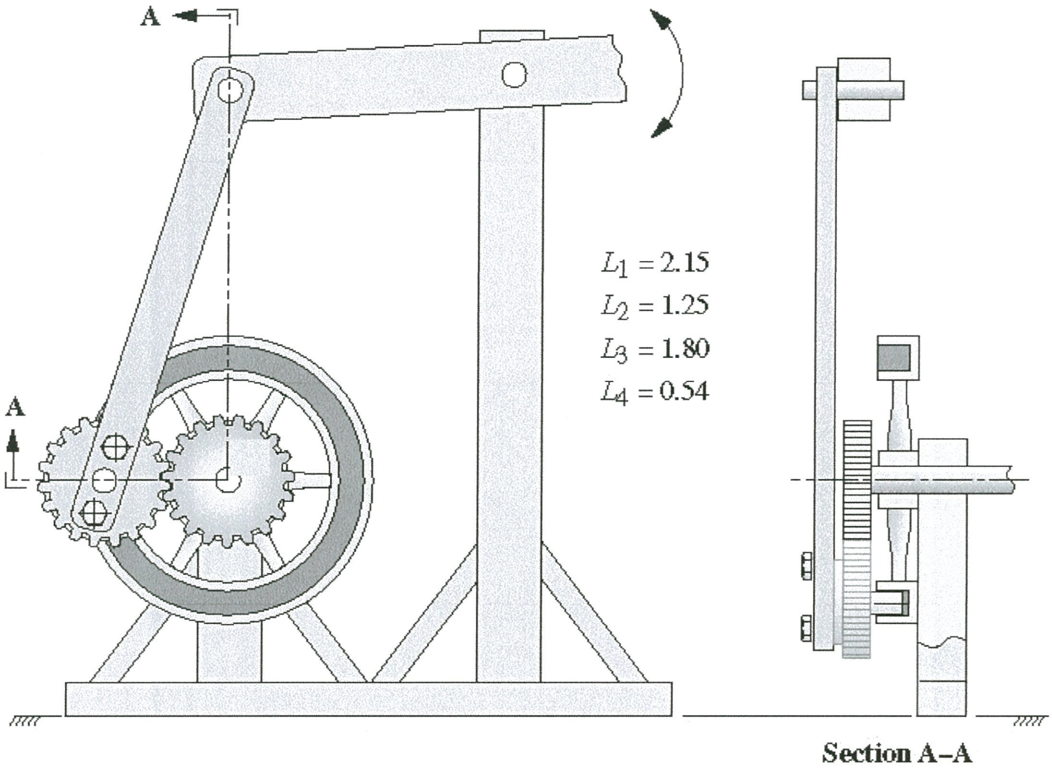

Figure Q1

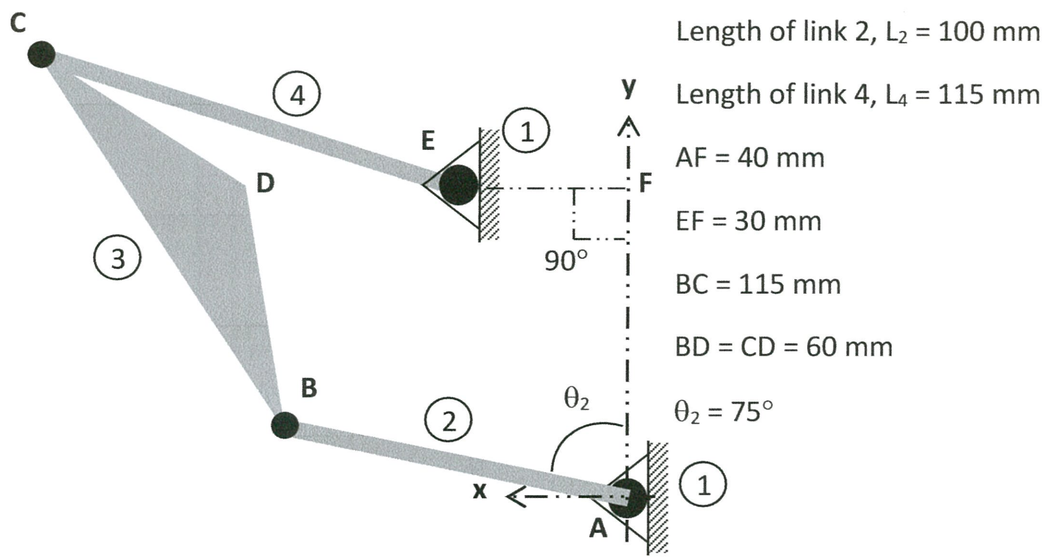

Figure Q2

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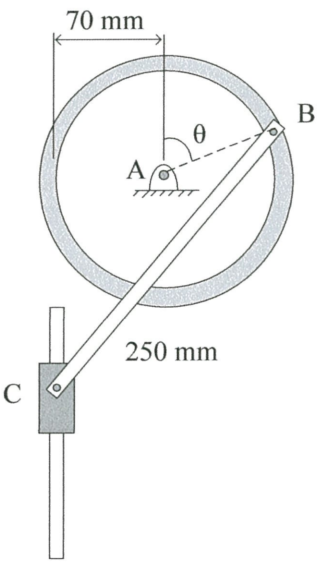

Figure Q3

$$
\begin{aligned}
\Delta R(\theta, b, c, d, C_a) := &\ \text{if } \left(\theta \le \frac{b}{2}\cdot\beta\right) \wedge (b \ne 0) \wedge (\theta > 0) \\
&\quad C_a \cdot H_i \cdot \left[\frac{b}{\pi\cdot\beta}\cdot\theta - \left(\frac{b}{\pi}\right)^2 \cdot \sin\left(\frac{\theta}{b\cdot\beta}\cdot\pi\right)\right] \\
&\ \text{else} \\
&\quad \text{if } \left(\theta \ge \frac{b}{2}\cdot\beta\right) \wedge \left(\theta \le \frac{1-d}{2}\cdot\beta\right) \\
&\quad\quad C_a \cdot H_i \cdot \left[\frac{\theta^2}{2\cdot\beta^2} + b\cdot\left(\frac{1}{\pi} - \frac{1}{2}\right)\cdot\frac{\theta}{\beta} + b^2\cdot\left(\frac{1}{8} - \frac{1}{\pi^2}\right)\right] \\
&\quad \text{else} \\
&\quad\quad \text{if } \left(\theta \ge \frac{1-d}{2}\cdot\beta\right) \wedge \left(\theta \le \frac{1+d}{2}\cdot\beta\right) \wedge (d \ne 0) \\
&\quad\quad\quad C_a \cdot H_i \cdot \left[\left(\frac{b}{\pi} + \frac{c}{2}\right)\cdot\frac{\theta}{\beta} + \left(\frac{d}{\pi}\right)^2 + b^2\cdot\left(\frac{1}{8} - \frac{1}{\pi^2}\right) - \frac{(1-d)^2}{8} - \left(\frac{d}{\pi}\right)^2\cdot\cos\left[\frac{\pi}{d}\cdot\left[\frac{\theta}{\beta} - \left(\frac{1-d}{2}\right)\right]\right]\right] \\
&\quad\quad \text{else} \\
&\quad\quad\quad \text{if } \left(\theta \ge \frac{1+d}{2}\cdot\beta\right) \wedge \left[\theta \le \left(1 - \frac{b}{2}\right)\cdot\beta\right] \\
&\quad\quad\quad\quad C_a \cdot H_i \cdot \left[-\frac{\theta^2}{2\cdot\beta^2} + \left(\frac{b}{\pi} + 1 - \frac{b}{2}\right)\cdot\frac{\theta}{\beta} + \left(2\cdot d^2 - b^2\right)\cdot\left(\frac{1}{\pi^2} - \frac{1}{8}\right) - \frac{1}{4}\right] \\
&\quad\quad\quad \text{else} \\
&\quad\quad\quad\quad \text{if } \left[\theta \ge \left(1 - \frac{b}{2}\right)\cdot\beta\right] \wedge (\theta \le \beta) \wedge (b \ne 0) \\
&\quad\quad\quad\quad\quad C_a \cdot H_i \cdot \left[\frac{b\cdot\theta}{\pi\cdot\beta} + 2\cdot\frac{\left(d^2 - b^2\right)}{\pi^2} + \left[\frac{(1-b)^2 - d^2}{4}\right] - \left(\frac{b}{\pi}\right)^2\cdot\sin\left[\frac{\pi}{b}\cdot\left(\frac{\theta}{\beta} - 1\right)\right]\right] \\
&\quad\quad\quad\quad \text{else} \\
&\quad\quad\quad\quad\quad 0
\end{aligned}
$$

Figure Q4

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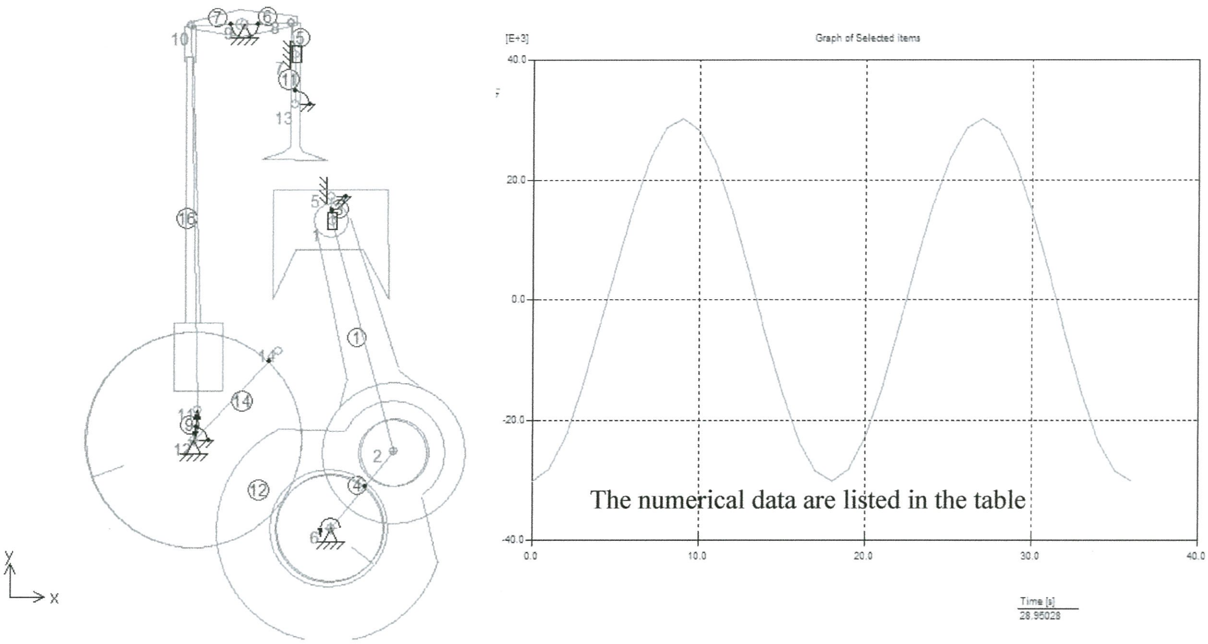

Result listing SAM 6.1.55 . Mechanism: MOTOR

Nr: [-]	Time [s]	Vx(2) [mm/s]	Nr: [-]	Time [s]	Vx(2) [mm/s]
0	0	-30227.412			
1	1	-28193.613	19	19	-28228.2
2	2	-22762.66	20	20	-22825.9
3	3	-14588.949	21	21	-14673.2
4	4	-4657.361	22	22	-4752.45
5	5	5835.41	23	23	5740.927
6	6	15625.051	24	24	15542.56
7	7	23531.971	25	25	23471.41
8	8	28603.435	26	26	28572.11
9	9	30228.365	27	27	30230.04
10	10	28210.966	28	28	28245.44
11	11	22794.322	29	29	22857.45
12	12	14631.105	30	30	14715.27
13	13	4704.932	31	31	4800
14	14	-5788.156	32	32	-5693.64
15	15	-15583.808	33	33	-15501.2
16	16	-23501.709	34	34	-23441
17	17	-28587.8	35	35	-28556.3
18	18	-30229.24	36	36	-30230.8

Figure Q5

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