

Student Name: Student Number: Serial Number:

Second exam, second semester: 2016/2017 Mechanical Engineering Department

Course Title: theory of machines Course No: 620333 Lecturer: Eng. Laith Batarseh Date: 2 /1/2017 Time: 50min No. of pages: 4

○ Sun, Thu and Tue 12:10 – 1:00

○ Mon and Wed 12:45 – 2:15

Instructions:

ALLOWED: Non-programmable calculator, pens and drawing tools (no red color).

- NOT ALLOWED: Papers, literatures and any handouts. Otherwise, it will lead to the non-approval
 of your examination.
- Shut down Telephones, and other communication devices.
- Please note:
- Write your name and your matriculation number on every page of the solution sheets.
- All solutions together with solution methods (explanatory statement) must be inserted in the labeled position on the solution sheets.
- Support your answer with diagrams, equations and examples when possible
- You can submit your exam after the first ½ hour.
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Question 1:

General concepts

Chose the correct answer for the short questions in page 2 and fill the table given in page 1 of 4 with your answers. Use the symbol (X).

Ans/Q	1	2	3	4	5	6	7	8
a		X						
b	X				×		X	X
С				×		X		
d			Х					
е								

Page 1 of 4

(8marks)

Philadelphia Universi Faculty of Engineerin		Student N Student N Serial Nu	lumber:
Question 1: ^{continu}			(8marks)
1. A mechanism has 4 lir	iks will has a number of ins	tantaneous centers equal	
a. 15 (b.)	c.21	d.10	e. none of the previous
2. For the four bar meel	nanism shown in the		3
fig. if $\omega_2 = 1200$ RPM	M , $O_2 k = 40 cm$ and		
$O_4 k = 80 cm$. find the a	ingular speed of link	and the second	4 bar mech.
4 (ω ₄) in RPM	k	2	
0	x=0	4	itte itte
(a.)600 b. 150		d.1200	e. none of the previous
0	ngth equal 50cm and rotate	s about one of its joints by	y angular speed equal 50
	locity in m/s will equal	0	
a. 100 b.50	c.200	(d.25	e. none of the previous
	about one of its joints at a o	constant angular speed eq	ual 10 rad/s. then the
magnitude of its accel			
a. 3750 b. 13		d.600	e. none of the previous
	<u>statically</u> . If the force at one	e of its joints is :- 5i+ 7j, tl	he Cartesian vector for
the force in the other			
a5i + 7j 🛛 🜔 5i -	– 7j c7i +5j	d.7i – 5j	e. none of the previous
The flowing data are for			
When a cam rotates wit	h speed equal 600 RPM f	rom 0° to 90° it makes t	he follower to raise in
SHM from 0cm to 4cm.			
6. Find the follower disp	lacement at cam angle equa	d 45°.	
a. 3.72 cm b. 3.0	0 cm (c.)2.00 cm	d. 1.00 cm	e. none of the previous
7. Find the follower velo	city at cam angle equal 45°.	round the solution to two	decimal digits.
a. 3.15 m/s (b.)2.5	1 m/s c. 2.17 m/s	d. 1.26 m/s	e. none of the previous
8. An eccentric cam has	eccentricity (e) = 10 cm, fin	d the displacement at ang	$le = 180^{\circ}$.
a. 15.0 cm (b)20.	17.16 2018 80	d. 5.0 cm	e. none of the previous

This space can be used for the calculations in problem 1 and it will not be considered as a solution.

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Ans/Q	1	2	3	4	5	6	7	8
a				X		X		
b								
С			X					
d	Х	Х			X		X	X
е								

(8marks)

Philadelphia University Student Name: Faculty of Engineering Student Number: Serial Number: Question 1:continu (8marks) 1. A mechanism has 5 links will has a number of instantaneous centers equal (d.)0 e. none of the previous a. 15 b. 6 c.21 2. For the four bar mechanism shown in the 3 fig. if $\omega_2 = 2400$ RPM, $O_2 k = 40$ cm and $O_4 k = 80 cm$. find the angular speed of link 4 har mech 2 4 (ω_4) in RPM 1-1 d 2200 e. none of the previous b. 150 c.300 a. 600 3. A rigid bar link has length equal 50cm and rotates about one of its joints by angular speed equal 400 rad/s. its tangential velocity in m/s will equal b.50 c.200 d.25 e. none of the previous a. 100 4. a 1.5m bar link rotate about one of its joints at a constant angular speed equal 50 rad/s. then the magnitude of its acceleration equal in m/s²: e. none of the previous b. 1350 c.150 d.600 a. 3750 a bar link is analyzed statically. If the force at one of its joints is :-7i + 5j, the Cartesian vector for the force in the other joint will be d)7i – 5j c.-7i+5j e. none of the previous a. -5i + 7j b. 5i – 7j The flowing data are for questions 6 and 7: When a cam rotates with speed equal 600 RPM from 0° to 90° it makes the follower to raise in SHM from 0cm to 4cm. 6. Find the follower displacement at cam angle equal 75°. e. none of the previous a. B.72 cm b. 3.00 cm c. 2.00 cm d. 1.00 cm 7. Find the follower velocity at cam angle equal 75° .round the solution to two decimal digits. c. 2.17 m/s d. 1.26 m/s e. none of the previous a. 3.15 m/s b. 2.51 m/s 8. An eccentric cam has eccentricity (e) = 10 cm, find the displacement at angle = 300° . d. 5.0 cm e. none of the previous b. 20.0 cm c.13.4 cm a. 15.0 cm

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Ans/Q	1	2	3	4	5	6	7	8
а	Х				X			X
b			X					
с		X					X	
d				X		X		
е								

Philadelphia Univ Faculty of Engine				Student Name: Student Number: Serial Number:
Question 1: ^{continu}		complete the second		(8marks)
1. A mechanism has	6 links will has a	number of instanta	neous cent	ters equal
		c.21	d.10	e. none of the previous
2. For the four bar	mechanism shown	in the		89
fig. if $\omega_2 = 600$ RI	$PM, O_2k = 40cm a$	nd O₄k		
= 80cm. find the	angular speed of	link 4		4 bar mech.
(ω ₄) in RPM		k		$2 O_2 O_4$
0.0500			1 1 2 0 0	in in
	o. 150 (C.B 00	d.1200	e. none of the previous
			ut one of i	ts joints by angular speed equal 100
	al velocity in m/s v		105	f the second second
a. 100	5.50	c.200	d.25	e. none of the previous
			int angula	r speed equal 20 rad/s. then the
	acceleration equal		1000	64
	b. 1350	c.150	(d.600	e. none of the previous
56-51 C	A	he force at one of its	s joints is :	: 5i – 7j, the Cartesian vector for the
force in the other			1	
	5. 5i – 7j	c7i +5j	d.7i – 5	j e. none of the previous
The flowing data an				
When a cam rotates	s with speed equa	al 600 RPM from	0° to 90° i	it makes the follower to raise in
SHM from 0cm to 4				
6. Find the follower	displacement at c		-	
	o. 3.00 cm	c. 2.00 cm	d 1.00	
7. Find the follower	velocity at cam ar			tion to two decimal digits.
	o. 2.51 m/s	©2.17 m/s	d. 1.26	
8. An eccentric cam	has eccentricity (tent at angle = 120° .
(a) 15.0 cm b	o. 20.0 cm	c.13.4 cm	d. 5.0 c	e. none of the previous

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Ans/Q	1	2	3	4	5	6	7	8
а			X					
b		X		X		X		
С	X				×		X	X
d								
е								

(8marks)

Philadelphia U Faculty of Eng			Student Student Serial N	Number:
Question 1: ^{con}	tinu			(8marks)
1. A mechanism	has 7 links will ha	s a number of insta	antaneous centers equa	T
a. 15	b. 6	\mathcal{O}_{21}	d.10	e. none of the previous
	bar mechanism sho	own in the		3
	$0 \text{ RPM, } \mathbf{O}_2 \mathbf{k} = 40 \text{ cr}$			
•	the angular speed		and the second	1
(ω ₄) in RPM	8 1	k	2	$4_{\text{bar mech.}}$
5 20	\frown		7	thi th
a. 600	(b.)150	c.300	d.1200	e. none of the previous
			about one of its joints	by angular speed equal 200
	ential velocity in m	/s will equal		
a. 100	b.50	c.200	d.25	e. none of the previous
			onstant angular speed e	equal 30 rad/s. then the
	its acceleration equ			
a. 3750	b .1350	c.150	d.600	e. none of the previous
		If the force at one	of its joints is :7i – 5j, t	he Cartesian vector for the
	ther joint will be			
a5i + 7j	b. 5i – 7j	6 -7i +5j	d.7i – 5j	e. none of the previous
The flowing dat	a are for question	is 6 and 7:		
When a cam rot	tates with speed e	qual 600 RPM fro	om 0° to 90° it makes	the follower to raise in
SHM from 0cm	to 4cm.			
6. Find the follo	wer displacement a	at cam angle equal	60°.	
a. 3.72 cm	(b)3.00 cm	c. 2.00 cm	d. 1.00 cm	e. none of the previous
7. Find the follo	wer velocity at cam	angle equal 60° .r	ound the solution to tw	and a second
a. 3.15 m/s	b. 2.51 m/s	(c.)2.17 m/s	d. 1.26 m/s	e. none of the previous
8. An eccentric	cam has eccentricit		the displacement at an	$gle = 250^{\circ}$.
a. 15.0 cm	b. 20.0 cm	c.13.4 cm	d. 5.0 cm	e. none of the previous

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Question 2:

(6 marks)

Consider the following loop closure equation for four bar mechanism and the given data in the table:

Qunt.	d ₁	d ₂	d ₃	d ₄	Θ_2	θ ₃	θ4	ω2	ω3	ω4
value	0.9	0.2	0.7	0.5	60	25	110	300	?	?
Unit	m	m	m	m	Degree	Degree	Degree	RPM	RPM	RPM

 $d_1 U_0 + d_4 U_{\theta 4} = d_3 U_{\theta 3} + d_2 U_{\theta 2}$

1. Derive an expression to find ω_3 and ω_4

2. Substitute the values in table to find ω_3 and ω_4

1.
$$d_2\omega_2 U_{\theta 2} + d_3\omega_3 U_{\theta 3} = d_4\omega_4 U_{\theta 4}$$

Dot product both sides by $U_{\theta 3}$ to eliminate ω_3

$$d_2\omega_2\sin(\theta_3-\theta_2)+0=d_4\omega_4\sin(\theta_3-\theta_4)$$

Solve for ω_4 : $\omega_4 = \frac{d_2\omega_2\sin(\theta_3 - \theta_2)}{d_4\sin(\theta_3 - \theta_4)}$

To find ω_3 , dot product both sides of derivative equation by U₀₄ to eliminate ω_4 :

$$d_2 \omega_2 \sin (\theta_4 - \theta_2) + d_3 \omega_3 \sin(\theta_4 - \theta_3) = 0$$

Solve this equation for ω_3 :- $\omega_3 = -\frac{d_2\omega_2\sin(\theta_4 - \theta_2)}{d_3\sin(\theta_4 - \theta_3)}$

2. substitute the values from table

$$\omega_{3} = -\frac{(0.2)(300)\sin(110-60)}{0.7\sin(110-25)} = -65RPM = -66.9 \text{ Rad}$$

$$\omega_{4} = \frac{(0.2)(300)\sin(25-60)}{0.5\sin(25-100)} = 69RPM = -7.27 \text{ Pad}$$

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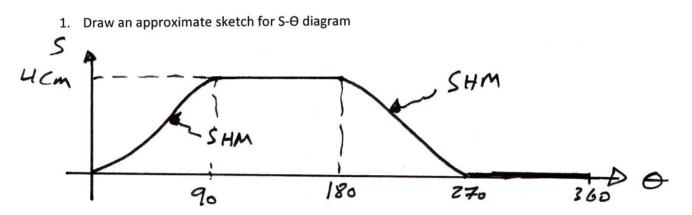
Student Name: Student Number: Serial Number:

Question 3:

(6 marks)

Assume a cam has basic radius of 6cm and has the following follower program

- \Box 0 \rightarrow 90° : SHM rise to 4cm
- $\square \quad 90^{\circ} \rightarrow 180^{\circ} : \text{Dwell}$
- \square 180° \rightarrow 270° : SHM return to 0
- \Box 270° \rightarrow 360° : Dwell



2. Complete the following table and show all the calculations you used to find these values

For SHM:
$$s(\theta) = \frac{H}{2} \left(1 - \cos\left(\frac{\pi\theta}{\beta}\right) \right)$$

For 45 degree: H = 4cm, β =90°, Θ =45

$$s(45) = \frac{0.04}{2} \left(1 - \cos\left(\frac{\pi 45}{90}\right) \right) = 0.02m$$

r_c = r_b + s = 2cm + 10cm = 12 cm

For 225 degree: H = 4cm, $\beta = 90^{\circ}$, $\Theta = 225-180=45$

 $s(225) = 4 - \frac{0.04}{2} \left(1 - \cos\left(\frac{\pi 45}{90}\right) \right) = 0.02m$ r_c = r_b + s = 2cm + 10cm = 12 cm

	Follower	Cam	
Cam angle (degree)	disp. (m)	radius (cm)	
45	0.02	128	
225	0.02	128	

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Theory of machines data sheet

Student name:_____ Reg. No:_____

$$\begin{split} S &= 2H \left(\frac{\theta}{\beta}\right)^2; \quad 0 < \theta < \beta/2 \qquad S = H \left(1 - 2\left(1 - \frac{\theta}{\beta}\right)^2\right); \quad \beta/2 < \theta < \beta \\ \dot{S} &= 4H \omega \left(\frac{\theta}{\beta^2}\right); \quad 0 < \theta < \beta/2 \qquad \dot{S} = 4H \frac{\omega}{\beta} \left(1 - \frac{\theta}{\beta}\right); \quad \beta/2 < \theta < \beta \\ \ddot{S} &= 4H \left(\frac{\omega}{\beta}\right)^2 \quad ; \quad 0 < \theta < \beta/2 \qquad \ddot{S} = -4H \left(\frac{\omega}{\beta}\right)^2 \quad ; \quad \beta/2 < \theta < \beta \end{split}$$

$$s(\theta) = \frac{H}{2} \left(1 - \cos\left(\frac{\pi\theta}{\beta}\right) \right)$$

$$s(\theta) = \frac{H}{2} \left(\frac{\pi\omega}{\beta}\right) \sin\left(\frac{\pi\theta}{\beta}\right)$$

$$s(\theta) = \frac{h}{\pi} \left(\frac{\pi\theta}{\beta} - \frac{1}{2}\sin\left(\frac{2\pi\theta}{\beta}\right) \right)$$

$$s(\theta) = \frac{h}{\pi} \left(\frac{\omega}{\beta}\right) \left(1 - \cos\left(\frac{2\pi\theta}{\beta}\right) \right)$$

$$s(\theta) = \frac{H}{2} \left(\frac{\pi\omega}{\beta}\right)^2 \cos\left(\frac{\pi\theta}{\beta}\right)$$

$$s(\theta) = 2h\pi \left(\frac{\omega}{\beta}\right)^2 \sin\left(\frac{2\pi\theta}{\beta}\right)$$

 $h = e\{1 - \cos(\theta)\}$ $v = \omega e \sin(\theta)$ $a = \omega^2 e \cos(\theta)$