Philadelphia University
Faculty of Engineering

(1)

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.
- Use the given space wisely. It will not be allowed to have a second sheet of solution.
- You may write on the back of these pages. However, you must mention that in the front pages.

Question 1: *(8marks)*

General concepts

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

Ans/Q	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
a		X						
b	X				X		X	X
c				X		X		
d			X					
e								

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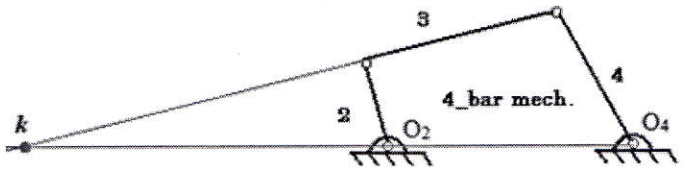
Question 1:continu ***(8marks)***

1. **A mechanism has 4 links will has a number of instantaneous centers equal**

a. 15 b. 6 c.21 d.10 e. none of the previous

2. **For the four bar mechanism shown in the fig. if ω_2 = 1200 RPM, O_2k = 40cm and O_4k = 80cm. find the angular speed of link 4 (ω_4) in RPM**



a. 600 b. 150 c.300 d.1200 e. none of the previous

3. **A rigid bar link has length equal 50cm and rotates about one of its joints by angular speed equal 50 rad/s. its tangential velocity in m/s will equal**

a. 100 b.50 c.200 d.25 e. none of the previous

4. **a 1.5m bar link rotate about one of its joints at a constant angular speed equal 10 rad/s. then the magnitude of its acceleration equal in m/s^2:**

a. 3750 b. 1350 c.150 d.600 e. none of the previous

5. **a bar link is analyzed statically. If the force at one of its joints is :- 5i+ 7j, the Cartesian vector for the force in the other joint will be**

a. -5i + 7j b. 5i – 7j c.-7i +5j d.7i – 5j e. none of the previous

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 45°.**

a. 3.72 cm b. 3.00 cm c. 2.00 cm d. 1.00 cm e. none of the previous

7. **Find the follower velocity at cam angle equal 45° .round the solution to two decimal digits.**

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 eccentricity (e) = 10 cm, find the displacement at angle = 180°.**

a. 15.0 cm b. 20.0 cm c.13.4 cm 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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(2)

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Question 1: ***(8marks)***

General concepts

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a				X		X		
b								
c			X					
d	X	X			X		X	X
e								

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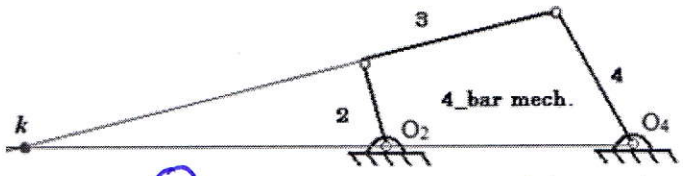
Question 1:continu ***(8marks)***

1. **A mechanism has 5 links will has a number of instantaneous centers equal**

a. 15 b. 6 c.21 d.10 e. none of the previous

2. **For the four bar mechanism shown in the fig. if ω_2 = 2400 RPM, O_2k = 40cm and O_4k = 80cm. find the angular speed of link 4 (ω_4) in RPM**



a. 600 b. 150 c.300 d.1200 e. none of the previous

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**

a. 100 b.50 c.200 d.25 e. none of the previous

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/s^2:**

a.3750 b. 1350 c.150 d.600 e. none of the previous

5. **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**

a. -5i + 7j b. 5i – 7j c.-7i +5j d.7i – 5j e. none of the previous

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°.**

a. 3.72 cm b. 3.00 cm c. 2.00 cm d. 1.00 cm e. none of the previous

7. **Find the follower velocity at cam angle equal 75° .round the solution to two decimal digits.**

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 eccentricity (e) = 10 cm, find the displacement at angle = 300°.**

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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Form (1)

(3)

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Question 1: ***(8marks)***

General concepts

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Ans/Q	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
a	X				X			X
b			X					
c		X					X	
d				X		X		
e								

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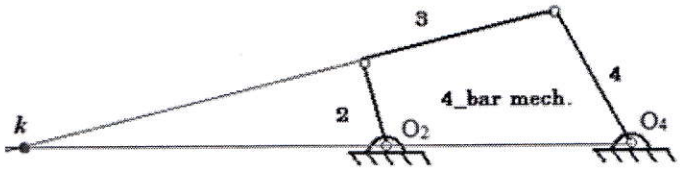
Question 1: *continu* ***(8marks)***

1. **A mechanism has 6 links will has a number of instantaneous centers equal**

a. 15 b. 6 c.21 d.10 e. none of the previous

2. **For the four bar mechanism shown in the fig. if ω_2 = 600 RPM, O_2k = 40cm and O_4k = 80cm. find the angular speed of link 4 (ω_4) in RPM**



a. 600 b. 150 c. 300 d.1200 e. none of the previous

3. **A rigid bar link has length equal 50cm and rotates about one of its joints by angular speed equal 100 rad/s. its tangential velocity in m/s will equal**

a. 100 b. 50 c.200 d.25 e. none of the previous

4. **a 1.5m bar link rotate about one of its joints at a constant angular speed equal 20 rad/s. then the magnitude of its acceleration equal in m/s^2:**

a. 3750 b. 1350 c.150 d.600 e. none of the previous

5. **a bar link is analyzed statically. If the force at one of its joints is : 5i – 7j, the Cartesian vector for the force in the other joint will be**

a. -5i + 7j b. 5i – 7j c.-7i +5j d.7i – 5j e. none of the previous

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 30°.**

a. 3.72 cm b. 3.00 cm c. 2.00 cm d. 1.00 cm e. none of the previous

7. **Find the follower velocity at cam angle equal 30° .round the solution to two decimal digits.**

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 eccentricity (e) = 10 cm, find the displacement at angle = 120°.**

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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Second exam, second semester: 2016/2017
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4

Course Title: theory of machines
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Lecturer: Eng. Laith Batarseh

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Question 1: ***(8marks)***

General concepts

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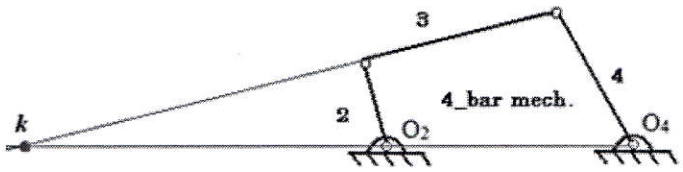
Ans/Q	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
a			X					
b		X		X		X		
c	X				X		X	X
d								
e								

Question 1: continu (8marks)

1. **A mechanism has 7 links will has a number of instantaneous centers equal**

a. 15 b. 6 c. 21 d.10 e. none of the previous

2. **For the four bar mechanism shown in the fig. if ω_2 = 300 RPM, O_2k = 40cm and O_4k = 80cm. find the angular speed of link 4 (ω_4) in RPM**



a. 600 b. 150 c.300 d.1200 e. none of the previous

3. **A rigid bar link has length equal 50cm and rotates about one of its joints by angular speed equal 200 rad/s. its tangential velocity in m/s will equal**

a. 100 b.50 c.200 d.25 e. none of the previous

4. **a 1.5m bar link rotate about one of its joints at a constant angular speed equal 30 rad/s. then the magnitude of its acceleration equal in m/s^2:**

a. 3750 b. 1350 c.150 d.600 e. none of the previous

5. **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**

a. -5i + 7j b. 5i – 7j c. -7i +5j d.7i – 5j e. none of the previous

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 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 follower velocity at cam angle equal 60° .round the solution to two decimal digits.**

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 eccentricity (e) = 10 cm, find the displacement at angle = 250°.**

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:

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

Qunt.	d_1	d_2	d_3	d_4	Θ_2	Θ_3	Θ_4	ω_2	ω_3	ω_4
value	0.9	0.2	0.7	0.5	60	25	110	300	?	?
Unit	m	m	m	m	Degree	Degree	Degree	RPM	RPM	RPM

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. $d_2\omega_2 \dot{U}_{\theta 2} + d_3\omega_3 \dot{U}_{\theta 3} = d_4\omega_4 \dot{U}_{\theta 4}$

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:- $\omega_4 = \dfrac{d_2\omega_2 \sin(\theta_3 - \theta_2)}{d_4 \sin(\theta_3 - \theta_4)}$

To find ω_3, dot product both sides of derivative equation by **$U_{\theta 4}$ 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:- $\omega_3 = -\dfrac{d_2\omega_2 \sin(\theta_4 - \theta_2)}{d_3 \sin(\theta_4 - \theta_3)}$

2. substitute the values from table

$$\omega_3 = -\frac{(0.2)(300)\sin(110-60)}{0.7\sin(110-25)} = -65RPM = -6.9 \frac{Rad}{s}$$

$$\omega_4 = \frac{(0.2)(300)\sin(25-60)}{0.5\sin(25-100)} = 69RPM = 7.22 \frac{Rad}{s}$$

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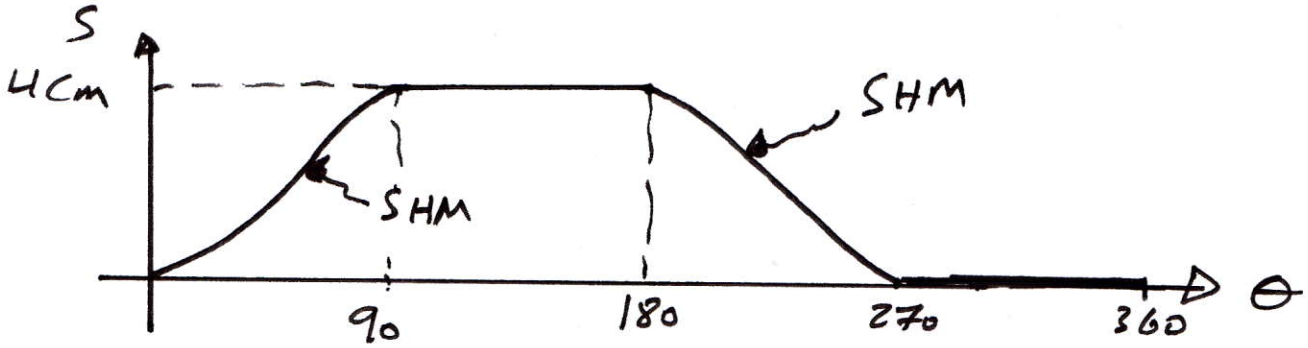
Question 3: ***(6 marks)***

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

- ❑ 0→ 90° : SHM rise to 4cm
- ❑ 90° → 180° : Dwell
- ❑ 180° → 270° : SHM return to 0
- ❑ 270° → 360° : Dwell

1. Draw an approximate sketch for S-Θ diagram



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

Cam angle (degree)	Follower disp. (m)	Cam radius (cm)
45	0.02	~~12~~ 8
225	0.02	~~12~~ 8

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

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

$r_c = r_b + s = 2cm + ~~10~~6cm = ~~12~~ 8 cm$

For 225 degree: H = 4cm, β=90°, Θ=225-180=45

$$s(225) = ~~4~~ 0.04 - \frac{0.04}{2}\left(1 - \cos\left(\frac{\pi 45}{90}\right)\right) = 0.02m$$

$r_c = r_b + s = 2cm + ~~10~~6cm = ~~12~~ 8 cm$

Theory of machines data sheet

Student name:_____ **Reg. No:**_____

$$S = 2H\left(\frac{\theta}{\beta}\right)^2; \quad 0 < \theta < \beta/2 \qquad S = H\left(1 - 2\left(1 - \frac{\theta}{\beta}\right)^2\right); \quad \beta/2 < \theta < \beta$$

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

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

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

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

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

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

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

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

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