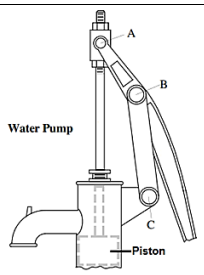
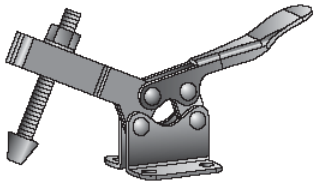
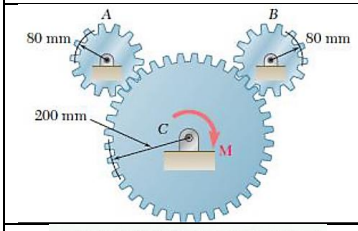
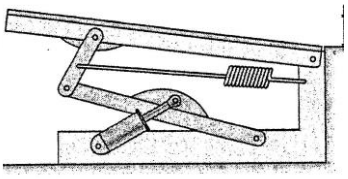
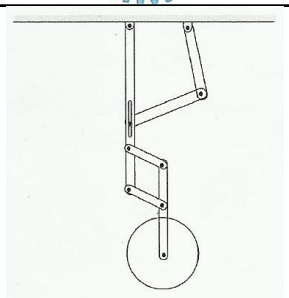
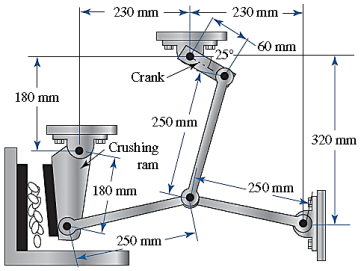
Lebanese University
Faculty of Engineering III
Mechanical Engineering department
Semester: V

Midterm Exam
Kinematics and Dynamics of machinery
Cinématique et dynamique des machines
CDM – DDM

Student name:
ID:

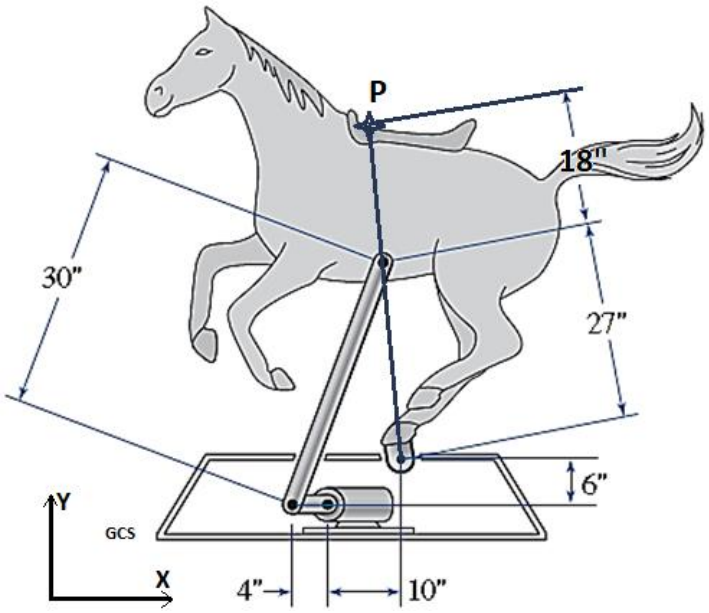
Date: 19/01/2022
Time: 1h00
Closed book exam
Dr. Jaafar Hallal

Question 1: Calculate the mobility of each mechanism and write it in the corresponding column:

Mechanism	Mobility	Grade	Mechanism	Mobility	Grade
	M=			M=	
	M=			M=	
	M=			M=	

Question2: Derive all the possible link combinations for 3 DOF, including sets up to 7 links, and link orders up to and including hexagonal links. For simplicity, assume that the links will be connected with only single, full rotating joints (Pin connecting only two joints). Fill the table accordingly.

Combination	B	T	Q	P	H	Grade
1						
2						
3						
4						
5						
6						
7						
8						



Question3: **The above figure shows a mechanism that operates a coin-operated child's amusement ride. At the instant shown, and given that the angular velocity of the electric motor is constant and equal to 5 rad/s, find the velocity and the acceleration of the point P.**

	Answer with unit	Grade
θ4 in the local CS		
θ3 in the local CS		
ω4		
ω3		
Velocity magnitude of Point P		
α4		
Acceleration magnitude of Point P		

Formula Sheet

Position Analysis

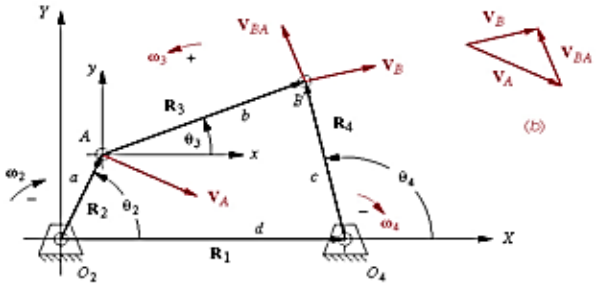
$$\theta_{4_{1,2}} = 2\arctan\left(\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}\right)$$

- $A = cos\theta_2 - K_1 - K_2 cos\theta_2 + K_3$
- $B = -2sin\theta_2$
- $C = K_1 - (K_2 + 1)cos\theta_2 + K_3$
- $K_1 = \frac{d}{a}$
- $K_2 = \frac{d}{c}$
- $K_3 = \frac{a^2 - b^2 + c^2 + d^2}{2ac}$

$$bcos\theta_3 = -acos\theta_2 + ccos\theta_4 + d$$

Velocity Analysis

$$\omega_3 = \frac{a\omega_2}{b}\frac{\sin(\theta_4 - \theta_2)}{\sin(\theta_3 - \theta_4)} \qquad \omega_4 = \frac{a\omega_2}{c}\frac{\sin(\theta_2 - \theta_3)}{\sin(\theta_4 - \theta_3)}$$



Acceleration Analysis

$$\alpha_3 = \frac{CD - AF}{AE - BD}$$

$$\alpha_4 = \frac{CE - BF}{AE - BD}$$

$$A = c\sin\theta_4$$

$$B = b\sin\theta_3$$

$$C = a\alpha_2 \sin\theta_2 + a\omega_2^2 \cos\theta_2 + b\omega_3^2 \cos\theta_3 - c\omega_4^2 \cos\theta_4$$

$$D = c\cos\theta_4$$

$$E = b\cos\theta_3$$

$$F = a\alpha_2 \cos\theta_2 - a\omega_2^2 \sin\theta_2 - b\omega_3^2 \sin\theta_3 + c\omega_4^2 \sin\theta_4$$