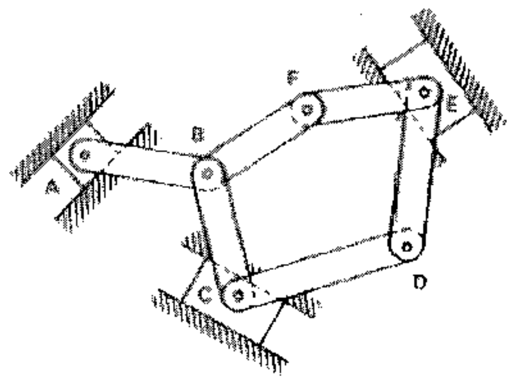
Kafrelsheikh University
Faculty of Engineering
Dept. of Mech. Engineering
Year: second Year
Subject: Theory of Machines

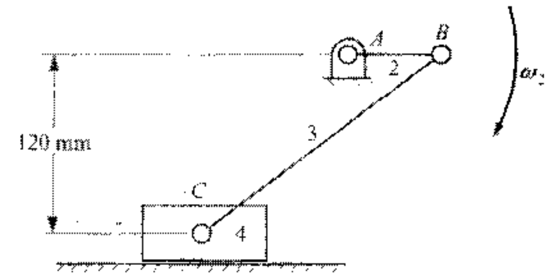
1st Semester
Final Examination
Date: March 18th, 2021
Time allowed: 3 hours
Full Mark: 100

1. a. (**8 Marks**) For the linkage shown in the figures, determine the number of degrees of freedom of the mechanisms.

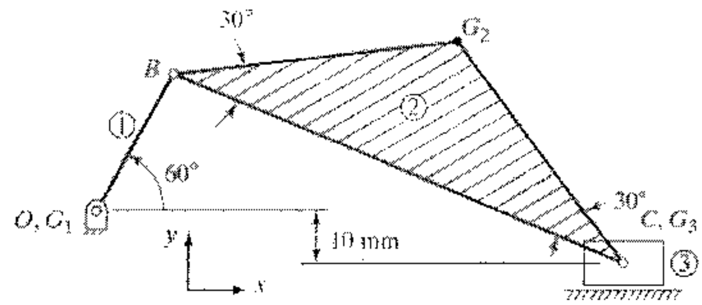


b. (**8 Marks**) Assume that you have a set of the following lengths: 20 mm, 30 mm, 45 mm, 56 mm, and 73 mm. Design a four-bar linkage that can be driven with a continuous-rotation electric motor. Justify your answer with appropriate equations, and make a freehand sketch of the resulting linkage. Label the crank, frame, coupler, and rocker (follower).

2. **(16 Marks)** For the mechanism shown, link 2 is rotating cw at the constant rate of 50 rad/s. in the position shown, link 2 is horizontal. Use analytical method to determine v_{C_4}, ω_3, a_C, and α_3. <u>Link lengths:</u> AB =60 mm, BC = 200 mm.



3. **(20 Marks)** The crank of the slider-crank mechanism, shown in the figure, has an instantaneous angular velocity of 10 rad/s clockwise and an angular acceleration of 200 rad/s^2 clockwise. Information related to acceleration is given in the figure. The connecting rod has a mass of 10 kg and a mass moment of inertia of about its center of mass, G_2, is 8000 kg.mm^2. The slider has a mass of 6 kg. The crank has a moment of inertia of 5000 kg.mm^2 about its stationary center of mass, determine all bearing forces and the input torque T_1 for the position shown.



$OB = 30$ mm

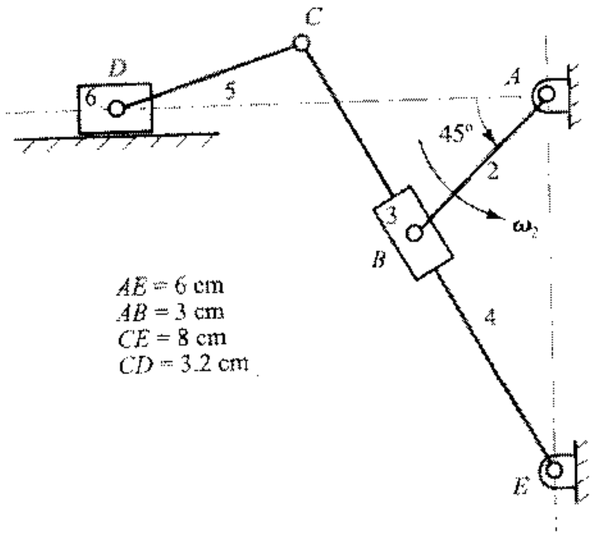
$BC = 90$ mm

$a_{G_2} = 3810\angle 325^\circ$ mm/s^2

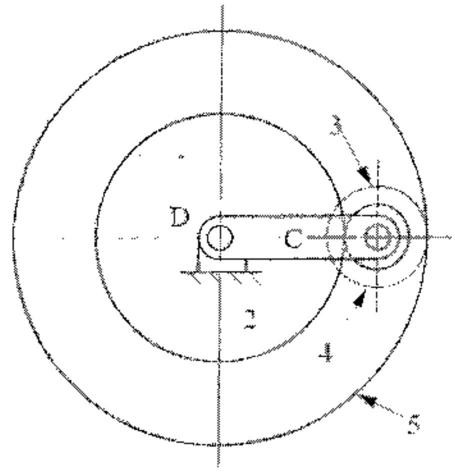
$\alpha_2 = 66.3$ rad/s^2 ccw

$a_{G_3} = 5800\angle 0^\circ$ mm/s^2

4. **(20 Marks)** In the mechanism shown, $\omega_2 = 20$ rad/s CCW (constant). Using the relative motion method, determine (a) the angular velocity, ω_4, and angular acceleration of link 4, α_4, and (b) the velocity, v_D, and acceleration of the slider, a_D.



5. **(12 Marks)** In the gear train shown, gears 3 and 4 are integral (compound gears). Gear 3 meshes with gear 2, and gear 4 meshes with gear 5. Gear 2 is fixed and $\omega_5 = 500$ rpm CCW.



$N_2 = 60T$
$N_3 = 16T$
$N_4 = 24T$
$N_5 = 100T$

6. Question 5 (10 Marks)

1. The smaller and generally the driving gear of a pair of mated gears is called __________
a) pitch c) rack c) pinion

2. The distance measured along the circumference of the pitch circle from a point on one tooth to the same point on the adjacent tooth is called ________________
a) pitch diameter b) circular pitch c) pitch point

3. The number of teeth per unit length of the pitch circle diameter is called _________________
a) diametral pitch b) module c) clearance

4. The ratio of the number of teeth on the gear to the number of teeth on the pinion is called ______
a) module b) gear ratio c) pitch point

5. The ratio of pitch diameter to the number of teeth is called __________
a) module b) addendum c) dedendum

6. The circle passing through the upper tips of the teeth is called __________________
a) pitch circle c) dedendum circle d) addendum circle

7. The radial height of a tooth above the pitch circle is called _____________
a) addendum b) dedendum c) rack

8. The radial difference between the addendum and the dedendum of the tooth is called __________
a) clearance b) rack c) line of action

9. Find the speed of the gear if the worm is a double thread worm rotating at 500 rpm. The gear has 20 teeth.
a) 100 rpm b) 75 rpm c) 50 rpm

10. In a simple gear train, if the number of idle gears is odd, then the motion of driven gear will
a) be same as that of driving gear
b) be opposite as that of driving gear
c) depend upon the number of teeth on the driving gear

7. **(14 Marks)** Draw the displacement schedule for a follower that rises through a total displacement of 60 mm with cycloidal motion in 120° of cam rotation. The follower then dwells for 90° and returns with simple harmonic motion in 90° of cam rotation. The follower then dwells for 60° before repeating the cycle. Determine the maximum velocity and acceleration of the follower.

You may use the following formulae

Motion	Rise	Fall
Simple harmonic	$y = \frac{L}{2}\left(1 - \cos\frac{\pi\theta}{\beta}\right)$	$y = \frac{L}{2}\left(1 + \cos\frac{\pi\theta}{\beta}\right)$
Cycloidal	$y = L\left(\frac{\theta}{\beta} - \frac{1}{2\pi}\sin\frac{2\pi\theta}{\beta}\right)$	$y = L - L\left(\frac{\theta}{\beta} - \frac{1}{2\pi}\sin\frac{2\pi\theta}{\beta}\right)$