An-Najah National University  
Faculty of Engineering  
Mechanical Engineering Department  
Theory of Machines (67310)  
Second Exam

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Student Name:  
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Student Grade

Exam Notes:

1. Solve all the problems.
2. Closed books and notes.
3. Read each problem carefully before attempting to solve it.
4. Write all work on this exam paper.
Question 1:

The figure shows the Scotch yoke mechanism. At the instant shown the crank $OP$ has an angular velocity of 10 rad/s and an angular acceleration of 30 rad/s$^2$. Determine the acceleration of the guide using polygons. For the acceleration use the scale 1 cm = 2 m/s$^2$.

\[
\ddot{a}_p = (\ddot{a}_p)_n + (\ddot{a}_p)_t
\]

- $\ddot{a}_p_n = \omega^2 r_{P10} = (10^2)(0.2) = 20 \text{ m/s}^2$
- $\ddot{a}_p_t = \alpha r_{P10} = 30(0.2) = 6 \text{ m/s}^2$

\[
\ddot{a}_Q = \ddot{a}_p + (\ddot{a}_{Q/p})_{xy} + \ddot{a}_w \times (\ddot{V}_{Q/p})_{xy}
\]

$\ddot{a}_Q \approx 4.15 \text{ cm} = 0.43 \text{ m/s}^2$
Question 2:

The displacement curve for a flat faced follower is shown in the figure, where it has been found that cycloidal motion C-5 and C-6 are suitable to fit motion continuity requirements as shown. If the minimum radius of the cam \( C = 50 \text{mm} \), determine:

1) The maximum velocity in rise motion.

\[
\text{From the acceleration curve, } V_{\max} \Rightarrow a = 0 \Rightarrow \sin \left( \frac{2\pi \theta}{B} \right) = 0 \Rightarrow \theta = \frac{B}{2}
\]

\[
\Rightarrow V = \frac{20}{70x180} \left( 1 - \cos \theta \right) = 38.2 \text{ mm/s}
\]

2) The maximum absolute velocity in return motion.

\[
\text{between } E \text{ and } F \text{ at } \theta = \frac{\pi}{2}
\]

\[
V_{\max} = \frac{20}{60x180} \left( 2 \right) = 38.2 \text{ mm/s}
\]

3) The velocity and acceleration of the follower at \( \theta = 255^\circ \).

\[
V = 0 \quad a = 0 \quad \text{Dwell}
\]

4) Determine the coordinates of the contact point \((x, y)\) when \( \theta = 255^\circ \).

\[
x = R (\cos \theta - L \sin \theta) = 70 \cos (255) = -54.5 \text{ mm}
\]

\[
y = R \sin \theta + L \cos \theta = 70 \sin (255) = -67.6 \text{ mm}
\]

5) The theoretical face width of the follower.

\[
L_{\text{theoretical}} = \left| V_{\max} \right| \text{ Lift} + \left| V_{\max} \right| \text{ Return} = 38.2 + 38.2 = 76.4 \text{ mm}
\]

6) The acceleration of the follower at \( \theta = 180^\circ \).

\[
\theta = 180 - 150 = 30 = \frac{\pi}{6}
\]

\[
a = \frac{-2 \pi L}{B^2} \left( \sin \frac{2 \pi \theta}{B} \right) = \frac{-2 \pi \left( \frac{23}{30} \right) \left( \sin \left( \frac{2 \pi \left( \frac{30}{30} \right)}{180} \right) \right)}{180} = \frac{160 \sin \left( \frac{2 \pi \left( \frac{30}{30} \right)}{180} \right)}{180} = 89.3 \text{ mm/s}^2
\]