INSTRUCTIONS
Begin each problem in the space provided on the examination sheets. If additional space is required, use the yellow paper provided to you.

Work on one side of each sheet only, with only one problem on a sheet.

Each problem is worth 20 points.

Please remember that for you to obtain maximum credit for a problem, it must be clearly presented, i.e.

- the coordinate system must be clearly identified.
- where appropriate, free body diagrams must be drawn. These should be drawn separately from the given figures.
- units must be clearly stated as part of the answer.
- you must carefully delineate vector and scalar quantities.

If the solution does not follow a logical thought process, it will be assumed in error.

When handing in the test, please make sure that all sheets are in the correct sequential order and make sure that your name is at the top of every page that you wish to have graded.

Problem 1
Problem 2
Problem 3
Total
Problem 1a - Kinematics (6 points).
A pin travels along a path denoted by the expression \( r = 2 \sin(\theta) \), where \( r \) is in meters and \( \theta \) is in radians. When \( \theta = \pi/6 \) radians, \( \dot{\theta} = 0.5 \text{ rad/s} \) and \( \ddot{\theta} = 0 \text{ rad/s}^2 \), please determine the velocity vector in polar coordinates and the acceleration vector in polar coordinates.

\[
\mathbf{v} = 0.866 \mathbf{u}_r + 0.5 \mathbf{u}_\theta
\]

\[
\mathbf{a} = -0.5 \mathbf{u}_r + 0.866 \mathbf{u}_\theta
\]
Problem 1b – Kinematics (4 points). A vehicle starts at rest on a horizontal circular track with a radius of 80-m. If the car increases its speed at a uniform rate to reach a speed of 80m/s in 10 seconds, determine the magnitude of the total acceleration $|\vec{a}|$ when $t = 10$ seconds.

$|\vec{a}|_{10\text{seconds}} = 80.4 \text{ m/s}$
Problem 1c - Kinetics (6 points). Please determine the magnitude of the acceleration of the 100-lb block for the two cases shown (3 points each case).

\[ a_{\text{100 case (a)}} = 6.44 \text{ ft/s}^2 \]

\[ a_{\text{100 case (b)}} = 16.10 \text{ ft/s}^2 \]
Problem 1d – Kinetics (4 points). Determine the constant speed the block must have if there no normal force at point B.

$V_B = 4.85 \text{ m/s}$
2. For the device shown, the motion of the pin P is governed by \( x = 0 + t^3 \) and \( y = 2 + 2t^2 \), where \( x \) and \( y \) are measured in inches and \( t \) is in seconds. Please place your answers on the lines provided.

Please complete the following problems:

2a. The position in rectangular coordinates when \( t = 2 \) seconds (2 points).

\[
\vec{r} = (8\hat{i} + 10\hat{j}) \text{ in}
\]

2b. The velocity vector \( \vec{v} \) in rectangular coordinates when \( t = 2 \) seconds (2 points).

\[
\vec{v} = (12\hat{i} + 8\hat{j}) \text{ in/s}
\]
2c. The magnitude of the velocity $|\vec{v}|$ when $t = 2$ seconds (2 points).

$$|\vec{v}| = 14.4 \text{ in/s}$$

2d. The acceleration vector $\vec{a}$ in rectangular coordinates when $t = 2$ seconds (2 points).

$$\vec{a} = \left(12 \hat{i} + 4 \hat{j}\right) \text{ in/s}^2$$

2e. The magnitude of the acceleration $|\vec{a}|$ when $t = 2$ seconds (2 points).

$$|\vec{a}| = 12.6 \text{ in/s}^2$$

2f. The rate of change of the speed of P, $\dot{v}$, when $t = 2$ seconds (5 points).

$$\dot{v} = 12.2 \text{ in/s}^2$$
2g. The radius of curvature of the path $\rho$ when $t=2$ seconds (5 points)

$$\rho = 62.5\text{ in}$$
3. The block shown is sitting inside a cone section. At the moment of interest the block is a fixed distance (0.2 meters) from the axis of rotation. The block has a mass of 2-kg. The outside angle of the cone is 30° as shown. Please show all work as you complete 3a and 3b.

3a. Consider the situation when there is no reliance on friction $\mu_{ks}=0$.

Begin with a free-body diagram for the case with no friction (4 points).
Determine the angular rate of rotation, $\omega$, to keep the box at its current location when there is no frictional force (6 points).

\[ N = 22.7 \text{ N} \]
\[ \omega = 5.32 \text{ rad/s} \]
3b. Consider the situation when friction is required to keep the block in place and the friction coefficients (static and kinetic) are $\mu_{ks} = 0.5$.

Begin with a free-body diagram for the case where friction prevents the block from moving (4 points).

Determine the maximum angular rotation that can be achieved without allowing the block to slip (6 points).

\[ N = 31.8 \text{ N} \]

\[ \omega = 8.62 \text{ rad/s} \]