ME 270 - Fall 2010
Examination No. 3

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.

Please circle your instructor’s name:

Jones    Nauman    Dare    Murphy    Hess

Problem 1 _____

Problem 2 _____

Problem 3 _____

Total _________
1. A particle follows a specified path described by, $y = \frac{1}{125}x^4$, where $x$ and $y$ are measured in inches. When $x = 5$ inches, $\ddot{x} = 2 \text{in/s}$ and $\dddot{x} = -1.5 \text{in/s}^2$.

1a. Please draw the tangential and normal basis vectors for the instant when $x = 5$ inches on the figure above. (2 points)

1b. Please draw the polar basis vectors when $x = 5$ inches on the figure above. (2 points)

1c. Calculate $\dot{y}$ and $\ddot{y}$ for $x = 5$ inches. (4 points)

$$\dot{y} = 8 \text{in/s} \quad \ddot{y} = 3.6 \text{in/s}^2$$
1d. Please determine the magnitude of the velocity for \( x = 5 \) inches. (2 points)

\[ |\vec{v}| = 8.25 \text{ in/s} \]

1e. What is the magnitude of the acceleration when \( x = 5 \) inches? (2 points)

\[ |\vec{a}| = 3.9 \text{ m/s}^2 \]

1f. Determine the basis vector in the tangential direction. Express it in terms of its \( \vec{i} \) and \( \vec{j} \) components (4 points).

\[ \overrightarrow{U_t} = 0.242 \vec{i} + 0.97 \vec{j} \]

1g. Calculate the rate of change of speed and the radius of curvature at the instant that \( x = 5 \) inches (4 points)

\[ \ddot{v} = 3.129 \text{ in/s}^2 \]

\[ \rho = 29.2 \text{ in} \]
2a. (8 points) A ball is thrown into the air and reaches a height of 10 meters. Please determine the initial velocity in the y-direction, \( v_{0y} \), and the time it will take for the ball to reach that peak height, \( t_{peak} \), if we assume that we can neglect air resistance. Full credit will require a free body diagram and demonstration of all of your work.

\[
\begin{align*}
    v_{0y} &= 14 \text{ m/s} \\
    t_{peak} &= 1.43 \text{ s}
\end{align*}
\]
2b. (12 points) In case I, a 100 N force is applied directly to the end of the rope, while in case II, a block is attached to the end of the rope instead. Block A has a weight of 150 N and block B has a weight of 100 N.

First, determine the relationship between the acceleration at the end of the rope (the free end in case I and block B in case II) and the acceleration of block A.
Second, determine the acceleration of block A in case I. Indicate whether the acceleration of block A is directed \textit{up or down}.

\[ a_A = -3.27 \text{ m/s}^2 \quad \text{(i.e., up).} \]

Third, determine the acceleration of block A in case II. Indicate whether the acceleration of block A is directed \textit{up or down}.

\[ a_A = -0.892 \text{ m/s}^2 \quad \text{(i.e., up)} \]
3a (12 pts)
A block with a mass of 3 kg is given an initial push and then released so that it slides up a 30° incline with an initial velocity of 5 m/s. The coefficient of static friction between the block and the incline is 0.5 and the coefficient of kinetic friction between the block and the incline is 0.3.

Draw the free body diagram on the geometry provided (3 pts)

Calculate the block’s acceleration in the x-direction (5 pts)

\[ a_x = -7.45 \text{ m/s}^2 \]

How far will the block travel up the incline before coming to a stop? (4 pts)

\[ \Delta x = 1.677 \text{ m} \]
3b (8 pts)
A particle is initially at rest before being accelerated along a straight line according to \( a(v) = 2v \).

How far has the particle traveled when it reaches a velocity of 10 m/s?

\[
\Delta s = 5 \text{ m}
\]