Instructions:
- Closed book, closed notes test, one 8 1/2 inch 
  by 11 inch sheet of handwritten formulas 
  allowed. (no worked problems)
- 105 minute time limit – strictly enforced.
- Follow the problem-solving process and show all of 
  your work for problems #2, #3, and #4 (30 pts each).

For problems #1 - #5 (2 pts each), circle the letter corresponding to the best answer to the question.

1a. Which one of the following situations is impossible?
   a. An object has velocity directed north and acceleration directed south.
   b. An object has non-zero velocity but zero acceleration.
   c. An object has constant non-zero acceleration and constant velocity.
   d. An object has velocity directed south and acceleration directed south.
   e. An object has velocity directed east and acceleration directed north.

1b. In which one of the following does a car have an eastward acceleration?
   a. The car travels eastward at constant speed.
   b. The car travels eastward and slows down.
   c. The car starts from rest and moves westward.
   d. The car starts from rest and moves eastward.
   e. The car travels westward and speeds up.
   f. no acceleration since speed is constant

1c. The figure on the right shows the path of a scooter on a flat 
    horizontal surface. It starts at point A and moves at constant 
    speed to point F. During which segment does the acceleration 
    have an acceleration component to the right?
   a. AB
   b. BC
   c. CD
   d. DE
   e. EF
   f. no acceleration since speed is constant

1d. A ball is suspended motionless from a string. The ball’s acceleration is
   a. 1 g up
   b. 1 g down
   c. zero
   d. answer depends on weight of ball

1e. A particle traveling in the positive y-direction is subjected to a constant acceleration in the opposite 
    direction. Which of the following y-position vs. time (x) graphs shown more closely describe the possible 
    position of the particle as a function of time?
2. Two masses A and B are arranged with pulleys as shown on the right. Each block weighs 12.60 lb. The blocks are released from rest.
   a) Find the cable tension, T?
   b) Find the velocities of each block at t=4.0s.
   c) How far has block B traveled from t=0s to t=4.0s?

   If you think it will be easier, work this problem with the mass of each block at 12.60 kg instead of a weight of 12.60 lb.

   Given: \( W_A = W_B = 12.60 \text{ lb} \)

   Solution:
   \[ \sum F_A = m_A a_A = 2T - W \]
   \[ a_A = \frac{2T}{m_A} - g \]
   \[ \sum F_B = m_B a_B = 3T - W \]
   \[ a_B = \frac{3T}{m_B} - g \]

   \[ 2S_A + 3S_B = \ell \]
   \[ 2V_A + 3V_B = 0 \]
   \[ 2a_A + 3a_B = 0 \]

   \[ a_A = \frac{2(4.85/\ell)}{12.6 \ell} - 32.2 \text{ ft/s}^2 \]
   \[ a_B = \frac{3(4.85/\ell)}{12.6 \ell} - 32.2 \text{ ft/s}^2 \]

   \[ a_A = \frac{2(4.85/\ell)}{12.6 \ell} - 32.2 \text{ ft/s}^2 \]
   \[ a_B = \frac{3(4.85/\ell)}{12.6 \ell} - 32.2 \text{ ft/s}^2 \]

   \[ V = V_0 + a t \]
   \[ V^2 = V_0^2 + 2a (S - S_0) \]

   \[ V_A = 0 + (7.41 \text{ ft/s})(4.9) \]
   \[ V_B = 0 + (4.98 \text{ ft/s})(4.9) \]

   \[ (S - S_0) = \frac{V_B^2 - V_0^2}{2a} = \frac{(19.92 \text{ ft/s})^2 - 0 \text{ ft/s}^2}{2(4.98 \text{ ft/s})} = 39.8 \text{ ft} \]
3. A car exits a highway at point A along a curve with a constant radius of \( r = 313 \text{ feet} \). The car has a speed of 60 ft/sec at point A where it decelerates uniformly to a speed of 40 ft/sec at point C. The car continues at the constant speed of 40 ft/sec to the end of the curve at point D. \( S \) is the distance along the curve from A to D.

a) Sketch \( \dot{S} \) vs. time, \( \ddot{S} \) vs. time, and \( S \) vs. time curves for the car's motion along the path with numerical values at points A, C, and D.

b) Find \( X \) and \( Y \) components of total acceleration at location B.

c) Find location along the curve (distance \( S \) and angle from +X axis) when the car has traveled for 7.0 seconds from point A.

\[
V^2 = v_0^2 + 2a_t (S - S_0) \\
p = \frac{v^2 - v_0^2}{2(S - S_0)} \\
a_t = \frac{40 \text{ ft/sec}^2 - (60 \text{ ft/sec})^2}{2 \times 245.8 \text{ ft}} = -41.0 \text{ ft/sec}^2
\]

\[
S = S_0 + v_0 t + \frac{1}{2} a_t t^2 \\
S' = 245.8 \text{ ft} \\
S'' = 245.8 \text{ ft} + (40 \text{ ft/sec})(7 - 4.91) + 0 \\
S''' = 329.4 \text{ ft} \\
\theta = 60.3 \text{°}
\]

\[
\theta = \frac{329.4 \text{ ft}}{(1/2)(13 \text{ ft})} \cdot 90° = 60.3°
\]
4. A projectile is launched with an initial speed of 200 m/s at an angle of 60° with respect to the horizontal +X axis. The incline is at an angle of 20° with respect to the horizontal +X axis.

a) Find time \( t_B \) to impact the incline at point B (in seconds).

b) Find range \( R \) as measured along the incline in meters.

c) Find projectile’s velocity immediately prior to impact at point B in \( X \) and \( Y \) component form.

\[ v_0 = 200 \text{ m/s} \quad \theta = 60^\circ \quad \text{Incline} = 20^\circ \]

**Solution:**

\[ \vec{a} = (0, -9.81 \text{ m/s}^2) \]

\[ \vec{v} = (0, -9.81 \text{ m/s}^2 \cdot t) \]

\[ \vec{v}_0 = (200 \cos 60^\circ, 200 \sin 60^\circ - 9.81 \text{ t}) \text{ m/s} \]

\[ \vec{r} = (200 \cos 60^\circ \cdot t, 200 \sin 60^\circ \cdot t - 4.905 \cdot t^2) \text{ m} \]

\[ R_{\sin 20^\circ} = 200 \sin 60^\circ \cdot t - 4.905 \cdot t^2 \]

\[ R_{\cos 20^\circ} = 200 \cos 60^\circ \cdot t \quad R = 106.4 \text{ t} \]

\[ 106.4 \cdot 2.79 \text{ sec} \]

\[ t = 2.79 \text{ sec} \]

\[ R = (106.4 \cdot 2.79) = 297.8 \text{ m} \]

\[ \vec{v} = (-200 \cos 60^\circ, 200 \sin 60^\circ - (9.81 \cdot 2.79 \text{ sec})) \text{ m/s} \]

\[ = (-100, 100, 5) \text{ m/s} \]

\[ 30 \sqrt{30} \]