INSTRUCTIONS: PLEASE READ THE FOLLOWING BEFORE YOU START THE EXAM

1. Write your name and your recitation instructor's name on each page of the exam.
2. This exam consists of X pages, with 2 sections:
   a) SECTION I: One LAB question. (Graded separately from Midterm)
   b) SECTION II: Midterm Exam (this part will be curved)
      Part A. 8 multiple choice questions (5 points each). These questions receive NO partial credit.
      Part B. 2 problems (30 points each). You are required to show work to receive any credit on this part of the exam.
3. This is a closed book, closed note exam. You may have a calculator and a writing implement.
4. You have 48 min to complete the entire exam. If you find yourself getting stuck on a problem, move on to the next problem.

Constants and equations:

acceleration due to gravity on earth: \( g = 9.8 \, \text{m/s}^2 \)
\[ \sum \vec{F} = m \vec{a} \]
\[ v = v_{\text{initial}} + at \]
\[ x = x_{\text{initial}} + v_{\text{initial}}t + \frac{1}{2}at^2 \]
\[ v^2 = v_{\text{initial}}^2 + 2a(x - x_{\text{initial}}) \]
1. The average velocity of an object is equal to its instantaneous velocity. This statement is:
   a) always true
   b) never true
   c) is true only when the velocity is constant
   d) is true only when the velocity is increasing at a constant rate
   e) is true only when the object is moving in a straight line

   **Answer c.**

2. A runner runs one quarter around a circular path of radius 10 m. What is the magnitude of the displacement of the runner?
   a) 0
   b) 10.0 m
   c) 14.1 m
   d) 15.7 m
   e) 31.0 m

   **Answer c.** One quarter around the track, the runner will have traveled 10 m in x direction and 10 m in y direction. Displacement = square root of ((10 m)² + (10 m)²)

3. A golf ball is hit from the ground with a velocity of 20 m/s at an angle of 30° to the vertical. Neglect air resistance. What is the speed of the ball at its maximum height?
   a) 0
   b) 9.8 m/s
   c) 10 m/s
   d) 17.3 m/s
   e) 20 m/s

   **Answer d.** speed is magnitude of the velocity. Vertical component will be zero. Horizontal component will be constant. Speed = 20 cos 30.

4. Three books (X, Y and Z) rest on a table. The weight of each book is indicated. The force exerted by book Z on book Y is:
   a) 0
   b) 5N
   c) 9N
   d) 14 N
   e) 19 N

   **Answer c.** Block Z needs to support BOTH block Y and block X.
5. A motorist travels 30 miles at 60 mph and another 60 miles at 30 mph. The average speed of the motorist for the entire trip is:
   a) 32 mph  
   b) 36 mph  
   c) 40 mph  
   d) 45 mph  
   e) 55 mph

**Answer b. Speed is distance/time. Distant is 90 miles. Time is 2.5 hours.**

6. A 50kg suitcase is lying at rest on a horizontal floor. The coefficient of static friction between the suitcase and the floor is 0.90 and the coefficient of kinetic friction is 0.70. You push on the suitcase with a horizontal force of 75 N. During this time the force of friction on the suitcase is:
   a) 50 N  
   b) 75 N  
   c) 343 N  
   d) 441 N  
   e) 490 N

**Answer b. Maximum static friction is 0.9 * normal. In this case, the Normal equals weight, 50 kg x 9.8 m/s^2 or approximately 500 N. Max static friction force is 0.9 x 500=450 N. This is MUCH greater than 75 N. 75 N is insufficient to get the suitcase to move. The frictional force exerted will be enough static friction to balance the 75N force.**

7. Ball 1 is thrown upward from the ground with an initial speed of 25 m/s. At the same instant, Ball 2 is dropped from a window. If Ball 2 hits the ground at the same time as Ball 1 reaches the window, how high up is the window?
   a) 9.9 m  
   b) 11.9 m  
   c) 21.9 cm  
   d) 31.9 m  
   e) 41.9 m

**Answer d. v^2=v_0^2+2ad \Rightarrow d=(25)^2/(2*9.8)**

8. One 5.0kg bucket is hanging by a massless cord from another 5.0kg bucket also hanging by a massless cord as shown. If the two buckets are pulled upward with an acceleration of 1.8 m/s^2 by the upper cord, the tension in the lower cord is
   a) 116N  
   b) 40N  
   c) 49N  
   d) 98N  
   e) 58N

**Answer e. T-mg=ma.**
A crate of mass 90 kg is sliding down on a ramp that is tilted at an angle $\theta = 30^\circ$. The coefficient of kinetic friction between the crate and the slope is 0.41.

a) (8 pts) Draw a free body diagram for the crate showing all forces acting on it. Clearly indicate the direction of these forces in your diagram.

b) (8 pts) The crate starts from rest and travels 4 m along the plane when it is found to have a velocity of 3.35 m/s. Find the acceleration of the crate down the incline.

\[
v_f^2 = v_i^2 + 2ad \\
(3.35)^2 = (0)^2 + 2a(4) \\
a = 1.4 \text{ m/s}^2
\]

c) (7 pts) What is the magnitude of the net force acting on the crate parallel to the ramp?

\[
ma = F_{\text{net}} \\
(90\text{ kg})(1.4 \text{ m/s}^2) = 126.25 \text{ N}
\]

d) (7 pts) What is the magnitude of the net force acting on the crate normal to the ramp?

\[
ma = F_{\text{net}} \\
(90\text{ kg})(0 \text{ m/s}^2) = 0 \text{ N. The object is not moving perpendicular to the ramp.}
\]

Note the question asks for the NET force normal (i.e. perpendicular) to the ramp.
Problem 2
An archer (at ground level) shoots an arrow into the air (at time t=0) at an angle of $\theta^o$ above the horizontal.

\[ \begin{align*}
    v &= 35 \text{ m/s} \\
    \theta &= 45^o
\end{align*} \]

\[ x = 0, \ y = 0 \]

a. (7 pts) In the initial velocity of the arrow is 35 m/s at $45^o$ above the horizontal, find the x and y components of the arrow's velocity vector.

\[ v_{ox} = 35 \cos 45 = 24.75 \text{ m/s} \]

\[ v_{oy} = 35 \sin 45 = 24.75 \text{ m/s} \]

b. (7 pts) Find the maximum height reached by the arrow.

\[ v_{fy}^2 = v_{oy}^2 + 2 \ a \ d \]

\[ 0 = (35 \cos 45)^2 + 2(-9.8)(\text{height}) \]

**Height = 31.25 m**

c. (8 pts) Find the x and y components of the landing position if the launch position is x= 0, y = 0 m.

Time to land: \[ v_{fy} = v_{oy} + at \Rightarrow 2(24.75 \text{ m/s})/(9.8 \text{ m/s}^2) = 5.05 \text{ s} \]

\[ X = 24.75 \text{ m/s} \times 5.05 \text{ s} = 125 \text{ m} \]

Y = 0 (on the ground)

d. (8 pts) Find the velocity (x and y components) of the arrow when it lands.

\[ v_{ox} = 24.75 \text{ m/s} \]

\[ v_{oy} = -24.75 \text{ m/s} \]