Physics 3A: Midterm (10/19/2012, 3:00 pm-3:50 pm)

Name_____________; ID _____________; Discussion________________

Multiple Choices (1-3, 7% each; 4-7, 10% each)

1. Car A and car B are both driving on a straight road. Car A comes from behind and passes car B at \( t = 0 \) s. It then comes from behind and passes car B again at a later time. For this to be able to happen the velocity versus time graphs of A and B must be those shown in

\[
\begin{align*}
\text{a.} & & \text{b.} & & \text{c.} \\
\text{d.} & & \text{e.} & & \text{\( V_A > V_B \) at \( t = 0 \) and another later time}
\end{align*}
\]

2. The point at which the velocity and acceleration of a projectile are perpendicular to one another occurs
   a. when \( v_x = 0 \).
   b. just before the projectile hits the ground.
   c. when the projectile is at maximum height.
   d. when the projectile is at half the maximum height.
   e. at both times when \( |v_y| \) is a maximum.

3. A group of students needs to cross a river in the shortest time. The water in the river flows downstream at a speed of 10 m/s. The boat has a maximum speed of 20 m/s. In what direction should the students head the boat?
   a. Downstream
   b. Directly toward the opposite shore
   c. 27° away from downstream
   d. 63° away from downstream
   e. Upstream
4. A vector \( \vec{A} \) is added to \( \vec{B} = 6\hat{i} - 8\hat{j} \). The resultant vector is in the positive \( x \) direction and has a magnitude equal to that of \( \vec{A} \). What is the magnitude of \( \vec{A} \)?
   a. 11
   b. 5.1
   c. 7.1
   d. 8.3
   e. 12.2

5. A rock is dropped from a height of 15.2 m. What is its speed in m/s when it is half way to the ground if its initial speed is zero?
   a. 7.60
   b. 8.63
   c. 12.2
   d. 74.5
   e. 149

6. A particle’s position on the \( x \)-axis is given by the equation \( x = 1 + 2t - t^2 \). What is its velocity in m/s at \( t = 2 \) s if \( x \) is measured in m and \( t \) in s?
   a. \(-2\)
   b. \(-1\)
   c. 0
   d. 0.5
   e. 1

7. An astronaut on the moon tosses a moon rock in the air while running forward at a constant speed of 3.2 m/s. The acceleration of gravity on the moon is 1.6 m/s\(^2\). She catches the rock 4.0 seconds after it is thrown. The angle at which she threw the rock (relative to the forward direction and the surface of the moon) is
   a. 0°
   b. 45°
   c. 63°
   d. 90°
   e. 135°
Free responses (39% each, show your work)

A catapult launches a rocket at an angle of 60.0° above the horizontal with an initial speed of 100 m/s. The rocket engine immediately starts a burn, and for 10.0 s the rocket moves along its initial line of motion with an acceleration of 10.0 m/s². Then its engine fails, and the rocket proceeds to move in free-fall. Find
(a) the maximum altitude reached by the rocket,
(b) its total time of flight,
(c) its horizontal range,
(d) the final speed of the rocket when it is about to hit the ground.

\[
\begin{align*}
\text{Stage 1:} & \quad \begin{array}{c}
a = 10 \text{ m/s}^2 \quad \theta = 60^\circ \quad t = 10.0 \text{ s} \\
V_f = V_i + at = 100 + 10 \times 10 = 200 \text{ m/s} \\
d = V_i t + \frac{1}{2} a t^2 = 100 \times 10 + \frac{1}{2} \times 10 \times (10)^2 = 1500 \text{ m}
\end{array} \\
\end{align*}
\]

\[
\begin{align*}
\text{Stage 2:} & \quad \begin{array}{c}
V_{ox} = 200 \cos 60^\circ = 100 \text{ m/s} \\
V_{oy} = 200 \sin 60^\circ = 173 \text{ m/s} \\
\Delta y = \frac{V_{oy}^2 - V_{fy}^2}{-2g} = \frac{0 - (173)^2}{-2 \times 9.8} = 1527 \text{ m} \\
\Delta x = V_{ox} t = 100 \times 17.7 = 1770 \text{ m}
\end{array} \\
\end{align*}
\]

\[
\begin{align*}
\text{Stage 3:} & \quad \begin{array}{c}
V_{ox} = 100 \text{ m/s} \quad V_{oy} = 0 \\
\Delta y = -(1500 \sin 60^\circ + 1527) = -2826 \text{ m} \\
V_{fy} = -\sqrt{V_{oy}^2 - 2 \Delta y g} = -\sqrt{0 - 2 \times 9.8 \times (-2826)} = -236 \text{ m/s} \\
t = \frac{V_{fy} - V_{oy}}{g} = \frac{-236}{-9.8} = 24.0 \text{ s} \\
X = V_{ox} t = 100 \times 24.0 = 2400 \text{ m}
\end{array} \\
\end{align*}
\]

(a) \( y_{max} = (1500 \sin 60^\circ + 1527) = 2826 \text{ m} \)
(b) \( t = 10.0 + 17.7 + 24.0 = 51.7 \text{ s} \)
(c) \( R = 1500 \cos 60^\circ + 1770 + 2400 = 4920 \text{ m} \)
(d) \( |V_f| = \sqrt{100^2 + (-236)^2} = 255 \text{ m/s} \)
It is also ok to solve time for Stage 2 & 3 together (steps with blue dots)

Stage 2 & 3:

\[ v_{ox} = 100 \text{ m/s} \quad v_{oy} = 173 \text{ m/s} \quad a_y = -(1500 \sin 60^\circ) = -1299 \text{ m/s}^2 \]

\[ \Delta y = v_{oy} t - \frac{1}{2} a_y t^2 \quad \Rightarrow \quad -1299 = 173 t - 4.9 t^2 \quad \Rightarrow \quad t^2 - 35.3 t - 265 = 0 \]

\[ t = \frac{35.3 \pm \sqrt{35.3^2 + 4 \times 265}}{2} = 41.7 \text{ s or } -6.45 \text{ s} \]

\[ x = v_{ox} t = 100 \times 41.7 = 4170 \text{ m} \]

\[ v_{f y} = v_{oy} - gt = 173 - 9.8 \times 41.7 = -23.6 \text{ m/s} \]

Then use the same steps as for stage 2 for the maximum height.