Physics 161: Exam # 1

Write your name in the upper right hand corner. Please write neatly, and state your assumptions and definitions clearly. A labeled sketch will often make this easier!

1. A particle moving along the $x$ axis has a position given by $x = (24t - 2.0t^3)$ m, where $t$ is measured in seconds. What is the magnitude of the acceleration of the particle when the particle is not moving? (5 points)
   (a) 24 m/s$^2$
   (b) zero
   (c) 12 m/s$^2$
   (d) 48 m/s$^2$
   (e) 36 m/s$^2$

   Why? (5 points)

2. An automobile traveling along a straight road increases its speed from 30.0 m/s to 50.0 m/s in a distance of 180 m. If the acceleration is constant, how much time elapses while the auto moves this distance? (5 points)
   (a) 6.00 s
   (b) 4.50 s
   (c) 3.60 s
   (d) 4.00 s
   (e) 9.00 s

   Why? (10 points)
3. A speedy tortoise can run with a velocity of 10 cm/s and a hare can run 20 times as fast. In a race, they both start at the same time, but the hare stops to rest for 2.0 minutes. The tortoise wins by a shell (20 cm). What was the length of the race? (20 points)

4. A juggler throws two balls to the same height so that one is at the halfway point going up when the other is at the halfway point coming down. At that point: (5 points)

(a) Their velocities and accelerations are equal.
(b) Their velocities are equal but their accelerations are equal and opposite.
(c) Their accelerations are equal but their velocities are equal and opposite.
(d) Their velocities and accelerations are both equal and opposite.
(e) Their velocities are equal to their accelerations.
5. If $A = 28\, \mathbf{i} + 11\, \mathbf{j}$ and $B$ is as shown, what is the magnitude of the sum of these two vectors? (5 points)

(a) 45
(b) 35
(c) 39
(d) 32
(e) 64

Why? (10 points)
6. A hiker wishes to cross a river that is 1.5 km wide and flows with a velocity of 5.0 km/h parallel to its banks. The hiker uses a small powerboat that moves at a maximum speed of 12 km/h with respect to the water. What is the minimum time for crossing? (10 points)

7. Two vectors starting at the same origin have equal and opposite $x$-components. Is it possible for the two vectors to be perpendicular to each other? Briefly justify your answer. (5 points)
8. A projectile starts at the coordinate origin, where the displacement vector also originates. The initial velocity $v_0$ makes an angle $\theta_0$ with the horizontal, where $0 < \theta_0 < 90^\circ$. At the instant when the projectile is at the highest point of its trajectory, the displacement, velocity and acceleration vectors are $r$, $v$, and $a$. Which statement is true? (5 points)

(a) $r$ is parallel to $v$
(b) $r$ is perpendicular to $v$
(c) $v$ is parallel to $a$
(d) $v$ is perpendicular to $a$
(e) $r$ is perpendicular to $a$

Why? (10 points)
9. The apparent weight of a fish in an elevator is greatest when the elevator: (10 points)
   (a) moves downward at constant velocity
   (b) moves upward at constant velocity
   (c) accelerates downward
   (d) accelerates upward
   (e) when the elevator is not moving

10. A student in the front of a school bus throws a ball to another student in the back of the bus while the bus is moving forward at constant velocity. The speed of the ball as seen by a stationary observer in the street: (5 points)
   (a) is less than that observed inside the bus
   (b) is the same as that observed inside the bus
   (c) is greater than that observed inside the bus
   (d) may be either greater or smaller than that observed inside the bus
   (e) cannot be determined with knowing the magnitudes of the velocities.

11. A particle moves clockwise along the circular path shown below, with non-uniform speed. The speed is decreasing in time. At the point indicated by the arrow, sketch in the velocity vector. (5 points)
    Sketch in the radial and tangential acceleration vectors. (10 points)
12. Two projectiles are fired at precisely the same instant, as shown, one with initial velocity $v_1$, making an angle $\theta_1$ with the horizontal, and the other with initial velocity $v_2$, making an angle $\theta_2$ with the horizontal. Projectile 1 is fired from the origin of coordinates, projectile 2 from the point $x_{02}$. Which of these is true? (10 points)

(a) The projectiles collide at $t = x_{02}/(v_1 \sin \theta_1 - v_2 \sin \theta_2)$ if and only if $v_1/v_2 = \cos \theta_2/\cos \theta_1$.
(b) The projectiles collide at $t = x_{02}/(v_1 \sin \theta_1 + v_2 \sin \theta_2)$ if and only if $v_1/v_2 = \cos \theta_2/\cos \theta_1$.
(c) The projectiles collide at $t = x_{02}/(v_1 \cos \theta_1 + v_2 \cos \theta_2)$ if and only if $v_1/v_2 = \sin \theta_2/\sin \theta_1$.
(d) The projectiles collide at $t = x_{02}/(v_1 \cos \theta_1 - v_2 \cos \theta_2)$ if and only if $v_1/v_2 = \sin \theta_2/\sin \theta_1$.
(e) The projectiles collide at $t = x_{02}/[v_1 \cos(\theta_1 - \theta_2)]$ if and only if $v_1/v_2 = \cos \theta_2/\cos \theta_1$.

**Why?** (25 points)
13. The $x$-position of a particle $vs$ time is shown in the figure below.

Sketch the particle’s velocity and acceleration $vs$ time. (20 points)
14. A projectile is fired from a cliff of height $y_0$ m with initial speed $v_0$ m/s, at an angle $\theta$ with respect to horizontal. Neglecting air resistance, how far from the base of the cliff does the projectile land? (10 points)

(a) 
\[ \frac{v_0^2}{g} \sin \theta \cos (\theta + v_0/y_0) \left( 1 + \sqrt{1 + \frac{2y_0g}{v_0^2 \sin^2 \theta}} \right) \]

(b) 
\[ \frac{v_0^2}{g} \sin \theta \cos \theta \left( 1 + \sqrt{1 + \frac{2y_0g}{v_0^2 \sin^2 \theta}} \right) \]

(c) 
\[ \frac{v_0^2}{g} \sin \theta \cos \theta \left( 1 + \sqrt{1 + \frac{2y_0g}{v_0^2 \sin^2 \theta}} \right) \]

(d) 
\[ \frac{v_0^2}{g} \sin \theta \cos \theta \left( 1 + \sqrt{g + \frac{2y_0g}{v_0^2 \sin^2 \theta}} \right) \]

Why? (20 points)