Physics 151

Roster No.: __________________________

Score: 28 pts. possible

SPRING 2006 Midterm Exam #1, Part A

Exam time limit: 50 minutes. You may use a calculator and both sides of ONE sheet of notes, handwritt
only. Closed book; no collaboration. For multiple choice questions, circle the letter of the one best answer (unl
more than one answer is asked for).

Physical constants: \( g = 9.80 \text{ m/s}^2 \)

Useful conversions: \( 1 \text{ y} = 3.156 \times 10^7 \text{ s} \) \( 1 \text{ Å} = 10^{-10} \text{ m} \)

1. (8 pts.) Convert the following quantities into the units specified. Fill in the blanks. (You do NOT need to show your work.) Use scientific notation where appropriate (very large or very small values), and express all final values to 2 significant figures.

   a. \( 630 \text{ nm} = \) \text{ Å} (see conversion factor above)

   b. \( 1.3 \times 10^{-4} \text{ g} = \) \text{ µg}

   c. \( 2200 \text{ cm}^2 = \) \text{ m}^2

   d. \( 2.5 \text{ mm/s} = \) \text{ km/y} (see conversion factor above)

2. a. (1 pt.) How many significant figures does the value “0.080900 kg” have?
   
   A. 2 \hspace{1cm} D. 5
   
   B. 3 \hspace{1cm} E. 6
   
   C. 4 \hspace{1cm} F. 7

   b. (2 pts.) Write the value “0.080900 kg” in scientific notation: __________________________ kg

      (Write your answer as compactly as possible, i.e., using the fewest digits necessary to write the number.)

3. A bird tries to propel itself through the air at 8.0 m/s due north, but it does so in a crosswind that blows due east at 3.0 m/s. The bird’s total velocity (relative to the ground) is the vector sum of these two velocities.

   a. (2 pts.) What is the magnitude of the bird’s total velocity?
   
   A. 6.8 m/s \hspace{1cm} D. 9.2 m/s
   
   B. 7.4 m/s \hspace{1cm} E. 9.9 m/s
   
   C. 8.5 m/s \hspace{1cm} F. 11 m/s

   b. (2 pts.) What is the direction of the bird’s total velocity?
   
   A. 21˚ east of north \hspace{1cm} D. 30˚ east of north
   
   B. 24˚ east of north \hspace{1cm} E. 33˚ east of north
   
   C. 27˚ east of north \hspace{1cm} F. 36˚ east of north

4. (1 pt.) An object’s speed is equal to:
   
   A. the magnitude of the object’s displacement
   
   B. the magnitude of the object’s velocity
   
   C. the direction of the object’s displacement
   
   D. the direction of the object’s velocity
5. A racecar, facing in the +x-direction, moves only along the x-axis. Its *velocity* as a function of time is described by the graph at right:

a. (6 pts.) What is the car’s *acceleration* during each of the three time segments? (You do NOT need to show your work.) Be sure to include *correct units* on your answers.

**segment A:**

**segment B:**

**segment C:**

b. (1 pt.) Which one of the following is TRUE about the car during **segment B**?
   
   A. The car’s position is constant.
   B. The car is moving in the +x-direction.
   C. The car is at rest.
   D. The car’s speed is increasing.

c. (2 pts.) If the car starts at the origin at *t* = 0, what is its *position* at *t* = 30. s?

   A. 200 m  
   B. 400 m  
   C. 600 m  
   D. 800 m  
   E. 1000 m  
   F. 1200 m

6. Suppose that, near the surface of some planet without air resistance, a mass *m* is released from rest and falls a distance of Δ*y* during the first second.

a. (1 pt.) A *larger mass* 2*m* in the same situation would fall…

   A. the same distance Δ*y* during the first second.
   B. distance √2 Δ*y* during the first second.
   C. distance 2Δ*y* during the first second.
   D. distance 4Δ*y* during the first second.

b. (2 pts.) What *additional distance* does the original mass *m* fall during the **next second** (i.e., during the time interval from *t* = 1.0 s to *t* = 2.0 s)?

   A. Δ*y*  
   B. 2Δ*y*  
   C. 3Δ*y*  
   D. 4Δ*y*
1. Suppose that an 85.0-kg treasure chest is at the center of a tug-of-war between two ropes: rope $A$, pulled directly to the left with 315 N; and rope $B$, pulled directly to the right with 275 N. The treasure chest sits on frictionless level ground.

   a. (2 pts.) At right, draw a free-body diagram showing (and labeling) ALL forces acting on the chest:

   b. (4 pts.) What are the magnitude and direction of the chest’s acceleration?

   c. (3 pts.) What are the magnitude and direction of the normal force acting on the chest?

   d. (1 pt.) Suppose that, at some later time, the person pulling on rope $B$ changes the strength of $F_B$ so that the chest slides along the ground at a constant speed of 0.250 m/s. ($F_A$ did not change.) What is the new magnitude of $F_B$?

   A. zero  
   B. 254 N  
   C. 293 N  
   D. 296 N  
   E. 315 N  
   F. 336 N
2. You have a homemade catapult that launches all objects (of any mass) at an initial velocity of 25.0 m/s, and can only launch at an angle of 35.0° above the horizontal. Ignore air resistance throughout this problem.

a. (4 pts.) Calculate $v_{0x}$ and $v_{0y}$ (the $x$- and $y$-components of the initial velocity, $v_0$) for the object as it leaves the catapult. Show your work.

b. (4 pts.) Suppose that you use the catapult to launch an object on level ground, so that the object lands at the same height from which it was launched. What is the object’s total time of flight? Show and clearly explain your work.

c. (4 pts.) Using your catapult, what is the greatest possible height that an object can reach (above the level from which it is launched)?
2. continued:

**BONUS** (2 pts.): You want to launch a gift from the ground into the middle of your friend’s dorm room window, which is located 9.00 m higher than your catapult. **Horizontally, how far** from the building should you position your catapult for success? **Note:** There are TWO solutions! Depending on your approach, you may need the quadratic formula:

\[
ax^2 + bx + c = 0, \text{ solutions are: } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.
\]