*First Name:* SOLUTIONS *Last Name:* _____ *Section:* _____

September 25, 1998 Physics 207

# Exam 1

Print your name and section clearly on all five pages. (If you do not know your section number, write your TA's name.) Show all work in the space immediately below each problem. Your final answer must be placed in the box provided. Problems will be graded on reasoning and intermediate steps as well as on the final answer. Be sure to include units wherever necessary, and the direction of vectors. Each problem is worth 25 points. In doing the problems, try to be neat. Check your answers to see that they have the correct dimensions (units) and are the right order of magnitudes. You are allowed one 8½ x 11" sheet of notes and no other references. The exam lasts exactly 50 minutes.

*(Do not write below)*

SCORE:

Problem 1: _____

Problem 2: _____

Problem 3: _____

Problem 4: _____

**TOTAL:** _____

*First Name:* _____ *Last Name:* _____ *Section:* _____

1. While driving down a highway, you clock the time between two successive mile markers at 70 seconds.

a. What is your average speed in mi/hr? *(5 pts.)*

$$v = \frac{1\,mi}{70\,s}\ \frac{3600\,s}{1\,hr} = 51.4\,mi/hr$$

51.4 mi/hr

b. Assuming the markers are accurate, but your time estimate has an error of ± 1 s, what is the error in your speed estimate in mi/hr? *(5 pts.)*

$$\Delta v = v\,\Delta t/t = \frac{51.4 \times 1}{70} = \pm 0.7\,mi/hr$$

± 0.7 mi/hr

c. If 1 km = 0.621 mi, what is your average speed in m/s? *(5 pts.)*

$$v = \frac{1\,mi}{70\,s}\ \frac{1000\,m}{0.621\,mi} = 23.0\,m/s$$

23.0 m/s

d. If you filled the gas tank 5 hours ago and it is now ¼ full, how many more miles can you go before running out of gas, assuming your speed has been and will remain the same as calculated in part a above? *(5 pts.)*

$$d = \frac{1/4}{3/4}\,vt = \frac{1}{3} \times 51.4 \times 5 = 85.7\,mi$$

85.7 mi

e. If your gas tank holds 18 gallons, how many miles per gallon are you getting? *(5 pts.)*

$$mpg = \frac{d}{18/4} = \frac{4d}{18} = \frac{4 \times 85.7}{18} = 19.0\,mi/gal$$

19.0 mi/gal

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2. A ball is thrown vertically upward and reaches a height of 12 m before falling back to the point at which it was released.

a. With what initial speed was the ball released? *(9 pts.)*

$$v^2 = v_0^2 + 2ax = v_0^2 - 2gx = 0$$

$$v_0^2 = 2gx$$

$$v_0 = \sqrt{2gx} = \sqrt{2 \times 9.8 \times 12} = 15.3 \text{ m/s}$$

15.3 m/s

b. How much time elapsed from the instant the ball was released until it reached its maximum height? *(8 pts.)*

$$v = v_0 + at = v_0 - gt = 0$$

$$t = \frac{v_0}{g} = \frac{15.3}{9.8} = 1.56 \text{ s}$$

1.56 s

c. If the ball was released 2 m above the ground, at what speed does it hit the ground? *(8 pts.)*

$$v^2 = v_0^2 + 2a(x - x_0) = v_0^2 - 2gx$$

$$v = \sqrt{v_0^2 - 2gx}$$

$$= \sqrt{(15.3)^2 + 2 \times 9.8 \times 2} = 16.5 \text{ m/s}$$

16.5 m/s

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3. An automobile travels 4 miles east and then turns and travels 3 miles north.

a. What total distance was traveled? *(5 pts.)*

$d = x + y = 4 + 3 = 7\ mi$

7 mi

b. What is the magnitude of the displacement vector? *(5 pts.)*

$R = \sqrt{x^2 + y^2}$

$= \sqrt{16 + 9} = 5\ mi$

5 mi

c. What is the angle of the displacement vector relative to north? *(5 pts.)*

$\theta = \tan^{-1}\left(\frac{x}{y}\right) = \tan^{-1}\left(\frac{3}{4}\right) = 36.9°$

36.9°

d. If the trip took 6 minutes, what was the average speed in mi/hr? *(5 pts.)*

$v = \frac{d}{t} = \frac{7}{6/60} = 70\ mi/hr$

70 mi/hr

e. What was the average velocity? *(5 pts.)*

$v = \frac{R}{t} = \frac{5}{6/60} = 50\ mi/hr$

(with direction in c above)

50 mi/hr

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4. A field goal in American football requires kicking the ball from ground level over a goal post 3 meters high. Assume a kicker kicks the ball at an angle of 45° above the ground at a horizontal distance of 35 yards (32 meters) from the goal post.

a. What initial speed must the ball have to just clear the goal post? *(5 pts.)*

$v_{0x} = v_{0y} = v_0/\sqrt{2}$, $y = v_{0y}t - \frac{1}{2}gt^2$

$x = v_{0x}t \Rightarrow t = x/v_{0x}$, $t^2 = 2x^2/v_0$

$v_{0x} = x\sqrt{\frac{g}{x-y}} = 32\sqrt{\frac{9.8}{32-3}} = 18.6\,m/s$

18.6 m/s

b. How long is the ball in the air before crossing the goal post? *(5 pts.)*

$t = \frac{x}{v_{0x}} = \frac{\sqrt{2}\,x}{v_0} = \frac{\sqrt{2}\times 32}{18.6}$

$= 2.43\,s$

2.43 s

c. How far beyond the goal post does the ball hit the ground? *(5 pts.)*

$0 = x - gx^2/v_0^2$

$x = v_0^2/g = \frac{(18.6)^2}{9.8} = 35.3$

$\Delta x = x - 32 = 3.3\,m$

3.3 m

d. At what speed does the ball strike the ground? *(5 pts.)*

$v = v_0 = 18.6\,m/s$

18.6 m/s

e. At what angle from the horizontal does the ball strike the ground? *(5 pts.)*

$\theta = \theta_0 = 45°$

45°