Name _____

***PLEASE* READ THIS FIRST**:

- Time limit: 80 minutes
- Please remove hats and turn off and put away any communication devices.
- You may use **one sheet of prepared notes** (8 ½ x 11, both sides). Please staple it to the back of this exam when you are finished.
- Perform all of your work on these sheets. If you need more space, use the back of the same sheet. If you run out of space, ask me for a blank sheet of paper and staple it to the back of your exam before turning it in.
- Read each problem *carefully* and be sure to pay attention to any hints that are provided. The credit you receive on each problem will depend more on how you get your answer than on what answer you get. There is *no* need to be as "wordy" as I ask you to be on homework, but you must show your work or give *at least* a brief explanation for *every* answer. I give ***no* credit for unsupported answers**. I do give partial credit for partially correct solutions, but *only* when I can determine that what you are doing is partially correct.
- Make *certain* that all numerical answers are given with a ***reasonable number of significant digits*** (when in doubt, *three* is usually a good compromise) and that you have included ***appropriate and simplified units.***
- Check your answers for **physical *reasonableness*** whenever possible; I do deduct a small number of points for ridiculous answers that you don't comment on.
- Please use $g = 10.0$ m/s^2 in all problems (unless otherwise specified)to make the arithmetic easier.

1. a) [5 pts] "Work" is defined as a product of force and distance, e.g., $W = F \cdot d$, and "power" can be defined as the rate at which work is done, e.g., $P = \frac{dW}{dt}$. What are the "*dimensions*" of power? (Don't forget: "No credit for unsupported answers." I don't want a long explanation, I just need to see how you get your answer.)

   b) [5 pts] *Convert* the speed "11.0 kilofurlongs/fortnight" to units of ft/sec.
   [Note: One mile is 5280 ft, a fortnight is 2 weeks, and a furlong is 1/8 of a mile.]

2. [15 pts] A car slows from 25 m/s to 15 m/s in a distance of 100 m. What was a) its *acceleration* (a vector!) *and* b) the *time* it took to slow down? [Big hint: What was its *average* speed?]

3. [20 pts total] Exactly three forces act on an object that has a mass of 17 kg and that moves with *constant* velocity. The magnitudes of the three forces are
$|\vec{F}_1| = 5.0$ N, $|\vec{F}_2| = 7.0$ N, and $|\vec{F}_3| = 10.0$ N

   a) [3] What is the *acceleration* of the object? (***Always*** remember to support ***every*** answer by showing your work or including a brief explanation. ***No credit*** for unsupported answers.)

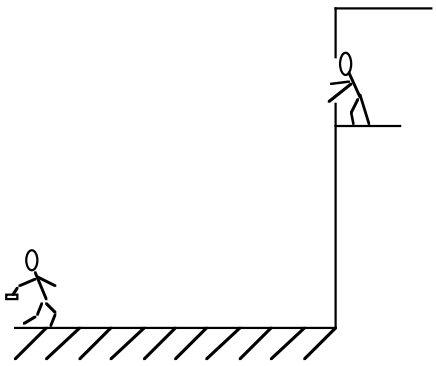
   b) [3] *How do you know* that $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$?

   c) [3] What is $F_1 + F_2 + F_3$? (Note: This is *not* the same question as part b!)

   d) [5] What is $|\vec{F}_2 + \vec{F}_3|$? [Hint: Use the information given in part b]

   e) [6] What is the *angle* between $\vec{F}_2$ and $\vec{F}_3$? [Use the back of this sheet.]

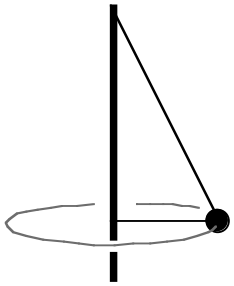
4. [20 pts total] You were supposed to meet a friend of yours for a noon picnic in the city park, but she works in a building that has no stairs and a temporarily broken elevator. It's now well past noon and she's getting *very* hungry. Fortunately, you have an egg sandwich for her in your basket, so you decide to try to launch it to her with a sling. You position yourself 30 meters away from the base of the building while she stands in a window 21 meters higher.



a) [16] If the sandwich gets to her 3.0 seconds after being launched, what was its *velocity* just after being launched? Express your answer in terms of magnitude *and* direction. [Please ignore the effects of air resistance.]

b) [4] Is the sandwich *rising or falling* in altitude just before your friend catches it? Explain.

5. [20 pts total] A small steel ball with a mass of 200 g moves in a horizontal circular path around a vertical pole to which it is attached by two light strings as shown. One of the strings is 60 cm long and remains horizontal. The other is 150 cm long. It takes 1.5 seconds for the ball to complete one revolution around the pole.



   a) [5] What is the *magnitude of the acceleration* of the ball?

   b) [6] In the space at right, draw a *free body diagram* for the ball. Make sure that it clearly shows
   1) all of the forces acting on the ball,
   2) the acceleration of the ball,
   3) a coordinate system of your choice, and
   4) angles for vectors that do not lie along the axes of that coordinate system.

   c) [6] Using your free body diagram, apply Newton's second law to the ball in order to obtain and simplify *two equations* relating the magnitudes of the forces to the magnitude of the acceleration.

   d) [3] Solve your equations to find the *tension* in the horizontal string.

EXTRA CREDIT [5 pts] What is the *maximum period* of the circular motion that will keep the horizontal string from going slack? (Show your work on the back of this sheet.)

6. [15 pts] A 30 kg box is pushed along a horizontal frictional surface by a constant force that is directed 20 degrees below the horizontal. The kinetic coefficient of friction is 0.25. Starting from rest, the block moves 4.0 meters in 5.0 seconds. What is the *magnitude of the pushing force*? [Hints: Find the acceleration of the box first. Then just use the method I've shown you for doing Newton's second law problems!]