TA's Name:____________________ Section: ____
Your Name: _________________________________

Assignment 2

Concepts:

motion with constant acceleration
free fall
proportional reasoning
dimensional analysis

vectors and scalars
addition and subtraction of vectors
components of vectors and unit vectors
$\vec{r}$, $\vec{v}$, and $\vec{a}$

Reading in text: Chapter 2: Sections 1-10; Chapter 3: Sections 1-6; Chapter 4: 1-6

Assignment: Due in lecture on Wednesday, September 6.

Please turn in this sheet stapled to the top of your work.

A. On-Line Math Warm-Up Problems: If you'd like some practice with the math skills relevant to the work we're doing this week and next, please go to *www.blackboard.cornell.edu*, log in to the Physics 207 Math Review website, and then do the Unit Tests on Triangles and Vectors, Proportions and Sines and Cosines 1. You can attempt the tests as many times as you like.

B. Physics Problems:

1. A CRJ-100 jet plane needs to reach a speed of 360 km/h for takeoff, and requires a minimum runway length for takeoff of 1.8 km.

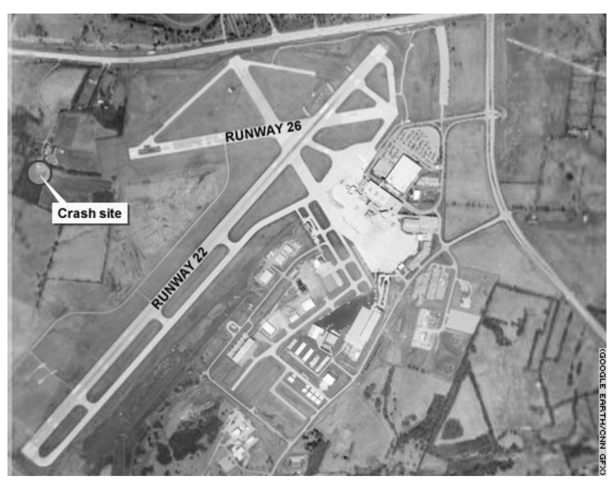
(a) What is the smallest (constant) acceleration (in m/s^2) needed for a 1.8 km long runway? What fraction of the magnitude of the acceleration due to gravity, *g*, is this? (Is your answer consistent with your feeling of being pushed into your seat during takeoff?)

(b) How long does this takeoff last?

(c) Sketch graphs of *x* versus *t*, *v* versus *t*, and *a* versus *t* for this takeoff.

(d) A BMW advertisement a few years ago bragged that one of its models could beat a commercial jet in a 0 to 100 km/h race. Most cars can accelerate from 0 to 100 km/h in 9 s. How does their average acceleration compare with that for the jet of part (a)? (Of course, unlike a BMW, a jet can keep on accelerating on up to 900 km/h.)

(e) On Sunday morning, August 27, 2006, a Comair CRJ-100 jet crashed during takeoff from Lexington, KY. The pilot mistakenly tried to take off from the short Runway 26 instead of the 2.1 km long Runway 22. Assuming that the pilot used the same thrust and thus achieved the same acceleration as in part (a) (expecting a full-length runway), what was the plane's speed when it reached the end of the runway? (Determine the runway length from the photograph of the Lexington airport at right.)



2. Chapter 2, Problem 107

3. The flea *Spilopsyllus* can jump to a height of 25 cm (about 10 inches). (a) Sketch graphs of y(t), v(t), and a(t) for the flea from the start of the jump to when it returns to the ground (after failing to cling to a passing dog.) (a) What must be the flea's speed just after it leaves the ground? (b) How long is the flea in the air? (c) The flea must attain the speed in (a) by accelerating from rest over a distance comparable to the length of its legs (about 0.4 mm). What is the average acceleration of the flea during its jump (i.e., during the time that its legs are in contact with the ground), and what is this time interval? Express your answer for the acceleration in g's. (For comparison, a rattlesnake's head can achieve 5 g's during a strike at, e.g., a Hollywood "B" movie actor. Humans black out at accelerations > 5 g's.)

4. Chapter 2, Problem 60

5. For a small sphere moving slowly through a "thick" fluid (e.g., corn syrup), the drag force D exerted on it by the fluid depends on the sphere's radius r, its velocity v, and a parameter η called the viscosity that measures how "thick" is the fluid. The units of η are kg m^{-1} s^{-1}. Using dimensional analysis (consistency of units), determine the relationship between the viscous drag force D and r, v, and η. In other words, write a proportionality D $\propto$ *something* rather than an equation D = *something*).

6. Chapter 3, Problem 14

7. Chapter 3, Problem 22

8. A baseball leaves a pitcher's hand horizontally at a speed of 161 km/h. The (horizontal) distance to the batter is 18.3 m. Ignore the effects of the air (and thus spin) and use *g*=10 m/s^2.
   (a) Sketch $v_x(t)$ and $v_y(t)$ on separate graphs, one below the other, using the same time scale in both graphs. Your graphs need only cover the interval from the time the ball leaves the pitcher's hand until it arrives at the batter.
   (b) How long does the ball take to travel the first half of the (horizontal) distance from the pitcher to the batter?
   (c) How long does it take to travel the second half?
   (d) How does the total time of travel compare with a typical human reaction time (which doesn't include the time to swing the bat) of ~0.2 s?
   (d) How far does the ball fall freely during the first half?
   (e) How far does it fall freely during the second half?
   (f) Why aren't the answers to parts (d) and (e) equal?
   (To learn more about the remarkable feat performed in hitting a fastball, see, e.g., http://www.exploratorium.edu/baseball/biobaseball.html and http://sportsfigures.espn.com/sportsfigures/lp_math_reaction03.htm)

Text questions, exercises, and problems for study and review:

Chapter 2: Questions 5, 7, 8, 9. Problems 22, 23, 24, 27, 28, 30, 33, 34, 35, 37, 39, 40, 41, 52, 56, 62
Chapter 3: Questions 2, 4. Problems 1, 3, 5, 8, 9, 11, 15, 23, 24
Chapter 4: Question 2. Problems 4, 5, 10