University Physics I

Homework Set 4

1. A truck covers 40.0 *m* in 8.50 *s* while smoothly slowing down to a final speed of 2.8 *m/s*.
   a. Find its original speed.
   b. Find its acceleration.

2. The fastest measured pitched baseball left the pitcher's hand at a speed of 45.0 *m/s*. If the pitcher was in contact with the ball over a distance of 1.5 *m* and produced a constant acceleration:
   a. What acceleration did he give the ball?
   b. How much time did it take him to pitch it?

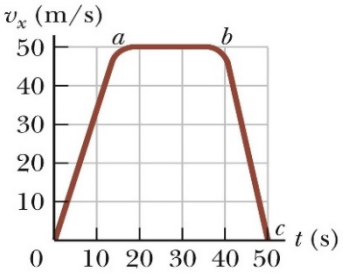
3. In the fastest measured tennis serve, the ball left the racquet at 73.14 *m/s*. A served tennis ball is typically in contact with the racquet for 30.0 *ms* and starts from rest. Assuming constant acceleration:
   a. What was the ball's acceleration during the serve?
   b. How far did the ball travel while in contact with the racquet?

4. The human body can survive an acceleration trauma incident (*sudden stop*) if the magnitude of the acceleration is less than 250 m/s^2. If you are in an automobile accident with an initial speed of 105 *km/h* (65 *mph*) and are stopped by an airbag that inflates from the dashboard, over what distance must the airbag stop you for you to survive the crash? Would you survive this type of accident? Explain.

5. A bullet is fired through a board 10.0 *cm* thick, with the line of motion perpendicular to the surface of the board. If the bullet enters with a speed of 400 *m/s* and emerges with a speed of 200 *m/s*, what is its acceleration as it passes through the board? (*assume constant acceleration*)

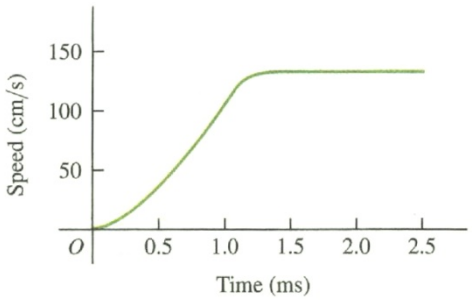
6. A particle moves along the *+x-axis*. Its position is given by the equation $x(t) = 2 + 3t - 4t^2$, with x in meters and t in seconds. Determine:
   a. Its position when it changes direction.
   b. Its velocity when it returns to the position it had at $t = 0$.

7. ** The figure at right represents part of the performance data of a car owned by a proud physics student.
   a. Calculate the total distance traveled by computing the area under the curve.
   b. What distance does the car travel between the times t = 10 *s* and 40 *s*.
   c. Draw a graph of a_x-t.



8. The acceleration of a bus is given by $a_x(t) = \alpha t$, where $\alpha = 1.2\ m/s^3$.
   a. If the bus's velocity at time $t = 1.0$ s is 5.0 *m/s*, what is its velocity at time $t = 2.0$ *s*?
   b. If the bus's position at $t = 1.0$ *s* is 6 *m*, what is its position at $t = 2.0$ *s*?
   c. Sketch a_x-t, v_x-t and x-t graphs for the motion from t = 0 to 10 s.

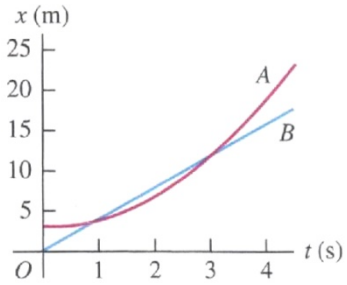
9. ** High-speed motion pictures (3500 frames/sec) of a jumping, 210 μg flea yielded the data used to create the plot in the figure at right. (See "The Flying Leap of a Flea" by M. Rothschild, Y. Schlein, K. Parker, C. Neville, and S. Sternberg in the November 1973 *Scientific American*.) This flea was about 2 *mm* long and jumped at a nearly vertical takeoff angle. Use the graph to answer the following questions:



   a. Is the acceleration of the flea ever zero? If so, when? Explain.
   b. Approximate the maximum height the flea reached in the first 2.5 *ms*.
   c. Approximate the flea's acceleration at 0.5 *ms*, 1.0 *ms*, and 1.5 *ms*.
   d. Approximate the flea's height at 0.5 *ms*, 1.0 *ms*, and 1.5 *ms*.

10. A speeding motorcyclist is traveling at a constant speed of 36.0 *m/s* when he passes a police car parked on the side of the road. The radar, positioned in the police car's rear window, measures the speed of the motorcycle. At the instant the motorcycle passes the police car, the police officer starts to chase the motorcyclist with a constant acceleration of 4.0 m/s^2.
   a. How long will it take the police officer to catch the motorcyclist?
   b. What is the speed of the police car when it catches up to the motorcycle?
   c. How far will the police car have traveled from its original position?

11. ** Two cars, A and B, move along a straight dual lane highway in the same direction (*x*-axis). The figure at right shows a plot of the positions of A and B versus time.



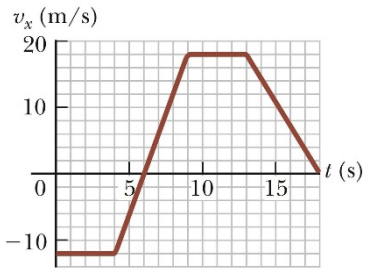
   a. At what time(s), if any, do A and B have the same position?
   b. At what time(s), if any, do A and B have the same velocity?
   c. At what time(s), if any, does car A pass car B?
   d. At what time(s), if any, does car B pass car A?

12. Picture yourself in the castle of Helm's Deep from the *Lord of the Rings*. You are on the top of the castle wall and are dropping rocks on assorted monsters that are 18.35 *m* below you. At the same time you release the rock from rest, an orc archer, located directly below you, shoots an arrow straight up toward you with an initial velocity of 47.4 *m/s*. The arrow hits the rock in midair. How long after you release the rock does this happen?

13. Earthquakes produce several types of shock waves. The most well-known are the **P-waves** (P for *primary* or *pressure*) and the **S-waves** (S for *secondary* or *shear*). In the earth's crust, P-waves travel at about 6.5 *km/s* and S-waves move at about 3.5 *km/s*. The time delay between the arrival of these two waves at a seismic recording station tell geologists how far away an earthquake occurred. If the time delay is 33 *s*, how far (*in km*) from the seismic station did the earthquake occur? (*Using this data from several seismic stations, the exact location of the earthquake can be determined*)

14. The froghopper *Philaenus spumarius* is supposedly the best jumper in the animal kingdom. To start a jump, this insect can accelerate at 4.00 km/s^2 over a distance of 2.00 *mm* as it straightens its specially adapted "jumping legs". Assuming constant acceleration:
    a. Find the upward velocity (*in m/s*) at which this insect takes off.
    b. In what time interval does it reach this velocity?
    c. How high (*in m*) would the insect jump if air resistance were ignored? How does this compare to the actual height of 70 *cm*? Is it safe to ignore air resistance in this case?

15. ** An object is at $x = 0$ at $t = 0$ and moves along the *x-axis* according to the v_x-*t* graph at right.



    a. What is the object's acceleration between 0 and 4.0 *s*?
    b. What is the object's acceleration between 4.0 *s* and 9.0 *s*?
    c. What is the object's acceleration between 13.0 *s* and 18.0 *s*?
    d. At what time(s) is the object moving with the lowest speed?
    e. Through what total distance has the object moved between $t = 0$ and $t = 18.0$ *s*?

16. ** (*Spreadsheet*) Astronauts on a distant planet toss a rock into the air. With the aid of a camera that takes pictures at a steady rate, the record the rock's height as a function of time as given in the following table.
    a. Find the rock's average velocity (v_{avg}) in the time interval *between* each measurement and the next.
    b. Plot v_{avg} *vs t* (*using the mid-pt time*) and use a trendline to best fit the data in order to determine the acceleration of the rock. Does the rock move with constant velocity? Explain.

Time (s)	Height (m)	Time (s)	Height (m)
0.00	5.00	2.75	7.62
0.25	5.75	3.00	7.25
0.50	6.40	3.25	6.77
0.75	6.94	3.50	6.20
1.00	7.38	3.75	5.52
1.25	7.72	4.00	4.73
1.50	7.96	4.25	3.85
1.75	8.10	4.50	2.86
2.00	8.13	4.75	1.77
2.25	8.07	5.00	0.58
2.50	7.90		