Problem Set 1

Motion in one dimension

PHYS-101(en)

1. Review: Units

a. A snail crawls at a speed of 5.00 m/hr. Express this speed in miles/fortnight. Note that a mile corresponds to 1609.31 meters and a "fortnight" lasts 14 days.

b. The density of water is 1 g/cm^3. Express this density in kg/m^3, g/dm^3 and kg/mm^3.

c. The speed of light is 3.0×10^8 m/s. How many km does light travel in 365.24 days?

2. Review: Uncertainty and significant figures

a. State the number of significant figures:

1. 0.00001
2. 10.002
3. 200
4. 2.0×10^3
5. 0.02×11.235
6. $z = xy + y^2$, where $x = 1.2 \pm 0.2$ cm and $y = 2.5 \pm 0.8$ cm

b. A ball is dropped from a given height 5 different times. The recorded times are:

0.23 s, 0.35 s, 0.44 s, 0.33 s, 0.38 s

Calculate the result of this experiment and its estimated error, i.e., the standard error.

3. The tortoise and the hare

The tortoise and the hare are racing a distance L along a straight track. The tortoise and hare start with constant velocities, $v_t = C_t$ and $v_h = C_h$ respectively. The hare is not taking this race seriously, so $C_h < C_t$. Once the tortoise arrives at a bridge a distance $L' < L$ from the start, the hare realizes it could lose and accelerates with a constant acceleration a. They tie, both reaching the distance L at the same moment. Sketch a rough plot of the positions of the tortoise and hare as a function of time.

4. The jumping salmon

a. The problem of rectilinear motion under constant acceleration a is given by

$$\ddot{x} = a.$$

Show by integration that the solution is

$$x(t) = \frac{1}{2}at^2 + v_0 t + x_0.$$

Interpret the constants v_0 and x_0. (Remember that $\dot{x}$ is the first derivative of the x with respect to time, i.e. dx/dt, and $\ddot{x}$ is the second derivative of x with respect to time, i.e. d^2x/dt^2.)

b. A salmon jumps vertically out of a lake with an initial velocity of v_0 in the upwards direction. The salmon is subject to a constant acceleration equal to $-g$ due to gravity. Show graphically the vertical position and velocity of the salmon as a function of time.

c. What is the maximum height of the salmon? How long does the fish stay in the air? Assume that $v_0 = 3$ m/s and $g = 10$ m/s^2.

5. The train

A regional train follows a straight trajectory. For 1 minute it accelerates at constant acceleration from 0 to 72 km/hr, then it maintains its velocity for 5 minutes, and then, during 2 minutes, it slows down at constant acceleration and comes to a stop. Plot (with numerical values) the position, velocity and acceleration as a function of time.