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. Note that the result is the mean value of the recorded times and the estimated error is the standard deviation of them.

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 an 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.