Week 1-Problems

1-1 Consider two circular race tracks of radii r_1 and r_2. Show that the difference between the track lengths is determined only by (r_2- r_1).

1-2 The radius of the hydrogen atom is $0.5X10^{-10}$m. How many hydrogen atoms will fit in one centimeter?

1-3 One of the ways to determine the diameter of large polymeric molecules is to take the liquid and drop a small bubble of volume $0.1cm^3$ onto the surface of water. If it spreads into a slick of diameter 5m what would you estimate is the "size" of the polymer molecule (we assume that the slick has thickness of 1 molecule).

1-4 You are standing just outside a circular tank of 6m diameter. A fountain is playing in the center and being 6ft tall, you estimate that the top of the fountain is about 30^{o} above the horizon from your perspective. How high is the water top from the ground? Express your answer in meters.

1-5 The space shuttles orbit the Earth at an attitude of 300 km.

i) What is the radius of their orbit if the Earth has a radius of 4,000 miles?

ii) What is the circumference of their orbit? Express your answer in meters using three (3) significance figures and "powers of ten".

1-6 Antarctica is roughly semi circular in shape with a radius of 2,000 km. The average thickness of the ice cover is 3,000m. What is the volume of the ice in (i) cubic inches, (ii) Liters? Why?

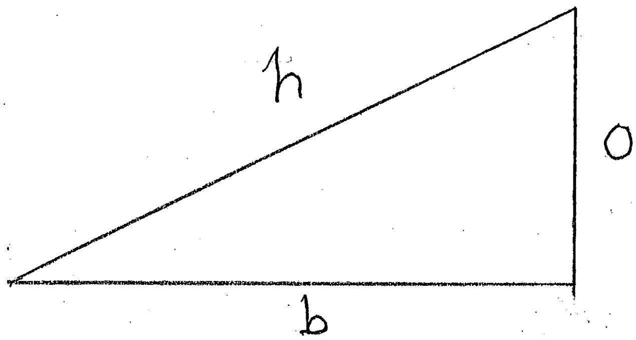
1-7 If the radius of a sphere is written as (10 ± 0.2) cm, what is the uncertainty in a) its diameter b) its surface area c) The volume? Why?

1-8 What is the volume of your body? What experiment would you suggest to roughly check your estimate?

1-9 What are (i) the surface area and (ii) the volume of a cube whose each side is 1 μm? Why?

1-10 Measure the diameter of (i) a penny (ii) a nickel and (iii) a quarter. The moon has a radius of 1.7x 10^3km and is at a distance of 3.8x 10^5km from Earth. At what distance in front of your eye would you hold one of these coins so that it just "covers" the moon completely?

1-11 Consider the triangle shown. Pythagoras' theorem tell us that $h^2=o^2+b^2$. Show that it is exactly equivalent to the trigonometric equation $\sin^2\theta` + \cos^2\theta`=1$ or $\tan^2\theta`=1+\sec^2\theta`$.



1-12 Show that when the angle ϑ is small (ϑ<<1), $\sin\vartheta \cong \vartheta$ and $\cos\vartheta \cong 1-\frac{\vartheta^2}{2}$.
(Make a numerical check using your calculator.) (You will need this equation to understand the experiment in Week 3.)

1-13 Write down the following vectors using the unit vectors, $\hat{x}, \hat{y}, \hat{z}$?

a. 5m along positive x.
b. 3m along negative y.
c. 3m along positive x, 6m along negative z.
d. 1m along positive x, +2m along negative y, 3m along positive z.

1-14 In Week 3 you will do a very fundamental experiment (first studied by Galileo) in which you will measure the period (T) of a pendulum and find that T is controlled only by its length (ℓ) The formula is:

$$T=2\pi\sqrt{\frac{\ell}{g}}$$

What must be the dimensions of g for this equation to be dimensionally correct?