Tutorial Problems 1.

Topics:

1. Units and conversions
2. Dimensional analysis
3. Mathematical notations and order of magnitude
4. Measurements and uncertainties

1. Units and conversions

Express the following quantities in questions 1.1 - 1.4 using the prefixes listed in Table 1.4 (slide 13) and the unit abbreviations. For example, 20000m = 20 km.

1.1. The average *peak* power output of a single lightning stroke:

P = 10 000 000 000 000 watts

1.2. Distance from Earth to Moon: s = 3.8 x 10^8 meter

1.3. Mass of a mosquito: m = 0.00004 kilogram

1.4. Period (T) of a radio wavelength 30 m (shortwave): T = 0.1 x 10^{-6} seconds

1.5. What is the frequency of this radio wave if f = 1 / T?

1.6. How many seconds in (a) an hour? (b) in a day (24 hrs)? in a year (365 days)? What is your age in seconds?

1.7. Express speed of light in vacuum, c = 3 x 10^8 m/s, in km / hr.

1.8. Astronomical distances are often measured by **lightyear (LY)**. 1 lightyear is the distance that light covers in 1 year. What is 1 lightyear in meters and kilometres?

1.9. Calculate the density of a solid cube that measures 5 cm on each side and has a mass of 350 g. (density = mass / volume)

1.10. How many grams of copper are required to make a hollow spherical shell with an inner radius of 5.70 cm and an outer radius of 5.75 cm? The density of copper is 8.93 g/cm^3. The volume of a sphere is $V = \frac{4}{3}\pi r^3$

2. Dimensional Analysis

2.1. Show that the expression $x = vt + \frac{1}{2}at^2$ is dimensionally correct, where x is a coordinate and has units of length (L), v is velocity – L/T , a is acceleration – L / T^2, and t is time (T)

2.2. Which of the equations below are dimensionally correct?

(a) $v = v_0 + a\,x$

(b) $v = \sqrt{2gh}$ where *v* is velocity, g is acceleration of gravity, *h* is height

2.3. Derive units of force using *F = ma,* where *m* is mass, and *a* is acceleration

2.4. Newton's gravitational law is given by $F = G\frac{Mm}{r^2}$. Here F is the force of gravity, M and m are masses, and r is a length. What are the SI units of proportionality constant G?

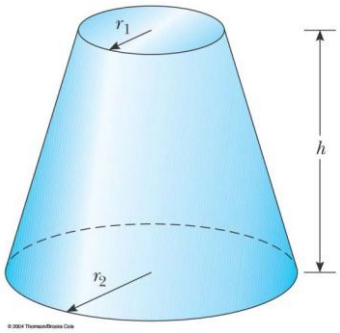
2.5. Figure shows a *frustrum of a cone*. Of the following mensuration (geometrical) expressions, which describes

(a) the total circumference of the flat circular faces,

(b) the volume, and

(c) the area of the curved surface?

(i) $\pi(r_1 + r_2)[h^2 + (r_1 - r_2)^2]^{1/2}$ *(ii)* $2\pi(r_1 + r_2)$ *(iii)* $\pi h(r_1^2 + r_1 r_2 + r_2^2)$.



3. Mathematical notations and order of magnitude

3.1. The mass of the Sun is 1.99×10^{30} kg, and the mass of an atom of hydrogen, of which the Sun is mostly composed, is 1.67×10^{-27} kg. How many atoms are in the Sun?

3.2. The mean radius of the Earth is 6.37×10^6 m, and that of the Moon is 1.74×10^8 cm. From these data calculate

(a) the ratio of the Earth's surface area to that of the Moon and

(b) the ratio of the Earth's volume to that of the Moon.

Recall that the surface area of a sphere is $4\pi r^2$ and the volume of a sphere is $\frac{4}{3}\pi r^3$.

3.3. The distance from the Sun to the nearest star is 4×10^{16} m. The Milky Way galaxy is roughly a disk of diameter ~10^{21} m and thickness ~10^{19} m. Find the order of magnitude of the number of stars in the Milky Way. Assume the distance between the Sun and our nearest neighbour is typical.

3.4. Assuming 60 heartbeats a minute, estimate the total number of times the heart of a human beats in an average lifetime of 70 years.

4. Measurements and uncertainties

4.1. The radius of a solid sphere is measured to be (6.50 ± 0.20) cm, and its mass is measured to be (1.85 ± 0.02) kg. Determine the density of the sphere in kilograms per cubic meter and the uncertainty in the density.

4.2. How many significant figures are in the following numbers?

- 78.9 ± 0.2
- 3.788×10^{9}
- 2.46×10^{-6}
- 0.0053

4.3. A rectangular plate has a length of (21.3 ± 0.2) cm and a width of (9.8 ± 0.1) cm. Calculate the area of the plate including its uncertainty.