Prof. Awni B. Hallak
Department of Physics
The Hashemite University

Physics 101
Second Semester
2012/2013

Suggested Problems from Chapter 1

9. Kinetic energy K (Chapter 7) has dimensions of $kg.m^2/s^2$. It can be written in terms of the momentum p (Chapter 9) and mass m as:

$$K = \frac{p^2}{2m}$$

(a) Determine the proper units for momentum using dimensional analysis. (b) The unit of the force is the Newton N, where 1 N =1 kg. m/s^2. What are the units of momentum p in terms of a Newton and another fundamental SI units?

(a) We can rewrite the above equation as follows:

$$p = \sqrt{2\,m\,K}$$

Units of K : kg.m2/s2

Units of 2 : No units (just a number)

Units of m : kg

Units of p : $= \sqrt{kg.kg.\frac{m^2}{s^2}}$

$$= \sqrt{kg^2.\left(\frac{m}{s}\right)^2}$$

$$= kg.\frac{m}{s}$$

(b) **Units of force :** $= N = kg.\frac{m}{s^2}$

Units of p = $kg.\frac{m}{s} = kg.\frac{m}{s^2}.s = N.s$

10. Newton's law of universal gravitation is represented by:

$$F = G\frac{Mm}{r^2}$$

where **F is the magnitude of the gravitational force** exerted by one small object on another, M and m are the masses of the objects, and **r** is a distance. Force has the SI units **kg . m/s²**. What are the SI units of the proportionality constant G?

We can rewrite the above equation as shown below.

$$G = \frac{F.\, r^2}{Mm}$$

Units of G: = $\dfrac{\left(kg.\dfrac{m}{s^2}\right).\, m^2}{kg.kg} = \dfrac{m^3}{kg.s^2}$

---

11. Which of the following equations are dimensionally correct?
(a) $v_f = v_i + ax$ (b) y = (2 m) cos (kx), where k = 2 m^{-1}

(a) The equation is $v_f = v_i + a\,x$, where a is the acceleration, v is the velocity and x is the displacement.

Left side:
v_f : has units of m/s

Right side:
v_i : has units of m/s ⇒ has the same dimensions as the left side ⇒ OK

a x :has unit of (m/s^2) m= m^2/s^2 ⇒ not the same units of the left side ⇒ NOT OK

The left side and the right side do not have the same units. That is, the equation is dimensionally not correct.

(b) y = (2 m) cos (kx), where k = 2 m^{-1}, x and y are displacements.

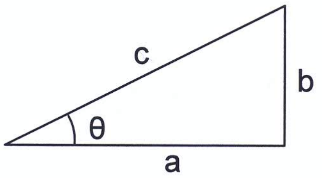
Left side:
y : has units of meter m.

Right side:
The constant **2** : has units of m which is the same units of the left side ⇒ OK.

However this is multiplied by cos (kx). The question is what are the units of kx and cos (kx).

kx :has units of m^{-1}.m. i.e. has no units.

cos (kx) : has no units also since as shown in the following triangle, cos θ =a/c. i.e. m/m. The cosine has no units



$\Rightarrow$ The above equation is dimensionally correct since the left side and the right side have the same units.

---

13. A solid piece of lead (الرصاص) has a mass of 23.94 g (g means gram) and a volume of 2.10 cm^3. From this data, calculate the density of lead in SI units (kilogram per cubic meter, kg/m^3).

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

The mass = 23.94 g = 23.94 x10^{-3} kg   (1 g = 10^{-3} kg)

The volume = 2.10 cm^3 = 2.10 x10^{-6} m   (1 cm =10^{-2} m, 1cm^3 = $(10^{-2})^3$ = 10^{-6} m^3)

$$\text{Density of lead} = \frac{23.94 \text{ x } 10^{-3}}{2.10 \text{ x } 10^{-6}} = 11.40 \text{ x } 10^{3} \text{ kg/m}^3$$