Chapter A - Problems

Blinn College - Physics 2425 - Terry Honan

Problem A.1

Suppose that x is a length, t is a time and a is an acceleration. To get a general expression for x as a function of both t and a, we choose the general form:

$$x = \kappa \, a^m \, t^n$$

where κ is a dimensionless constant. For this expression to be dimensionally correct what must m and n be?

Problem A.2

Three fundamental constants G, c and $\hbar$ have dimensions:

$$[G] = \frac{\mathrm{L}^3}{\mathrm{M}\cdot\mathrm{T}^2}, \ [c] = \frac{\mathrm{L}}{\mathrm{T}} \text{ and } [\hbar] = \frac{\mathrm{M}\cdot\mathrm{L}^2}{\mathrm{T}}.$$

(a) What must m, n and p be to make L_0 a length, when

$$L_0 = G^m \cdot c^n \cdot \hbar^p.$$

(b) $\hbar$, called "h bar", is a rescaled version of Plank's constant h; it is usually also called Plank's constant.

$$\hbar = \frac{h}{2\pi} = 1.054 \times 10^{-34} \, \mathrm{J \cdot s}$$

Using this and the values of G and c given in the book evaluate L_0.

Comment: G is *Newton's Gravitational constant*, c is the *speed of light* which plays a central role in Relativity and $\hbar$ is called *Plank's constant*, which appears in Quantum theory. L_0 is known as the *Plank length*; it is the very small distance that will set the scale of some ultimate theory of *Quantum Gravity*. Quantum Gravity is some yet undiscovered theory that consistently combines Gravity, Relativity and Quantum theory.

Problem A.3

(a) The period (time) for small oscillations of a simple pendulum T is given by:

$$T = 2\pi \sqrt{\frac{L}{g}},$$

where L is the length of the pendulum and g is the acceleration due to gravity. Verify that this expression is dimensionally correct.

(b) The velocity as a function of time for small oscillations of a pendulum is given by:

$$v = A \sin(\omega \, t + \phi),$$

where t is time. A, ω and ϕ are constants, the amplitude, angular frequency and phase. What are the dimensions and SI units of these constants?

Problem A.4

Which of the following equations are dimensionally correct?

(a) $v^2 - v_0^2 = 2\,a\,x$ (b) $x = v_0\,t + \frac{1}{3}\,a\,t^3$ (c) $x = \frac{1}{2}\left(v + v_0\right)t^2$

v and v_0 are velocities, a is acceleration, t is time and x is a distance.

Problem A.5

Newton's Law of Universal Gravitation $F = G\,\frac{m_1\,m_2}{r^2}$ will be discussed in Chapter I. It relates the gravitational force F between point masses m_1 and m_2 separated by a distance r. G is Newton's Universal constant. What are the SI units of G?

Problem A.6

Suppose volume V varies with time t by the relation: $V = \alpha\,t^2 + \beta\,t + \gamma$. What are the SI units of the constants α, β and γ?

Problem A.7

One acre is $43\,560\ \text{ft}^2$. How many acres are in a square mile? How many square meters in an acre?

Problem A.8

Some units are obscure. In horse racing the length unit of furlongs is used. There are 8 furlongs to a mile. A fortnight is an obscure unit for time, where 1 fortnight = 14 days.

Suppose these units are used to study velocity and acceleration. Convert $1\,\frac{\text{furlong}}{\text{fortnight}}$ and $1\,\frac{\text{furlong}}{\text{fortnight}^2}$ to SI units.