PHYSICS 161, Spring 2003

Lecture Quiz, Due begining of class, Friday, Feb 14

This Lecture Quiz is to be done in groups of two minimum and three maximum.

Special Note: It is <u>*dishonest*</u> *to put your name on work to which you did not contribute. Consider that cheating. No Make-Ups.*

Reading Assignment: Chapter 3, Chapter 4, Sections 4.1, 4.2

Dimensions of a Physical Quantity

Please read Section 1.4, Serway & Beichner pgs 10-12 for more elementary discussion of relevant concepts.

In physics, the dimensions of any physical quantity can be constructed from length L, time T and mass M. From now on, whenever I put square brackets around a quantity, I am talking about its dimensions in terms of L, T and M. For example velocity $[v] = L/T$ and acceleration $[a] = L/T^2$.

Dimensional Analysis Example I: Ball Thrown Vertically Upwards

In the last lecture, I introduced "dimensional analysis", a very powerful technique to analyze physical problems. The example we studied was that of a ball thrown vertically upwards with an initial velocity v_0 in the presence of gravity. In this case, the initial velocity v_0 and the acceleration due to gravity g are the *only* dimensionful quantities that characterize the system. Therefore, the answers to any questions about time like "how long does it take the ball to reach maximum height or halfway to its maximum height" etc will all involve the combination (read function) of v_0 and g which has the dimensions of time. We will call this the *natural time* for the problem.

$\mathbf{t}_{\mathrm{natural}}$: We begin by guessing that t_{natural} is a product of some power n of the velocity and some other power m of g. Then equating dimensions on both sides, we will determine m and n.

$$t_{\mathrm{natural}} = (v_0)^n g^m$$
$$[t_{\mathrm{nat}}] = [v_0]^n [g]^m$$
$$T = (L/T)^n \, (L/T^2)^m$$
$$T = L^{n+m}/T^{n+2m}$$

This implies that $n + m = 0$ and $n + 2m = -1$. The solution of these two simultaneous equations gives us $n = 1$ and $m = -1$. Thus, $t_{\mathrm{nat}} = v_0/g$.

$\mathbf{h}_{\text{natural}}$: Similarly, we find the natural height.

$$h_{\text{natural}} = (v_0)^n g^m$$
$$[h_{\text{nat}}] = [v_0]^n [g]^m$$
$$L = (L/T)^n \, (L/T^2)^m$$
$$L = L^{n+m}/T^{n+2m}$$

Now we want $n + m = 1$ and $n + 2m = 0$. This gives $n = 2$ and $m = -1$. So $h_{\text{natural}} = (v_0)^2/g$.

As you've seen already, the time to reach maximum height t_{max} is indeed given by $t_{\text{max}} = v_0/g = t_{\text{nat}}$; the time to reach the midway point is given by $t_{1/2} = 0.3(v_0/g) = 0.3t_{\text{nat}}$. Similarly, the maximum height reached by the ball is given by $h_{\text{max}} = (v_0)^2/2g = 1/2h_{\text{natural}}$. So dimensional analysis does not tell us the precise numerical coefficients but it gets us real close.

Question I: Ball Dropped from a height h:

Suppose that a ball is dropped at rest from a height h. What I would like you to do now is to find the natural time and the natural velocity for this problem. Note that in this case, h and g are the only two characteristic dimensionful quantities for this case.

Question II: I assigned Serway & Beichner problem 37, Ch 3 for HW. For this quiz:

a). Write down the vectors $\vec{F}_1$ and $\vec{F}_2$ in terms of components.

b). Find $\vec{F}_1 - \vec{F}_2$ both graphically and by using components. *Note: If this were the total force, which way would the blue shirt guy be pulling the horse?*