PHY 121: Mechanics: Homework 1

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Due: Tuesday, May 24th, 2011

1. The mean density of ordinary air is $1.29\,kg/m^3$, and $22.4\,liters$ ($1\ liters = 10^{-3}m^3$) of air contain 6.0 x 10^{23} molecules. Estimate the mass of an air molicule to 2 significant figures in S.I. unit (express your answer in scientific notation).

2. Using basic units find the dimension of the following quantities,

   (a) velocity

   (b) momentum (momentum is defined as $p = m$ x v)

   (c) acceleration ($a =$ rate of change of velocity)

   (d) force ($F = m$ x a)

3. Show that the expression $E = mc^2$ is dimentionally correct. According to this equation, what mass m equals the total yearly energy consumption in United States (approximately 5 x 10^{18} Joules) ? Use c (the speed of light) to be 3 x $10^8\,m/sec$

4. A golf ball released from a height of $1.5\,m$ above a concrete floor bounces back to a height of $1.1\,m$. If the ball is in contact with the floor for 6.2 x $10^{-4}\,s$, what is the average acceleration of the ball while in contact with the floor? What is the direction of the average acceleration?

5. Suppose you throw a stone straight up with an initial speed of $15.0\,m/sec$

   (a) If you throw a second stone straight up $1.00\,s$ after the first, with what speed must you throw this second stone if it is to hit the first at a height of $11.0\,m$? (There are two answers, are both plausible?)

(b) If you throw the second stone $1.30\,s$ after the first, with what speed must you throw the second stone if it is to hit the first at a height of $11.0\,m$?

6. A car moves a total distance of 190 m. The maximum speed that the car moves in is 305 m/min.The acceleration and decelartion of the car both have magnitudes 1.22 m/s^2.

   (a) How far does the car move while it accelerates to its maximum speed from rest?

   (b) What time does it take to travel the total dostance (without stopping in between), starting and ending at rest?

7. A ball after being projected moves by 40 m in the horizontal direction and 50 m in the vertical direction in two seconds. What are the (a) horizontal and (b) vertical components of the initial velocity of the projectile? (c)When the projectile achieves the maximum height above ground level, how far is it displaced horizontally from its point of projection? (d) What is the range of the projectile? (e) If there was no acceleration due to gravity how would the ball move after being projected? In such a case if the initial postion vector (i.e. the position of the point of projection) is $\vec{r} = 3\hat{i} + 5\hat{j} + 2\hat{k}$, how would the postion vector change with time?

8. The postion $\vec{r}$ of a particle moving in xy plane is given by $\vec{r} = (2.00t^3 - 5.00t)\hat{i} + (6.00 - 7.00t^4)\hat{j}$, with $\vec{r}$ in metres and t in seconds. Calculate (a) $\vec{r}$ (b) $\vec{v}$ (c) $\vec{a}$ for $t = 2.00\ sec$. (d) What is the orientation of a line that is tangent to this particle's path at this time?

9. Erica whirls a stone tied to a string of lenth 2.0 m in a horizontal circle at a height of 3.0 m above the ground lavel. The string breaks, and the stone flies off horizontally and strikes the ground after travelling a horizontal distance of 12 m. What is the magnitude of centripetal acceletarion of the stone when Erica was swirling it in a circle ?

10. A particle P travels with a constant speed on a circle of radius r and completes one revolution in T seconds. The particle is on the positive x axis at time $t = 0$. Find the paricle's position, velotiсy and acceleration vectors after a time interval of t.

11. A d metre wide river has water flowing with a speed v_o from North to South . A person tries to cross the river on a motor boat that moves with a constant speed v_b with respect to the water. He wishes to reach a point on the other bank that is l metres North of his present postion on the other bank. In what direction must the boat be pointed to travel in a straight line and reach the destination on the other bank? How long will the boat take to make it to the destination?

12. The position of a particle of mass m as a function of t is given as $\vec{r} = a\ cos(wt)\hat{i} + a\ sin(wt)\hat{j} + c\hat{k}$, where a, w and c are constants. Find the linear momentum ($\vec{p}$) and angular momentum ($\vec{L} = \vec{r}$ x $\vec{p}$) of the particle.