PHYS 113- 2^{nd}-Homework
Due: 18 October 2007

1. A boy tries to get the attention of his girlfriend by throwing little stones at her window. Due to the fence around the garden, and the fierce dog inside, he can not go very close to the window. If the window is 50 m away from where he is and 13 m high and if the maximum speed with which he can throw a stone is 25 m/s, can he hit the window? If not, with what speed he has to throw so that he can hit the window?

2. Suppose that

$$\vec{A}(t) = \hat{x}\cos\omega t + \hat{y}\sin\omega t \tag{1}$$

where ω is a constant. Find $d\vec{A}/dt$. Show that $d\vec{A}/dt$ is perpendicular to $\vec{A}$ (H. C. Ohanian, 'Physics,' pg. 72, Q33)

3. Define the unit vector $\hat{r}$ as:

$$\hat{r} = \hat{x}\sin\theta\cos\phi + \hat{y}\sin\theta\sin\phi + \hat{z}\cos\theta \tag{2}$$

Then define two other vectors as:

$$\hat{\theta} = \frac{d\hat{r}/d\theta}{|d\hat{r}/d\theta|} \tag{3}$$

$$\hat{\phi} = \frac{d\hat{r}/d\phi}{|d\hat{r}/d\phi|} \tag{4}$$

where $|\vec{V}| = \sqrt{\vec{V}\cdot\vec{V}}$ denotes the magnitude of the vector $\vec{V}$. Show that all three unit vectors are perpendicular to each other. Calculate the vector product $\hat{\theta}\times\hat{\phi}$.

4. Suppose that the acceleration vector of a particle is given by

$$\vec{a} = \hat{x}2\frac{m}{s^2} + \hat{y}(-2)\frac{m}{s^2} + \hat{z}\frac{m}{s^2} \tag{5}$$

If the particle is initially at rest at the point $(x, y, z) = (0, 0, 0)$,

   (a) What is the velocity of this particle as a function of time?

   (b) What is the position of this particle as a function of time?

5. A golfer claims that a golf ball launched with an elevation angle of 12° can reach a horizontal range of 250 m. Ignoring air friction, what would the initial speed of such a ball have to be? What maximum height would it reach? (H. C. Ohanian, 'Physics,' pg. 13, Q13)

6. (a) A golfer wants to drive a ball to a distance of 240 m. If he launches the ball with an elevation angle of 14°, what is the appropriate initial speed? Ignore air resistance.

   (b) If the speed is too great by 0.6 m/s, how much farther will the ball travel when launched at the same angle?

   (c) If the elevation angle is 0.5° larger than 14°, how much farther will the ball travel if launched with the speed calculated in part (a)?
   (H. C. Ohanian, 'Physics,' pg. 94, Q24)

7. Suppose the two forces acting on a mass of $m = 2kg$ are given by:

$$F_1 = 2N\hat{x} - 2N\hat{y} + 1N\hat{z} \tag{6}$$
$$F_2 = 1N\hat{x} + 2N\hat{y} - 1N\hat{z} \tag{7}$$

   (a) Calculate the acceleration of the particle.

   (b) If the particle initially at the origin and has the velocity vector $\vec{v} = 1m/s\hat{z}$, calculate the velocity of the particle as a function of time.

   (c) What is the position of this particle as a function of time?

8. Two heavy boxes of masses 20 kg and 30 kg sit on a smooth frictionless surface. The boxes are in contact and a horizontal force of 60 N pushes horizontally against the smaller box. What is the acceleration of the two boxes? What is the force that the smaller box exerts on the larger box? What is the force that the larger box exerts on the smaller box? (H.C. Ohanian, 'Physics,' pg. 120, Q25)

9. A flexible massless rope is placed over a cylinder of radius R. A Tension T is applied to each end of the rope, which remains stationary. Show that each small segment $d\theta$ of the rope in contact with the cylinder pushes against the cylinder with a force $Td\theta$ is the radial direction. By integration of the forces exerted by all the small segments, show that

the net vertical force on the cylinder is $2T$ and the net horizontal force is zero. *H. C. Ohanian, 'Physics,' pg. 121, Q33)

10. Protons in accelerators typically have momentum around $p \simeq 10^{-19} kqm/s$. What is the velocity of such a proton (ignore relativistic effects)? If a mass of $1kq$ would have the same momentum, what would be its velocity?