12-1-15 Au-7 ②

#3

Date: 15th January, 2015 **Problem Set: 3** **Phy102**

Polar Coordinates and Newton's laws: (Rough sketches given at the back)

1. A particle moves on the path given by $r = \frac{r_0\phi}{\pi}$, where r_0 is a constant and $\phi = \omega t$ i) Sketch the trajectory, ii) What is slope of the path at $\phi = 0, \frac{\pi}{2}, 2\pi$. iii) Find the radial and transverse component of acceleration. (ω is a constant).

2. A disk rotates with constant angular velocity ω. Two masses, m_A and m_B, slide without a friction in a groove passing through the center of the disc. They are connected by a light string of length l, and initially held in a position by a catch, with mass m_A at a distance r_A from the center. Neglect gravity. At $t = 0$, the catch is removed and the masses are free to slide. Find $\ddot{r}_A$ immediately after the catch is removed in terms of m_A, m_B, l, r_A and ω. (Kleppner 2.30).

3. A bead of mass of mass m is free to slide on a thin rod rotating in a plane about one end with a constant angular velocity ω. Show that the position of the bead is given by $r = Ae^{-\gamma t} + Be^{\gamma t}$. What is γ? Neglect gravity. Find the constants A and B in terms initial conditions ($r(t=0) = r_0$ and $v(t=0) = v_0$). What is the situation when r decreases continually with time. (Exclude the case when the bead hits the origin). Refer to the problem 2.33 of Kleppner and Kolenkow for figure)

4. A mass m whirls around on a string which passes through a ring as shown. Neglect gravity. Initially the mass is at a distance r_0 from the center and is revolving with an angular velocity ω_0. The string is pulled with a constant velocity V starting at $t = 0$ so that the radial distance to the mass decreases. Find i) $\omega(t)$ and ii) the force needed to pull the string. (Refer to Kleppner 2.34)

5. A river of width d flows with a constant velocity v_0 along its length. A man swims in the river with the same velocity v_0, with respect to the water, directed toward a fixed point O on the shore. He starts from the point A directly opposite to O on the other shore of the river.

(a) Find the equation of the trajectory in polar co-ordinates with O as origin and OA as the x-axis.

(b) At what distance from O will he land the shore?

Additional Problems:

1. i) Find out the unit vectors in spherical polar coordinate system and hence show that the co-ordinate system is orthogonal.

ii) Find out that an elementary volume.

iii) Express the components of velocity and acceleration of a particle in this coordinate system.

2. A particle of charge q and mass m is moving in an electromagnetic field; the constant magnetic field B is applied in the z-direction, discuss the motion of the particle. Generalize to the case when there is an electric field that lies in the x-direction also when the electric field lies in the y-z plane.

Reading Material:

Worked out examples: Kleppner: Chapter 2