PH103 (Physics-I) **Tutorial-II (August 23, 2018)**

1. In class we discussed about curvilinear coordinate systems and also learnt the methods for obtaining the scale parameters. To practice your Physics drawing skills, make a sketch of the elemental volume $d\tau$ for: (a) Spherical polar coordinates, and (b) Cylindrical polar coordinates. Also write down the expressions for these elemental volumes.

2. One quick way to quickly check if a particular force ($\vec{F}$) is conservative in nature is to see if $\nabla \times \vec{F} = 0$ (if it is so, the force is conservative). Find out if the following forces are conservative in nature: (a) $\vec{F_1} = -2x\hat{i} - 2y\hat{j} - 2z\hat{k}$, and (b) $\vec{F_2} = y\hat{i} - x\hat{j}$.

3. For $\vec{F} = 3m\dot{r}\dot{\theta}\hat{\theta}$, show that, $\dot{r} = \pm\sqrt{Ar^4 + B}$, where A and B are arbitrary constants.

4. A particle is sliding along a smooth radial groove in a circular turntable which is rotating with constant angular speed Ω. The distance of the particle from the rotation axis at time t is observed to be $r = b\,cosh(\Omega t)$ for $t \geq 0$, where b is a positive constant. Find the speed of the particle (relative to a fixed reference frame) at time t, and also find the magnitude and direction of the acceleration.
Note: $cosh(x) = \frac{1}{2}(e^x + e^{-x})$.

5. The luckless Daniel (D) is thrown into a circular arena of radius a containing a lion (L). Initially the lion is at the centre O of the arena while Daniel is at the perimeter. Daniels strategy is to run with his maximum speed u around the perimeter. The lion responds by running at its maximum speed U in such a way that it remains on the (moving) radius OD. (i) Set up the differential equation satisfied by r (the distance of L from O). (ii) Find r as a function of t. (iii) If $U \geq u$, show that Daniel will be caught, and find how long this will take. (iv) Show that the path taken by the lion is a circle. (v) For the special case in which $U = u$, sketch the path taken by the lion and find the point of capture.

6. A bee flies on a trajectory such that its polar coordinates at time t are given by
$r = \frac{bt}{\tau^2}(2\tau - t)$ and $\theta = \frac{t}{\tau}$; $(0 \leq t \leq 2\tau)$
where b and τ are positive constants. Find the velocity vector of the bee at time t. Show that the least speed achieved by the bee is b/τ. Find the acceleration of the bee at this instant.