Tutorial-8

PH101

1) A uniform sphere of mass M and radius R (MI $= 2/5MR^2$) rotates about a vertical axis. A massless string wound around the sphere passes over a massive pulley of radius b and MI I_p (about its CM) and is attached to mass m as shown in the figure 1 (left). Consider the mass to be released from rest. What is its acceleration after it is released ?

2) In an old fashioned rolling mill grain is ground by a massive wheel that rolls without slipping along a horizontal circle driven by a vertical shaft of radius R and spins with an angular speed Ω as shown in figure 1 (right). The wheel has mass M and radius b. The wheel is held by a massless axle to the shaft. The wheel exerts a downward force twice its weight (normal force).
(a) What is the relation between the angular speed ω of the wheel about its axle and the angular speed Ω about the vertical axis ?
(b) Find the time derivative of the angular momentum about the point P, dL_P/dt . What is the torque about P ?
(c) What is the value of Ω ?

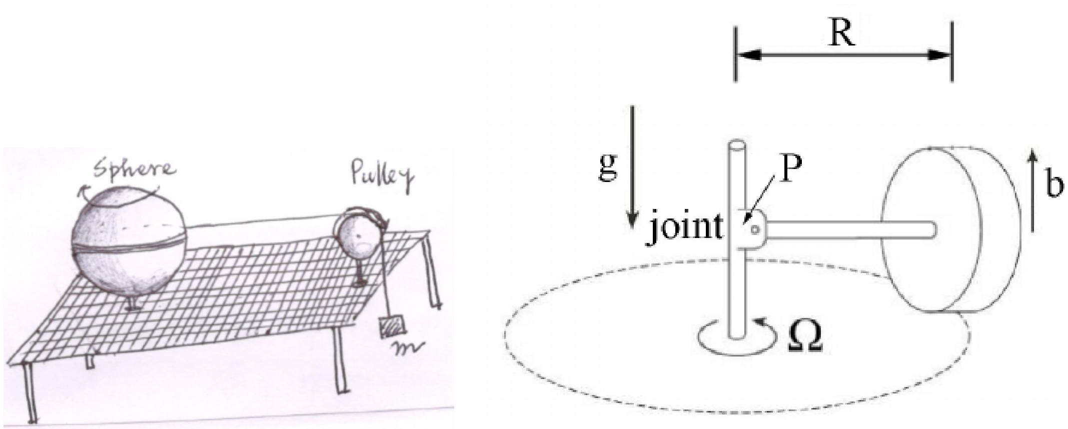

Figure 1:

3) Under the rotation in x-y plane, the coordinates transform as $x' = x\cos\theta + y\sin\theta$, $y' = y\cos\theta - x\sin\theta$ and $z' = z$. Any vector $\vec{b}$ also transforms as $b'_x = b_x\cos\theta + b_y\sin\theta$, $b'_y = b_y\cos\theta - b_x\sin\theta$ and $b'_z = b_z$. Show that the following equations

(a) $ds^2 = dx^2 + dy^2 + dz^2$ (the distance element in Euclidean space) , and

(b) $\frac{d^2\vec{r}}{dt^2} = \vec{F}$ (Newton's law of motion),

are invariant under the above mentioned transformation rules.

4) Show that the source free Maxwell's equations of electromagnetism are not invariant under Galilean transformation. You can assume that under the Galilean transformations, $\vec{E}(\vec{r}', t') = \vec{E}(\vec{r}, t)$ and $\vec{B}(\vec{r}', t') = \vec{B}(\vec{r}, t)$.

[Maxwell's equations are : $\nabla.\vec{E} = 0$, $\nabla.\vec{B} = 0$, $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$, $\nabla \times \vec{B} = \frac{1}{c^2}\frac{\partial \vec{E}}{\partial t}$]