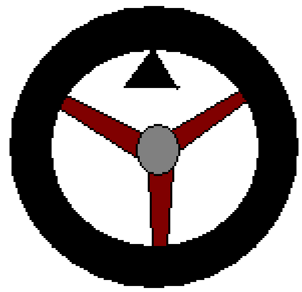
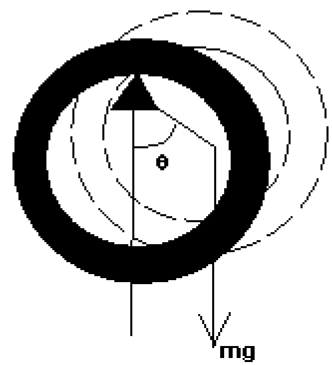
Q 7.1 Flywheel weighing 30kg was alowed to swing as d pendulum about a knife-edge at inner side of the rim. If the measured oeriod of oscillatons was 1.22s , determine the moment of inertia of flywheel about its geometric axis.



Flywheel



Given: mass of flywheel m=30kg

Time period T=1.22s

Let the centre of mass be deviated by an angle θ, very small Writing torque equations about pivot point

$$j_p\ddot{\theta} + mgr\ \sin\theta = 0$$

$$j_p = j_{cm} + mr^2$$

Icm of flywheel = mr^2 (hollow disk)

Substituting in the equation above j_p =2 mr^2

therefore 2mr^2 $\ddot{\theta}$ +mgr $\sin\theta$ =0

since θ is very less, $\sin\theta \approx \theta$

$$2mr^2\ddot{\theta} + mgr\theta = 0$$

$$\ddot{\theta} + \frac{g}{2r}\theta = 0$$

also

$$\frac{2\pi}{T} = \sqrt{\frac{g}{2r}}$$

solving we get =

$$r = \frac{gT^2}{8\pi^2} \quad \frac{9.81*1.22^2}{8*3.1416^2} = 0.185m$$

Moment of inertia about Icm = mr^2 =30*0.185 2

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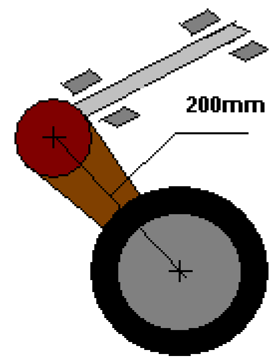
Q.7.2 A steel shaft 1.5 m long and 20mm in diameter is used as a trosion spring for the wheels of a lightautomobile.Determine the natural frequency of the system if the weight of wheel and tyre assembly and its radius of gyration about its axle is 50mm. Discuss the difference in natural frequency with wheel locked and when unlocked to the arm.

Given : length of shaft =1.5m

Diameter = 30mm

Mass of wheel and tyre assembly=25kg

Radius of gyration about axle= 50mm



Wheel Tyre assembly

Assume pure
Case I
When wheel tyre assembly is locked at a distance of 0.2m
I= mr^2 moment of inertia about shaft axis

$$J = 25\times(0.2)^2 = 25\times 0.04 = 1kgm^2$$

$$K_t = \frac{GI_p}{l} = \frac{0.8\times10^{11}\times\frac{\pi}{32}(0.02)^4}{1.5}$$

Polar moment $= \left[\frac{\pi}{32}d^4\right] = \frac{\pi}{32}\times(0.02)^4$

K t = 837.76 Nm/rad

$$\omega = \sqrt{\frac{K_t}{J}} = \sqrt{\frac{837.76}{1}} = 28.9\ c/s$$

Case II
displacement during motion $|\bar{y}| = \gamma\theta$

$|\bar{y}| = y_{cm}$ of the wheel

$y_{cm} = \ell\phi = \gamma\theta$

Now the total every is constant

KE of wheel about its axis = $\frac{1}{2}I_{cm}\dot{\theta}^2$

KE of wheel about the shaft = $\frac{1}{2} I_{ws}\, \dot{\theta}^2$

PE in wheel = $\frac{1}{2} K_t\, \phi^2$

$$TE = \frac{1}{2} I_{cm}\, \dot{\theta}^2 + \frac{1}{2} I_{ws}\, \dot{\theta}^2 + \frac{1}{2} K_t\, \phi^2$$

$$\theta = \frac{\ell}{\gamma}\, \phi$$

$$\Rightarrow \quad \frac{1}{2} I_m \left(\frac{\ell}{\gamma}\right)^2 \dot{\phi}^2 + \frac{1}{2} I_{ws} \dot{\phi}^2 + \frac{1}{2} K_t \phi^2$$

differentiate w.r.t. time

$$\left[I_m \left(\frac{\ell}{\gamma}\right)^2 + I_{ws} \right] \ddot{\phi} + K_t \phi = 0$$

$$\omega_n = \sqrt{\frac{K_t}{I_m \left(\frac{\ell}{\gamma}\right)^2 + I_{ws}}}$$