'I_1' and his angular speed ω_i. The product "$I_1\omega_i$" is the angular momentum which remains constant. When he pulls the dumbells towards his chest, his moment of inertia 'I_2' decreases. Now he spins faster as 'ω_f' increases to keep '$I_2\omega_f$' = const.

Q. 5.13 :- 'A geo-stationary satellite covers 120° of longitude, so the whole of the Earth's surface for global transmission can be covered by three correctly positioned geo-stationary satellites.

NUMERICAL PROBLEMS

Note :- The solutions to the numerical problems are given below. For Problems see last page.

P. 5.1 :- As given :- Diameter of beam = arc length = $S = 2.5\,m$,

Distance of moon = radius of circle = $r = 3.8\times10^8\,m$,

$\theta = ?$ Using : $S = r\theta$, $\theta = \frac{S}{r} = \frac{2.5}{3.8\times10^8} = 6.6\times10^{-9}$ rad

$\therefore\ \theta = 6.6\times10^{-9}$ rad.

P. 5.2 :- As given : Initial angular velocity = $\omega_i = 0$

Final angular velocity = $\omega_f = 45$ rev/min

or $\omega_f = \frac{45\times2\pi}{60} = \frac{45\times2\times3.14}{60}$

$\therefore\ \omega_f = 4.71\ rad\,s^{-1}$.

$t = 1.6\,s$, α = ang. acc. = ?

using the eq. $\omega_f = \omega_i + \alpha t$

Putting values : $4.71 = 0 + \alpha(1.6) \Rightarrow \alpha = \frac{4.71}{1.6}$

$\therefore\ \alpha = 2.94\ rad\,s^{-2}$.

P. 5.3 :- As given: Moment of Inertia $= I = 0.8\ kg\,m^2$

Constant Angular velocity $= \omega = 100\ rad\,s^{-1}$

(i) Angular momentum $= L = ?$

(ii) Torque $= ?$

→ (i) Using the eq. $L = I\omega = 0.8 \times 100\ kg\,m^2 s^{-1}$

or $L = 80\ kg\,\frac{m^2}{s} \times \frac{s}{s} = 80\ kg\,\frac{m}{s^2} \times m \times s$

$\therefore\ L = 80\ Nms = 80\ Js$

→ (ii) $\because \tau = I\alpha$, but as 'ω' is constant,

so $\alpha = 0$, $\therefore \tau = 0$

P. 5.4 :- As given :- $m = 5\ kg$, $F = 0.6\ N$,

$r = 0.2\ m$, $\theta = 90$ $(\because \vec{r} \perp \vec{F})$.

(i) $\tau = ?$, (ii) $\alpha = ?$

→ (i) using relation: $\tau = rF\sin\theta$

Putting values : $\tau = 0.2 \times 0.6 \times \sin 90 = 0.12\ Nm$

$\therefore\ \tau = 0.12\ Nm$

→ (ii) using the relation: $\tau = I\alpha$

but: $I = \frac{1}{2} m r^2$, $\therefore\ \tau = \frac{1}{2} m r^2 \alpha$.

Putting values: $0.12 = \frac{1}{2} \times 5 \times (0.2)^2 (\alpha)$

$0.12 = 0.1(\alpha) \Rightarrow \alpha = \frac{0.12}{0.1} = 1.2\ rad/s^2$

$\therefore\ \alpha = 1.2\ rad\,s^{-2}$.

P. 5.5 :- As given :- $M = 2 \times 10^{30}\ kg$, $R = 7 \times 10^5\ km = 7 \times 10^8\ m$,

$T = 20\ days = 20 \times 86400 = 1.728 \times 10^6\ s$

(i) $L = ?$ (ii) $K.E_r = ?$

→ (i) using eq. $L = I\omega$, where $I = \frac{2}{5} MR^2$ for a sphere, because heavenly bodies are considered as spheres. Therefore: $L = \frac{2}{5}MR^2 \times \frac{2\pi}{T}$ $(\because \omega = \frac{2\pi}{T})$

putting values: $L = \frac{2}{5} \times 2\times10^{30} \times (7\times10^{8})^2 \times \frac{2\times3.14}{1.728\times10^{6}}$

$\therefore$ $L = 1.42 \times 10^{42}\ kg\,m^2 s^{-1}$.

-(ii)→ $\because K.E. = \frac{1}{2}I\omega^2 = \frac{1}{\cancel{2}} \times \frac{\cancel{2}}{5}MR^2 \times (\frac{2\pi}{T})^2$

putting values: $K.E = \frac{1}{5} \times (2\times10^{30}) \times (7\times10^{8})^2 \times (\frac{2\times3.14}{1.728\times10^{6}})^2$

$\therefore$ $K.E = 2.59 \times 10^{36}\ J$.

P.5.6 :- As given: $m = 1000\ kg$, $V = 144\ km/hr$

or $V = 144 \times \frac{1000}{3600} = 40\ m/s$, $r = 100\,m$,

$F_c = ?$

using the relation: $F_c = \frac{mV^2}{r} = \frac{1000\times(40)^2}{100} = 16000\,N$

$\therefore$ $F_c = 16000\ N = 1.6 \times 10^4\ N$.

P.5.7 :- As given: $r = 1000\,m$, $V = ?$, $g = 9.8\ m/s^2$

using the relation: $T + W = \frac{mV^2}{r}$ (at highest pt.)

$\because$ for a plane $T = 0$ (no string, no tension).

$\therefore$ $0 + mg = \frac{mV^2}{r}$ $\Rightarrow \cancel{m}g = \frac{\cancel{m}V^2}{r}$

or $V = \sqrt{gr} = \sqrt{9.8 \times 1000} = 98.99 = 99\ m/s$

$\therefore$ $V = 99\ m/s$.

P.5.8 :- As given: Radius of moon $= r_m = 1.74\times10^{6}\,m$,

Distance between Earth and Moon $= r = 3.85\times10^{8}\,m$,

L_s = spin angular momentum,

L_o = orbital " " , $\frac{L_s}{L_o} = ?$

$\because$ $L_s = I\omega = \frac{2}{5}mr_m^2\omega$, $L_o = mr^2\omega$

$\Rightarrow$ $\frac{L_s}{L_o} = \frac{\frac{2}{5}\cancel{m}r_m^2\cancel{\omega}}{\cancel{m}r^2\cancel{\omega}} = \frac{2}{5}(\frac{r_m^2}{r^2}) = \frac{2}{5} \times \frac{(1.74\times10^{6})^2}{(3.85\times10^{8})^2}$

$\therefore$ $\frac{L_s}{L_o} = 8.17 \times 10^{-6}$.