CIRCULAR MOTION

(1) Data

$\omega = ?$

$v = ?$

$r = 10\,cm = 0.1\,m$

$T = 60\,min = 3600\,s$

Solution :

$\omega = \frac{2\pi}{T} = \frac{2\pi}{3600} = 1.745 \times 10^{-3}$ rad/s

$v = r\omega = 0.1 \times 1.745 \times 10^{-3}$

$= 1.745 \times 10^{-4}$ m/s

(2) Data :

$r = 2m$

$n = 1800\,rpm = \frac{1800}{60}\,rps$ (30)

$v = ?$

$v_{r/2} = ?$

Solution :

$\omega = 2\pi n = 2\pi \times 30$

$= 60\pi$

$v = r\omega = 2 \times 60\pi$

$= 376.8\,m/s$

$v_{r/2} = \left(\frac{r}{2}\right)\omega$

$= 1 \times 60\pi$

$= 188.4\,m/s$

(3) Data :

$m = 2000\,kg$

$r = 250m$

$v = 90\,\frac{km}{hr} = 90 \times \frac{5}{18}$

$\therefore = 25\,m/s$

$\omega = ?$

$a_c = ?$

$F_c = ?$

Solution

a) $v = r\omega$

$\therefore \omega = \frac{v}{r} = \frac{25}{250}$

$= 0.1$ rad/s

b) $a_c = \frac{v^2}{r} = \frac{(25)^2}{250}$

$= 2.5\,m/s^2$

c) $F_c = ma_c$

$= 2000 \times 2.5$

$= 5000\,N$

(4) Data :

$r = 0.75m$

$v_{up} = ?$

$\omega = ?$

Solution :

$v_{up} = \sqrt{gr} = \sqrt{9.8 \times 0.75}$

$= 2.711\,m/s$

$\omega = \frac{v}{r} = \frac{2.711}{0.75}$

$= 3.615 \text{ rad/s}$

(5) Data:

$v = 5 \text{ m/s}$

$r = 25 \text{ m}$

$\theta = ?$

$\mu = ?$

$v = \sqrt{rg \tan\theta}$

$(5)^2 = (25)(9.8)\tan\theta$

$\tan\theta = \frac{25}{25 \times 9.8}$

$\therefore \theta = 5^\circ 50'$

$v = \sqrt{\mu r g}$

$(5)^2 = \mu (25)(9.8)$

$\mu = \frac{25}{25 \times 9.8}$

$\therefore \mu = 0.1020$

(6) Data

$m = 1 \text{ kg}$

$r = 0.5 \text{ m}$

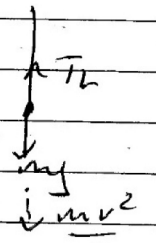
$T_L = ?$

$T_M = ?$

$T_H = ?$

Solution:

(a)



$T_L = mg + \frac{mv^2}{r}$

$T_L = 1 \times 9.8 + \frac{1 \times (\sqrt{5g})^2}{r}$

$= 9.8 + \frac{(\sqrt{5 \times 9.8 \times 0.5})^2}{0.5}$

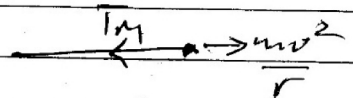
$= 58.8 \text{ N}$

(c) $T_H = T_L - 6mg$

$= 58.8 - 6 \times 1 \times 9.8$

$= 0 \text{ N}$

(b)



$T_M = \frac{mv^2}{r}$

$T_m = \frac{m(\sqrt{3gr})^2}{r}$

$= 3gm$

$= 3 \times 9.8 \times 1$

$= 29.4\,N$

(7) Data:

$m = 0.5\,kg$

$r = 0.5\,m$

$T_L = 5 \times 9.8\,N$

$v = ?$

$n = ?\ (rpm)$

Solution:

$T_L = mg + \frac{mv^2}{r}$

$5 \times 9.8 = \frac{0.5 \times 9.8 + 0.5 \times v^2}{0.5}$

$\therefore v = 6.641\,m/s$

$v = r\omega$

$\therefore \omega = \frac{v}{r} = \frac{6.641}{0.5}$

$2\pi n = \frac{6641}{0.5}$

$n = \frac{13.282}{2\pi}$

$n_{rpm} = \frac{13.282}{2\pi} \times 60$

$= 126.7\,rpm.$

(8) Data

$m = 4400\,kg$

$r = 200\,m$

$v = 60 \times \frac{5}{18} = \frac{50}{3}\,m/s$

$\mu = ?$

$\theta = ?$

Solution

$v = \sqrt{\mu rg}$

$\left(\frac{50}{3}\right)^2 = \mu \times 200 \times 9.8$

$\mu = 0.1417$

$v = \sqrt{rg \tan\theta}$

$\left(\frac{50}{3}\right)^2 = 200 \times 9.8 \times \tan\theta$

$\therefore \theta = 8°4'$

(9) WRONG QUESTION.

(10) Data:

$m = 50\,kg$

$v = 250\,m/s$ (const)

$r = 5000\,m$

Solution:

(a) $N_1 = \frac{mv^2}{r} - mg$

$= \frac{50 \times (250)^2}{5000} - 50 \times 9.8$

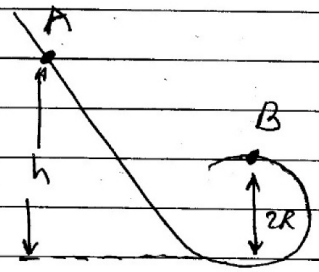
$= 135\,N$

(b) $N_2 = mg + \frac{mv^2}{r}$

$= 50 \times 9.8 + 50 \times \frac{(250)^2}{5000}$

$= 1115\ N$

(11)



$TE_A = TE_B$

$KE_A + PE_A = KE_B + PE_B$

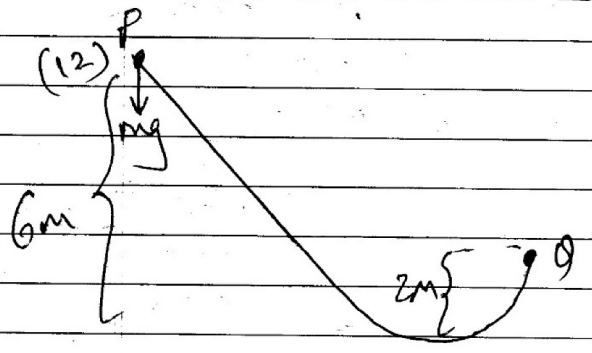
$0 + mgh = \frac{1}{2}mv_B^2 + mg(2R)$

$gh = \frac{1}{2}(\sqrt{gR})^2 + g(2R)$

$h = \frac{R}{2} + 2R$

$h = \frac{5R}{2}$

(12)



$TE_P = TE_Q$

$KE_P + PE_P = KE_Q + PE_Q$

$0 + mg(6) = \frac{1}{2}mv^2 + mg(2)$

$6g = \frac{v^2}{2} + 2g$

$\frac{v^2}{2} = 4g$

$v = \sqrt{8g}$

$a_c = \frac{v^2}{r} = \frac{8g}{r} = \frac{8g}{2}$

$= 4g = 39.2\ m/s^2$

$a = \sqrt{a_t^2 + a_c^2}$

$= \sqrt{9.8^2 + 39.2^2}$

$= 40.41\ m/s^2$

(13) ~~Data~~

$r = 500\ m$

$\theta = 10°$

$\mu = 0.25$

$v_{max} = ?$

$v = ?$

$g = 9.8\ m/s^2$

Solution

$$v_{max} = \sqrt{rg\left(\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right)}$$

$$= \sqrt{500 \times 9.8\left(\frac{0.25 + \tan 10}{1 - 0.25\tan 10}\right)}$$

$$= 46.7 \text{ m/s}$$

$$v_{opt} = \sqrt{rg\tan\theta}$$

$$= \sqrt{500 \times 9.8 \tan 10}$$

$$= 29.39 \text{ m/s}$$

(d) $a_c = \omega^2 r \quad (\because v = r\omega) \quad \frac{v^2}{r}$

$= (1.454 \times 10^{-4})^2 \times 0.015$

$= 3.17 \times 10^{-10} \text{ m/s}^2$

(e) $a_t = \frac{dv}{dt} = 0 \text{ m/s}^2$

(f) $a = \sqrt{a_t^2 + a_c^2}$

$= \sqrt{0^2 + (3.17 \times 10^{-10})^2}$

$= 3.17 \times 10^{-10} \text{ m/s}^2$

(14) Data

$T = 12 \times 3600 \text{ s}$

$r = 1.5 \text{ cm} = 0.015 \text{ m}$

(a) Solution

$\omega = \frac{2\pi}{T} = \frac{2\pi}{12 \times 3600}$

$= 1.454 \times 10^{-4} \text{ rad/s}$

(b) $v = r\omega$

$= 0.015 \times 1.454 \times 10^{-4}$

$= 2.182 \times 10^{-6} \text{ m/s}$

(c) $\alpha = \frac{d\omega}{dt} = 0 \text{ rad/s}^2$