Couple due to weight of flywheel

$M_c = N \times l$

$= m \times g \times l$

$= 10 \times 9.81 \times 0.15$

$= 14.71$ N-m

N.K.T Gyroscopic Couple

$C = I . \omega . \omega_p$

$14.71 = (10)(0.2)^2 (104.77)\, \omega_p$

$\omega_p = 0.35$ rad/sec

∴ The axis OX is precession with angular velocity $\omega_p = 0.35$ rad/sec clockwise when viewed from top

An aeroplane makes a complete circle of 150 m radius towards the East of flying at 200 km/h. The rotary engine of propeller of plane has a mass of 400 kg and a radius of gyration 0.3 m the engine rotates at 2400 rpm clockwise when viewed from rear. Find the gyroscopic couple of aeroplane and state it's effect

=

Given

$R = 150$ m

$v = 200$ km/h

$= \frac{200 \times 1000}{3600}$

$= 55.55$ m/s

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$m = 400\ kg$

$k = 0.3\ m$

$N = 2400\ rpm$

$\omega = \frac{2\pi N}{60}$ $\qquad \omega_p = \frac{V}{R}$

$= \frac{2\pi(2400)}{60}$ $\qquad = \frac{55.55}{15}$

$= 251.32\ rad/s$ $\qquad = 3.7\ rad/sec$

$C = I.\omega.\omega_p$

$= mk^2\omega.\omega_p$

$= (400)(0.3)^2(251.32)(3.7)$

$= 33.47\ kN\text{-}m$

* The aero plane takes turn left and the engine rotates clockwise when viewed from rear

Nose is raised

tail is lowered.

S.NO	Turn	Total rotation	View	Nose	tail
1.	left	C.W	rear	raised	lowered
2.	right	C.W	rear	lowered	raised
3.	left	C.C.W	"	"	"
4.	Right	"	"	raised	lowered
5	left	C.W	front/nose	lowered	raised

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$P = C/x$

∴ the vertical reaction at each of outer & inner wheel $= P/2$

$P = C/2x$

Note:-

when engine & wheels are rotating opposite reaction

$C = C_W - C_E$

when $C_E > C_W$ then C will be negative. thus the the reaction will be vertically downward on outer wheel and vertically upwards upwards

3. Effect of Centrifugal Couple:-

since the vehicle moves along a curved path. therefore the centrifugal force act outwardly at the centre of gravity of vehicle. the effect of this centrifugal force is also to overturn of vehicle.

the centrifugal force $F.C = m\omega_p^2 r$

$= m \times \frac{v^2}{R^2} \times R \quad \omega_p = v/R$

$= m \times \frac{v^2}{R}$

∴ the couple tending to overturn the vehicle

$CO = Fc \times h$

$= \frac{mv^2}{R} \times h$

this overturning couple is balanced by

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the road surface not tampered. the centre of gravity lies (with respect to 4-wheel)

Given

$R = 100m$

$I_N = 2.5 kg-m^2$

$d_N = 0.6m$

$r_N = 0.3m$

$I_E = 1.2 kg-m^2$

$G = \frac{\omega_E}{\omega_N} = 3$

$m = 1600 kg$

$h = 0.5m$

$x = 1.5m$

$W = mxg$
$= 1600 \times 9.81$
$= 15696 N$

$W/4 = \frac{15696}{4}$
$= 3924 N$

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Let V = limiting speed of vehicle in (m/s)

W.K.

$\omega_N = V/R_N$

$\omega_N = V/R_W$

$\dot{V} =$

$= \frac{V}{0.3}$

$= 3.33V$

$\omega_P = V/R$

$= \frac{V}{100}$

$= 0.01V$

$C_N = 4 I_N \omega_N \omega_P$

$= 4(2.5)(3.33V)(0.01V)$

$C_N = 0.33V^2$ N-m

gyroscopic Couple due to rotating

$C_E = I_E \omega_E \omega_P$

$= (1.2)(3\omega_N)(0.01v)$

$= 0.12v^2$ N-m

Net gyroscopic Couple

$C = C_R \pm C_E$ [same direction in sign]

$= 0.33v^2 + 0.12v^2$

$= 0.45v^2$

due to this gyroscopic Couple the reaction will be vertically upward on outer wheel and downwards of inner wheel. let the magnitude of this each outer & inner bike will be P/2

$P/2 = \frac{C}{2R}$

$= \frac{0.45v^2}{2(1.5)}$

$= 0.15v^2$

W.K.T

$FC = \frac{mv^2}{R}$

$= \frac{1600(v)^2}{100}$

$= 16v^2$

$\therefore CO = FC \times h$

$= 16v^2 \times 0.5$

$= 8v^2$

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N.K.T gyroscopic Couple

$$C_1 = \frac{V^2}{R^2}\left[I_N + G\,I\,E\right]\cos\theta$$

$$= \frac{(25)^2}{(50)(0.3)}\left[2(1)+5(0.3)\right]\cos\theta$$

$$= 145.87\cos\theta$$

$$C_2 = \frac{mv^2}{R} \times h\cos\theta$$

$$= \frac{(150)(25)^2}{50} \times 0.6\cos\theta$$

$$= 1875\cos\theta$$

$$CO = C_1 + C_2$$

$$= 145.87\cos\theta + 1875\cos\theta$$

$$= 2022.87\cos\theta$$

N.K.T balan Couple

$$= m \times g \times h\sin\theta$$

$$= (150)(9.81)(0.6)$$

$$= 1471.5\sin\theta$$

$$(145.87)1875\cos\theta = 1471.5\sin\theta$$

$$\theta = \tan^{-1}\left(\frac{2022.87}{1471.5}\right)$$

$$\theta = 53.96^\circ$$

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