Question #81307

Find the angle of inclination with respect to vertical of a two wheeler negotiating a turn. Combined mass of the vehicle with its rider is 250 kg.

Moment of inertia of the engine flywheel – 0.3 kg m^2

Moment of inertia of each road wheel – 1 kg m^2

Speed of the flywheel is 5 times the speed of the road wheel and in the same direction. Height of the centre of gravity of the rider with vehicle is 0.6 m. Speed of the two wheeler is 90 KMPH. Wheel radius is 300 mm. Radius of turn is 50 meters.

Answer:

The gyroscopic couple is given by:

$$C_1 = \frac{v^2}{Rr}(2I_w + GI_e)\cos\theta,$$

where v = 90 km/hr = 25 m/s, R = 50 m, r = 300 mm = 0.3 m, I_w = 1 kg.m^2, I_e = 0.3 kg.m^2,

G = 5 – the gear ratio (the ratio of the engine flywheel speed to road wheel speed),

θ – the angle of inclination with respect to vertical of the two wheeler.

The centrifugal couple is given by:

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

where m = 250 kg, h = 0.6 m. Substitute:

$$C_1 = \frac{25^2}{50 \cdot 0.3}(2 \cdot 1 + 5 \cdot 0.3)\cos\theta = 145.8\cos\theta,$$

$$C_2 = \frac{250 \cdot 25^2}{50} \times 0.6\cos\theta = 1875\cos\theta.$$

Thus, the total overturning couple is

$$C_O = C_1 + C_2 = 145.8\cos\theta + 1875\cos\theta = 2020.8\cos\theta.$$

The balancing couple is given by:

$$C_B = mgh\sin\theta = 250 \cdot 9.81 \cdot 0.6\sin\theta = 1471.5\sin\theta.$$

For the equilibrium conditions, the overturning couple is equal to the balancing couple. Thus:

$$C_O = C_B,$$

$$2020.8\cos\theta = 1471.5\sin\theta,$$

$$\tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{2020.8}{1471.5} = 1.373 \;\rightarrow\; \theta = 53.9°.$$