Answer on Question #40129, Physics, Mechanics | Kinematics | Dynamics

a) What is the maximum torque exerted by a 60 kg person riding a bike, if the rider puts all his weight on each pedal when climbing a hill? The pedals rotate in a circle of radius 17cm

b) A ball of mass 1.5 kg rolling to the right with a speed of, 6.31ms−1 collides head-on with a spring with a spring constant of .0.22Nm−1 Determine the maximum compression of the spring and the speed of the ball when the compression of the spring is 0.10 m

Solution

a) A torque is an influence which tends to change the rotational motion of an object. One way to quantify a torque is

$$\tau = \left|\vec{r} \times \vec{F}\right| = rF \sin\alpha,$$

where τ – torque, $\vec{F}$ - force applied, $\vec{r}$ - lever arm, $\times$ - cross product, α – angle between force and lever arm.

The maximum torque would be when $\sin\alpha = 1$. So

$$\tau = rF.$$

The force is the weight of the cyclist

$$F = W = mg.$$

The maximum torque is

$$\tau = rmg = 0.17\ m \cdot 60\ kg \cdot 9.8 \frac{m}{s^2} = 100\ N \cdot m.$$

Answer: 100 N·m.

b) $m = 1.5\ \mathrm{kg}$ - mass of ball, $v_0 = 6.31 \frac{\mathrm{m}}{\mathrm{s}}$ – initial speed of ball, $k = 0.22 \frac{\mathrm{N}}{\mathrm{m}}$ - spring constant, $\Delta x = 0.10\ \mathrm{m}$ - compression of the spring.

Total energy of the system is the sum of the kinetic energy of the ball and the potential energy of the spring:

$$E = \frac{mv^2}{2} + \frac{kx^2}{2}.$$

The maximum compression of the spring would be when the ball stopped (we use the law of conservation of energy):

$$\frac{mv_0^2}{2} = \frac{kx_{max}^2}{2} \rightarrow x_{max} = v_0\sqrt{\frac{m}{k}} = 6.31\sqrt{\frac{1.5}{0.22}} = 16.5\ m.$$

The speed of the ball when the compression of the spring is 0.10 m:

$$v_1^2 = v_0^2 - \frac{k}{m}\Delta x^2 \rightarrow v_1 = \sqrt{v_0^2 - \frac{k}{m}\Delta x^2} = \sqrt{6.31^2 - \frac{1.5}{0.22} \cdot 0.10^2} = 6.30 \frac{\mathrm{m}}{\mathrm{s}}.$$

Answer: $\mathbf{16.5}\ \boldsymbol{m}$; $\mathbf{6.30} \frac{\mathbf{m}}{\mathbf{s}}$.