Answer on Question #39587, 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 17 cm.
b) A ball of mass 1.5 kg rolling to the right with a speed of 3.6m/s, collides head-on with a spring with a spring constant of 2.0Nm^-2.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) Torque, moment or moment of force, is the tendency of a force to rotate an object about an axis. Just as a force is a push or a pull, a torque can be thought of as a twist to an object. Mathematically, torque is defined as the cross product of the lever-arm distance and force, which tends to produce rotation.

The formula for torque is:

$$\tau = |\vec{r} \times \vec{F}| = rF\sin\theta$$

The word "maximum" implies that the force is applied at a 90° angle to the radius, so the factor sinθ becomes 1, and really the torque is:

$$\tau = rF$$

The force is the weight of the cyclist:

$F = mg$

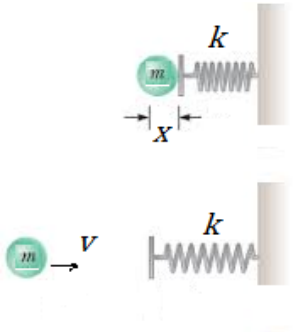
$F = (60\ \text{kg}) \cdot (9.8\ \text{m/s}^2) = 588\ \text{N}$

$r = 0.17\ \text{m}$

Thus

$$\tau = rF = 0.17 \cdot 588 = 99.96\ \text{N} \cdot \text{m}$$

b)



m = 1.5 kg
v = 3.6 m/s
k = 2.0 Nm^{-2}
x = 0.10 m.

Conservation of energy tells us that the kinetic energy of the ball is equal to the potential energy of the spring

KE = PE

$$\frac{mv^2}{2} = \frac{kx_{max}^2}{2}$$

$$x_{max} = v\sqrt{\frac{m}{k}} = 3.6\sqrt{\frac{1.5}{2.0}} = 3.12\ \text{m}.$$

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

$$v_x = v - x\sqrt{\frac{k}{m}} = 3.6 - 0.1\sqrt{\frac{2.0}{1.5}} = 3.484 \approx 3.48 \text{ m/s}$$

Answer. a) $\tau = 99.96 \text{ N} \cdot \text{m}$;

b) $x_{max} = 3.12 \text{ m}$, $v_x = 3.48 \text{ m/s}$.