5: Rotational Kinetic Energy

As we have seen so many times in this chapter, we can have very direct ways of showing that there are similar formulas between **translational** and **rotational** motion.

- Kinetic energy (AP data sheets use just the symbol "K") is another good example of this, since we now have ways to describe mass (moment of inertia) and velocity (angular velocity).

Translational	Rotational
$K=\frac{1}{2}mv^2$	$K=\frac{1}{2}I\omega^2$

K = kinetic energy (J)
m = mass (kg)
v = translational velocity (m/s)
I = moment of inertia (kg m^2)
ω = angular velocity (rad/s)

Example 1: Grindstones have been used since ancient times to sharpen tools and weapons. They are made of a large piece of stone that spins around its axis. The object that needs to be sharpened is pressed against it as it spins. A typical grindstone would have a mass of 20 kg and a radius of 25 cm. If it spins around once every 0.80 s, **determine** its angular kinetic energy.

We will need the moment of inertia for the grindstone, a solid wheel of stone. This formula would be given to you.

$$I=\frac{1}{2}mr^2=\frac{1}{2}(20)(0.25)^2=0.625\,kg\,m^2$$

There are a few ways to get the angular velocity. One of them is…

$$\omega=\frac{2\pi}{T}=\frac{2(3.14)}{0.80}=7.85\,rad/s$$

And then we calculate the angular kinetic energy.

$$K=\frac{1}{2}I\omega^2=\frac{1}{2}(0.625)(7.85)^2=19.25703=19\,J$$

What we must consider is that in many common situations, objects will have both **translational** ***and*** **rotational** kinetic energy at the same time. Imagine, for example, a tire turning as it moves to the right on a road.

- It has **translational** kinetic energy since it is a mass moving to the right. We would calculate its "classic" kinetic energy like we did in previous chapters.
- Assuming that the wheel is turning (not slipping), it will also have **rotational** kinetic energy.
- What we need to do is calculate both kinetic energies and add them together. Remember, **energy is scalar**, so there is no need to have a discussion of the direction of the energy.

$$K=\frac{1}{2}mv^2+\frac{1}{2}I\omega^2$$

Example 2: Our grindstone from the previous example has broken off of it's stand and is rolling across the floor. If it is moving with a translational velocity of 1.2 m/s, **determine** its kinetic energy.

We have all the information we need to calculate the translational kinetic energy, and we can still use the moment of inertia we calculated previously, but we will need to figure out its new angular velocity.

$v = r\omega \qquad \omega = \frac{v}{r} = \frac{1.2}{0.25} = 4.8\, rad/s$

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$K = \frac{1}{2}(20)(1.2)^2 + \frac{1}{2}(0.625)(4.8)^2$$

$$K = 21.6\, J$$