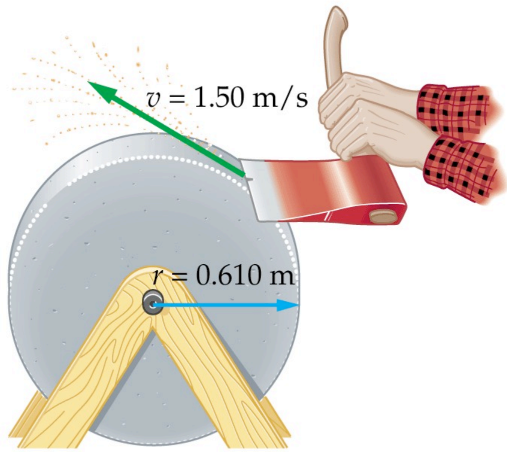
Name: Section:

PHYS 1410: College Physics I Spring 2009

Each question is worth 3 points. The points will be added as bonus to your semester total.



Paul Bunyan is sharpening up his ax. The whetstone has a tangential velocity **v = 1.50m/s** (**ω_o = v/r**)at the instant shown. The large lumberjack holds the ax steady in place until it is sharp. When he lifts the ax, the stone is still spinning, with **ω_f = 1.25 rad/s**. It has turned through **15 full revolutions**. The stone has a mass **m = 25 kg**. (Hints as big as Babe the Blue Ox: Solve IN ORDER from A to E. Carry values DOWN, not UP. This is not a kinematic problem or a N#2 problem. And ask yourself if there is *any* translational motion occurring *any*where at *any* time.)

$$v = 1.50\,\tfrac{\text{m}}{\text{s}} \quad \omega_o = \frac{v}{r} = \frac{1.50\,\frac{\text{m}}{\text{s}}}{0.610\text{m}} = 2.46\,\tfrac{\text{rad}}{\text{s}} \quad m = 25\text{kg}$$

$$r = 0.610\text{m} \quad \omega_f = 1.25\,\tfrac{\text{rad}}{\text{s}} \quad \theta = 15\text{rev} = 30\pi\text{rad}$$

A) Treating it as a disk, calculate the initial **kinetic energy K_o** of the stone.

$$K_o = \tfrac{1}{2} I\omega_o^2$$

$$K_o = \tfrac{1}{2}\left(\tfrac{1}{2}mr^2\right)\omega_o^2 = \tfrac{1}{4}mv^2$$

$$K_o = \tfrac{1}{4}(25\text{kg})\left(1.50\,\tfrac{\text{m}}{\text{s}}\right)^2 = 14.1\text{J}$$

B) Calculate the **final kinetic energy K_f** of the stone at the instant when the ax is removed.

$$K_f = \tfrac{1}{2} I\omega_f^2$$

$$K_f = \tfrac{1}{2}\left(\tfrac{1}{2}mr^2\right)\omega_f^2$$

$$K_f = \tfrac{1}{4}(25\text{kg})(0.610\text{m})^2\left(1.25\,\tfrac{\text{m}}{\text{s}}\right)^2 = 3.63\text{J}$$

C) Use angular work-energy ($K_o + W = K_f$) to determine how much **work** the ax does on the stone as it comes to rest.

$$W = K_f - K_o = 3.63\text{J} - 14.1\text{J} = -10.5\text{J}$$

D) Use angular work-energy ($K_o + \tau\theta = K_f$) to find the **torque** exerted by the ax on the stone.

$$K_o + \tau\theta = K_f$$

$$14.1\text{J} + \tau(30\pi\text{rad}) = 3.63\text{J}$$

$$\tau = -0.111\text{N}\cdot\text{m}$$

E) Use angular impulse-momentum ($I\omega_o + \tau t = I\omega_f$) to determine how much **time** it takes to stop the stone turning.

$$I\omega_o + \tau t = I\omega_f$$

$$\tau t = \left(\tfrac{1}{2}mr^2\right)(\omega_f - \omega_o)$$

$$(-0.111\text{N}\cdot\text{m})t = \tfrac{1}{2}(25\text{kg})(0.610\text{m})^2\left(1.25\,\tfrac{\text{rad}}{\text{s}} - 2.46\,\tfrac{\text{rad}}{\text{s}}\right)$$

$$t = 50.7\text{s}$$