2015 F=ma Exam: Problem 15

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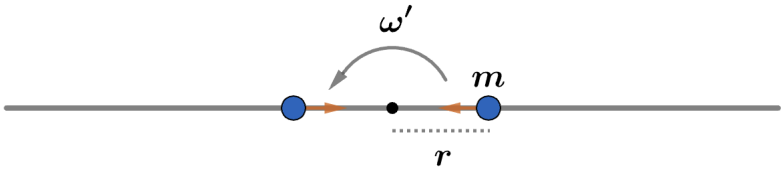

There is no net external torque on the system of two masses since the tensions pulling them inward cancel out. Thus, we have conservation of angular momentum. Choosing the center of the rod as our pivot point, the initial moment of inertia I_i is

$$I_i = 2m\left(\frac{L}{2}\right)^2 = \frac{mL^2}{2} = \frac{(5\,\text{kg})(3\,\text{m})^2}{2} = 22.5\,\text{kg}\,\text{m}^2$$

The final moment of inertia I_f is

$$I_f = 2mr^2 = 2(5\,\text{kg})(0.5\,\text{m})^2 = 2.5\,\text{kg}\,\text{m}^2$$

The angular momentum L is

$$L = L_i = I_i\omega = (22.5\,\text{kg}\,\text{m}^2)(4\,\text{s}^{-1}) = 90\,\frac{\text{kg}\,\text{m}^2}{\text{s}}$$

By the work-energy theorem and using the fact that angular momentum is conserved,

$$W = E_f - E_i = \frac{L^2}{2I_f} - \frac{L^2}{2I_i} = \frac{L^2}{2}\left(\frac{1}{I_f} - \frac{1}{I_i}\right) = \frac{90^2}{2}\left(\frac{1}{2.5} - \frac{1}{22.5}\right)\,\text{J} = 1440\,\text{J}$$

so the answer is $\boxed{\text{D}}$.