Physics Workshop
Rotational Kinematics
Suggested Checkpoint Questions with Answers

- Checkpoint following 2:

1. What are the *dimensions* of a radian? (Length, mass, time,…?)

- Checkpoint following 3:

1. Where should you go on a rotating object to have the smallest speed?
2. Which point on a rotating object has the smallest acceleration?

- Checkpoint following 4:

1. This may be a good opportunity to preview the idea of a torque with students in some detail.
2. What do you suppose *resists* angular acceleration?

Answers to Checkpoint Questions:

- Checkpoint following 2:

1. The radian is a *dimensionless* unit of angle. This can be seen from the definition of a radian:

$$\theta = \frac{s}{r}$$

Where s and r both have units of length. So when you've got angular quantities in a calculation, it's important to remember that the units of radians can be taken away or put back at your discretion, since they don't carry any dimensions. In fact, you can view radians as simply a word that is there as a reminder that we're talking about angular quantities.

- Checkpoint following 3:

1. All points on a rigid object make one revolution around the rotation axis in the same amount of time, so the points that have a smaller distance to travel will have lesser speed. Therefore, the closer you get to the axis of rotation, the smaller your speed will be.

2. The centripetal acceleration is v^2 / r, which is equal to $\omega^2 r$ where ω is the angular speed of the object (the same for the whole object). The tangential acceleration is αr, where α is the angular acceleration. So both components of the acceleration decrease with decreasing distance to the axis of rotation and therefore overall, the closer you are to the axis of rotation, the smaller the acceleration.

- Checkpoint following 4:

1. One good approach is to describe a torque as a force multiplied by the perpendicular distance between the line of force and the axis of rotation. That is, it's the product of the perpendicular components of the displacement vector (from the axis of rotation) of the point of application of the force, and the force vector itself. Of course this is just $\mathbf{r} \times \mathbf{F}$, but few students have any intuition for what a cross product means physically.
2. The most reasonable first instinct is mass, since this is the measure of linear inertia. However, this can't be right because it's easier to rotate a given object around one axis of rotation than another, even though it has the same mass either way. [It might be useful to have some metal rods around to demonstrate that it's much easier to rotate it around the axis along its length than an axis perpendicular to the length. Another useful prop is a couple of "mystery batons" which have the same mass but drastically different moments of inertia.] The goal of this question should simply be to arrive at the realization that the resistance to rotation has to do with the distribution of mass as well as the quantity of mass.