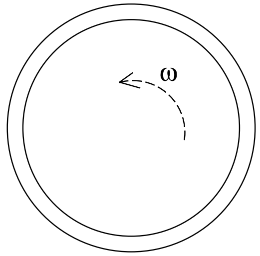
Problem 10.13

A race car travels on a 250. meter radius circular track. If the car moves with constant speed of 45.0 m/s:



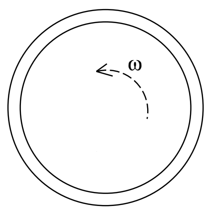
a.) What is its angular speed.

There are two relationships that link an object's rotational motion with its translational motion. These are *not* kinematic equations as they are always true (versus being true only with constant acceleration situation), but there are relationships you will use often when there is both rotational and translational motion happening at the same time. They are:

$$v = R\omega \quad \text{and} \quad a = R\alpha$$

Note: As derived (and you will see the derivation in class), this first expression gives you the translational speed "v" of a body moving with an angular speed *about* "ω" *a fixed point* and "R" units from that point.

Using the appropriate relationship here, we get:



$$v = R\omega$$

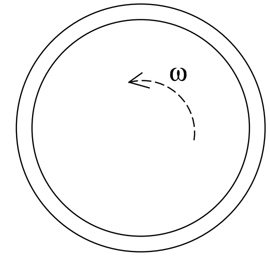
$$\Rightarrow \quad \omega = \frac{(45.0 \text{ m/s})}{(2.5\text{x}10^2 \text{ m})}$$

$$= .180 \text{ rad/s}$$

Minor Note: Notice that the units don't match up as presented. The calculation shows meters and seconds, but the solution is shown with units of "radians/sec." So what's going on?

There are two ways to look at this. The first is to note that the "R" value is really telling you how many "meters/radian" there are in the arc. This is a logical consequence of the definition of the radian, which will probably be mentioned in class when the "$v = R\omega$" relationships are derived. I prefer this approach as it helps the units be descriptive. The second way has to do with units. "Meters" is a unit attached to the MKS system of units, but both "radians" and "degrees" are generic and aren't attached to any system of units. As such, the "radians" part of the angular speed designation is often omitted leaving the answer in units of "1/seconds" (or "inverse seconds"). Using that designation, the solution to our problem would be $\omega = .180 \text{ s}^{-1}$.

b.) What is the magnitude and direction of it's net acceleration?



This is review. We know the car has no tangential acceleration because its speed is constant, so the only acceleration in the system is centripetal. Examining all the ways that can be calculated, then selecting the easiest to use (given what is given in the problem), we write:

$$a_c = \frac{v^2}{R} \qquad \left(= \frac{(R\omega)^2}{R} = R\omega^2 \right)$$

$$\Rightarrow \quad a_c = \frac{(45.0 \text{ m/s})^2}{(2.5\text{x}10^2 \text{ m})}$$

$$= 8.10 \text{ m/s}^2$$

In other words:

$$\vec{a} = \left(8.10 \text{ m/s}^2\right)\left(-\hat{r}\right)$$