Physics 2130 Additional Problems

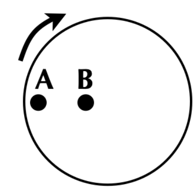
Week 10

Questions

a) If a problem asks, “How many times does the wheel go around?” it is asking for
A) $\Delta\theta$ **B)** ω **C)** α

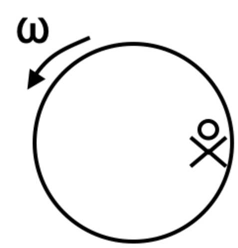
b) A wheel has $\omega = -4$rad/s and an angular acceleration of $\alpha = -3$rad/s/s. The wheel is
A) slowing down **B) speeding up**

c) Two points are marked on a spinning wheel. Which of the following is true about the points' linear velocities v and angular velocities ω?



A) vA = vB, ωA > ωB **B) vA = vB, ωB > ωA**
C) vA > vB, ωA = ωB **D) vA < vB, ωA = ωB**

d) A person rides on a merry-go-round that is slowing down. What direction does the rider's acceleration point?



A) ↑ **B)** ↖ **C)** ← **D)** ↙ **E)** ↓

e) If a disk turns around exactly once, its angular displacement Δθ is
A) 1 rad **B) π rad** **C) 2π rad** **D) 360 rad**

Problems

1. A wheel is spinning so that it goes around 6 times every second. A brake is then applied to the wheel, causing it to slow to a frequency of 3 times per second in 5 seconds. What is the angular acceleration of the wheel during the braking?

$\Delta\theta$	DKDC
ω_i	6 rev/s
ω_f	3 rev/s
α	NEED
Δt	5s

"6 times per second" describes an angular velocity, and can be written as "rev/s". Keeping that in mind, we see that we have three knowns, and want to solve for the angular acceleration, so we pick the equation without $\Delta\theta$:

$$\omega_f = \omega_i + \alpha\Delta t$$

$$3\text{rev/s} = 6\text{rev/s} + \alpha(5\text{s})$$

$$\implies \alpha = \frac{3\text{rev/s} - 6\text{rev/s}}{5\text{s}}$$

which is **-0.6 rev/s²**. If we want this in radians per second squared, we multiply by $\frac{2\pi \text{ rad}}{1 \text{ rev}}$ to get -3.8rad/s².

2. A wheel takes 5s to come to a stop, during which it goes around 8 times. How fast was the wheel spinning initially?

$\Delta\theta$	8 rev
ω_i	NEED
ω_f	0
α	DKDC
Δt	5

We are given the time, the final angular velocity (it "comes to a stop"), and the angular displacement ("goes around 8 times"), so we can solve for the initial angular velocity:

$$\Delta\theta = \frac{1}{2}(\omega_i + \omega_f)\Delta t$$

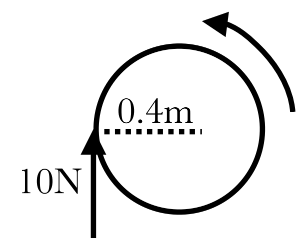
$$8 = \frac{1}{2}(\omega_i + 0)(5)$$

$$8 = 2.5\omega_i$$

$$\implies \omega_i = \frac{8}{2.5}$$

so ω_i is equal to **3.2rev/s** or 20.1rad/s.

3. A wheel with a radius of 0.4m and moment of inertia $I = 45\,\text{kg}\cdot\text{m}^2$ is spinning counterclockwise, when an upward force of 10N is applied to the wheel as shown, causing the wheel to come to a stop. If the wheel makes 5 complete revolutions before stopping, how long does it take to stop?



	x
$\Delta\theta$	+5 rev = 10π rad
ω_i	DKDC
ω_f	0
α	GIVEN
Δt	NEED

We are given the total angular displacement and the final angular velocity, and nothing else directly. However we *have* been given some information about the torque on the wheel, which we might use to get the angular acceleration, since $\tau = I\alpha$. The one force on the wheel is a force of 10N applied 0.4m from its rotational axis, so the torque on the wheel is -4Nm (negative because clockwise). Thus the angular acceleration is $\alpha = \frac{\tau}{I} = \frac{-4\,\text{Nm}}{45\,\text{kg m}^2}$ = -0.089rad/s². Using that in our kinematics equation, we use the formula without ω_i:

$$\Delta\theta = \omega_f \Delta t - \frac{1}{2}\alpha(\Delta t)^2$$

$$10\pi = 0 - \frac{1}{2}(-0.089)(\Delta t)^2$$

$$31.4 = 0.045(\Delta t)^2$$

$$\Delta t = \sqrt{\frac{31.4}{0.045}}$$

or **26.4s.**

4. The tire of a car has a radius of 0.26m. As the car travels down the street, the wheel spins with an angular velocity of ω=80rad/s.

a. How many times does the wheel spin per second?

"How many times does it spin per second" is asking for ω in rev/s.

$$80\frac{\text{rad}}{\text{s}} \times \frac{1\text{ rev}}{2\pi\text{ rad}} = \textbf{12.7 times per second.}$$

b. How fast is the car moving down the street?

For a wheel rolling on a ground without slipping, the relationship between its linear velocity and its angular velocity is

$v = r\omega = (0.26)(80) = \mathbf{20.8m/s}$. (Note that we *must* use radians whenever we multiply by the radius.)