

# Week 9 Activities Problems

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PHYS-111 2pm Lab

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## Rotational Kinematics

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1. A computer disk starts from rest at time 0, and accelerates uniformly for  $0.500s$  to an angular speed of  $2000rpm$ , then coasts at a steady angular velocity for another  $0.500s$ .

$$\omega = 209.\text{rad/s} = 33.\bar{3}\text{rev/s} \quad (1)$$

1. What is the disk's angular acceleration during the first  $0.500s$  interval?

$$\begin{aligned} \omega_{0.5s} &= \alpha(\Delta t) & (2) \\ \alpha &= \frac{\omega_{0.5s}}{t} \\ \alpha &= \frac{209.\text{rad/s}}{0.500s} \mid \alpha = \frac{33.\bar{3}\text{rev/s}}{0.500s} \\ \alpha &= 418.8790205 \text{ rad/s}^2 \mid \alpha = 66.\bar{6}\text{rev/s}^2 \\ &\underline{\alpha = 419. \text{ rad/s}^2} \end{aligned}$$

2. Through how many radians has it turned at time  $0.500s$ ? How many revolutions does this correspond to?

$$\begin{aligned} \theta &= \frac{1}{2}\alpha t^2 & (3) \\ \theta &= \frac{1}{2}(419.\text{rad/s}^2)(0.5s)^2 \mid \theta = \frac{1}{2}(66.\bar{6} \text{ rev/s}^2)(0.5s)^2 \\ \theta &= 52.35987759\text{rad} \mid \theta = 8.33\bar{3}\text{rev} \\ &\underline{\theta = 52.4\text{rad} = 8.33 \text{ revolutions}} \end{aligned}$$

3. Through how many radians has it turned at time  $1.00s$ ? How many revolutions does this correspond to?

$$\theta_f = \theta_{0.5s} + \omega t \quad (4)$$

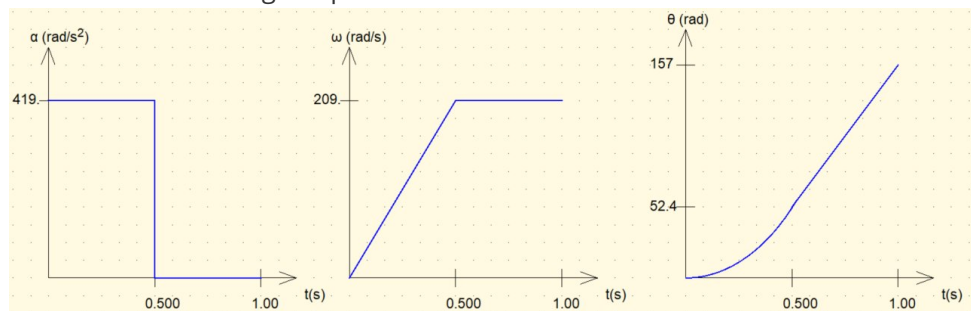
$$\theta_f = 52.4rad + 209.rad/s * 0.500s \quad | \theta_f = 8.33rev + 33.3\bar{3}rev/s * 0.500s$$

$$\boxed{\theta = 157.rad = 25.0rev}$$

4. What is the disk's angular velocity  $\omega$  at  $t = 1.00s$ ?

$$\omega_{1.00s} = 209.rad/s = 33.3rev/s \quad (5)$$

5. Sketch the angular acceleration, velocity, and position for  $0 \leq t \leq 1.00s$ . Assume the initial angular position of the disk is zero.



2. A vinyl record in an old fashioned record player always rotates at the same angular speed. CDs, by contrast, must have a constant tangential speed of  $v_t = 1.25m/s$  relative to the laser to read correctly.

1. As a CD plays from the center outward, does the angular speed change?  
Yes, it decreases.
2. What is the angular speed of the CD when the laser beam is  $2.50cm$  from the center?

$$\omega = \frac{v_t}{r} = \frac{1.25m/s}{2.50cm/rad} \quad (6)$$

$$\omega = 50rad/sec$$

$$\boxed{\omega = 50.0rad/s}$$

3. What is the angular speed of the CD when the laser beam is  $6.00\text{cm}$  from the center?

$$\begin{aligned}\omega &= \frac{v_t}{r} = \frac{1.25\text{m/s}}{6.00\text{cm/rad}} \\ \omega &= 20.8\overline{3}\text{rad/sec} \\ \underline{|\omega &= 20.8\text{rad/s}|}\end{aligned}\tag{7}$$

4. If the CD plays for  $66.5\text{min}$  and the laser beam moves radially outward from  $2.50\text{cm}$  to  $6.00\text{cm}$  during this time, what is the magnitude of the CD's average angular acceleration?

$$\begin{aligned}\alpha &= \frac{\Delta\omega}{t} \\ \alpha &= \frac{20.8\text{rad/s} - 50\text{rad/s}}{66.5\text{min}} \\ \alpha &= -7.309941520 \times 10^{-3}\text{rad/s}^2 \\ \underline{|\alpha &= -7.31 \times 10^{-3}\text{rad/s}^2|}\end{aligned}\tag{8}$$

3. A small rubber wheel is used to drive a large pottery wheel. The two wheels are mounted so that their circular edges touch. The small drive-wheel has a radius of  $2.20\text{cm}$  and accelerates at the rate of  $8.00\text{rad/s}^2$ , and it is in contact with the pottery wheel, who has a radius of  $28.0\text{cm}$ . Both wheels move without slipping. The rubber wheel rotates clockwise.

1. Find the angular acceleration of the large pottery wheel.  
Rotating wheels/circles/cylinders/etc that touch, assuming only one has an active force acting on it, will rotate in opposite directions.

$$\begin{aligned}r_d\alpha_d &= -r_p\alpha_p; \quad r_d = 2.20\text{cm}; \quad r_p = 28.0\text{cm}; \quad \alpha_d = 8.00\text{rad/s}^2 \\ \alpha_p &= -\frac{r_d\alpha_d}{r_p} \\ \alpha_p &= -\frac{(2.20\text{cm})(8.00\text{rad/s}^2)}{28.0\text{cm}} \\ \alpha_p &= -0.6285714\text{rad/s}^2 \\ \underline{|\alpha_p &= 0.629\text{rad/s}^2|}\end{aligned}\tag{9}$$

2. Calculate the time it takes the pottery wheel to reach its required speed of  $60\text{rpm}$ , if both wheels start from rest.

$$60rpm = 6.283185307...rad/s \quad (10)$$

$$\alpha = \frac{\omega}{t}; t = \frac{\omega}{\alpha}$$

$$t = \frac{6.283185307...rad/s}{0.6285714rad/s^2}$$

$$t = 9.995976625s$$

$$t = 10s$$