Pre-AP Physics Rotational Motion
Part 1 - Rotational Kinematics

Name _____

1. Convert 1.5 revolutions to both radians and degrees.

$\frac{1.5\ rev}{1} \left| \frac{360^\circ}{1\ rev} \right. = 540^\circ$ $\qquad \frac{1.5\ rev}{1} \left| \frac{2\pi\ rad}{1\ rev} \right. = 9.42$

2. A record spins on a phonograph at 33 rmps (revolutions per minute) clockwise. Find the angular velocity of the record.

$\omega = \frac{2\pi}{T}$

$\frac{33\ rev}{1\ min} \left| \frac{1\ min}{60\ s} \right| \frac{2\pi}{1\ rev} = 3.456\ rad/s$

$\omega = \frac{2\pi}{3.456} = 1.82\ rad/s$

3. Find the magnitude of the earth angular velocity in radians per second.

$\frac{2\pi\ rad}{24\ hr} \left| \frac{1\ hr}{3600\ s} \right. = 7.27 \times 10^{-5}$

4. A computer disk drive optimizes the data transfer rate by rotating the disk at a constant angular speed of 34.1 rad/s while it is being read. When the computer is searching for one of your files, the disk spins for 0.892 s.
   a. What is the angular displacement of the disk during this time?
   b. Through how many revolutions does the disk turn during this time?

a) $\omega = \frac{\Delta\theta}{\Delta t}$ $\qquad \Delta\theta = \omega \Delta t$

$= (34.1\ rad/s)(0.892\ s)$

$= 30.4\ rad$

b) $\Delta\theta = \frac{30.4\ rad}{2\pi\ rad} \left| \frac{1\ rev}{} \right. = 4.84\ rev$

5. A knight swings a mace of radius 1 m in two complete revolutions. What is the distance traveled by the mace?

$s = r\theta = (1m)(4\pi\ rad) = 12.6m$

6. A compact disc player is designed to vary the disc's rotational velocity so that the point being read by the laser moves at a linear velocity of 1.25 m/s. What is the CD's rotational velocity in revs/s when the laser is reading information on an inner portion of the disc at a radius of 0.03 m?

$v = r\omega$

$1.25 = (0.03)(\quad)$

$= 41.66\ r$

$\frac{41.67}{1} \left| \frac{1\ rev}{2\pi\ rad} \right. = \frac{261.8}{6.63}$

7. A carousel accelerates from rest to an angular velocity of 0.3 rad/s in a time of 10 seconds. What is its angular acceleration? What is the linear acceleration for a point at the outer edge of the carousel, at a radius of 2.5 meters from the axis of rotation?

$\alpha = \frac{\omega - \omega_0}{t} = \frac{0.3\ rad/s}{10\ s} = 0.03\ rad/s^2$

$a = r\alpha = (2.5)(0.03\ rad/s^2) = 0.075\ m/s^2$

8. You are doing your laundry. When the washing machine goes into its spin cycle, the tub starts from an angular speed of 2.30 rad/s, then speeds up smoothly for 8.00 s, until it is turning at 5.00 rev/s. Calculate the angular acceleration of the tub during this time.

$\omega_i = 2.30$ rad/s

$\omega_f = \frac{5.00 \text{ rev}}{1 \text{ sec}} \frac{2\pi \text{ rad}}{1 \text{ rev}} = 10\pi$ rad/s $= 3.64$ rad/s

$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{\omega_f - \omega_0}{t}$

$= \frac{10\pi \text{ rad/s} - 2.30 \text{ rad/s}}{8.0 \text{ sec}}$

9. The drill bit of a variable-speed electric drill has a constant angular acceleration of 2.50 rad/s2. The initial speed of the bit is 5.00 rad/s. After 4.00 seconds,
   a. what angular displacement has the bit turned through?
   b. what is the bit's final angular speed?

$\omega_0 = 5$
$\omega_f = ?$
$\Delta\theta = ?$
$\alpha = 2.50$
$t = 4.0$

$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$= (5)(4) + .5(2.50)(4)^2$

$= 20 + 20$

$\Delta\theta = 40$ rad

b) $\omega_f = \omega_0 + \alpha t^2$

$= 5 + (2.5)(4)$

$= 15$ rad/s

10. A basketball player is balancing a spinning basketball on the tip of his finger. The angular velocity of the ball slows down from 18.5 to 14.1 rad/s. During the slow-down, the angular displacement is 85.1 rad. Determine the time it takes for the ball to slow down.

$\omega_0 = 18.5$
$\omega_f = 14.1$
$\Delta\theta = 85.1$
$\alpha = -.84$
$t = t$ 5.23 s

$\omega = \omega_0 + \alpha t$

$t = \frac{\omega - \omega_0}{\alpha}$

$t = 5.23$ s

$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$(14.1)^2 = (18.5^2) + 2\alpha(85.1)$

$198.81 - 342.25 = 2\alpha(85.1)$

$\frac{-143.44}{85.1} = \frac{2\alpha\Delta\theta}{\Delta\theta}$

11. A flywheel has a constant angular deceleration of 2.0 rad/s2.
    a. Find the angle through which the flywheel turns as it comes to rest from an angular speed of 220 rad/s.
    b. Find the time required for the flywheel to come to rest.

$\omega_0 = 220$
$\omega = 0$
$\Delta\theta =$
$\alpha = (-2.0)$
$t = 110$ s

b) $t = \frac{0 - 220}{-20}$

$= 11$ s

a) $\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$0^2 = 220^2 + 2(-2)\Delta\theta$

$\frac{-48400}{-4} = \frac{-4\Delta\theta}{-4}$

$\Delta\theta = 12{,}100$

12. A bicyclist uniformly increases his pedaling from 30 rev/min to 120 rev/min in 5.0 s. The wheels of the bike each have a diameter of 60 cm. Determine:
    a. the angular acceleration of the bike wheels,
    b. the final linear (tangential) speed of the bike wheels
    c. the angular displacement of the bike wheels
    d. the linear distance travelled by the bike

$\frac{30 \text{ rev}}{1 \text{ min}} \frac{2\pi \text{ rad}}{1 \text{ rev}} \frac{1 \text{ min}}{60 \text{ s}} = 3.14$

$\frac{120 \text{ rev}}{1 \text{ min}} \frac{2\pi \text{ rad}}{1 \text{ rev}} \frac{1 \text{ min}}{60 \text{ s}} = 12.56$

$\omega_0 = 3.14$
$\omega = 12.56$
$\Delta\theta =$
$\alpha = 1.88$
$t = 5$ s

a) $\alpha = \frac{\omega - \omega_0}{t}$

$= \frac{12.56 - 3.14}{5}$

$\alpha = 1.88$ rad/s^2

b) $v = r\omega$

$= (.3)(12.57)$

$= 3.77$ m/s

c) $\Delta\theta = (3.14)(5) + (.5)(1.88)(5)^2$

$= 39.275$ rad

d) $s = r\theta$

$s = (.3)(39.27)$

$= 11.78$ m