Unit 11: Rotational Kinematics, General Physics

Worksheet 1: Practice working with rotation and revolution

Circular motion can involve rotation and/or revolution. Rotation occurs when the object spins about an internal axis. Revolution occurs when the axis lies outside of the object. Some objects do both at the same time! The time it takes for an object to make one rotation or one revolution is called its period.

Linear motion involves concepts we studied last semester such as displacement (Δx) and velocity ($\Delta x/\Delta t$). Circular motions involve changing an angle ($\Delta\theta$) and angular velocity (ω) which is how much this angle changes with respect to time: ($\Delta\theta/\Delta t$). Additionally, a rotating or revolving object also can move linearly or tangentially. The displacement is an arc around the circumference ($\Delta x = 2\pi r$); the velocity [called tangential velocity (v_t)] is this displacement over time. It is called tangential as the object's velocity is tangential to the arc.

As seen from the North Pole, the earth spins CCW once in 24 hours (actually it is slightly less).

1. (a) What is the $\Delta\theta$ in degrees and radians that the earth moves in 1 hour? (answer = 15 degrees)

(b) What is the Earth's angular velocity (ω) in rpm, degrees per hour, and radians per second? (answers = 6.94×10^{-4} rpm; 15 deg/hr; 7.27×10^{-5} rad/sec)

(c) If the earth's radius is about 6.4×10^{6} meters, what tangential velocity (m/s) does an object have at the equator? (answer = 465.4 m/s)

2. A traditional watch has three hands: an hour hand, a minute hand, and a second hand.

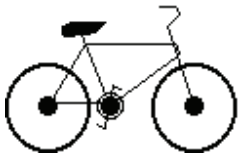
Determine the angular velocity (ω) in radians per second for each hand.

(a) hour hand (answer = 1.45×10^{-4} rad/s):

(b) minute hand (answer = 1.74×10^{-3} rad/s):

(c) second hand ((answer = 1.05×10^{-1} rad/s)

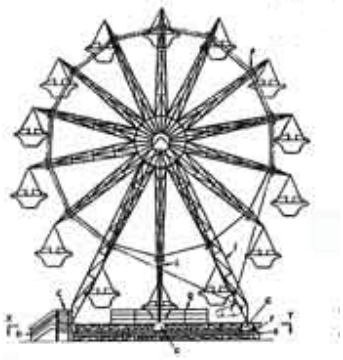
4. A 0.5-meter *diameter* bicycle wheel is rotating at 60 rpm.



(a) What is its initial angular speed in radians per second? (answer = 6.28 or 2π rad/s)

(b) What is the tangential velocity in m/s of a point on the rim of the wheel? (answer = 1.57 m/s)

5. Imagine a ferris wheel that is rotating at the rate of 45 degrees each second.
(a) What is the ferris wheel's period of rotation in seconds? (answer = 8 sec)
(b) What is the angular velocity in rotations per minute (rpm)? (answer = 7.5 rpm)
(c) What is the angular velocity in radians per second? (answer = 0.785 rad/s)
(d) If the tangential velocity of one of the cars is 7.85 m/s, how far (in meters) is it located from the center (axis of rotation)? (answer = 10 m)



Worksheet 2, Rotational Kinematics, continued:

Note: for my calculations using π, I use 3.14159. Your answers may be a bit different depending upon your value for pi and rounding.

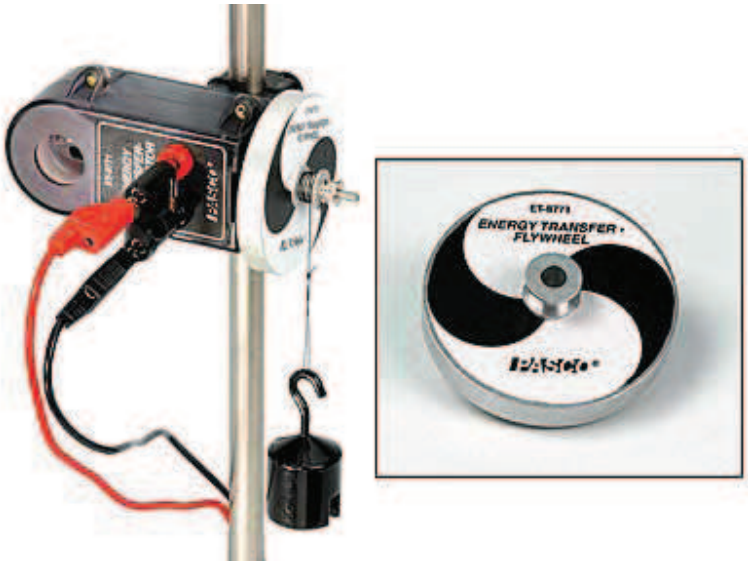
1. A fan that is turning at 10 rpm speeds up to 25 rpm in 10 seconds. How many radians and rotations does the blade require to alter its speed? (Note: You must first convert the rpm to rad/s. To use the equations, any angular quantities must be in radians.) (answer: 18.4 radians or 2.92 rotations)

2. An old phonograph played some records at 45 rpm or 4.71 rad/sec. Let's say the phonograph is turning at 45 rpm and then the motor is turned off, taking 0.75 seconds to come to a stop.

a) What is its average angular acceleration? (answer = - 6.28 rad/sec^2)

b) How many rotations did it make while coming to a stop? (θ = 1.77 radians or 0.281 rot)

3. A flywheel turning at 1200 rev/min (125.7 rad/s) constant angular velocity has a radius of 2.5 cm (0.025 m). As it turns, a string is to be wound onto its rim. How long a piece string will be wrapped in 10 seconds (i.e. how high will it lift the weight)? (answer = 31.4 m)



4. A wheel makes 4.0 rotations in 1 second, rotating at constant angular velocity. What will its angular displacement be after 13.0 s? Determine in rotations and radians. (answers = 52 rotations or 327 rad)

5. CDs are not only used in the music industry, but are also utilized in the computer industry. The information of a huge library can be stored on a single CD. The CD spins around and information is read or written to it as it rotates. One CDROM drive I saw mentions it has a stated angular velocity of 8560 rpm. If the CD starts from rest, what is the angular acceleration if it takes 120 milliseconds (0.12 seconds) for the CD to reach this angular velocity? (answer = 7470 rad/s^2)

6. Starting from rest, the tub of a washing machine reaches an angular speed of 5.2 rad/s, with an average angular acceleration of 4.0 rad/s^2.

(a) How long does it take the spin cycle to come up to speed? (answer = 1.3 sec)

(b) What angular displacement (in radians and rotations) does the tub rotate through as it reaches this angular velocity? (answer 3.38 radians or 0.54 rotations)

7. The blades of an electric blender are whirling with an angular velocity of +375 rad/s while the "puree" button is pushed in. When the "blend" button is then pressed, the blades accelerate and reach a greater angular velocity after the blades have rotated through an angular displacement of +44.0 rad (seven revolutions). The angular acceleration has a constant value of +1740 rad/s^2. Find the final angular velocity (ω_f) of the blades. (answer = 542 rad/s)

8. A 0.5-meter diameter bicycle wheel initially rotating at 60 rpm rolls to rest at a constant rate in 10 seconds. What is its angular acceleration, α, in radians per second per second? (answer = -0.628 rad/s^2)