Phys 111: Lecture 15

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October 15, 2019

"The 15th Day: 3 Blue Rupees"

Homework Wk #8 Due Thursday 10/17/19

Exam #2 Tuesday 10/29/19

Today's Topics

1. Rotational Quantities
2. Rotational Kinematics
3. Examples

Motivational Thoughts

You may have been thinking about the following:

1. What if an object speeds up and moves in a circle?
2. How can we approximate rotational motion?
3. We've ignored some rolling motion in previous examples.
4. How do forces affect rotation?
5. How does rotational energy and momentum work?

Uniform Circular Motion (UCM)

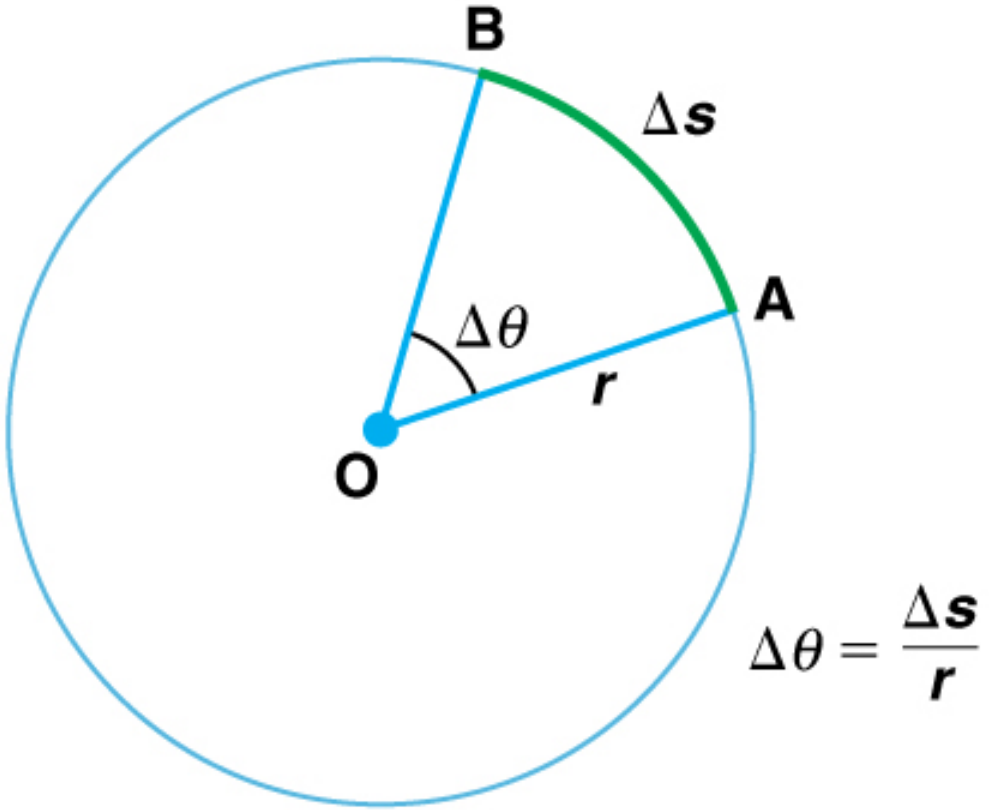

Figure: 15.1 Full revolution at constant rate: $v = 2\pi r/T$

Spin Rotation

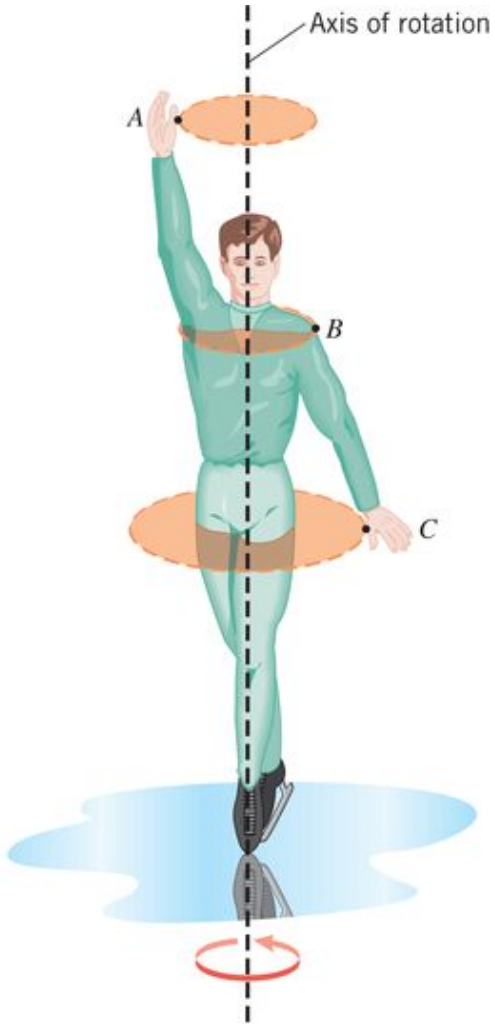

Figure: 15.2 Figure skating spins

Orbital Rotation

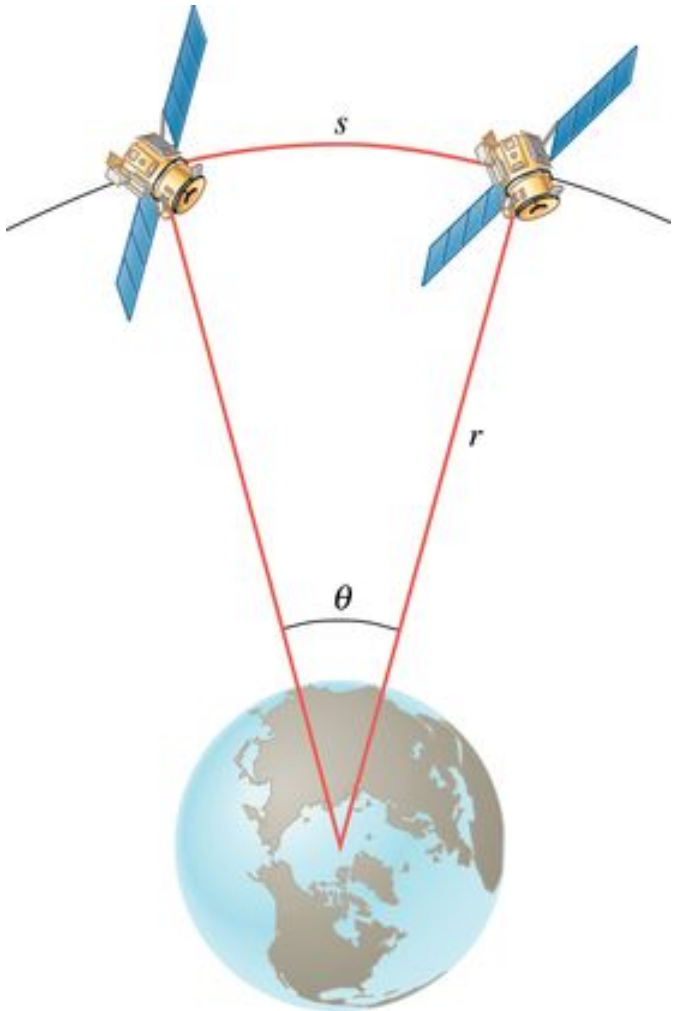

Figure: 15.3 Synchronous or "stationary" satellites

So Many: Symbols vs Sentences?

Rotational Motion	Quantity	Linear Motion
θ	Displacement	x
ω_o	Initial Velocity	v_o
ω	Final Velocity	v
α	Acceleration	a
t	Time	t

Translational vs Rotational Motion

Rotational Motion	Linear Motion
t	t
θ	s
$\omega = \frac{\Delta\theta}{\Delta t}$	$v = \frac{\Delta s}{\Delta t}$
$\alpha = \frac{\Delta\omega}{\Delta t}$	$a = \frac{\Delta v}{\Delta t}$

Constant Acceleration

Rotational Motion	Linear Motion
$\omega = \omega_o + \alpha t$	$v = v_o + at$
$\theta = \frac{1}{2}(\omega + \omega_o)t$	$x = \frac{1}{2}(v + v_o)t$
$\theta = \omega_o t + \frac{1}{2}\alpha t^2$	$x = v_o t + \frac{1}{2}at^2$
$\omega^2 = \omega_o^2 + 2\alpha\theta$	$v^2 = v_o^2 + 2ax$

Exercise #1

C&J FOC 8.4 A rotating object has an angular acceleration of $\alpha = 0\, rad/s^2$. Which one or more of the following three statements is consistent with a zero angular acceleration?

A. The angular velocity is $\omega = 0\, rad/s$ at all times.

B. The angular velocity is $\omega = 10\, rad/s$ at all times.

C. The angular displacement θ has the same value at all times.

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1. A, B, and C
2. A and B, but not C
3. A only
4. B only
5. C only

Exercise #2

C&J FOC 8.6 A rotating wheel has a constant angular acceleration. It has an angular velocity of $5.0\ rad/s$ at time t $= 0\ s$, and $3.0\ s$ later has an angular velocity of $9.0\ rad/s$. What is the angular displacement ($\Delta\theta$) of the wheel during the $3.0\ s$ interval?

a. 15 rad
b. 21 rad
c. 27 rad
d. There is not enough information given to determine the angular displacement.

Reasoning Strategy[1]

Applying the Equations of Rotational Kinematics

1. Make a drawing to represent the situation being studied, showing the direction of rotation.
2. Decide which direction of rotation is positive and which is negative. **Do not change** your decision during the course of a calculation.
3. Identify and write down known and unknown values and explicitly write down a note of what variables you are being asked to determine. Be careful about implied data such as reading "starts from rest".
4. Identify which physical relationships you are going to make use of and write down the relevant equations.
5. Simplify your equations by plugging int zeros and then solve.
6. There may be two possible answers to a kinematics problem. Try to visualize the different physical situations to which the answers correspond.

[1] More detailed set in section 8.3 from C&J.

Satellite Coverage (Collecting)

C&J 8.1 Example 1 Two adjacent synchronous satellites have an angular separation of $\theta = 2.00^\circ$ and both have a radius of $r = 4.23 \times 10^7\ m$. Find the arc length s that separates the satellites and think about the coverage of signal from the satellites.

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Need To Know Converting degrees to radians

$$\pi\ rad = 180^\circ$$

$$2.00^\circ = 2.00^\circ \left(\frac{\pi\ rad}{180^\circ} \right)$$

$$\theta = 0.0349\ rad$$

Satellite Coverage Answer

C&J 8.1 Example 1 $r = 4.23 \times 10^7\ m$, $\theta = 0.0349\ rad$. Find the arc length s between the two satellites from the definition relationship:

$$s = r\theta$$

$$s = (4.23 \times 10^7\ m)(0.0349\ rad)$$

$$s = 1.48 \times 10^3\ km$$

$$s = 920\ mi$$

Exercise #3

C&J 8.9 A Ferris wheel operates at an angular velocity of $0.24\ rad/s$. Starting from rest, it reaches its operating speed with an average angular acceleration of $0.030\ rad/s^2$. How long does it take the wheel to come up to operating speed?

Exercise #4

C&J 8.20 A figure skater is spinning with an angular velocity of $+15\ rad/s$. She then comes to a stop over a brief period of time. During this time, her angular displacement is $+5.1\ rad$. Determine

a. her average angular acceleration and

b. the time during which she comes to rest.

The End

Thanks for your time and attention!

Any questions?

Additional Practice #1

C&J 8.3 The earth spins on its axis once a day and orbits the sun once a year (365.25 days). Determine the average angular velocity (in rad/s) of the earth as it

a. spins on its axis and
b. orbits the sun. In each case, take the positive direction for the angular displacement to be the direction of the earth's motion.

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$$1\ day = (24)(3600)\ s$$

Additional Practice #2

C&J 8.13 Two people start at the same place and walk around a circular lake in opposite directions. One walks with an angular speed of $1.7 \times 10^3\ rad/s$, while the other has an angular speed of $3.4 \times 10^3\ rad/s$. How much time does it take for them to meet?

Additional Practice #3

C&J 8.17 A stroboscope is a light that flashes on and off at a constant rate. It can be used to illuminate a rotating object, and if the flashing rate is adjusted properly, the object can be made to appear stationary.

a. What is the shortest time between flashes of light that will make a three-bladed propeller appear stationary when it is rotating with an angular speed of $16.7\ rev/s$?

b. What is the next shortest time?