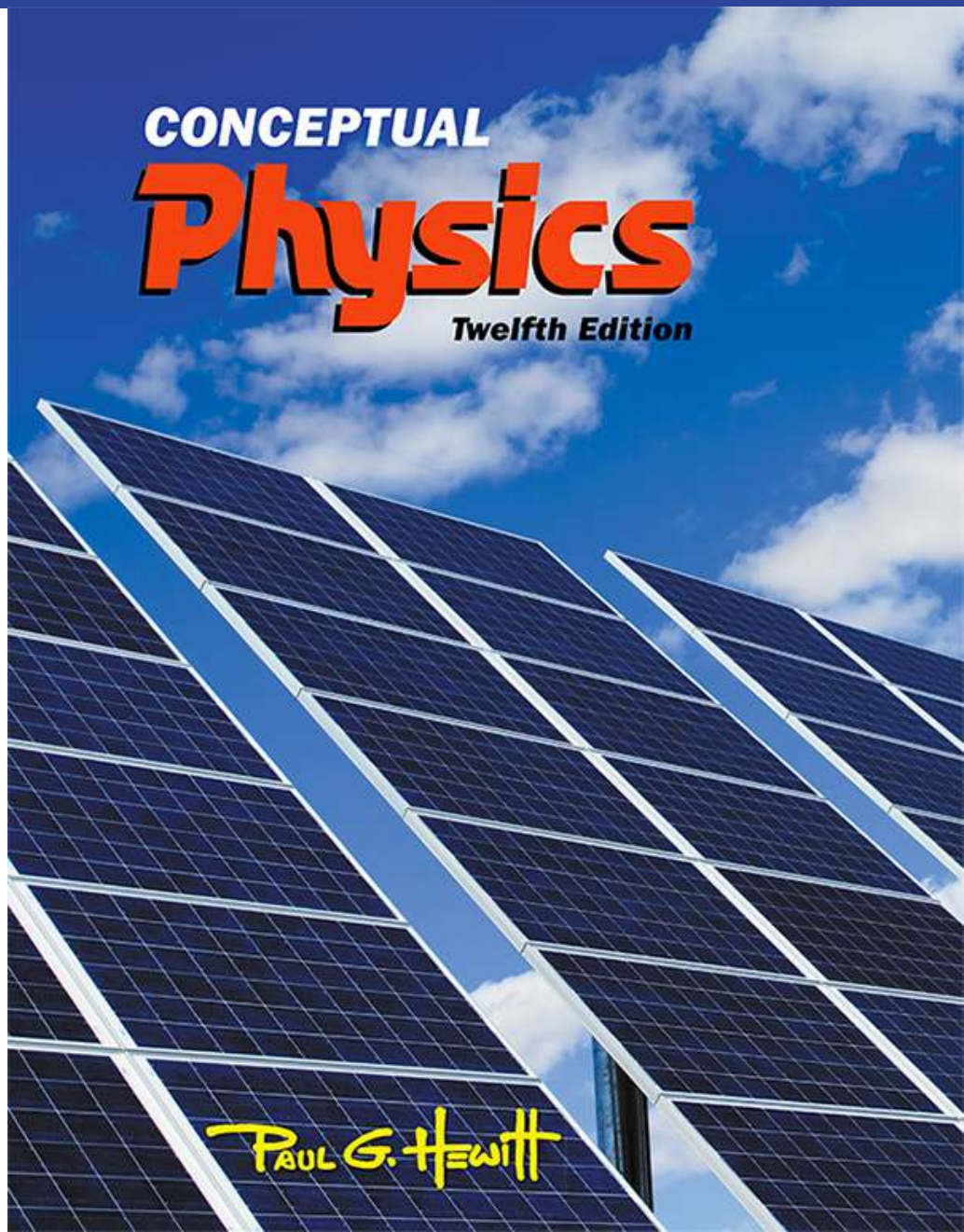
Lecture Outline

Chapter 8: Rotational Motion



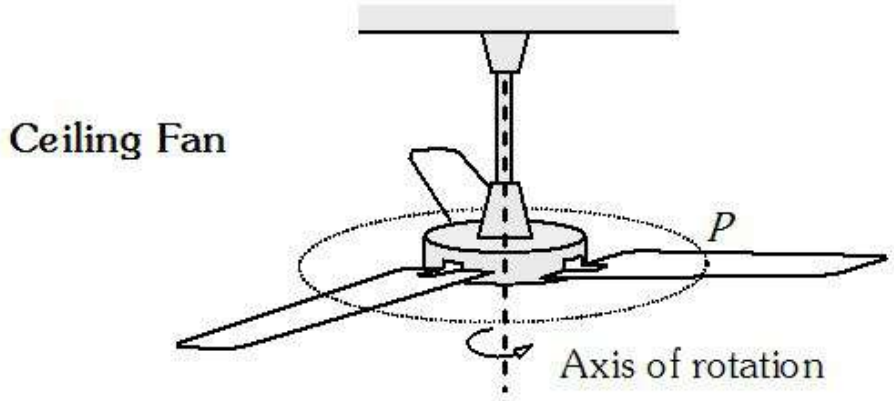
Section 1.
This lecture will help you understand:

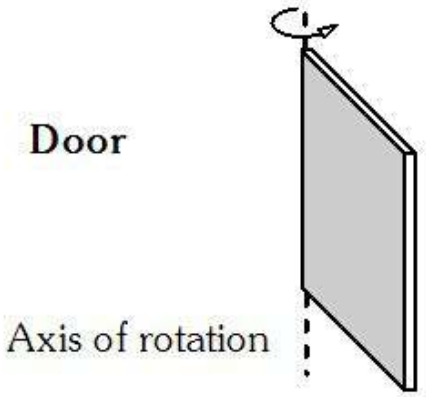
- circular motion…rotation vs revolution
- linear vs tangential speed
- how trains stay on tracks
- why hurricanes form
- why rockets are launched from Florida

UCM = uniform circular motion

- When an object moves **at constant speed** around a center point, it is called *uniform circular motion.*

- The center point is called the *axis*.

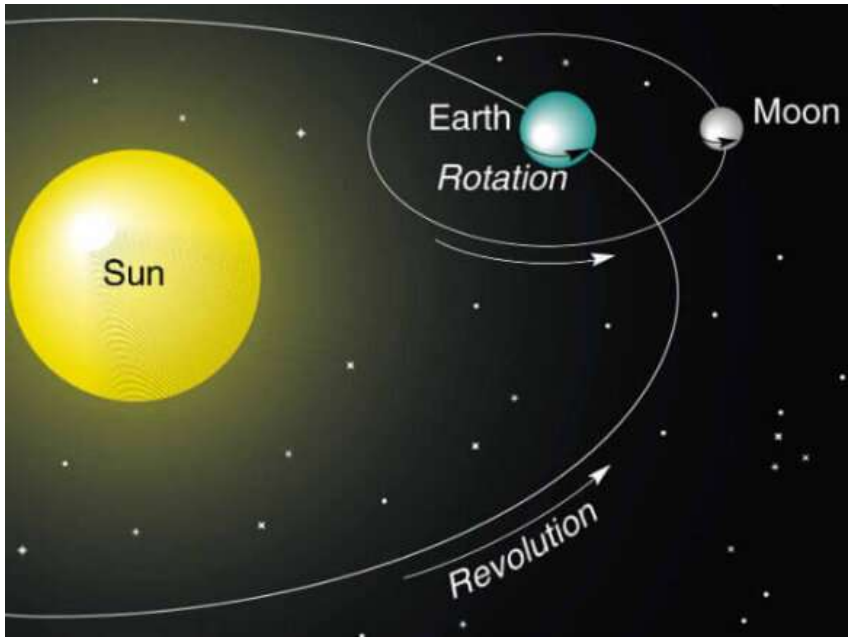




Rotation versus Revolution

- When an object turns about an internal axis, it is undergoing *rotation*.
- When an object turns about an external axis, it is undergoing *revolution*.

- How long does it take the Earth to rotate once? 24 h
- How long does it take the Earth to revolve once? 1 year



rotation or revolution?

revolution

rotation

Circular Motion

- Circular Motion is characterized by two kinds of speeds:

1. **tangential** (or linear) speed v.
   → how much distance covered per time

2. **rotational** (or circular) speed ω (omega).
   → angle or rotations per time (rpm)

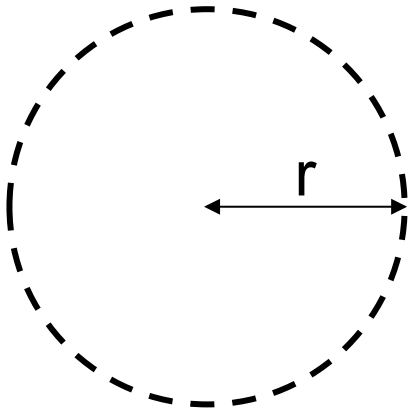
1. Tangential Speed

- The distance traveled by a point on the rotating object divided by the time taken to travel that distance is called its *tangential* speed (symbol *v*).

- tangential speed $v = \frac{distance\ traveled}{time}$

$= \frac{circumference}{time}$

$= \frac{2\pi \times radius}{time}$



Ex: Calculate tangential speed :

A car moves in a circle of radius of 30 m in 15 s.

1) What is its tangential speed?

$$v = \frac{circumference}{time} = \frac{2\pi\, radius}{time} = \frac{2(3.14)30\text{ m}}{15\text{ s}} = 13\text{ m/s}$$

2) What is the tangential speed if the same car drives in a circle of radius 60 m in the same time.

$$v = \frac{circumference}{time} = \frac{2\pi\, radius}{time} = \frac{2(3.14)60\text{ m}}{15\text{ s}} = 26\text{ m/s}$$

3) How much faster is the second car? 2 x

In UCM, the velocity is tangent to the circle:

- Tangential velocity = tangential speed + direction

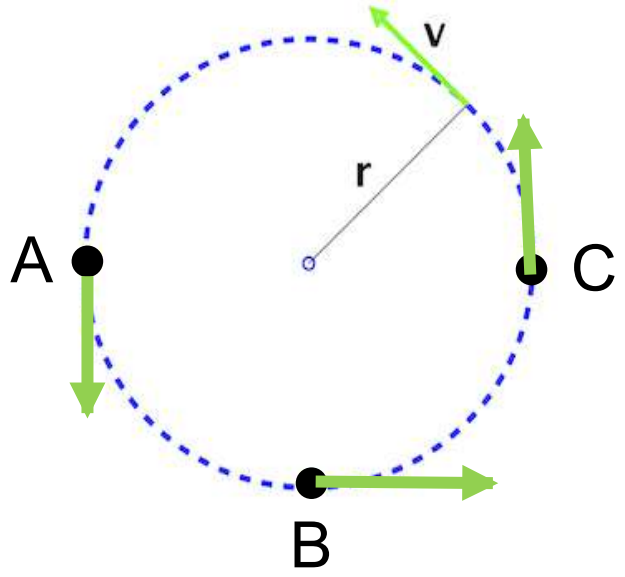
The tangential velocity v is always *tangent* to the circle.

What direction is v at A?

down

At B? right

At C? up



1) Is the velocity changing? yes

2) If a car travels *at constant speed* in a circle, is it accelerating? yes

2) Rotational Speed ω

- Rotational (angular) speed is the *number of rotations or revolutions per unit of time* (symbol *ω*).
- Units can be **rpm** (revolutions per minute)

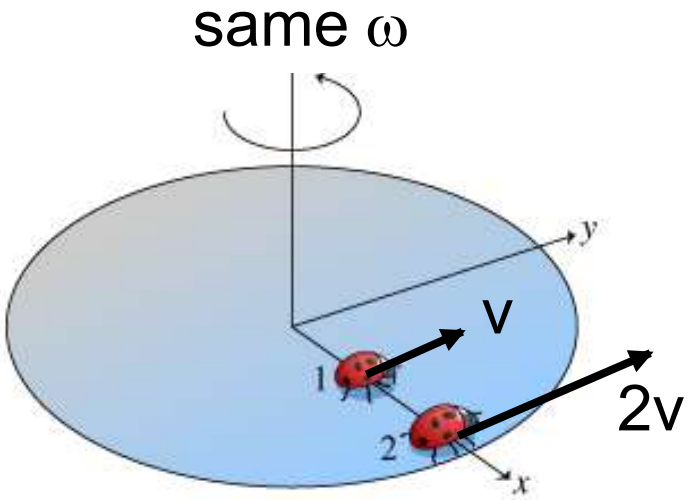
- All parts of a rigid merry-go-round turn about the axis of rotation in the same amount of time.
- So, all parts have the same rotational speed ω

Relationship between v and ω:

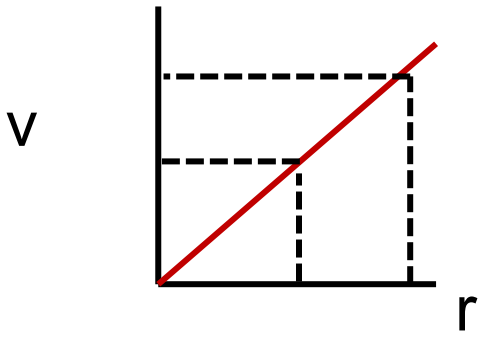
Tangential speed v depends on:

a) distance from the axis r; and

b) and the angular speed ω.



$$v = r\,\omega$$



If r is doubled, then v….

…doubles.

If r is tripled, then v….

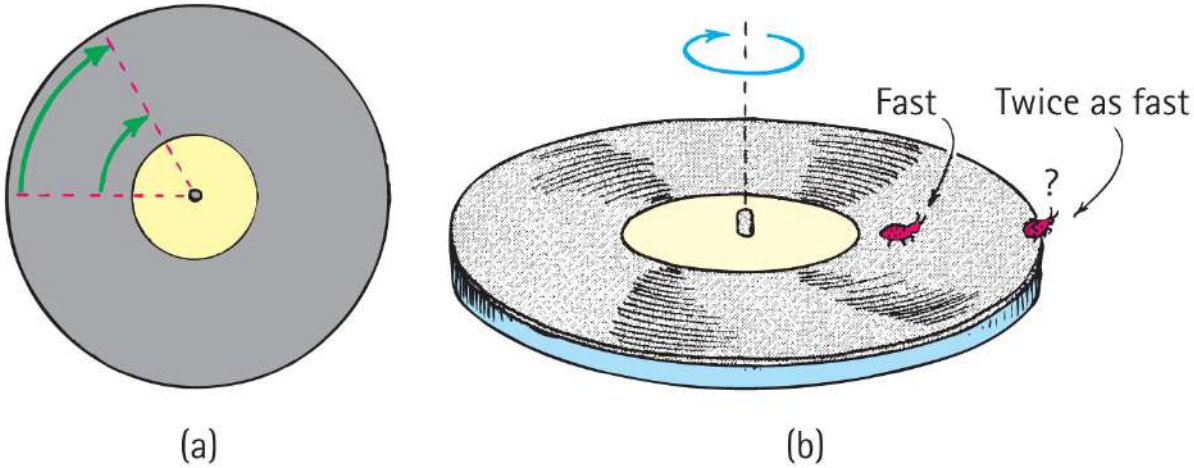
…triples.

v is directly proportional to r

$v \propto r$

Tangential Speed

- Points closer to the circumference have a higher tangential speed that points closer to the center.



- Why? they travel further in the same time
- Which point has a higher angular speed ω? neither

Rotational and Tangential Speed
CHECK YOUR NEIGHBOR

A ladybug sits *halfway* between the rotational axis and the outer edge of the turntable. When the turntable has a rotational speed of 20 RPM and the bug has a tangential speed of 2 cm/s, what will be the rotational and tangential speeds of her friend who sits at the outer edge?

	tangential	rotational
A.	2 cm/s	20 rpm
B.	2 cm/s	40 rpm
C.	4 cm/s	20 rpm
D.	4 cm/s	40 rpm

Rotational and Tangential Speed
CHECK YOUR ANSWER

A ladybug sits halfway between the rotational axis and the outer edge of the turntable. When the turntable has a rotational speed of 20 RPM and the bug has a tangential speed of 2 cm/s, what will be the rotational and tangential speeds of her friend who sits at the outer edge?

C. 4 cm/s

Explanation:

Tangential speed = $r\omega$

Rotational speed of both bugs is the same, so if radial distance doubles, tangential speed also doubles.

So, tangential speed is 2 cm/s x 2 = 4 cm/s.

Ex. Different places on Earth:

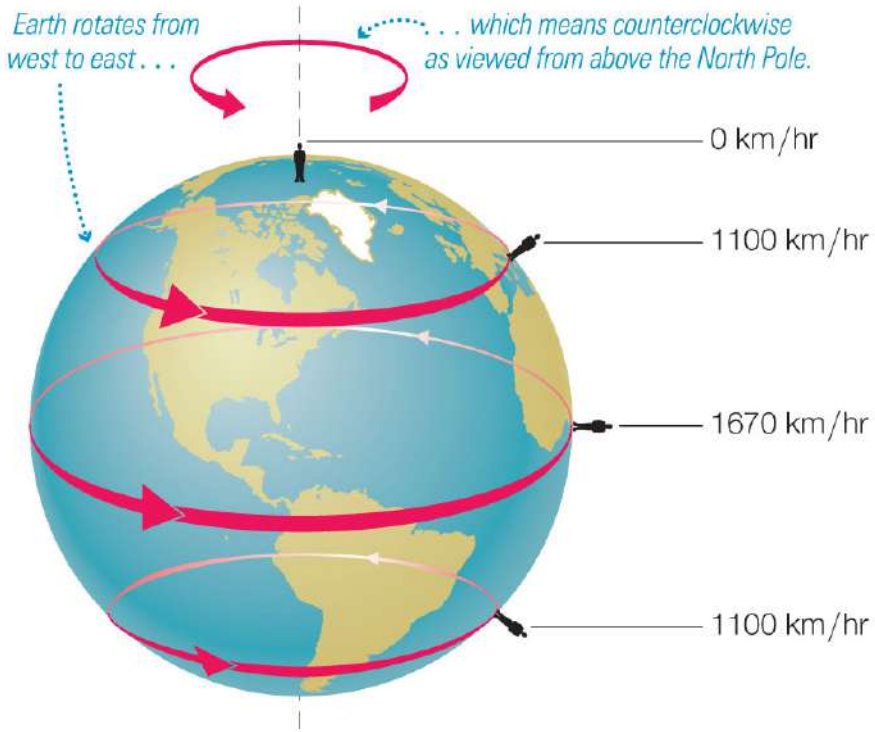
- Where on Earth is the tangential velocity the greatest?

  equator

- Where is it the least?

  poles

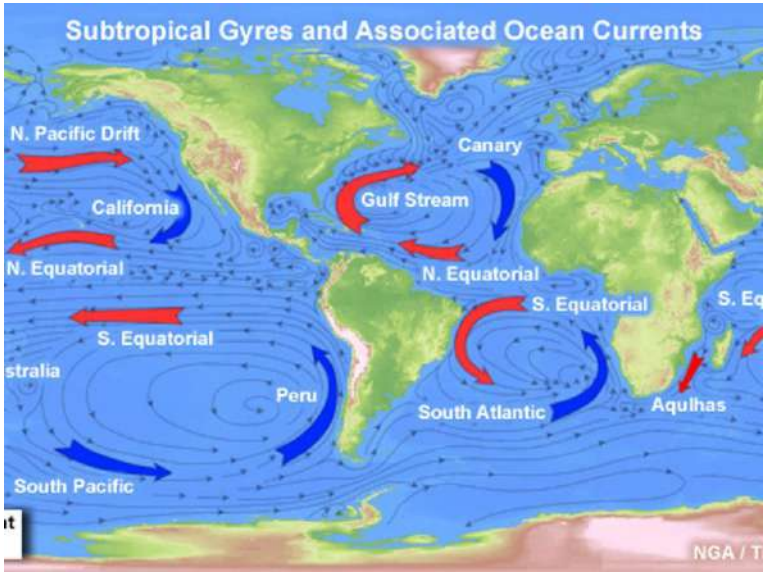
- Which location has the greatest angular velocity? same



Why are rockets launched from Florida?

fastest tangential velocity

The Coriolis Effect:

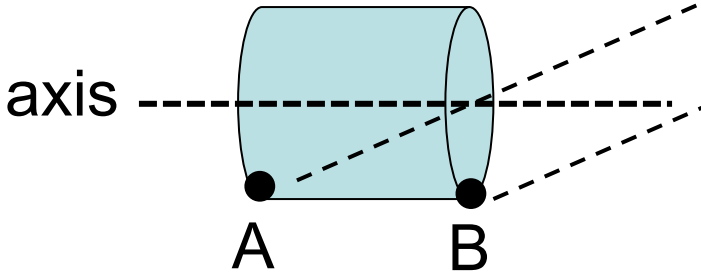


-winds and ocean currents curve to the right (north hemisphere) and to the left (south hemisphere)

-occurs because different locations have different tangential speeds:

https://www.youtube.com/watch?v=wFRbXnU7mkw

Ex. Why does a rolling cup curve?

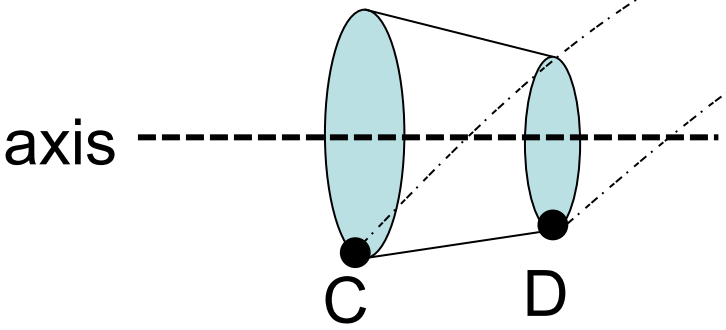


Which point, A or B, is further from the axis?

neither

Which point moves further and faster?

neither



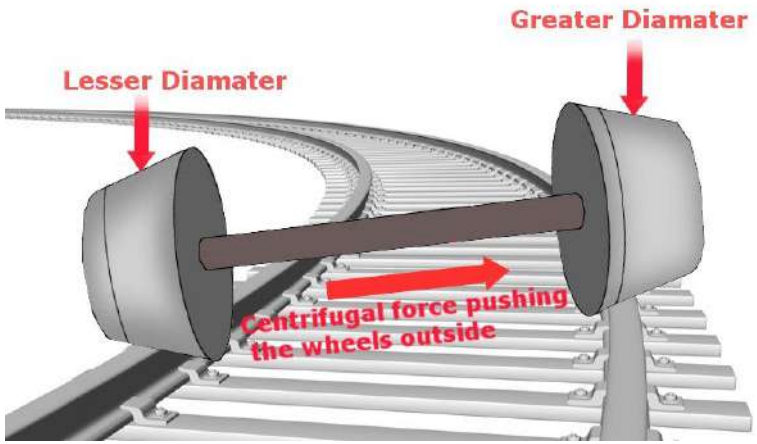
Which point, C or D, is further from the axis?

C

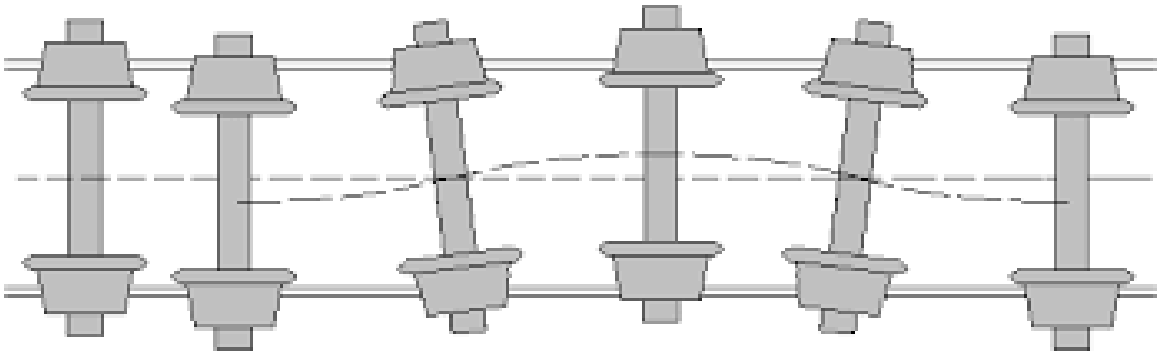
Which point moves faster?

C

Ex. Wheels on Railroad trains



On curves, the outside track is longer. So the wheel rides up onto its outer diameter, which is moving faster.



1. The axle trajectory.

- Train wheels self correct. This is called "hunting oscillations."

Homework: due by 7 pm tonight

- On page 153, do # 1-4
- On page 154, do #32
- On page 155: do #44
- On page 156, do #51 and 52