PHY 211 Lecture 10

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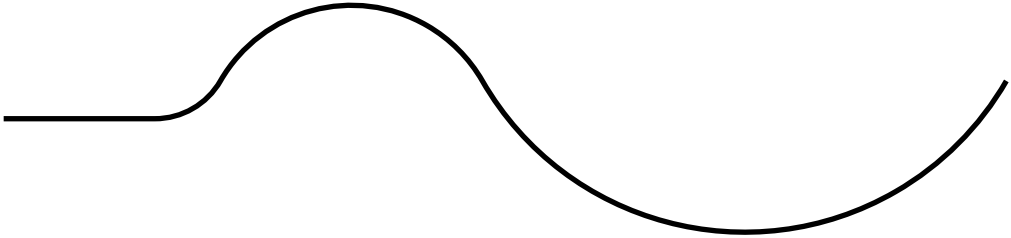
Vectors and motion

- Once we can move in more than one dimension, need to worry about relative direction of position, velocity, and acceleration
- In 1D, acceleration had to point either with velocity, or opposite
- But in 2 or 3D we can turn

Driving on curved road

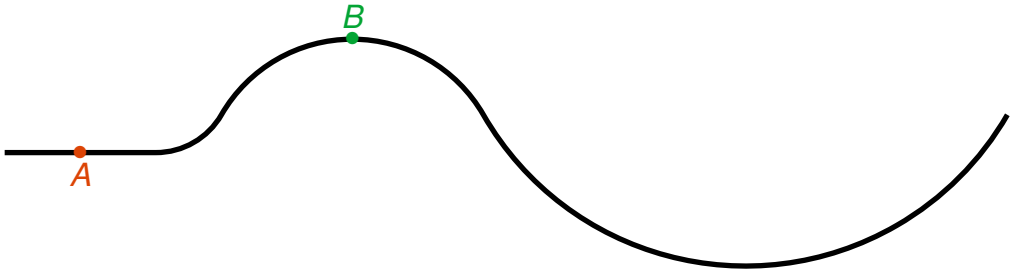
Motion graph with displacement and velocity

- Picture a car with cruise control (constant speed) on a curving road



Question

- Which vector represents the acceleration at point A?



(a) 

(b) 

(c) 

(d) • $(a = 0)$

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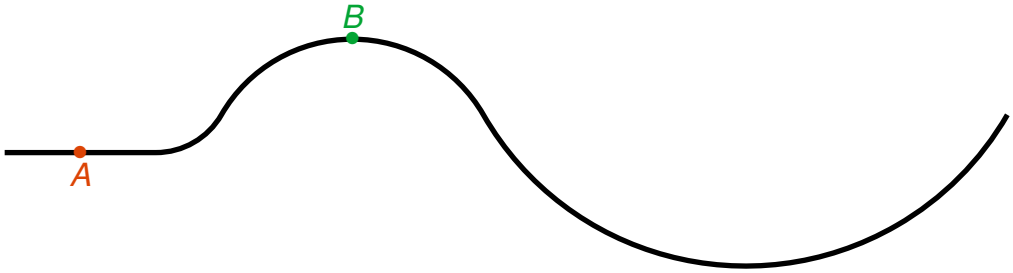

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(b) 

(c) 

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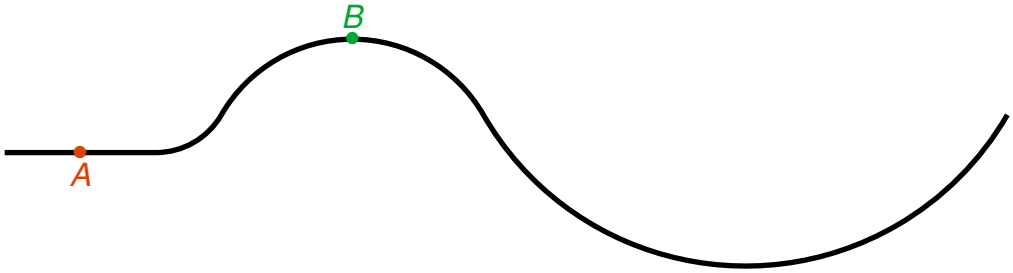
Question

- Which vector represents the acceleration at point B?



(a) 

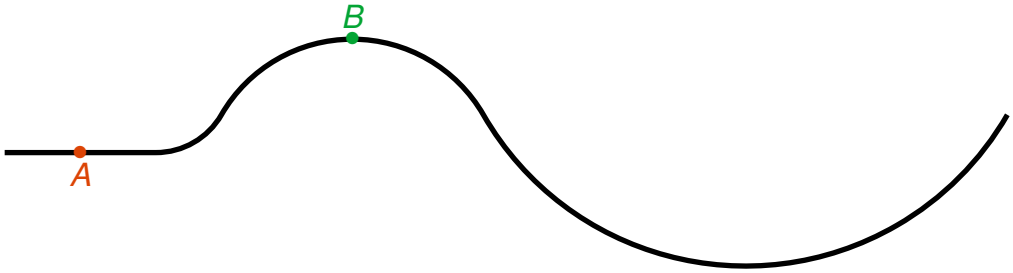
(b) 

(c) 

(d) $\bullet (a = 0)$

Question

- Which vector represents the acceleration at point B?



(a) →

(b) ↓ ✓

(c) ↘

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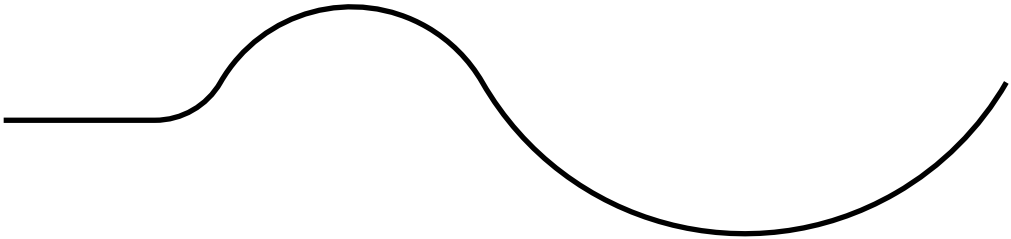
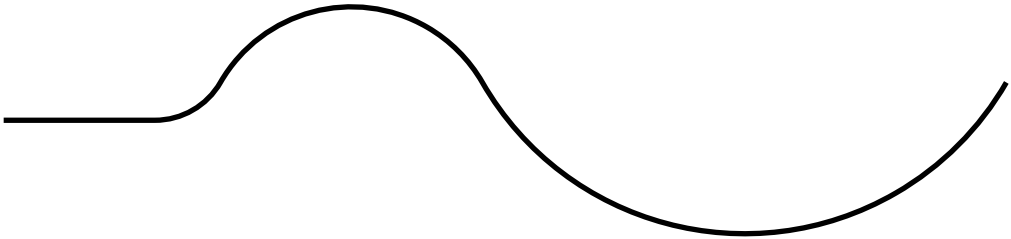
How to describe speeding up?



How to describe slowing down?



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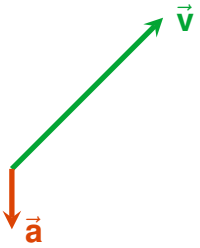
- In the following velocity and acceleration pair, which answer describes how the speed is changing in time?



(a) Speeding up
(b) Slowing down
(c) Constant speed

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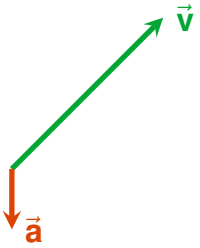

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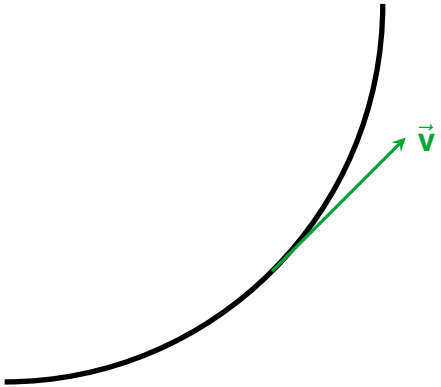
Does that make sense?

- Let's look at the components of $\vec{\mathbf{a}}$ with a good choice of axis



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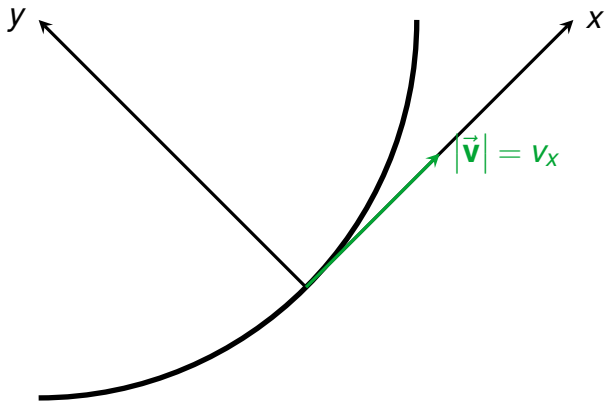

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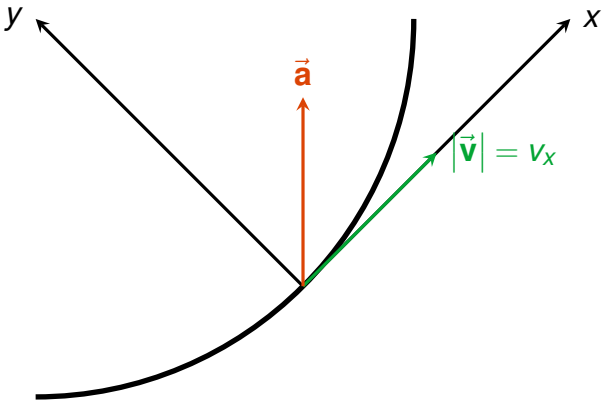

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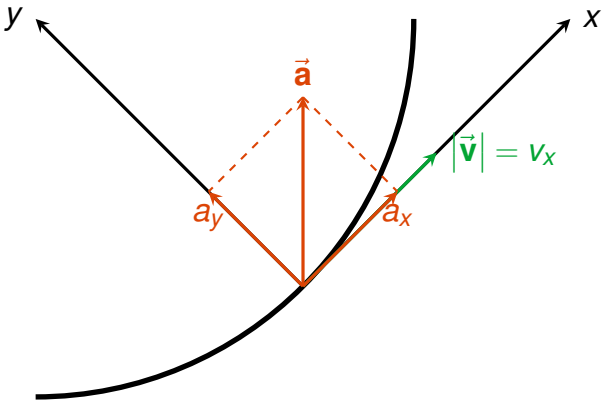


Radial and tangential

- Velocity is always tangential to the path – that's its definition!

Radial and tangential

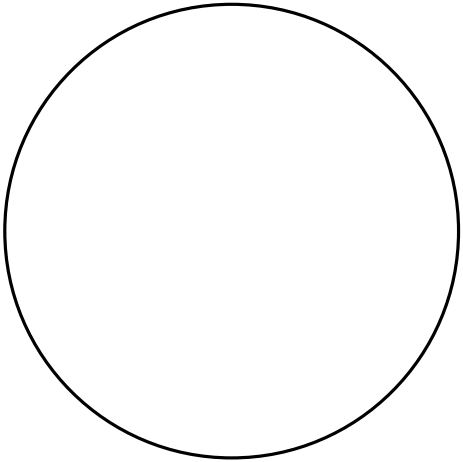
- Velocity is always tangential to the path – that's its definition!
- Acceleration can have a tangential component – that makes you speed up or slow down
- And a radial component – that makes you turn!

What happens at later times?

- Remember we were talking about the instantaneous velocity and acceleration
- In some problems we have constant acceleration at all times
- Other times the acceleration changes based on what is going on
  - Good example – driving a car. You aren't always turning or trying to speed up
  - You need to change acceleration to match the road
  - For these kind of problems, usually we will focus on only one instant of time

Turning on a circle

- We talked about acceleration when turning
- Know that for constant speed it points towards the inside of the curve
- For a circle this is exactly towards the center
- This is called centripetal acceleration
- That's the direction – what about the magnitude?



Pre-lecture question 1

- Can centripetal acceleration change the speed of a particle undergoing uniform circular motion?

  (a) Yes (29%) (b) No ✓(68%)

- Centripetal (or sometimes called radial for general turns) is the part that only changes direction

Pre-lecture question 2

- True or false: if two objects are moving around the same circle, and object A has twice as much speed as object B, then the magnitude of object A's centripetal acceleration is twice that of object B.

  True (30%) False ✓(69%)

Centipetal acceleration

$$a_C = \frac{v^2}{r}$$

or

$$a_C = \omega^2 r$$

- More velocity – harder to turn
- Smaller circle – harder to turn

Question

- In uniform circular motion, is there any tangential acceleration?
  (a) Yes (b) No

Question

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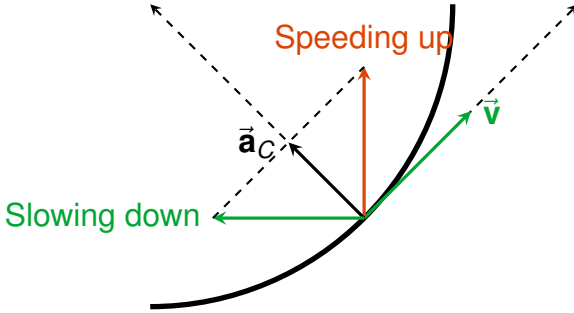
  (a) Yes (b) No ✓

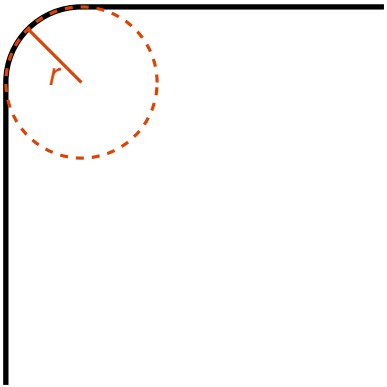
Changing speed

- Centripetal acceleration is just what makes you turn
- If, while, going around the circle, you add tangential acceleration you can speed up or slow down
- But if radial component is not the same you won't turn the same amount!



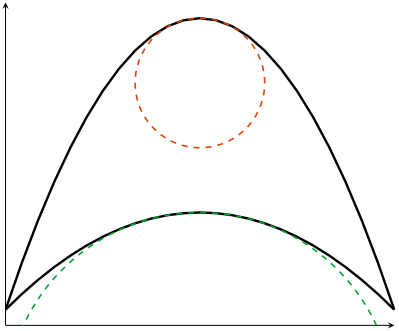
Works for turns!

- If you are turning, you draw an imaginary circle with the curvature of the current turn
- This circle's radius is the radius of curvature, which you use to calculate centripetal acceleration



Tighter turns

- Tighter turns have smaller radii – more centripetal acceleration needed
- The turn doesn't have to look like a circle!



Example

A Formula One race car is traveling at 89.0 m/s along a straight track enters a turn on the race track with radius of curvature of 200.0 m. What centripetal acceleration must the car have to stay on the track?

Image by witherspoony on wikimedia

Ball and ring

- When part of the ring is missing, what direction will the ball travel when it gets to that section?

(a) Around the circle

(b) Tangent to the circle

(c) Radially outward

(d) Some other angle out of the circle

Ball and ring answer

- When part of the ring is missing, what direction will the ball travel when it gets to that section?

(a) Around the circle

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Pre-lecture question 3

- True or false: you should draw the centripetal force on your free body diagram for a problem.

  (a) True (47%) (b) False ✓(50%)

Question

- Is centripetal force a new source of force like gravity, normal force, friction, etc.?

  (a) Yes

  (b) No

Answer

- Is centripetal force a new source of force like gravity, normal force, friction, etc.?

  (a) Yes (b) No ✓

- It is simply a statement about the sum of forces, when they give a centripetal acceleration

Centripetal forces

- What force causes the centripetal acceleration for Otto on a string?
- What force causes the centripetal acceleration for the ball in the ring?
- What force causes the centripetal acceleration for the racecar?

Roller coaster

- Which forces act on a roller coaster going around a loop?
- Which of these forces can contribute to the centripetal force?
- Does it matter what part of the loop it is on?
- What effects can the other forces have?

Image by Coasterman1234 on wikipedia

Inside the spinning tube

What will happen to the eraser?

A. Immediately fall down
B. Immediately start slowly sliding down
C. After a while it will quickly fall down
D. After a while it will start slowly sliding down

Stunt cyclist

A stunt cyclist rides on the interior of a cylinder 12 m in radius. The coefficient of static friction between the tires and the wall is 0.68. Find the value of the minimum speed for the cyclist to perform the stunt. (So basically riding on the wall)