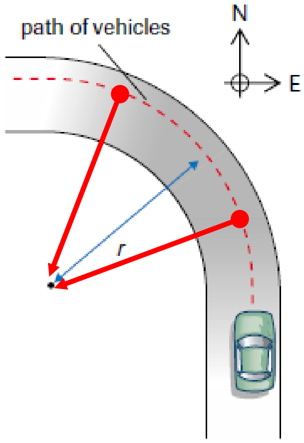
Sec. 3.2 - Forces in Circular Motion

Learning Goal: By the end of today, I will be able to determine the forces involved with keeping an object on a circular or curved path.

Feb 23-10:03 PM

The Direction of the Net Force in Uniform Circular Motion

Since centripetal acceleration is directed toward the centre of the circle , the net force must also be directed toward the centre of the circle. This force can usually be determined by drawing an FBD of the object in uniform circular motion.



$$F_{net} = ma \qquad a_c = \frac{v^2}{r}$$

$$\Sigma F = F_{net} = \frac{mv^2}{r}$$

$$\sum F = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2} = 4\pi^2 mrf^2$$

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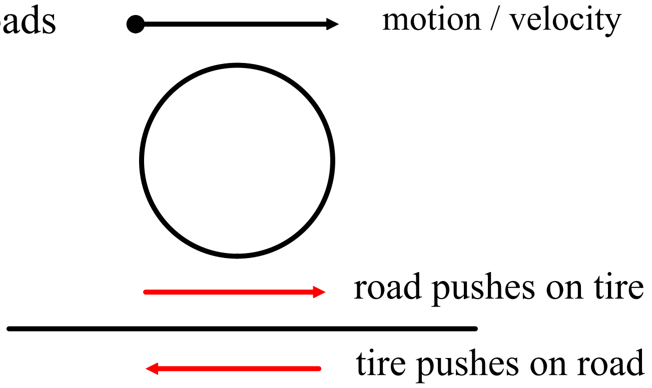
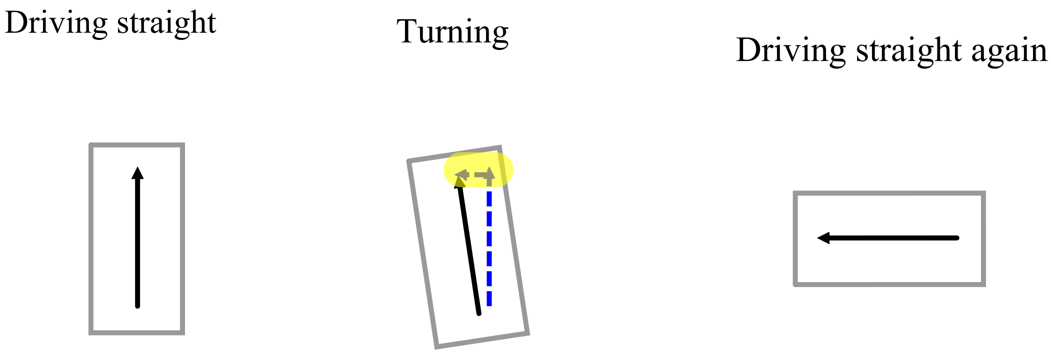
Tires on roads





radius of curvature - circle - aligns with this force

Imagine turning on black ice, the forward component still exists, but the left/right component is zero because there is no friction.

Sep 30-12:19 PM

Example

A car of mass 1.1×10^3 kg negotiates a level curve at a constant speed of 22 m/s. The curve has a radius of 85 m, as shown in **Figure 2**.

(a) Draw an FBD of the car and name the force that provides the centripetal acceleration.

(b) Determine the magnitude of the force named in (a) that must be exerted to keep the car from skidding sideways.

(c) Determine the minimum coefficient of static friction needed to keep the car on the road.

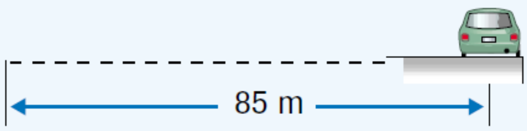
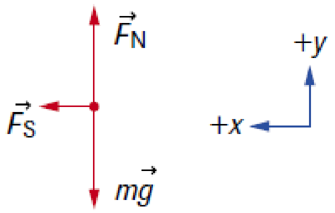
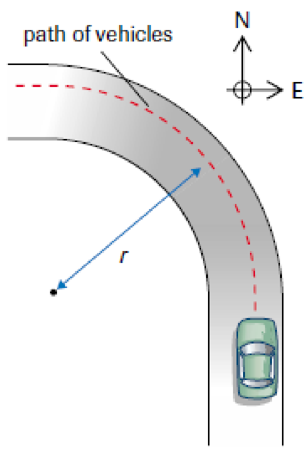


Figure 2
The radius of the curve is 85 m.



$$F_{net} = \frac{mv^2}{r}$$



A car of mass 1.1×10^3 kg travels around a frictionless, banked curve of radius 85 m. The banking is at an angle of 19° to the horizontal, as shown in **Figure 4**.

(a) What force provides the centripetal acceleration?

(b) What constant speed must the car maintain to travel safely around the curve?

(c) How does the required speed for a more massive vehicle, such as a truck, compare with the speed required for this car?

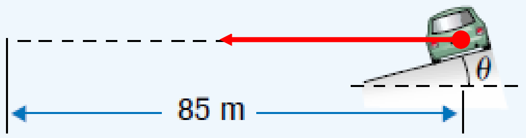
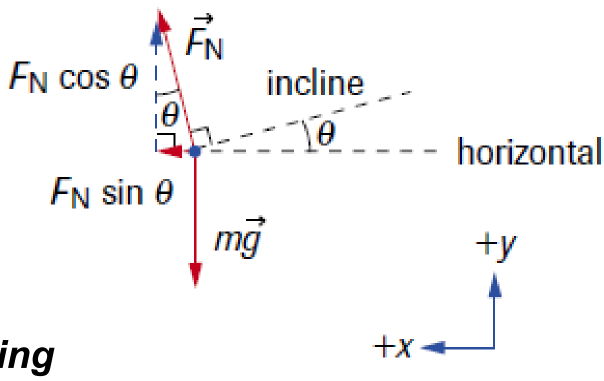


Figure 4
The radius of the curve is 85 m.

Note the change in approach, we are staying with the traditional axis, and finding the horizontal forces only. The Normal force is the only contributor in the horizontal direction.



Setup and solve without substituting numbers in until the end please.

ΣF_y

$0 = F_N \cos\theta - mg$

$\frac{mg}{\cos\theta} = F_N$

ΣF_x

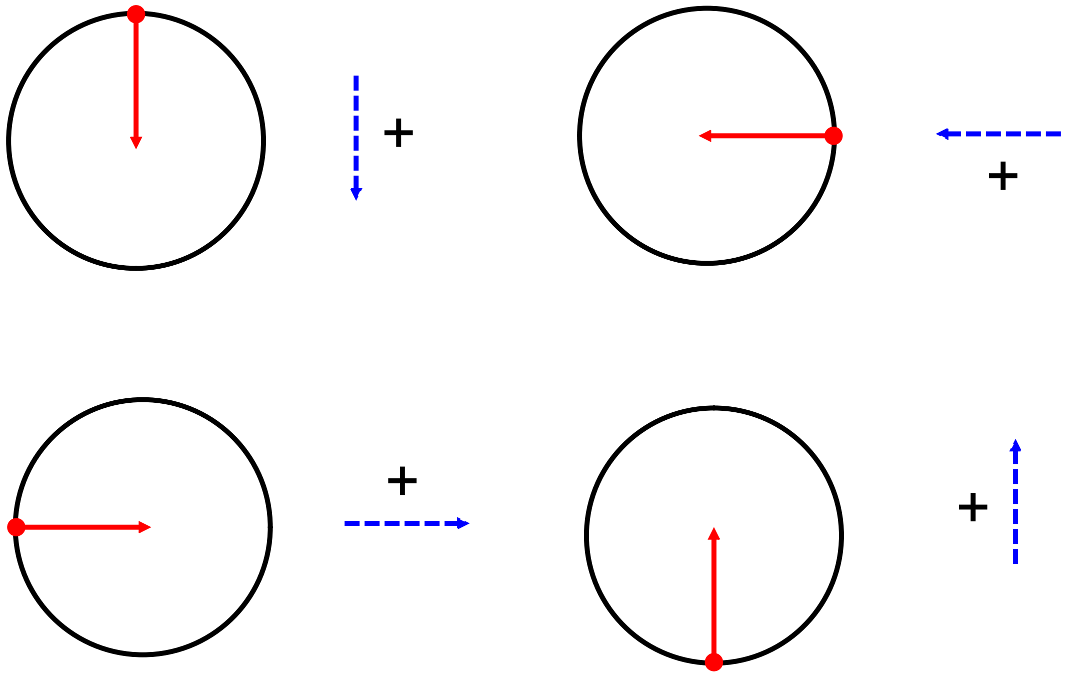
$m a_c = \frac{mg}{\cos\theta} \cdot \sin\theta$

$a_c = g \frac{\sin\theta}{\cos\theta}$

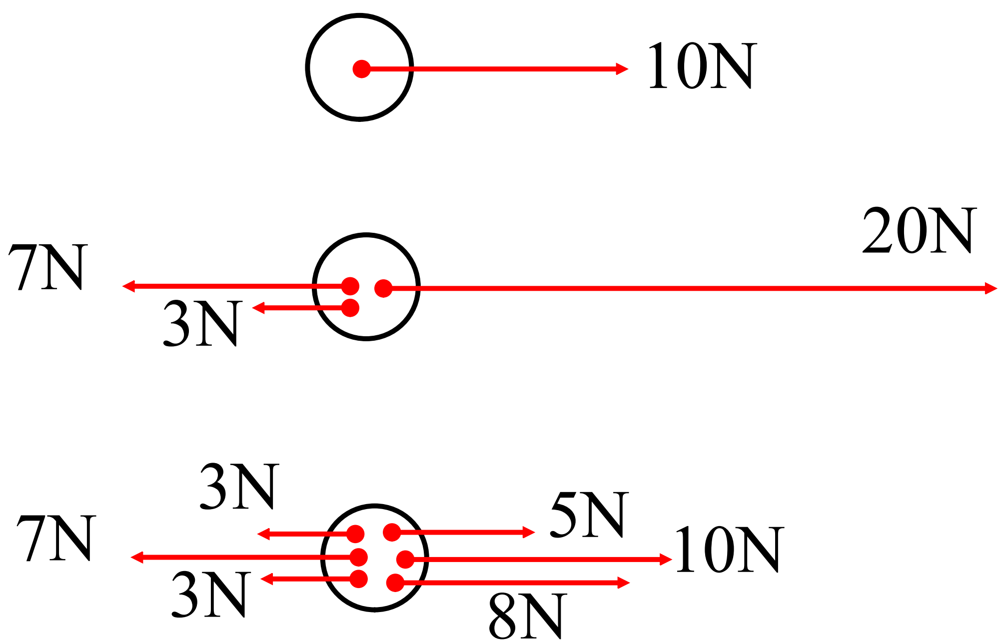
What would be different if we introduced friction on the road?

It is wise to make the acceleration towards the center of the circle the positive direction.

Obviously this can change for each FBD depending on where the object is on the circular path.



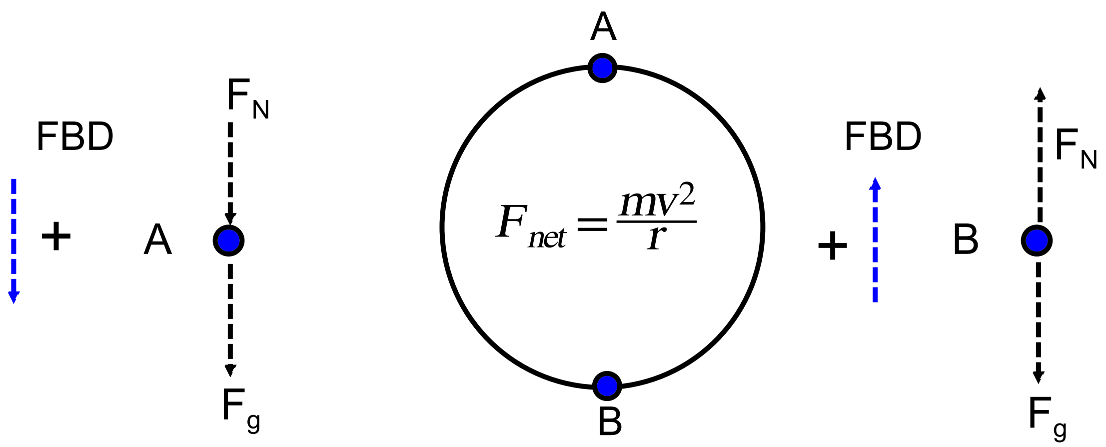
What is the Fnet on the following:



Can the particle "tell" the difference?

The "Vomit Wheel" is a carnival ride that rises from a horizontal position, to a vertical position, spinning passengers along the way. When the ride is completely vertical it spins at a constant rate of 8m/s. The radius of the ride is 10m.

What is the perceived (Normal) force at the highest point A, and the lowest point B, that is felt by a 50 kg passenger.



$$F_{net} = F_g + F_N$$

$$F_{net} = -F_g + F_N$$

$$\frac{mv^2}{r} = F_g + F_N$$

$$\frac{mv^2}{r} = -F_g + F_N$$

$$F_N = \frac{mv^2}{r} - F_g$$

$$F_N = \frac{mv^2}{r} + F_g$$

Sub in variable values

Rotating Frames of Reference

An accelerating frame of reference is a non-inertial frame in which Newton's law of inertia does not hold.

Case 1 - A turning car seen from Earth (an inertial frame of reference)

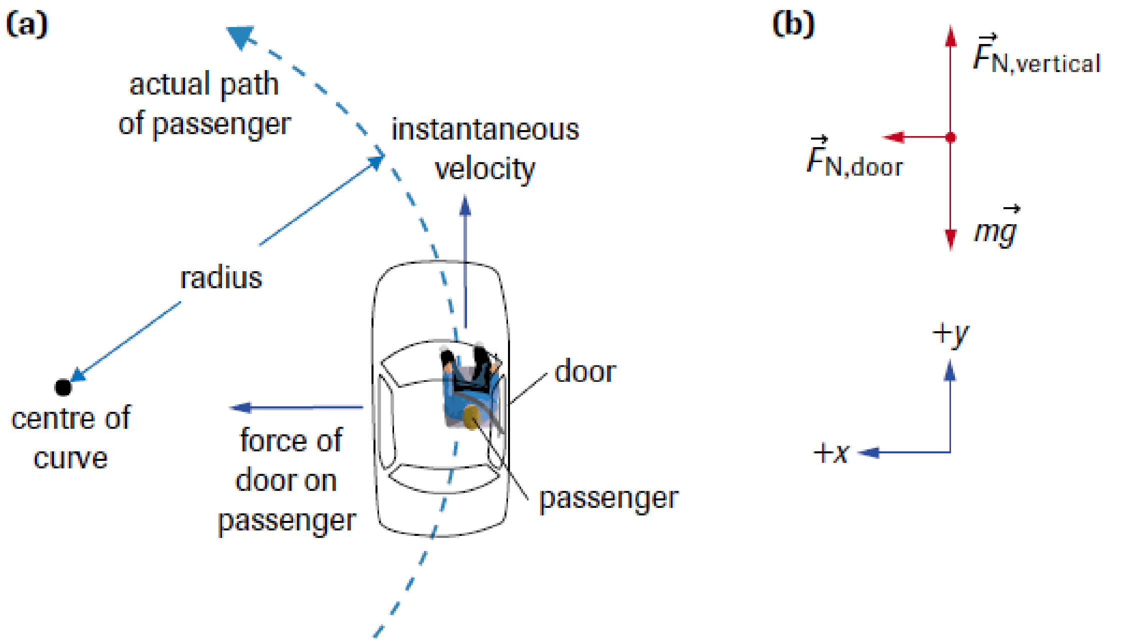
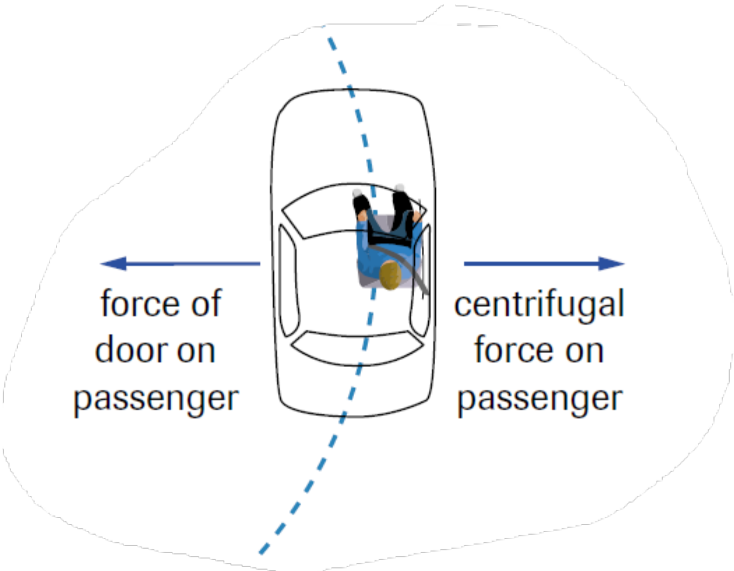
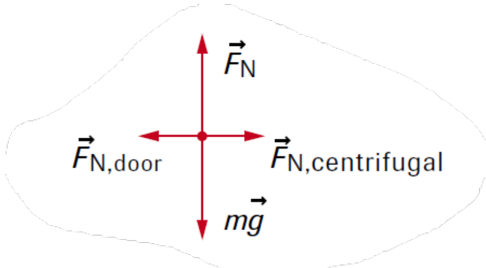


Figure 10
(a) The top view of a passenger in a car from Earth's frame of reference as the car makes a left turn
(b) The side-view FBD of the passenger

The normal force of the door provides the force to change the direction of the passenger.

Case 2 - A turning car seen from inside the car
(a non-inertial frame of reference)





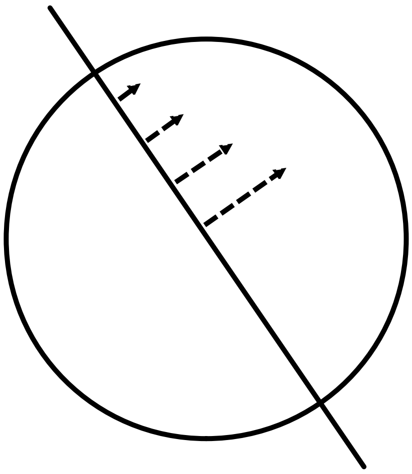
The force you feel that "pushes" you toward the door is a fictitious force called the centrifugal force.

Within the reference frame of the car you are considered to be stationary; therefore your net force is zero.

To balance the Fnet equation, we need to create a force that is in opposition to the normal force of the door that is pushing on your shoulder.

The Earth as a Non-inertial Frame of Reference

The centrifugal force is greatest at the equator and is zero at the poles.



The acceleration of an object at the equator is about 0.34% less than the acceleration due to gravity alone.

Foucault Pendulum

Foucault Pendulum

The Foucault Pendulum

In 1851, Jean Foucault, a French physicist, set up a pendulum to illustrate that Earth is a rotating frame of reference. The Foucault pendulum consists of a heavy bob suspended on a long wire; Foucault used a 28-kg bob attached to a 67-m wire.

The pendulum continues to swing in its plane, but the frame rotates around it; difficult to visualize.

Feb 27-8:05 PM

Homework

Read 128 - 138

page 133 #3, 6, 7, 8

page 138 #3, 5, 6