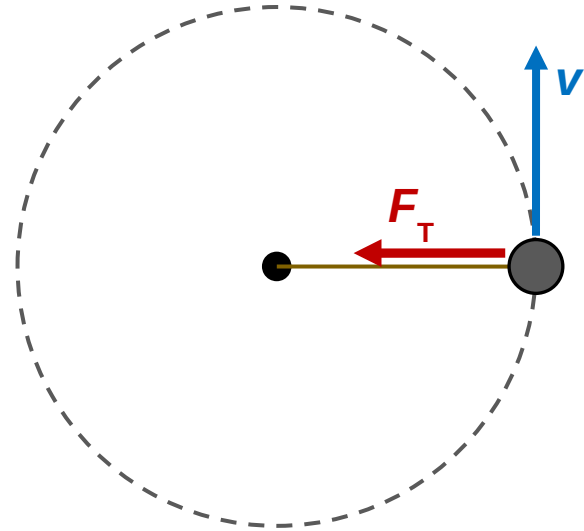


## Essential Question

What force keeps an object moving in a circle?

## Force Toward the Center

- Circular motion:  $a$  points to the center
- Newton's 2nd law: needs  $F_{\text{net}}$
- $F_{\text{net}}$  toward center = centripetal force



*the net force points to the center*

# The Centripetal Force Equation

$$F_{\text{net}} = ma_{\text{c}}$$
$$F_{\text{c}} = mv^2 / r$$

**$F_{\text{c}}$**   
force (N)

**$m$**   
mass (kg)

**$v$**   
speed (m/s)

**$r$**   
radius (m)

*direction: toward the center*

### Sources of Centripetal Force

- Not a new kind of force
- A real force pulls or pushes inward
- Always name the real force

#### **Tension**

ball on a string

#### **Friction**

car on a curve

#### **Gravity**

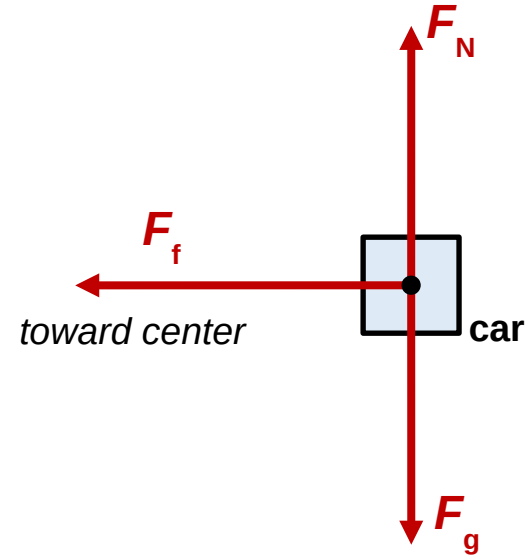
Moon around Earth

#### **Normal force**

rotor ride wall

## Free-Body Diagram: Car on a Curve

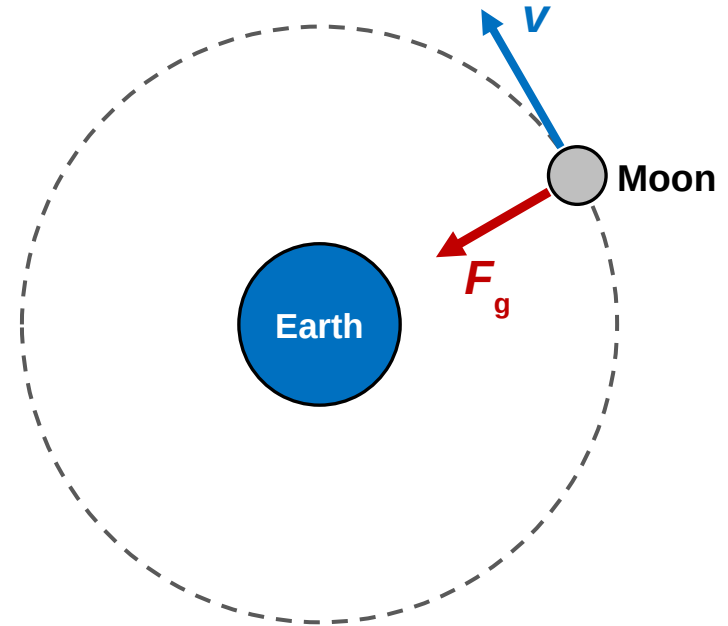
- Draw only real forces
- Friction points to the center
- No extra " $F_c$ " arrow



*friction is the centripetal force*

## Gravity in Orbit

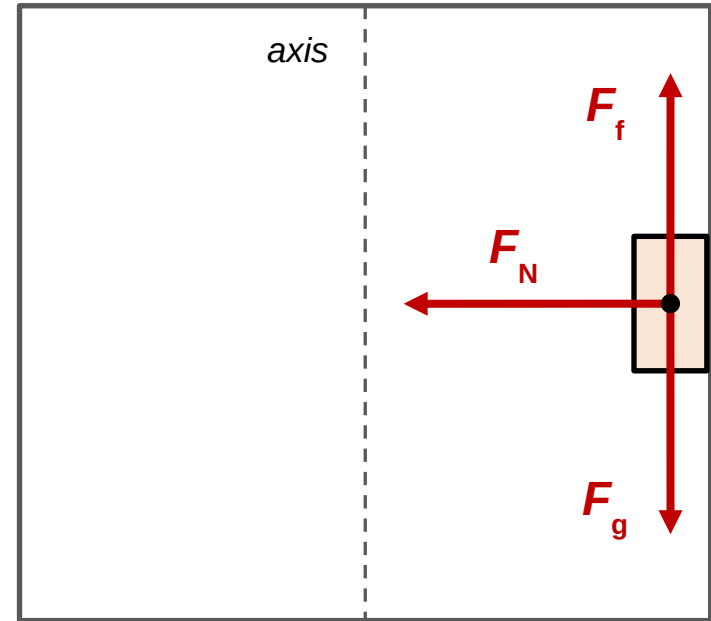
- Gravity pulls the Moon toward Earth
- Gravity is the centripetal force
- The Moon keeps falling around Earth



*gravity bends the Moon's path into a circle*

## Free-Body Diagram: Rotor Ride

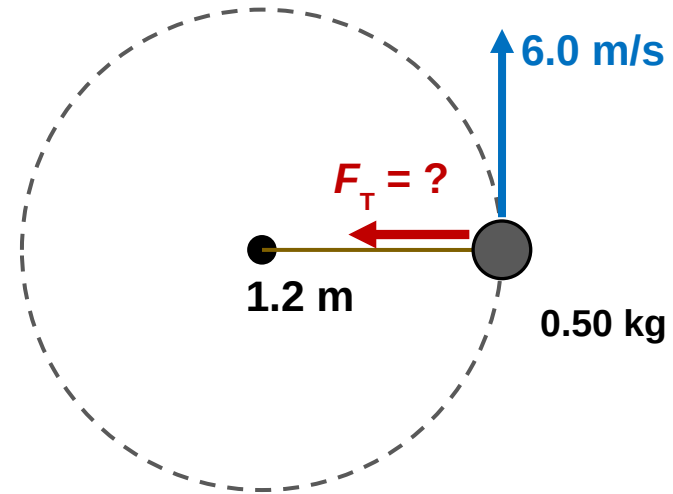
- Wall pushes rider toward the center
- Normal force is the centripetal force
- Friction holds the rider up



*the wall's push is the centripetal force*

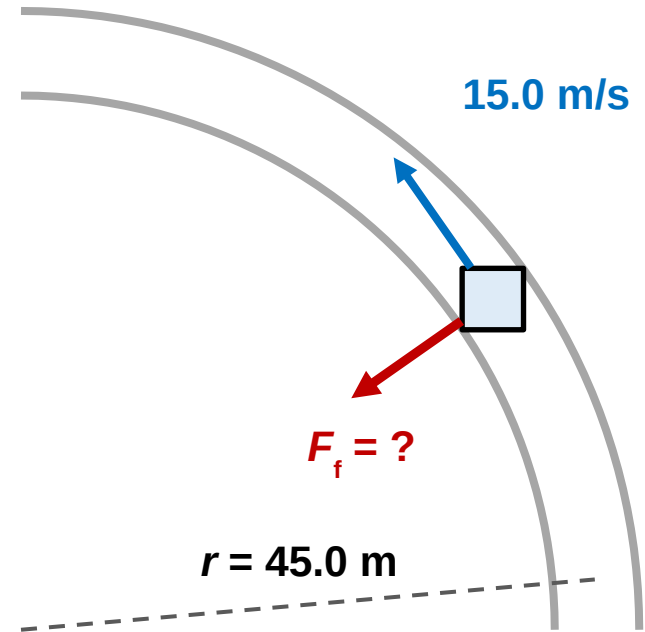
## Example: Puck on a String

A 0.50 kg puck on an air hockey table is tied to a string and slides in a circle of radius 1.2 m at 6.0 m/s. What is the tension in the string?



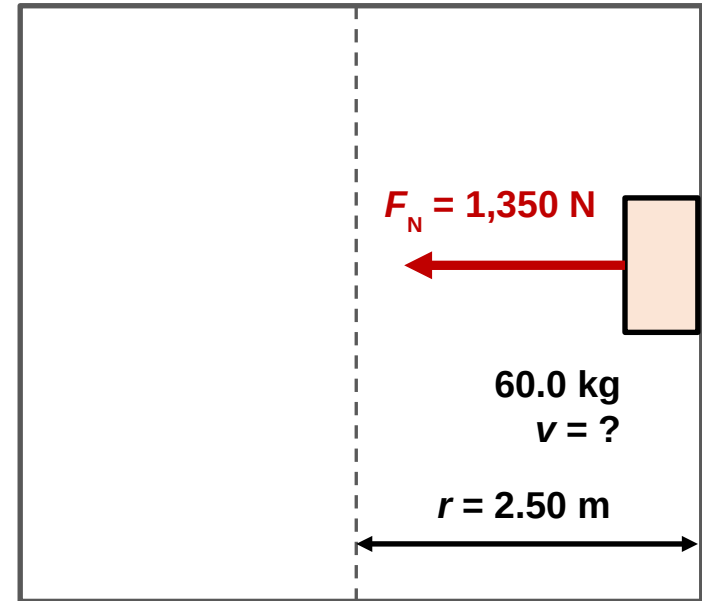
## Example: Friction on a Curve

A 1,350 kg car rounds a flat curve of radius 45.0 m at 15.0 m/s. How much friction force must the road provide?



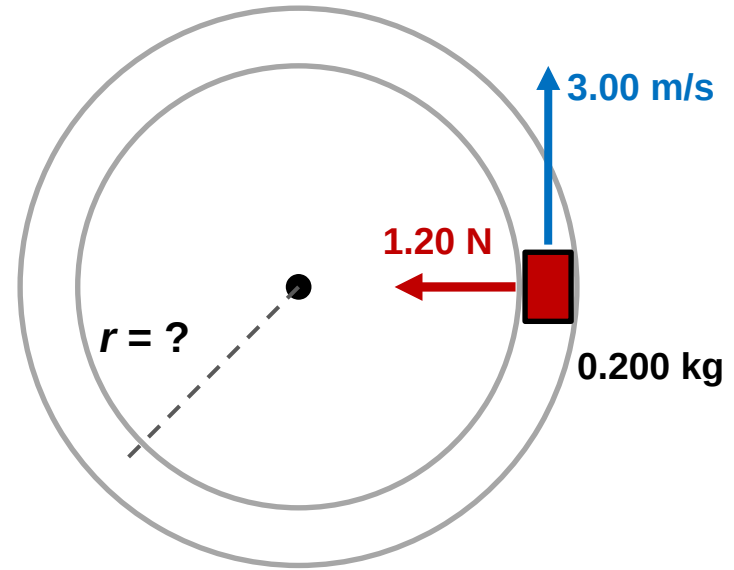
## Example: Rotor Ride Speed

A 60.0 kg rider stands against the wall of a rotor ride with a radius of 2.50 m. The wall pushes on her with a normal force of 1,350 N. How fast is she moving?



## Example: Toy Car Track

A 0.200 kg toy car moves at a constant 3.00 m/s around a flat circular track. Friction provides a 1.20 N force toward the center. What is the radius of the track?



### Big Ideas

- Circular motion needs  $F_{\text{net}}$  toward the center
- $F_c = mv^2/r$
- Tension, friction, gravity, or normal force does the job
- FBDs: real forces only, no extra  $F_c$