

# Using Newton's Laws

## Physics 1425 Lecture 7

# Today's Topics

- **Weight:** the force of gravity
- **The Normal Force:** a surface pushes back
- **Free Body Diagrams:** finding the *total* force on a body

# Weight: the Force of Gravity

- Newton introduced the idea of a **gravitational force** to explain Galileo's "natural downward acceleration".
- Previously, force was only used to describe **direct physical contact** forces, the idea of a gravitational force seemed weird—kind of irrational and magical.

# Weight and Inertial Mass

- All falling objects have the **same** acceleration (when air resistance is eliminated), so applying

$$\vec{F} = m\vec{a} = m\vec{g}$$

the gravitational **force** on an object—its **weight**—**must be directly proportional to its inertial mass**. (It isn't obvious why this should be true!)

- If an object is **taken to the Moon**, its inertial mass *doesn't change*—it takes the same energy to accelerate a car. But its weight *does* change.

# The Normal Force

- Right now, the force of gravity is pulling us all downwards—but we're not moving!
- What about  $\vec{F} = m\vec{g}$  ?
- Remember  $\vec{F}$  is the **total** force on a body.
- If the floor disappears, I **will** accelerate downwards!

# The Normal Force

- **Conclusion:** the **floor** is providing the force balancing that of gravity: it's called the **normal force**.
- **Question:** how can something as inert and immovable as the floor provide a force?
- **Clue:** how does a spring balance provide a force to measure weight?

# Normal Force and Springiness

- When the tomatoes are put on the scale, it moves down, compressing a spring until the spring's force balances gravity.
- **The floor is elastic too!**  
Where you stand, it sags a little, and pushes back like a very stiff spring.



## Clicker Question

I stand on roller skates facing a wall. I reach out and push against the wall, I accelerate backwards. What force caused my acceleration?

- A. My arm and back muscles
- B. My pushing against the wall
- C. The normal force from the wall
- D. Friction between the skates and the floor



## Clicker Question

What is the normal force from the elevator floor on a person weighing  $mg$ , if the elevator is accelerating upwards at  $0.1g$ ?

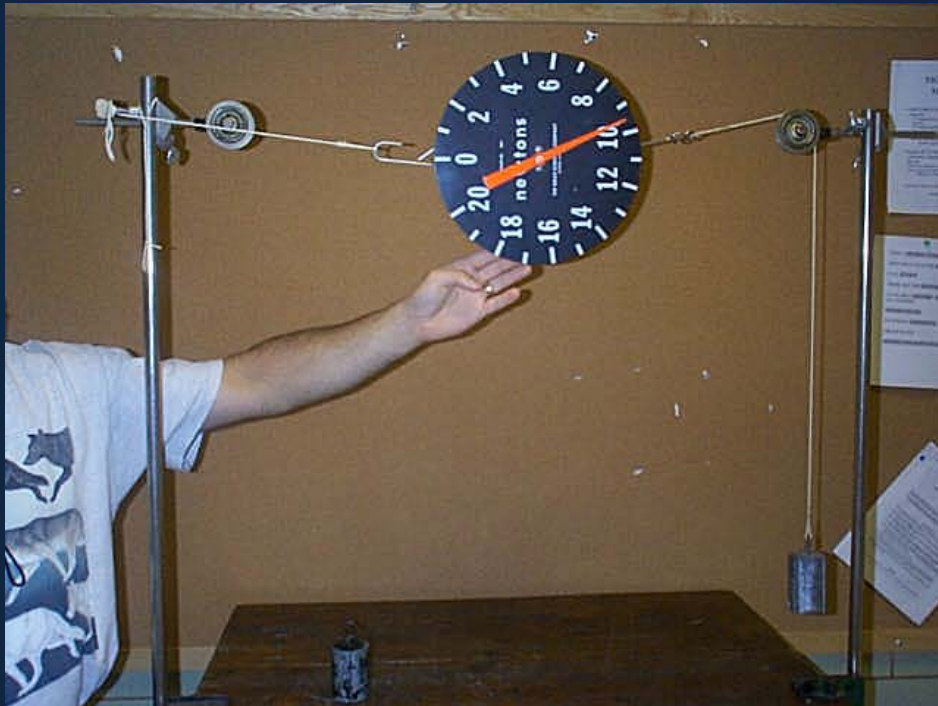
- A.  $1.1mg$
- B.  $mg$
- C.  $0.9mg$
- D. None of the above

# Tension!

- In Newton's original statement of his Third Law, he features a horse pulling a rope attached to a stone.
- The tension in the string means that if the stone is subject to a certain force from the horse's efforts, the horse feels an equal and opposite force from the tug of the string.
- The string is pulling **inwards** at both ends.

# Tension Puzzle...

- A one kg mass hangs from the string, **the other end is looped over a hook.**



- Suppose the looped end of the string is taken from the hook, put over the pulley, and a one kg mass is hung from that end too. **What will the spring scale read now?**

- A. About the same
- B. About double

# Free Body Diagrams

- To apply Newton's Laws to find how a body moves, we must focus on **that body alone** and add **all** the (vector) forces acting on it.
- The diagram showing all the forces on one body (or even part of a body) is called a "**free body diagram**"—we've "freed" the body from the rest of the system, representing everything else just by **the forces on this body**.
- The **net (total) force** then goes into  $\Sigma \vec{F} = m\vec{a}$ .

# Clicker Question

- The strings shown are all at  $120^\circ$  to each other. For the vertical string,  $T = Mg$ . What is  $T$  in one of the sloping strings?

- A.  $Mg/2$
- B.  $Mg$
- C.  $Mg/\sqrt{3}$

