Using Newton’s Laws

Physics 1425 Lecture 7

Michael Fowler, UVa.

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 immoveable 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

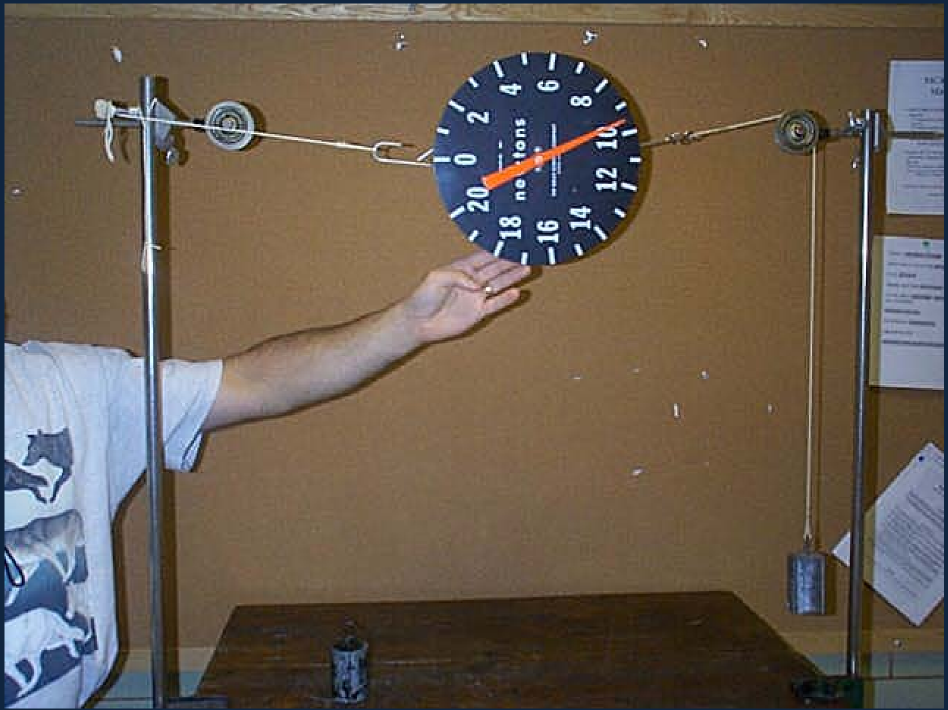
Tension!

- 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° to each other. For the vertical string, $T = Mg$. What is T in one of the sloping strings?

A. $Mg/2$

B. Mg

C. $Mg/\sqrt{3}$