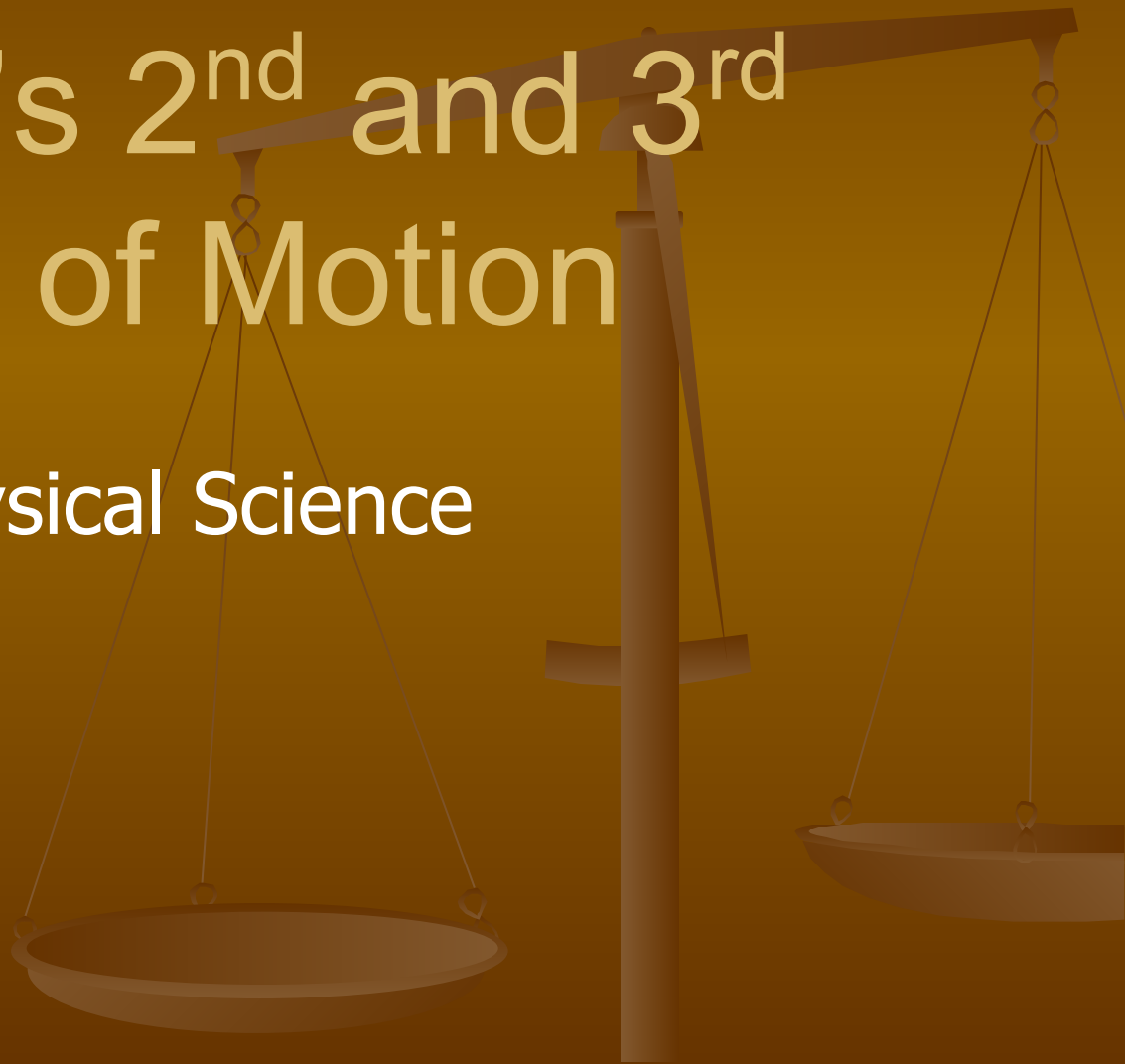
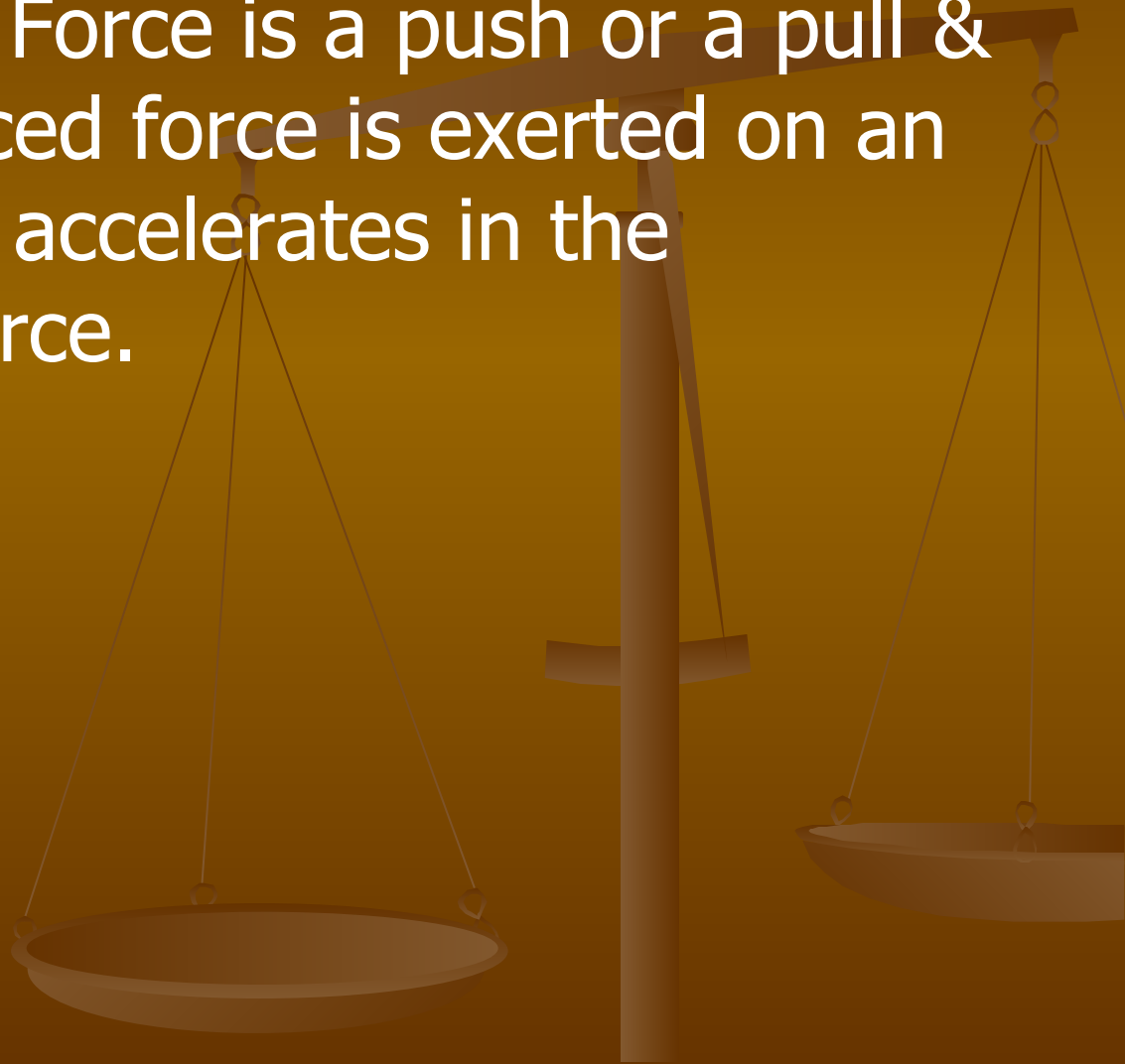
Newton's 2nd and 3rd Laws of Motion

Physical Science



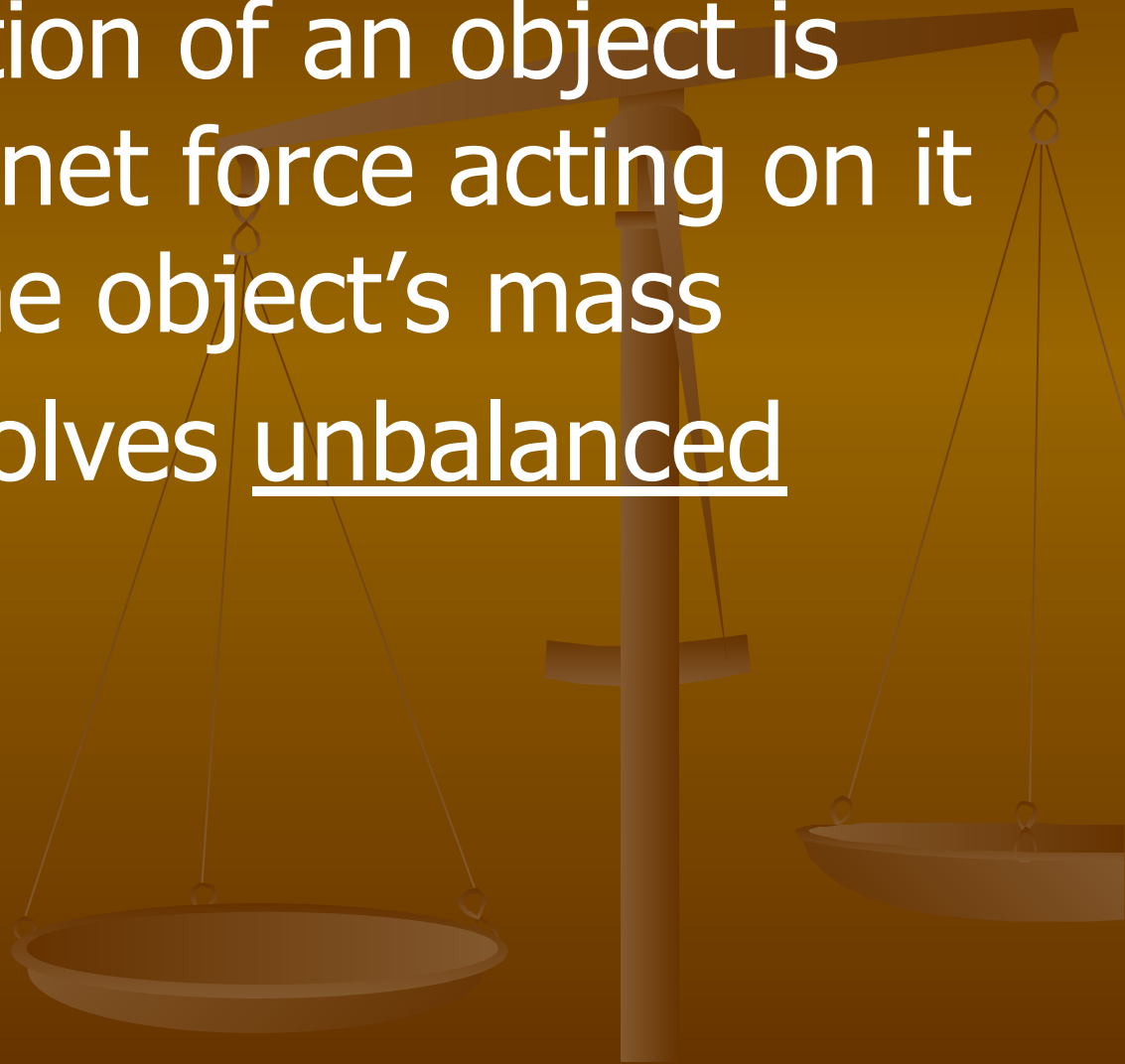
Forces Refresh

Remember that a Force is a push or a pull & when an unbalanced force is exerted on an object, the object accelerates in the direction of the force.



Newton's Second Law of Motion

- the acceleration of an object is equal to the net force acting on it divided by the object's mass
- Situation involves unbalanced forces



Newton's 2nd Law of Motion

- Newton's 2nd law can be represented with the equation:
  - **force = (mass) X (acceleration)** **OR**
    F = ma (a = F/m)

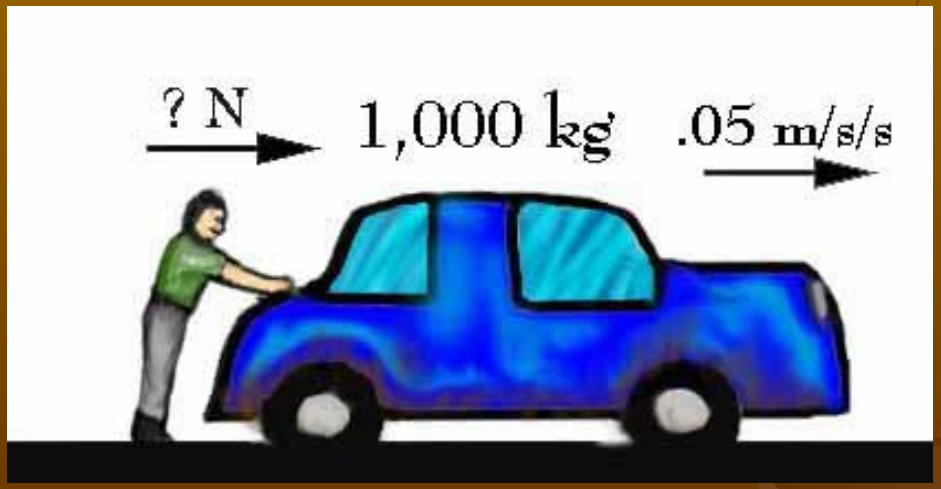
******Explains how acceleration due to gravity is the same for all objects even though the Force of gravity is greater on more massive objects******

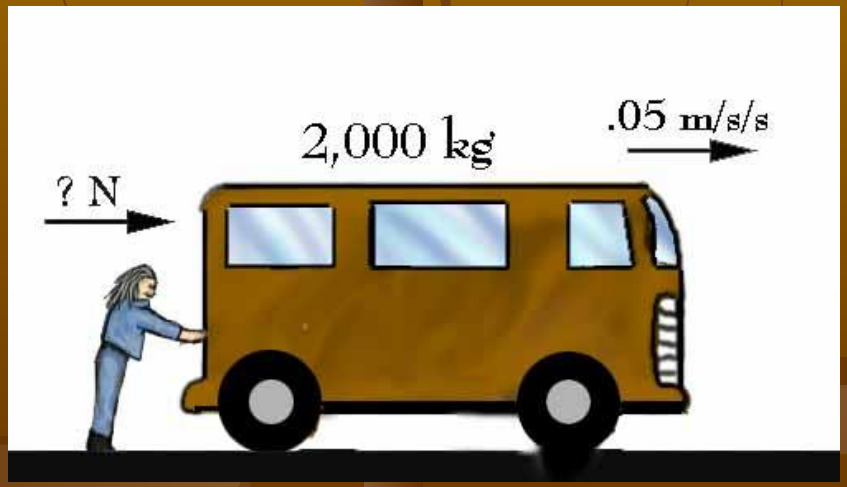
- *F = force, measured in Newton (N) kg · m/s2*
- *m = mass (kg)*
- *a = acceleration (m/s2)*

- it takes more force to move an object with more mass at the same acceleration

F = ma
F = 1,000 kg x 0.5 m/s^2
F = 500 N

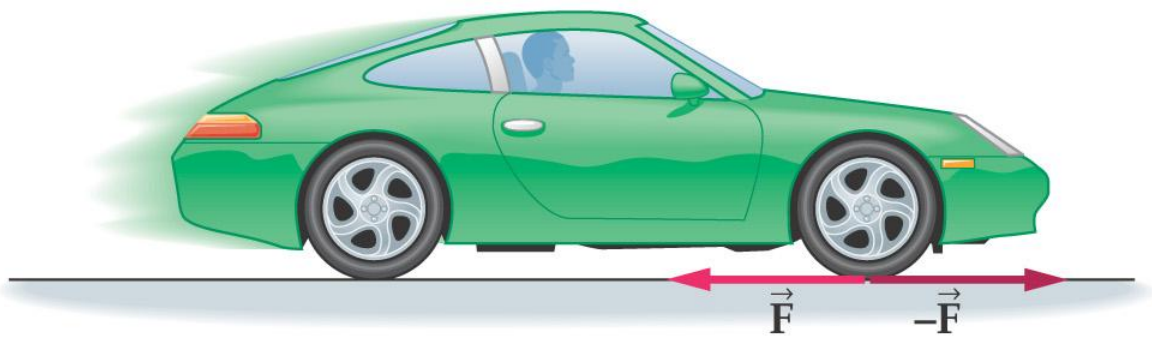
F = ma
F = 2,000 kg x 0.5 m/s^2
F = 1,000 N

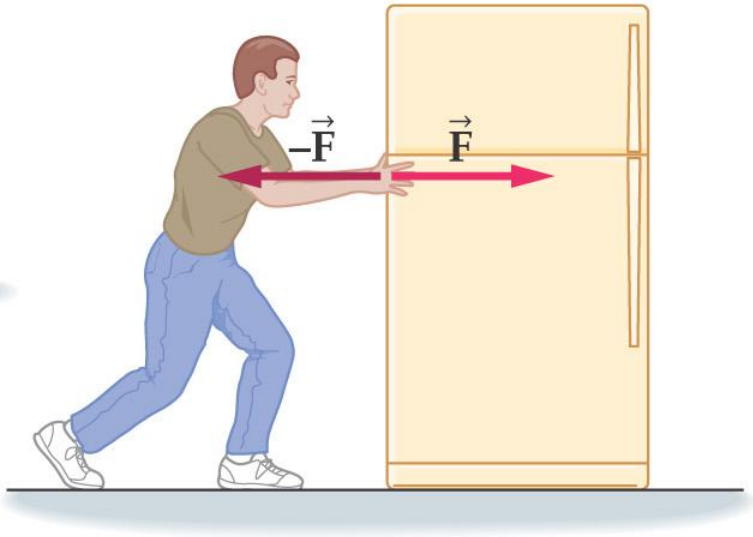




Newton's 3rd Law of Motion

- **Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object**
- **the two forces are called action and reaction**


F
−F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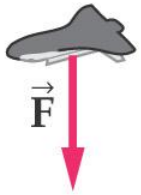
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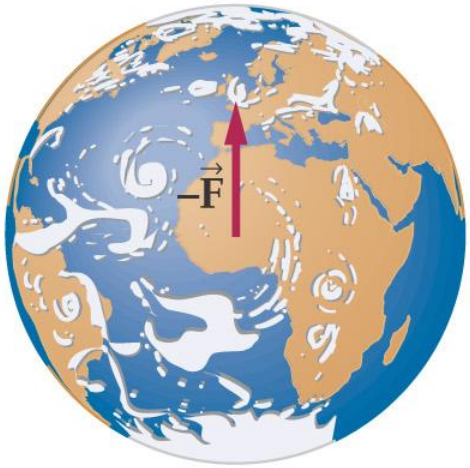
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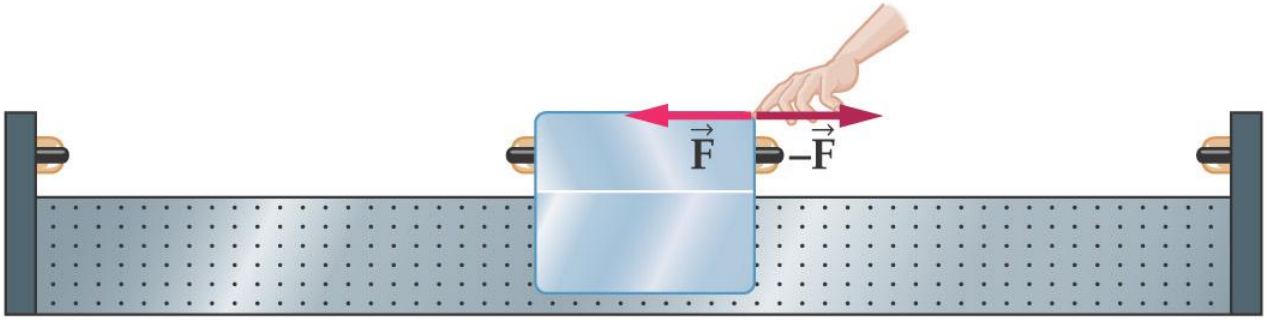
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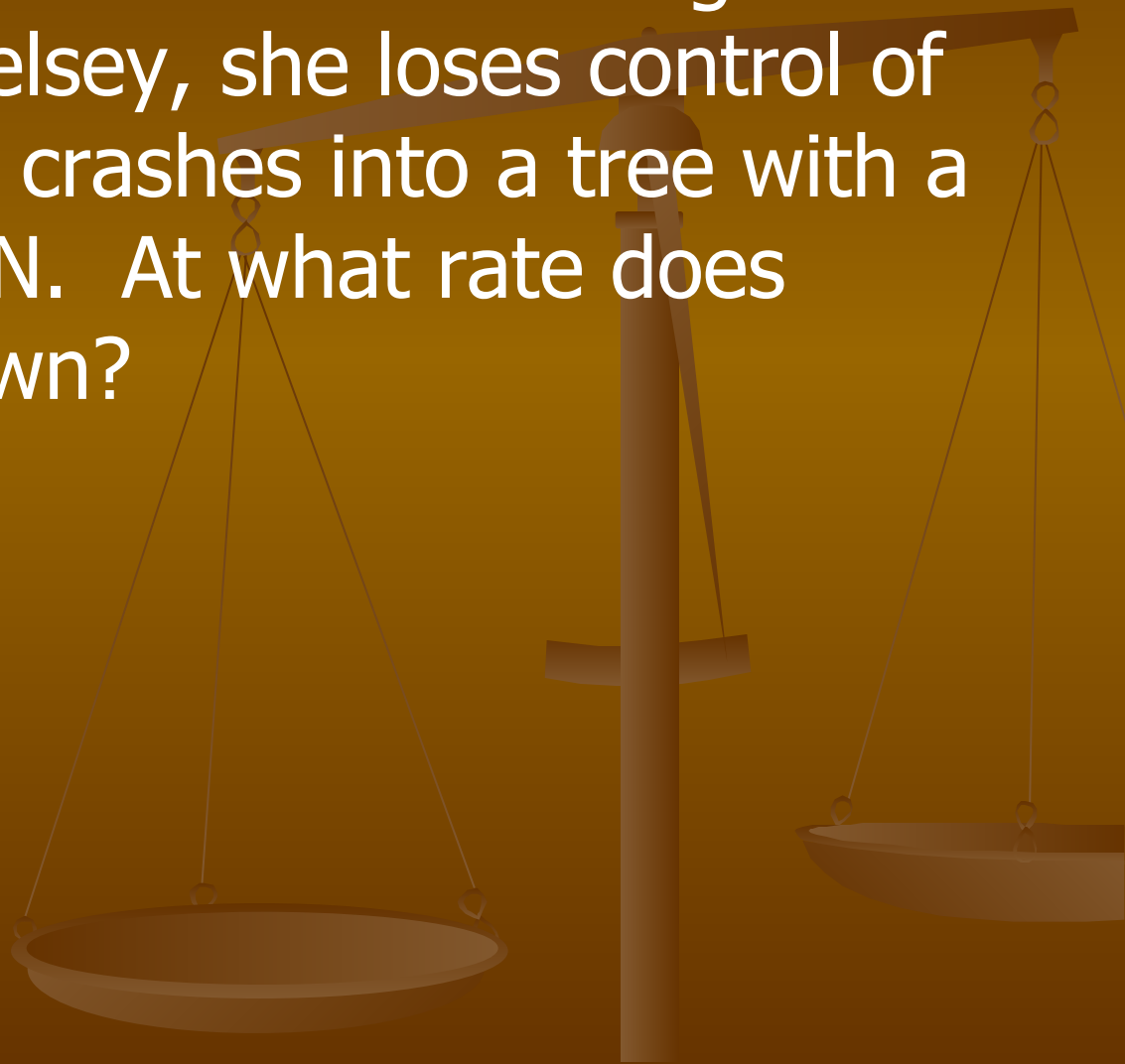
Practice Problems

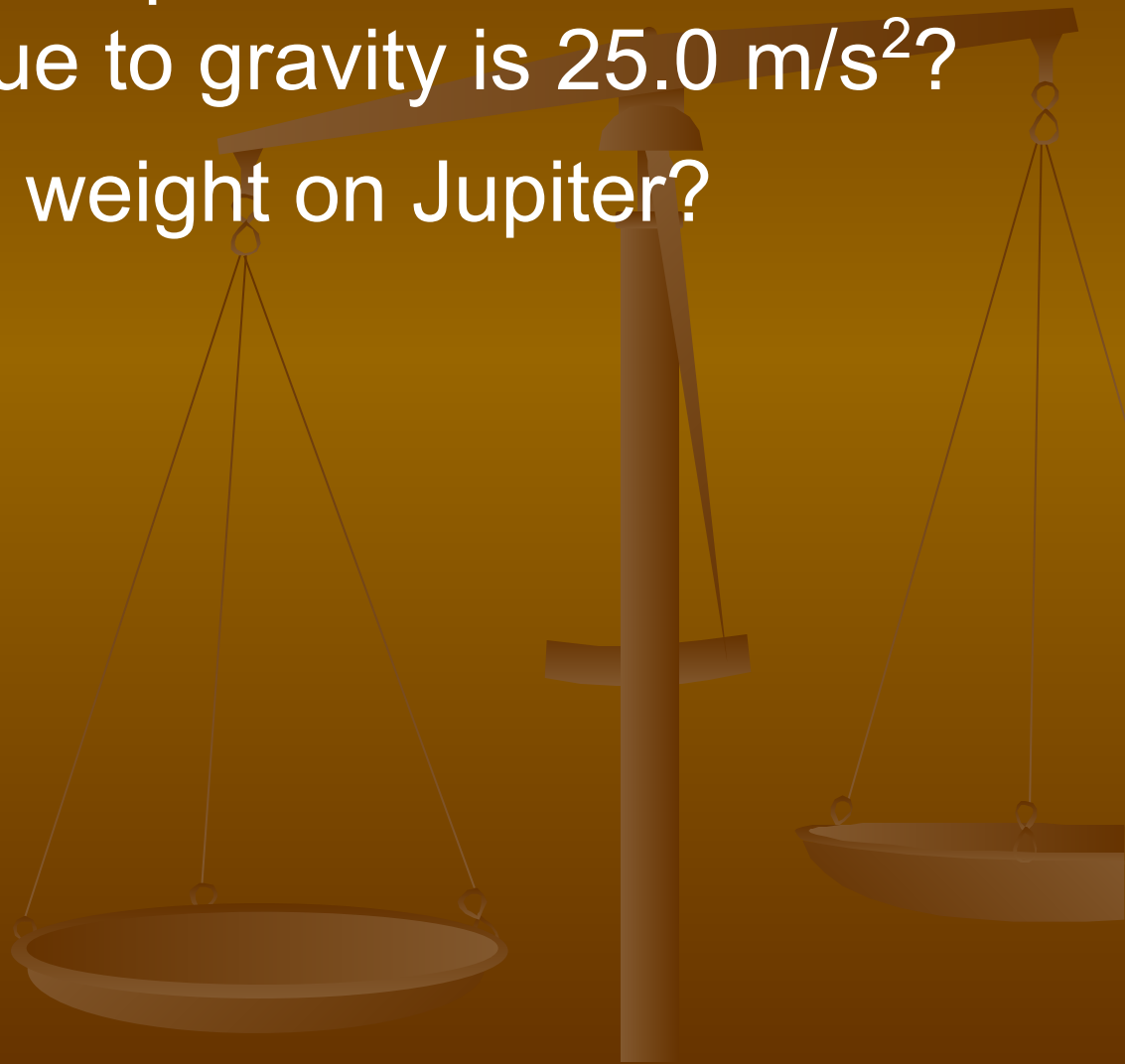
1. Hailey's car has a mass of 1000kg. While racing Kelsey, she loses control of his vehicle and crashes into a tree with a force of 12000N. At what rate does Hailey slow down?



2. JJ, the ballet dancer, has a mass of 45.0 kg.

a) What is JJ's weight on Earth? b) What is JJ's mass on Jupiter, where the acceleration due to gravity is 25.0 m/s^2?

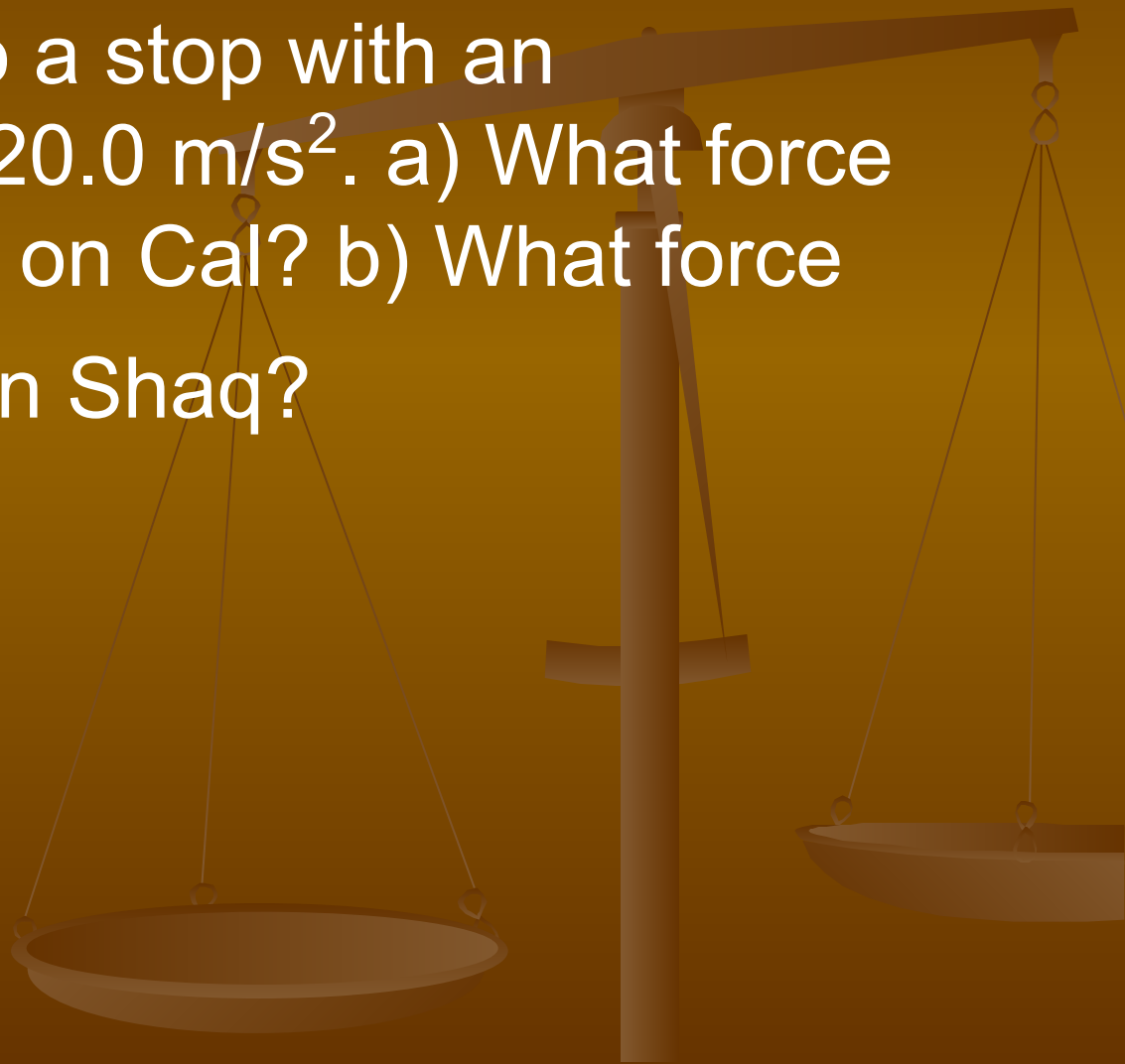
c) What is JJ's weight on Jupiter?



3. Brad swings at a 0.15 kg baseball and accelerates it at a rate of 3.0×10^4 m/s^2. How much force does Brad exert on the ball?

6. Imagine that Astronaut Lauren's tether broke and she is floating away from the Shuttle. Is there any way for her to move herself back to the ship? All she has is her spacesuit and backpack of tools.

7. Cal, the 72.0-kg star quarterback of New Bern High School's football team, collides with Shaq, a stationary left tackle, and is brought to a stop with an acceleration of -20.0 m/s^2. a) What force does Shaq exert on Cal? b) What force does Cal exert on Shaq?



FRICTION

QOD: How does friction affect the velocity of an object?

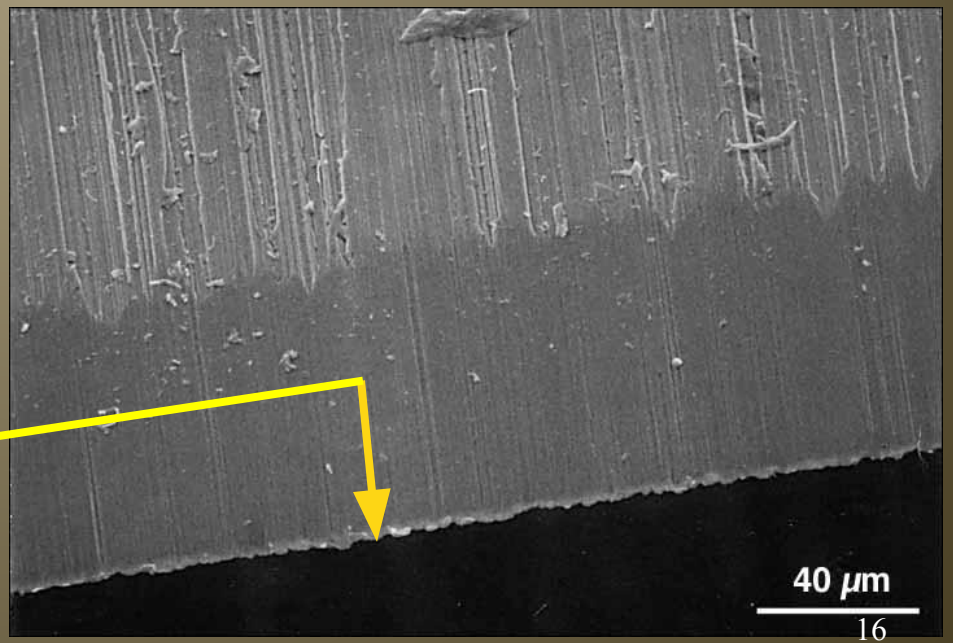
- **friction** –

  a force that opposes the motion of objects that touch as they move past each other

- all moving objects are subject to friction
- without friction, surfaces would be more slippery than ice
- friction acts at the surface where objects are in contact
  - this includes solid objects that are directly touching each other and objects moving through a liquid or a gas

- friction depends on the:
  - types of surfaces
  - force between the surfaces
- friction is greater:
  - between rough surfaces
  - when there's a greater force between the surfaces
  - ex: more weight
    - a semi truck has greater friction between the tires and the road than a small car

- friction is caused by rough surfaces of **all** materials



razor's edge

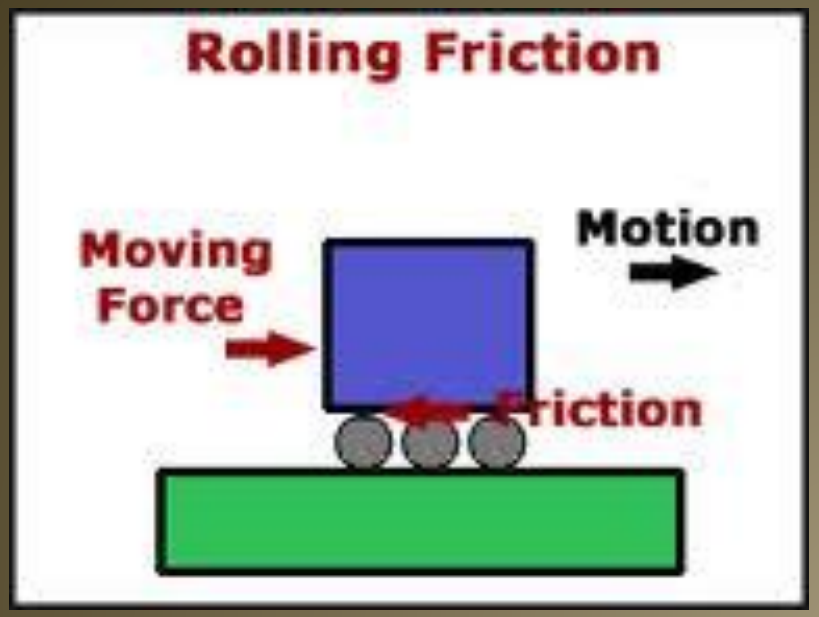
- there are four main types of friction:
  - static friction
  - sliding friction
  - rolling friction
  - fluid friction

- **<u>static friction</u>** – the friction that acts on objects that are not moving
- it always acts in the direction opposite to that of the applied force
- ex: taking steps & push off a step between your shoes and the ground

Static friction can make opening a pickle jar difficult.

- **<u>sliding friction</u>** – force that opposes the direction of motion of an object as it slides over a surface
- sliding friction is less than static friction, so less force is needed to keep an object moving once it is moving

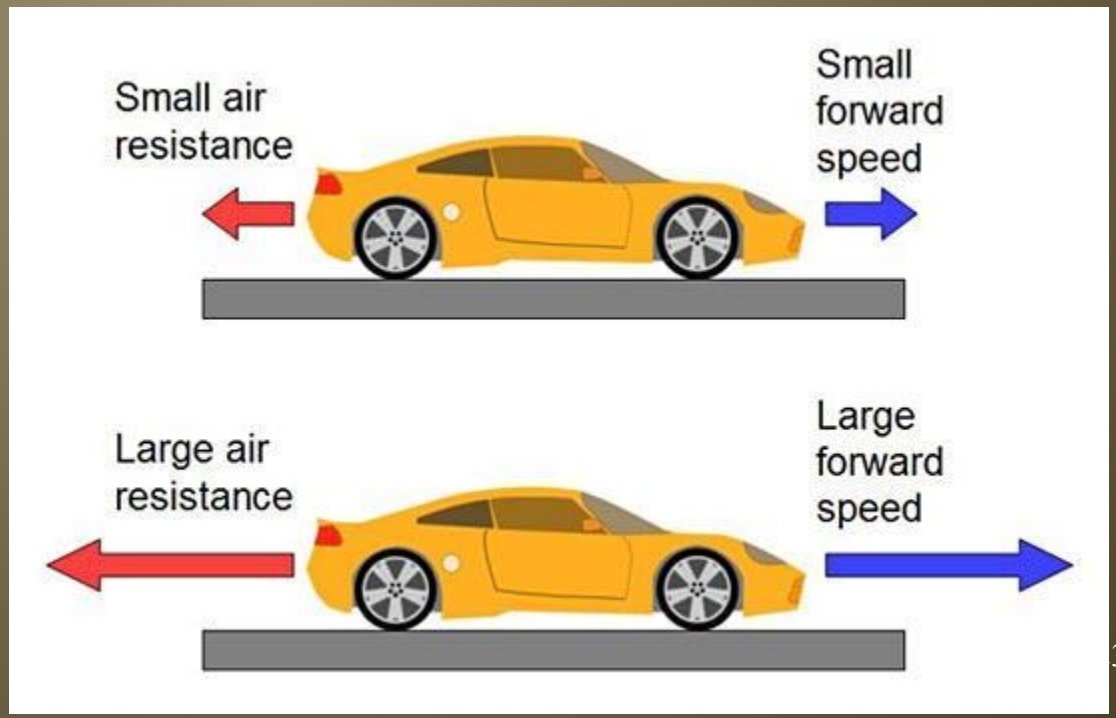
- **<u>rolling friction</u>** – the friction force that acts on rolling objects
- is about 100 to 1000 times less than the force of static or sliding friction
- when a round object rolls across a flat floor, both the object and the floor are bent slightly out of shape
- ex: ball bearings used to reduce friction (rolling friction replaces sliding friction) in inline skates, automobiles, bicycles, skateboards


Rolling Friction
Moving Force
Motion
Friction


Tyre
OIL
Shoe
Ball bearing
Increase Friction
Decrease Friction

- **fluid** – liquids such as water and a mixture of gases such as air
- **fluid friction** – the force that opposes the motion of an object through a fluid
- increases as the speed of an object moving through the fluid increases
- **air resistance** – fluid friction acting on an object moving through the air
- at higher speeds, air resistance can be a significant force

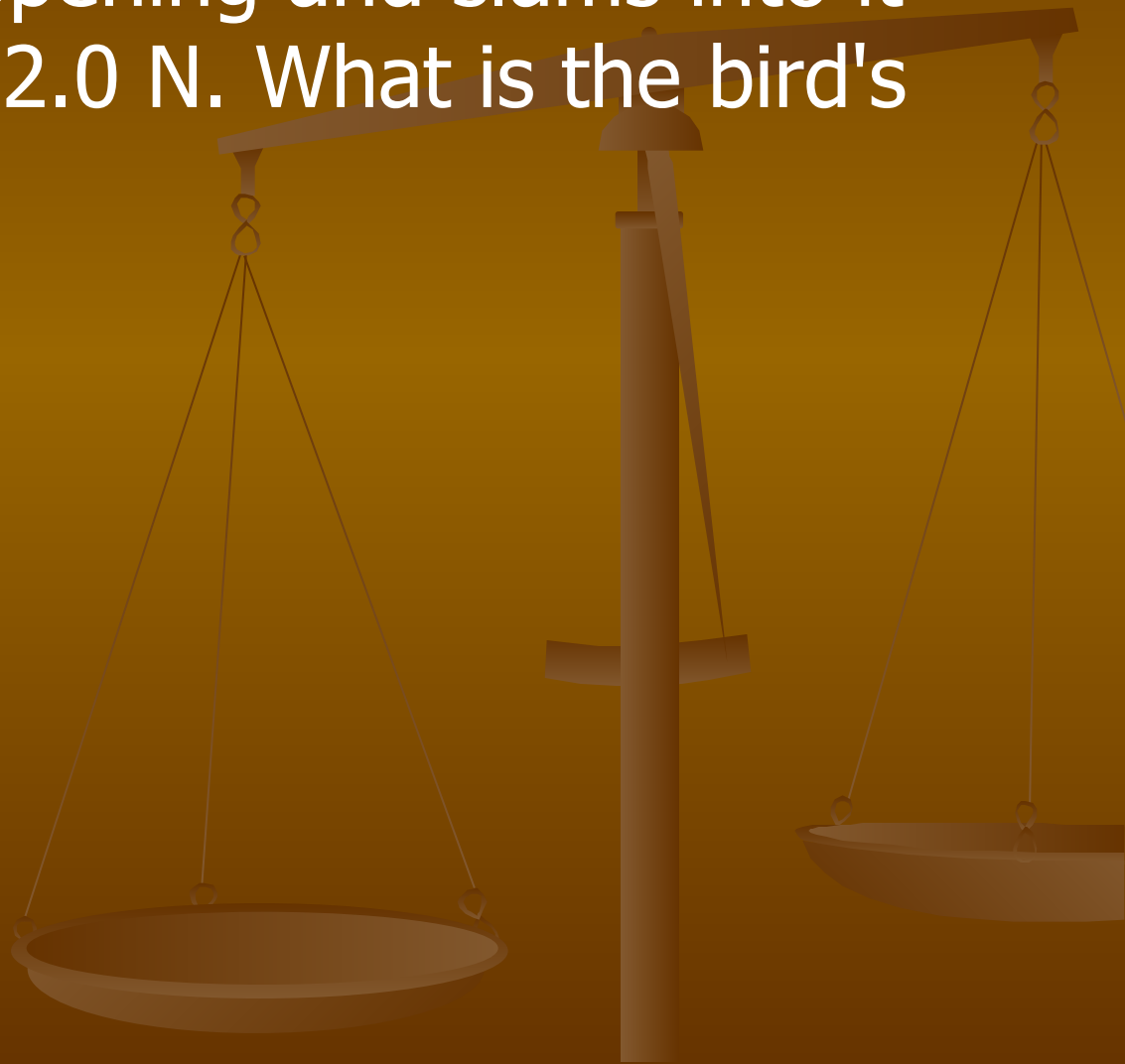
fluid friction



1. **<u>sliding</u>** – when solid objects grind over each other
    - ex: puck and ice, sliding into a base
2. **<u>rolling</u>** – tires spinning on an axle
    - skateboards eventually roll to a stop, using a dolly to move heavy objects
3. **<u>fluid</u>** – liquids or gases slow the motion of a solid
    - ex: wind resistance, pushing a surfer

8. The free fall acceleration of any object near the surface of the earth is 9.8 m/s^2. How much force does Sariah, who is 50 kg, exert on the earth?

9. A 20-g sparrow flying toward a bird feeder mistakes the pane of glass in a window for an opening and slams into it with *a* force of -2.0 N. What is the bird's acceleration?



10. I’Yana stubs her toe on the coffee table with a force of 100. N. a) What is the acceleration of I’Yana's 1.80-kg foot? b) What is the acceleration of the table if it has a mass of 20.0 kg? (Ignore any frictional effects.) c) Why would I’Yana's toe hurt less if the table had less mass?