CLIL Project – Physics in English

Anno scolastico 2013-2014

Newton's Laws
Force and Motion
Lecture 4

Classe 3ª A Linguistico

Istituto Superiore "Marini-Gioia" - AMALFI

The Second Law: Force, Mass, and Acceleration

Finding force from acceleration

- Wherever there is acceleration there must also be force.
- Any change in the motion of an object results from acceleration.
- Therefore, any change in motion must be caused by force.

The Second Law: Force, Mass, and Acceleration

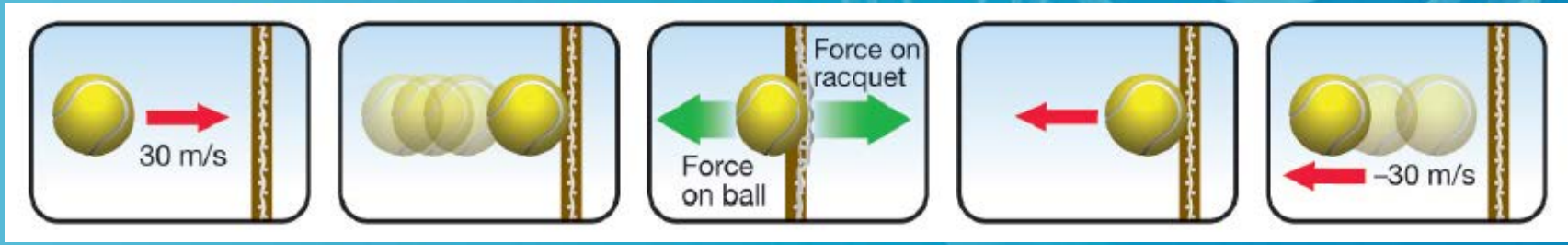
Calculating force

An airplane needs to accelerate at 5 m/sec^2 to reach take-off speed before reaching the end of the runway. The mass of the airplane is 5,000 kilograms. How much force is needed from the engine?

1. You asked for the force (F).
2. You are given the mass (m) and acceleration (a).
3. The second law applies: $a = F \div m$
4. Plug in the numbers. Remember: 1 N = 1 kg·m/s^2.

The Second Law: Force, Mass, and Acceleration

Calculating force



A tennis ball contacts the racquet for much less than one second. High-speed photographs show that the speed of the ball changes from -30 to +30 m/sec in 0.006 seconds.

If the mass of the ball is 0.2 kg, how much force is applied by the racquet?

The Second Law: Force, Mass, and Acceleration

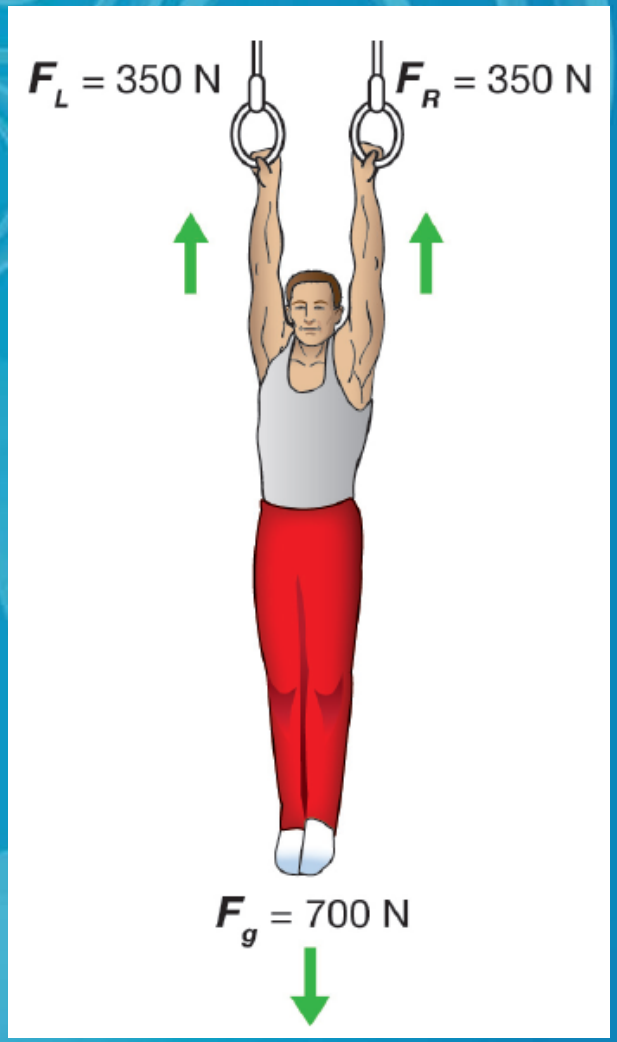
Equilibrium concept

- The condition of zero acceleration is called **equilibrium**.
- In equilibrium, all forces cancel out leaving zero net force.
- Objects that are standing still are in equilibrium because their acceleration is zero.

The Second Law: Force, Mass, and Acceleration

Equilibrium concept

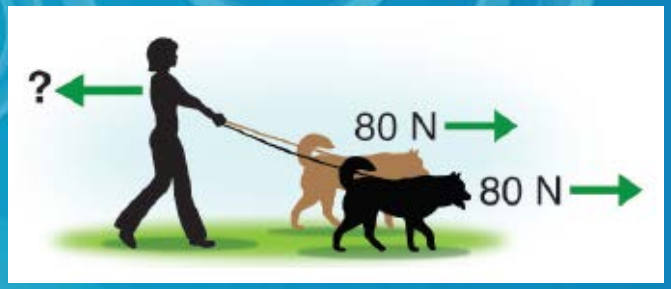
- *Objects that are moving at constant speed and direction are also in equilibrium.*
- *A **static** problem usually means there is no motion.*



The Second Law: Force, Mass, and Acceleration

Calculating force

A woman is holding two dogs on a leash. If each dog pulls with a force of 80 Newtons, how much force does the woman have to exert to keep the dogs from moving?



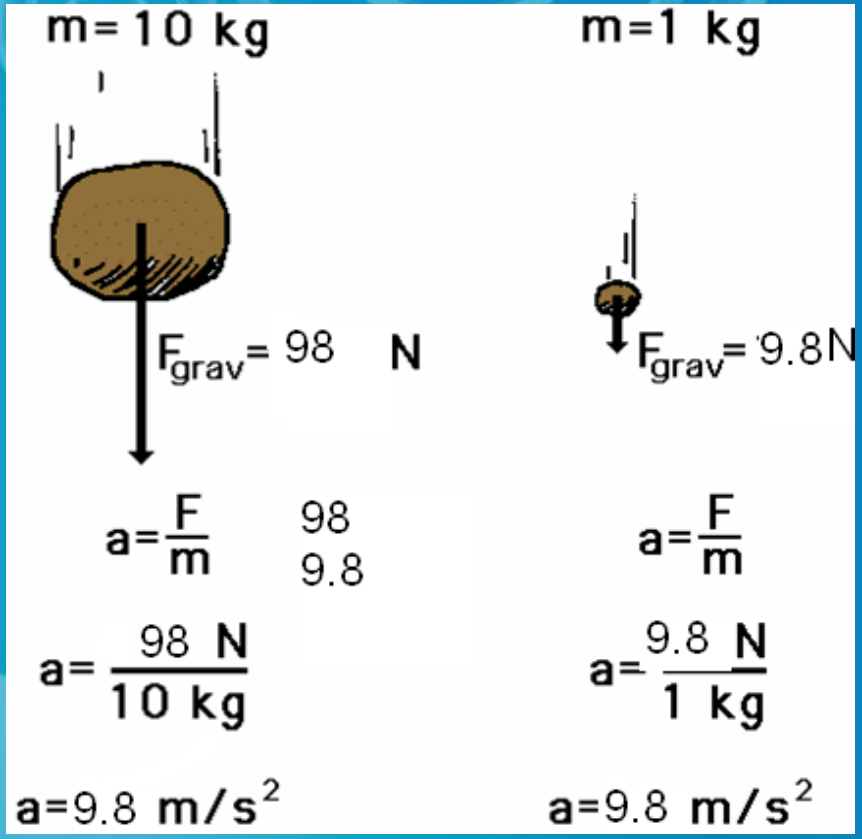
1. You are asked for force (F).
2. You are given two 80 N forces and the fact that the dogs are not moving (a = 0).
3. Newton's second law says the net force must be zero if the acceleration is zero.
4. The woman must exert a force equal and opposite to the sum of the forces from the two dogs.

The Second Law: Force, Mass, and Acceleration

Gravity force

Newton's 2nd Law proves that different masses accelerate to the earth at the same rate, but with different forces.

- *We know that objects with different masses accelerate to the ground at the same rate.*
- *However, because of the 2nd Law we know that they don't hit the ground with the same force.*



The Second Law: Force, Mass, and Acceleration

Vector form

The second law is commonly shortened to "F=m·a", however it's important to underline it concerns vectors

Correctly, it is :

$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}, \qquad \vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m}$$

- *Only forces which act on that object affect the acceleration of the object.*
- *Forces exert by the object on another object do not.*

The Second Law: Force, Mass, and Acceleration

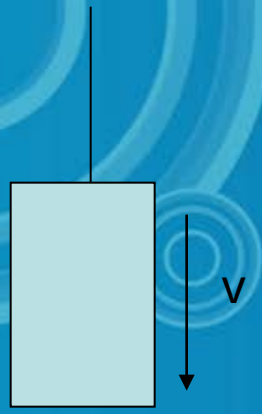
A rational approach to problems

1. Identify all forces acting on the object: **Pushes or Pulls, Frictional forces, Tension in a string , Gravitational Force** (or weight = mg where g is 9.8 m/s^2), **Normal forces** (one object touching another).
2. Draw a "Free-body Diagram": draw the object, show all forces acting on that object as vectors pointing in the correct direction. Show the direction of the acceleration.
3. Chose a coordinate system.
4. Translate the free-body diagram into an algebraic expression based on Newton's second law.

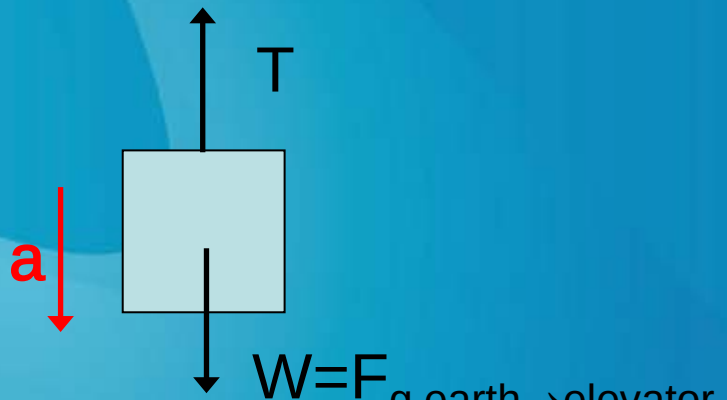
The Second Law: Force, Mass, and Acceleration

A rational approach to problems

Consider an elevator moving downward and speeding up with an acceleration of 2 m/s^2. The mass of the elevator is 100 kg. Ignore air resistance. What is the tension in the cable?



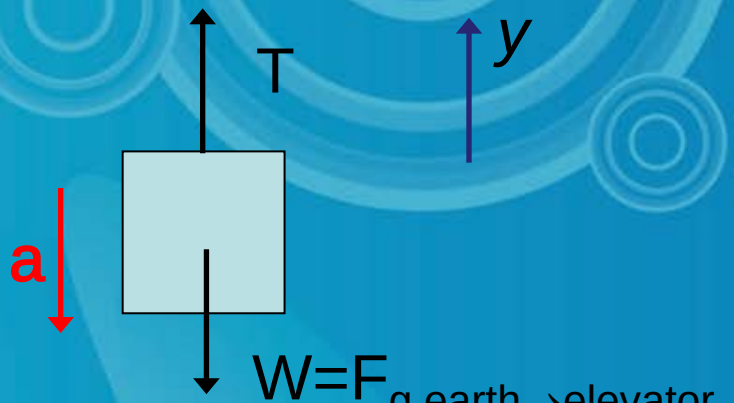
1. Identify Forces: Tension in cable, weight of the elevator
2. Draw free-body diagram:



The Second Law: Force, Mass, and Acceleration

A rational approach to problems

3. Chose coordinate system:
   Let up be the +*y* direction and down –*y*.
4. Translate the FBD into an algebraic expression:



$$T - W = m \cdot (-a)$$

$$T - 100Kg \cdot 9{,}81m/sec^2 = 100Kg \cdot (-2m/sec^2)$$

$$T = 781N$$

The Second Law: Force, Mass, and Acceleration

Video on second law…