Newton’s Laws of Motion

Newton's 1st Law of Motion

- Newton's first law of motion states that an object in motion tends to stay in motion while an object at rest tends to stay at rest until acted on by an outside force
  - It can be simply stated as inertia

Inertia

- What is inertia?
  - Inertia is a measure of the resistance an object has to changing its motion
  - The greater the inertia, the more force is required to cause a change in motion
  - Inertia is directly related to the mass of the object
  - Inertia cannot be transferred from one object to another

Newton's 2nd Law of Motion

- The acceleration of an object is a result of the force applied to its mass
  - Simply stated as acceleration
- $F = m \cdot a$
  - Force = mass times acceleration
- Force (F) is measured in Newtons (N)
- Mass (m) is measured in kilograms (kg)
- Acceleration (a) is measured in meters per second squared (m/s^2 or m/s/s)

Example Problems

1. How much force is required to accelerate a 1500kg car at a rate of 5.0m/s/s?

F

m

a

$F = ma$

$F = (1500kg)(5.0m/s^2)$

$F = 7500\ N$

Example Problems

2. At what rate will a 35kg box accelerate if a force of 70N is applied? Ignore friction.

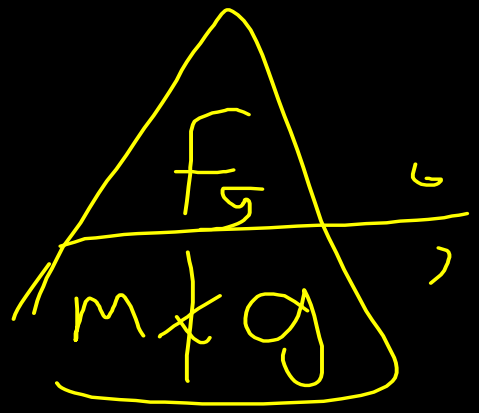
$$a = \frac{F}{m} = \frac{70N}{35kg} = 2 m/s^2$$

Example Problems

3. What is the mass of a ball that accelerated at a rate of 1.5m/s/s when a 3N force was applied to it?

$$m = \frac{F}{a} = \frac{3N}{1.5\ m/s^2} = 2\ kg$$

Weight



- Weight is a type of force
  - The force of gravity acting on a mass
- Unit: Newtons (N)
- Variable: F_g (the subscript g is for gravity)
- The formula for weight is a modified version of the force formula
- $F_g = m \cdot g$
  - g is acceleration due to gravity, which is 9.8 m/s/s on Earth

Example Problems

m F_g $a = g = 9.8\ m/s^2$

1. How much does a 70kg astronaut weight on Earth?

$$F_g = mg = (70\ kg)(9.8\ m/s^2)$$

$$F_g = 686\ N$$

Example Problems

$m = 70kg$

2. If this astronaut goes to the moon, where acceleration due to gravity is only 1.6m/s/s, how much will he weigh?

$a = g$

F_g

$F_g = mg = (70kg)(1.6 m/s/s)$

$F_g = 112N$

Example Problems

70 kg = m

F_g

3. On Mars, the astronaut has a weight of 266N. What is the acceleration due to gravity on Mars?

g

$$g = \frac{F_g}{m} = \frac{266\,N}{70\,kg} = 3.8\,m/s^2$$

Example Problems

$g = 3.8\ m/s^2$

4. Joining the astronaut on Mars is a Russian cosmonaut. If the cosmonaut has a weight of 228N on Mars, what is her mass?

m F_g

$$m = \frac{F_g}{g} = \frac{228N}{3.8\ m/s^2} = 60kg$$

Example Problems

$m = 60 kg$ F_g $g = 9.8 m/s^2$

5. How much does the cosmonaut weight on Earth?

$$F_g = Mg = (60 kg)(9.8 m/s^2)$$

$$F_g = 588 N$$

Newton's 3rd Law of Motion

- For every action there is an equal but opposite reaction
  - Equal in size, opposite in direction
- Simple definition: action-reaction
- Do not cancel out because they act on different objects
  - Example: The student pushed on the desk, the desk pushed back on the student