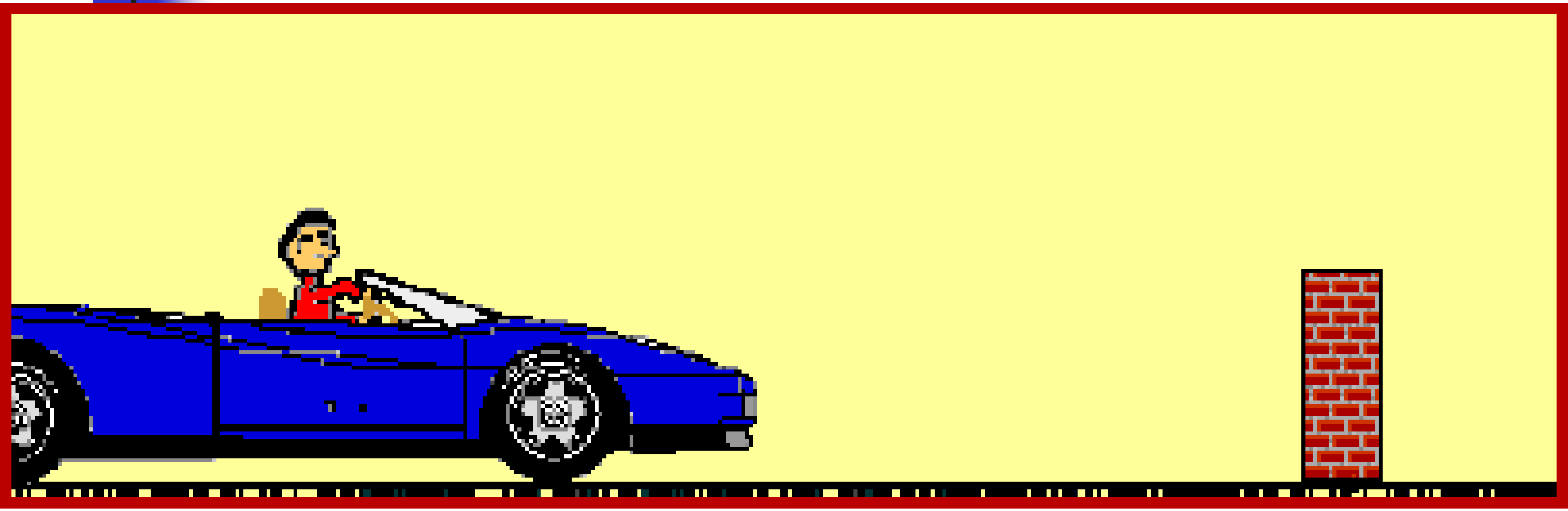
Chapter 2

Force and Newton’s Laws

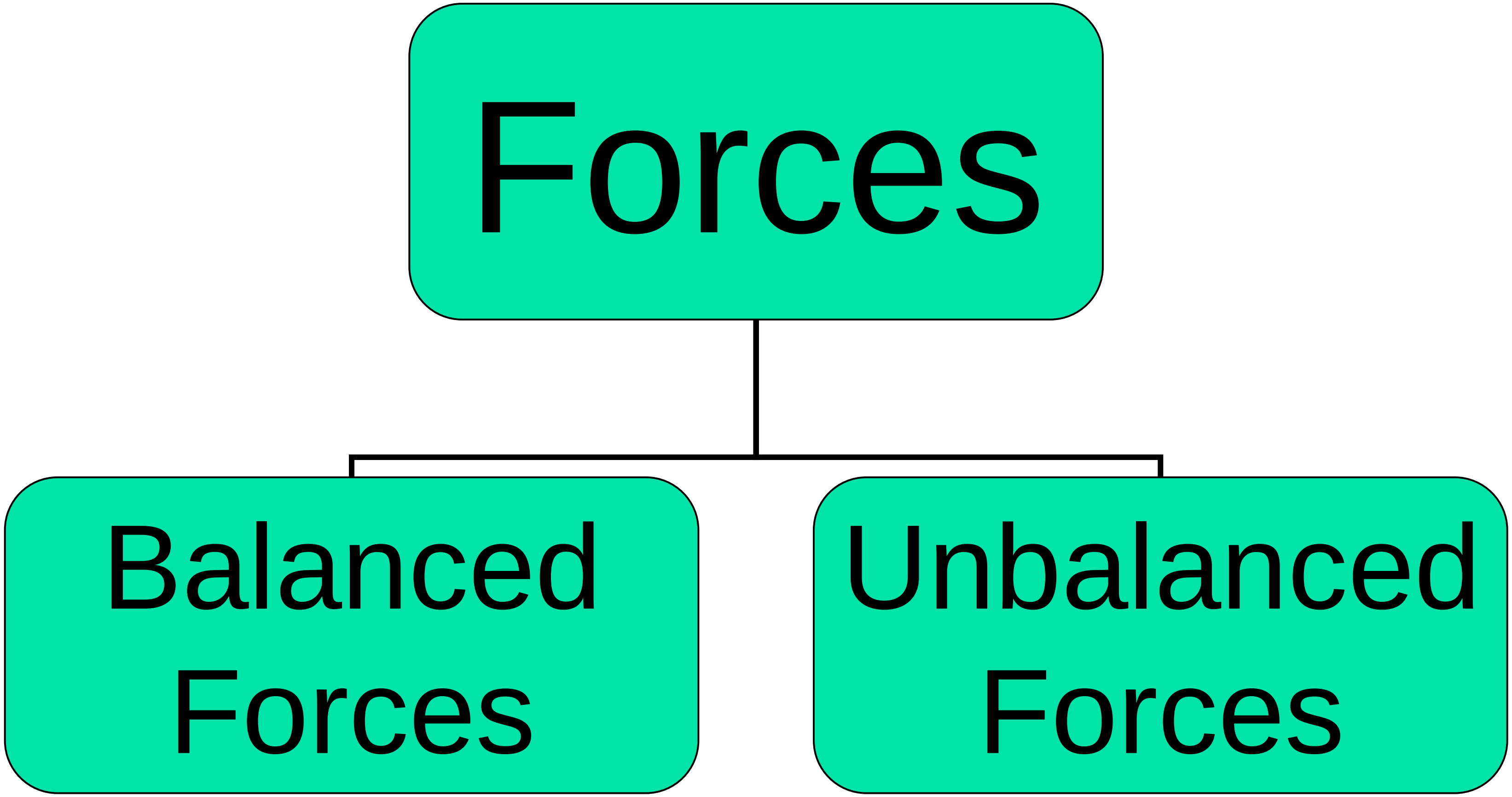
2 – 1 Newton's First Law

Force

- <u>Force</u> – A push or pull that one body exerts on another body.
  - Examples :



2 Categories of Forces



Balanced Forces

- Balanced Forces – Forces on an object that are equal in size and opposite in direction.
  - Results in the object not accelerating.

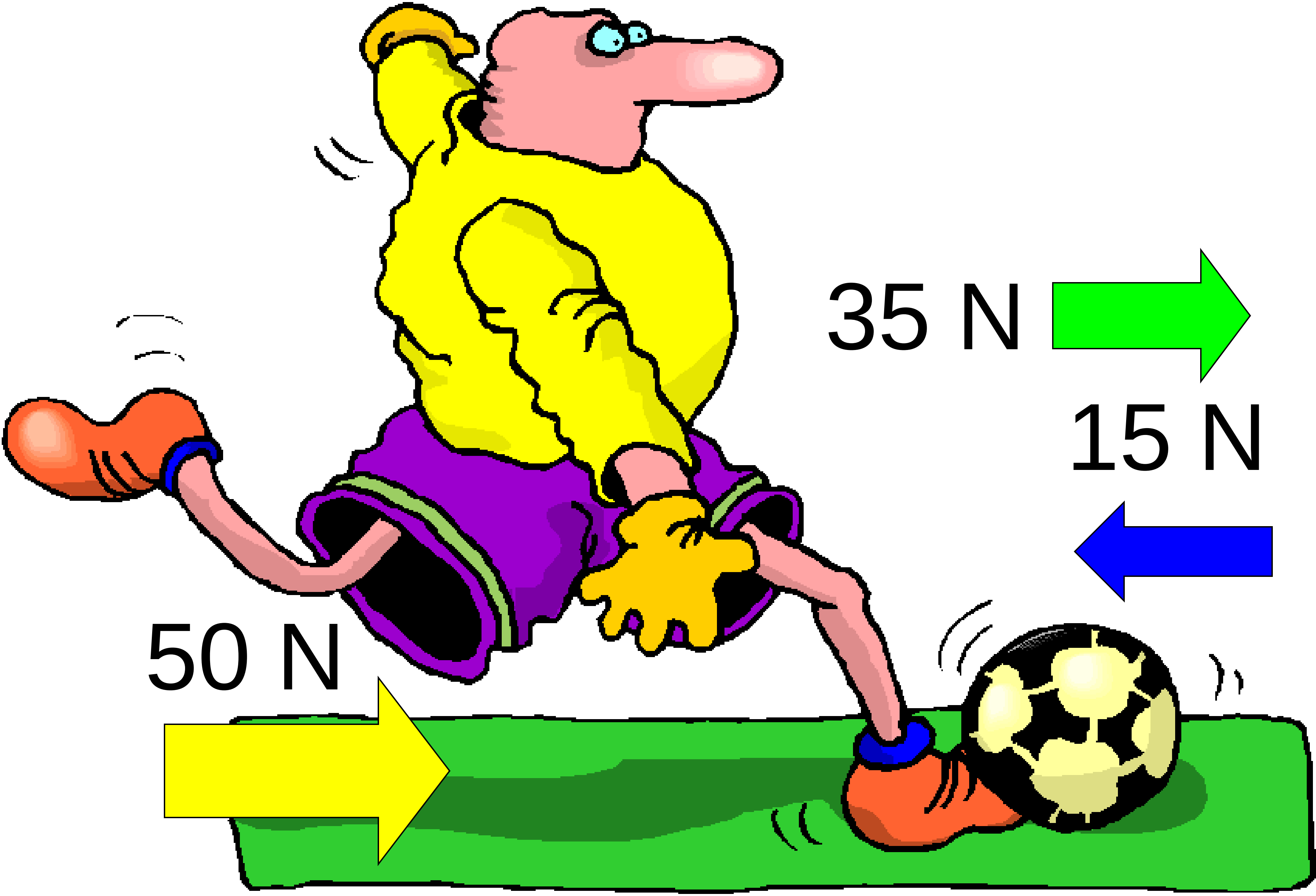
Unbalanced Forces

- Unbalanced Forces – Forces that are not balanced.
  - Results in an acceleration.
  - Caused by a "Net Force"

Net Force

- Net Force – The sum of the forces on an object when unbalanced forces are applied to it.
  - Changes the object’s speed, direction or both.

- A soccer ball rolls toward you with a force of 15 Newtons, you kick it in the opposite direction with a force of 50 Newtons. What is the Net Force on the soccer ball ?


35 N
15 N
50 N

Inertia

- Inertia – The tendency of an object to resist any change in its motion.
  - Examples : a hockey puck on ice, a ball rolling in the hall, a paper sitting on a desk

Inertia and Mass

- An object with more mass will have a higher inertia compared to an object with a lower mass.
  - Example : kicking a soccer ball compared to a bowling ball

Newton’s 1st Law of Motion

- Also known as the “Law of Inertia”.
- An object moving at a constant velocity keeps moving at a constant velocity unless a net force acts on it.
- If an object is at rest, it will remain at rest unless acted upon by a net force.

Friction

- Friction – The force that opposes motion between two surfaces that are touching each other.

Amount of Friction

- 2 Factors :

1. Force pressing the surfaces together.
2. Texture of the surfaces.

3 Examples of Friction

1. Static Friction – the type of friction that prevents an object from moving when a force is applied to it.
2. Sliding Friction – the type of friction that slows an object that is sliding.
3. Rolling Friction – the type of friction that slows an object that is rolling.

2 – 2 Newton's 2^{nd} Law

Newton's 2nd Law of Motion

- Newton's 2nd Law of Motion – A net force acting on an object causes the object to accelerate in the direction of the force.

Force Equation

- Force = Mass * Acceleration
- F = m a
- Units
  - Force – Newtons (N)
  - Mass – Kilograms (kg)
  - Acceleration – Meters per Seconds Squared (m/s^2)

Examples

- How much force is needed to accelerate a 1000 kg car at 3 m/s^2 ?

$F = ?$

$m = 1000\ kg$

$a = 3\ m/s^2$

$$F = m\,a$$

$$F = 1000\ kg * 3\ m/s^2$$

$$F = 3000\ N$$

- How much force is needed to accelerate a 55 kg runner at 6 m/s^2 ?

$F =$?

$m =$ 55 kg

$a =$ 6 m/s^2

$F = m\,a$

$F = 55\ kg * 6\ m/s^2$

$F = 330\ N$

- It takes a force of 3000 N to accelerate an empty 1000 kg car at 3 m/s^2. If a 160 kg wrestler is inside the car, how much force will be needed to produce the same acceleration ?

$F = ?$

$m = 1160\ kg$

$a = 3\ m/s^2$

$F = m\ a$

$F = 1160\ kg * 3\ m/s^2$

$F = 3480\ N$

- A 63 kg skater pushes off of the wall with a force of 300 N. What is the skater's acceleration ?

F = 300 N

m = 63 kg

a = ?

$$F = m\,a$$

$$\frac{300\text{ N}}{63\text{ kg}} = \frac{\cancel{63\text{ kg}}}{\cancel{63\text{ kg}}} * a$$

$$4.76\text{ m/s}^2 = a$$

- A 500 g ball is struck with a force of 200 N. What is the acceleration of the ball ?

$F = 200\ N$

$m = 0.5\ kg$

$a = ?$

$F = m\,a$

$$\frac{200\ N}{0.5\ kg} = \cancel{\frac{0.5\ kg}{0.5\ kg}} * a$$

$400\ m/s^2 = a$

Gravitational Force

- Gravity – A force that every object in the universe exerts on every other object in the universe.
  - Everything has gravity.
  - If it has mass, it has gravity… even the smallest objects

What determines gravity

- There are 2 things that determine Gravitational Force.

1. The mass of the objects.
2. The distance between the objects.

Gravitational Force cont…

- The further you are from Earth, the less the amount of gravitational force it has on you.
- Because we are so close to the Earth, its force drowns out all other gravitational forces we might feel.

- All objects accelerate at the same rate due to gravity.
- Acceleration due to gravity = 9.8 m/s^2.

Weight

- Weight – The measure of the force of gravity on an object.
  - Measured in Newtons (N)
  - The greater an objects mass, the greater the gravitational force on the object.
  - More mass = more weight

Weight cont…

- Weight depends upon where you are.
  - The further you are from the center of the Earth, the lower the gravitational force.
  - You weigh less on a tall mountain than at sea level.

Calculating Weight

- Weight = Mass * Acceleration
- W = m a
- Use Acceleration Due To Gravity ($9.8 m/s^2$)

Example

- Mr. Gill has a mass of 87 kg. What is his weight ?

$W = ?$

$m = 87\ kg$

$a = 9.8\ m/s^2$

$W = m\,a$

$W = 87\ kg * 9.8\ m/s^2$

$F = 852.6\ N$

Measuring Forces

- Scales are used to measure weight.
- Scales use the principle of balanced forces to measure weight.
- Your weight is balanced against the force produced by a spring.
- The distance the spring moves is converted to movement on a scale.

Falling Objects

- All objects fall because of gravity.
- The heavier the object, the stronger the force of gravity, but also the stronger the inertia working against the gravity.

Air Resistance

- Air Resistance – Frictional force air exerts on a moving object, acts in the opposite direction to the object's motion.

Factors Affecting Air Resistance

- 3 factors:

1. Speed
2. Size
3. Shape

Terminal Velocity

- Terminal Velocity – the highest velocity that will be reached by a falling object.


Gravity
Air Resistance

- As an object falls, its speed increases.
- The increase in speed increases the air resistance.
- Eventually the force of air resistance equals the force of gravity.
- Equal forces in opposite directions. (acceleration = 0)

Centripetal Force

- In order for acceleration to occur, there must be an unbalanced force.
- <u>Centripetal Force</u> – force acting toward the center of a curved or circular path.

Example

- When a car turns, the centripetal force is the friction between the tires and the roadway causing the car to turn.

Sir Isaac Newton

- Newton believed that a satellite could be launched by shooting it horizontally from a tall mountain.
  - Air resistance would slow it and cause it to crash to the ground.

Conventional Method

- Began in the 1950’s
- A “ Multistage Rocket ” lifts the satellite to the desired altitude then a second stage accelerates the satellite to the speed required for orbit.

Center of Mass

- The **center of mass** is the point in an object that moves as if all the object's mass were concentrated at that point.
- For a symmetrical object, such as a ball, the center of mass is at the object's center.
- However, for any object the center of mass moves as if the net force is being applied there.

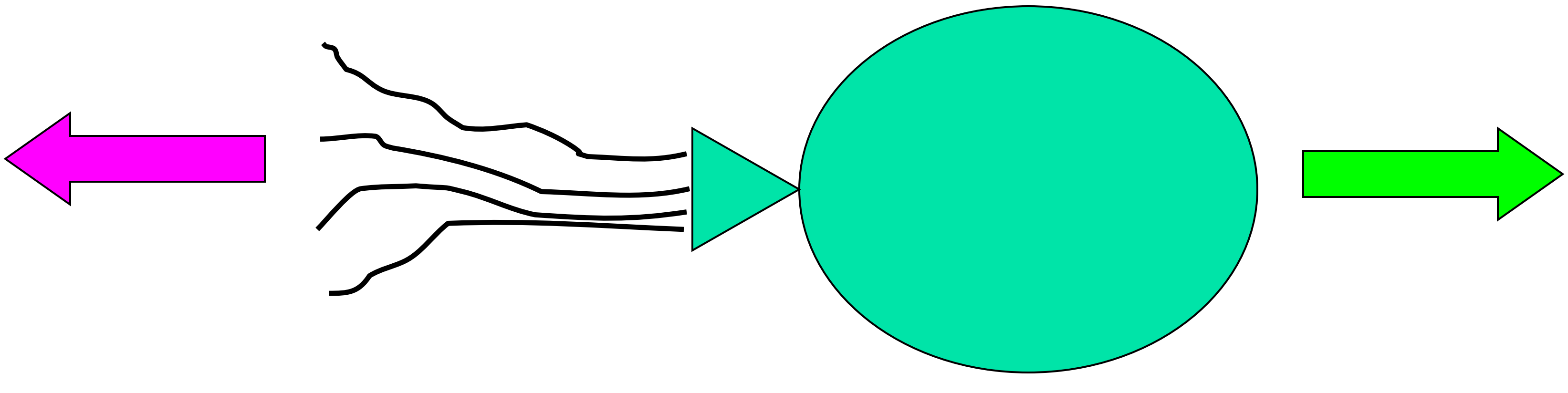
2 – 3 Newton’s Third Law of Motion

Newton's 3rd Law of Motion

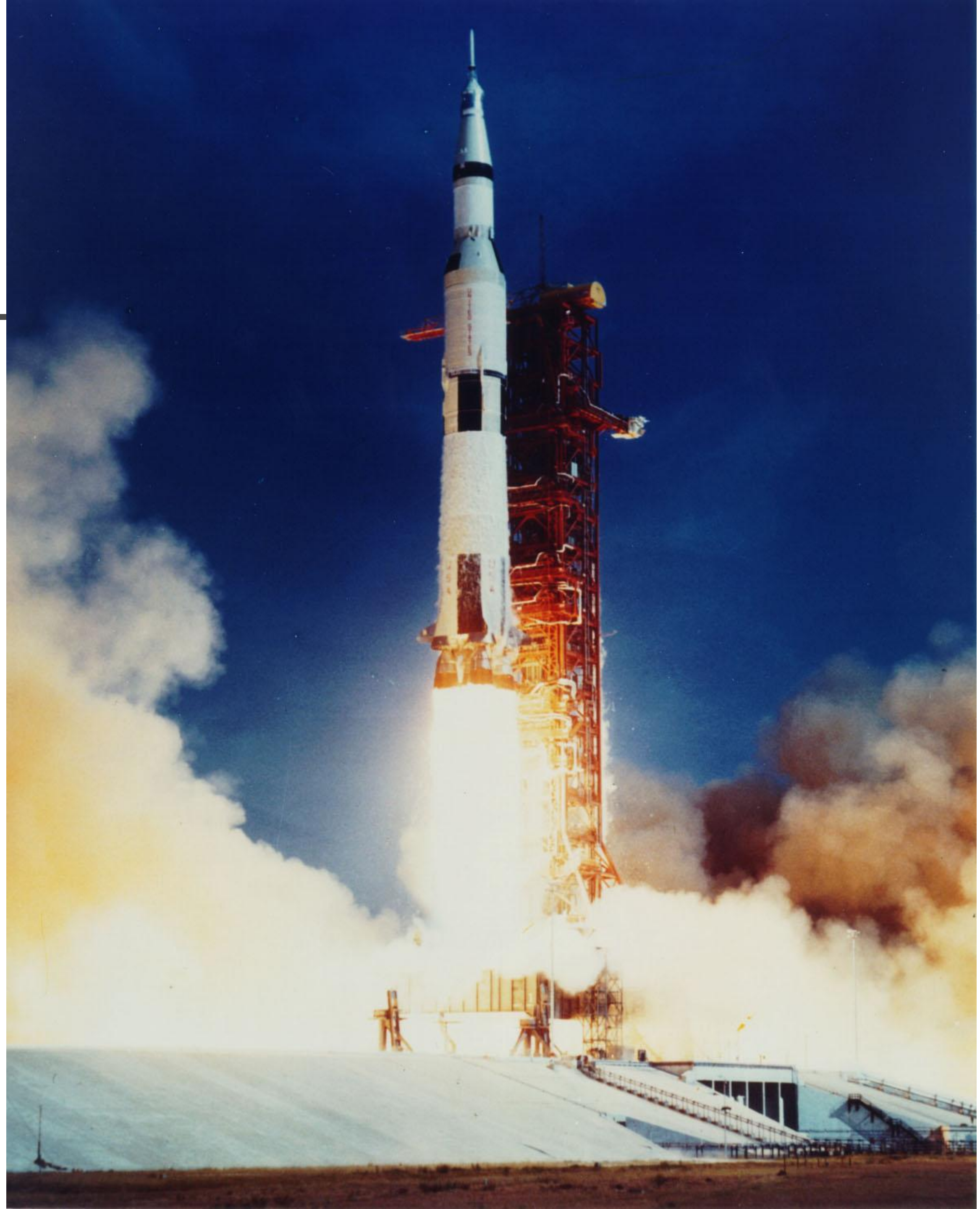
- Newton's 3rd Law of Motion – When one object exerts a force on a second object, the second object exerts a force on the first object that is equal in size and opposite in direction.

Examples

- Blowing up a balloon and then letting it go.



- Swimming – you push backward on the water, the water push forward on you.
- Jumping – you push down on the ground, the ground pushes back up on you.



Free-Falling

- Weight is measured by measuring the force being produced by gravity pushing down on a scale.
- Supposed that the scale is falling at the same rate the object being measured is falling.

- The scale cannot push back against the object on it, so it would read 0.
- This is what happens to astronauts in orbit.
- They are in “ free-fall ”