Name: _____ Date: _____

PHYSICS
UNIT 2: FORCES & ACCELERATION

BALANCED & UNBALANCED FORCES

If two objects interact, there may be cases when the forces are balanced and when the forces are unbalanced. If you recall about **Newton's 1st Law of Motion**, an object will maintain its original state of motion unless acted upon by an external unbalanced force. An object will maintain a constant velocity (straight-line, uniform rate of motion) **unless acted upon by an external unbalanced force**. Unbalanced forces cause objects to accelerate and change their states of motion.

What are Balanced Forces?

A state of **balanced forces** occurs when the forces that act upon an object are equal in magnitude and opposite in direction. The **net force** acting upon both objects is zero—the forces cancel each other out. **When forces are balanced, the object retains its original state of motion. Static equilibrium** (static = still, equilibrium = balance) is a specific case in which an object is affected by balanced forces that cause the object to remain motionless when it is originally motionless.

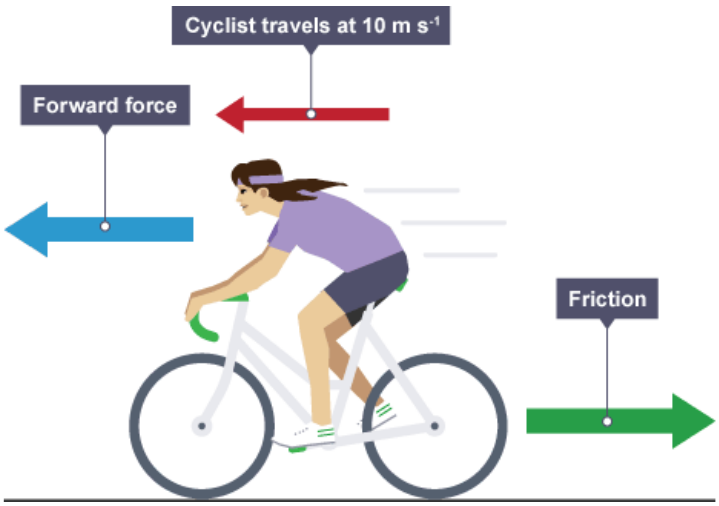
Illustrative Example 1

The two teams pull on the rope with equal force and in opposite directions: +300 N (to the right) and -300 N (to the left. The pull forces cancel each other out creating a net force of zero. Neither team will accelerate.

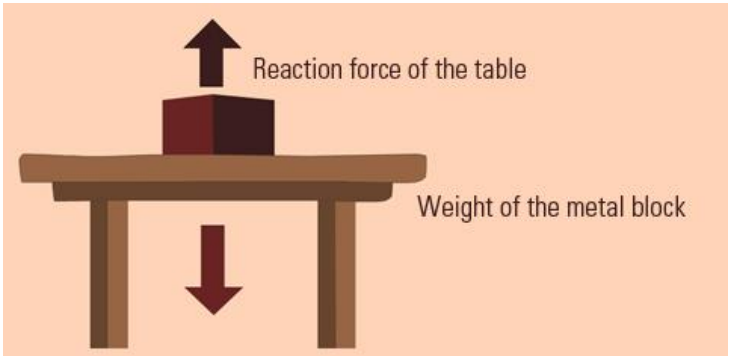
When forces acting upon an object are **balanced** (equal in magnitude and opposite in direction)

- **Net force = 0 Newtons** (all of the forces cancel each other out, no net force remains)
- If the object is initially motionless, the object will remain motionless (static equilibrium)
- If the object is initially moving, the object will remain moving at its original velocity (the same rate of motion and direction). There will be **no acceleration**.

Illustrative Example 2



The cyclist is affected by balanced forces. The cyclist will move at a constant velocity of 10 m/s because the forward force moving the bicycle is equal and opposite to the resisting force of friction. **Balanced forces** acting upon a moving object will make the moving object move at **constant velocity**. There is zero acceleration.



The metal box is at **static equilibrium**. It is affected by balanced forces. The weight of the box pressing down on the table is equal and opposite to the table pushing back on the box. The box is **motionless and will remain motionless** because zero net force is acting upon it.

What are Unbalanced Forces?

Unbalanced forces occur when the forces of two interacting objects that act upon each other are not equal in magnitude and/or are not in opposite directions. The net force acting upon the object or objects will not be zero. Unbalanced forces cause objects **to change their states of motion or accelerate**—objects will move faster with time, will move slower with time, or will change direction. **The acceleration is always in the direction of the net force.**

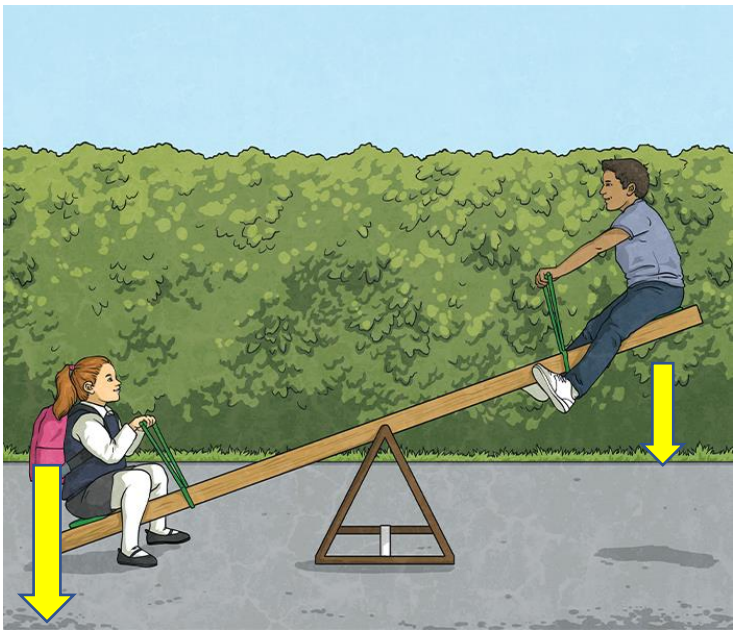
Illustrative Example 3

The two teams pull on the rope with unequal forces: +300 N (to the right) and -400 N (to the left. The pull forces do not cancel each other out. The net force acting upon both teams is -100 N, or 100 N to the left. The teams will accelerate to the left, in the direction of the net force.

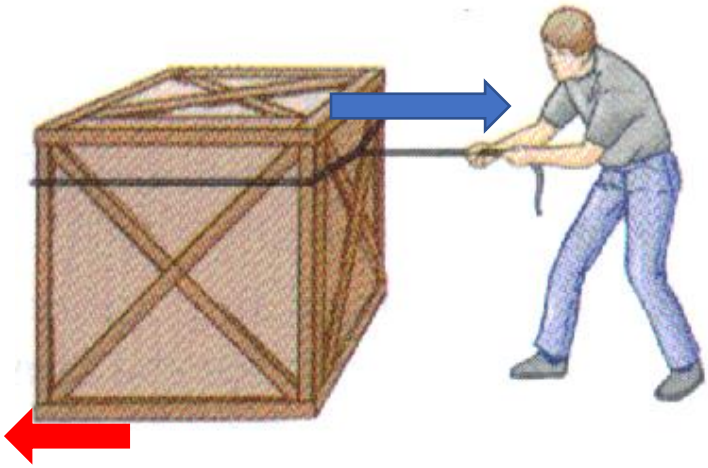
When forces acting upon an object are **unbalanced** (at least one force is greater than the other forces, forces do not cancel out)

- **Net force is > 0 N**. Forces acting upon an the object are NOT equal and opposite.
- If an object is initially motionless, it will start to move in the direction of the net force.
- If an object is initially in motion, its state of motion will change (get faster, get slower, or change direction) in the direction of the net force.

Illustrative Example 4

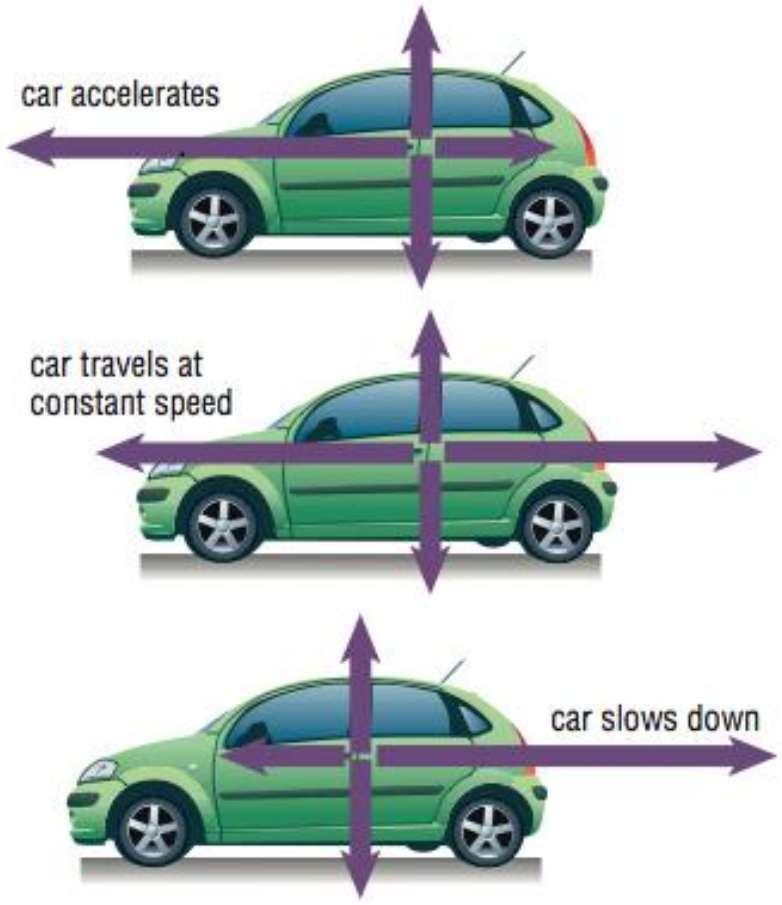


The force of the girl pushing down on the left side of the seesaw is greater than the force of the boy pushing down on the right side of the seesaw. The seesaw is at a state of unbalanced forces. The seesaw is tipped in the direction of the net force, which is in favor of the larger force on the left.



The crate is at a state of unbalanced forces. The pull force to the right is greater in magnitude than the friction force against the bottom of the crate. The crate will accelerate to the right.

Illustrative Example 4



Unbalanced forces. The force of the car's motor is greater than the force of friction. As a result, the car will get faster with time (accelerate in direction of current motion).

Balanced forces. The force of the car's motor is equal and opposite the force of friction. As result, the car will move at constant velocity (same rate, will not get faster or slower)

Unbalanced forces. The force of friction is greater than the force of the car's motor. As a result, the car will get slower with time (accelerate in the direction opposite of current motion).

What is a Net Force?

The **net force** (or **resultant force**) is the one force acting upon an object when all forces are added together and cancel each other out. The net force is the "leftover force", and the **acceleration of the object will always be in the direction of the net force**.

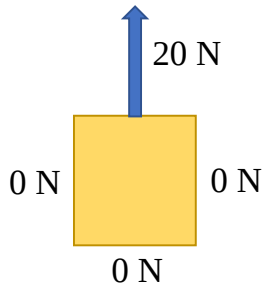
If all the forces acting on an object when added together cancel each other out, **the forces are balanced forces**. The **net force is 0 N.** Under balanced force conditions, the object will not accelerate—the object will keep its original state of motion. Objects in motion will continue to move at a constant velocity (rate and direction). Objects at rest will remain in a state of static equilibrium.

If all the forces when added together do not cancel each other out, the forces are unbalanced forces. The **net force > 0 N.** The object will accelerate in the direction of the net force. The magnitude of the acceleration is proportional to the net force—the greater the net force,

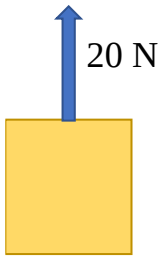
the greater the acceleration. Objects in motion will get faster with time, or get slower with time, or change direction. Objects initially at rest will begin to move in the direction of the net force.

Illustrative Example 5

Free body diagram

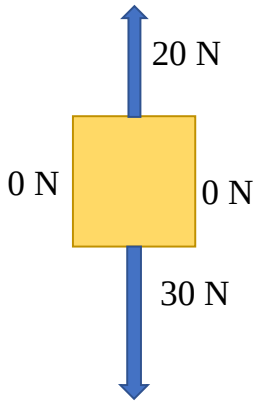


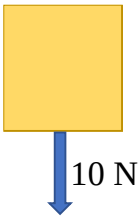
Net Force



Unbalanced forces: The object in the free body diagram is affected by one force, 20 N to the north. No force vectors are drawn on the E, S, or W sides of the free body diagram because the forces in those directions are zero.

The **net force** is 20 N north, the **one non-zero force** acting upon the object. The object will accelerate to the north.

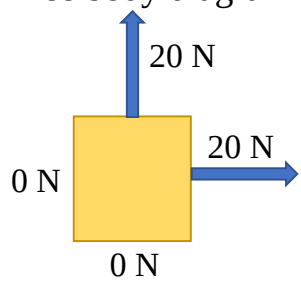




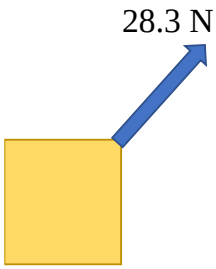
Unbalanced forces: The object in the free body diagram is affected by two forces, 20 N north and 30 N south. The two forces are opposite in direction, but not equal in magnitude.

The **net force** is 10 N south, the **leftover non-zero force** acting upon the object. The object will accelerate to the south.

Free body diagram



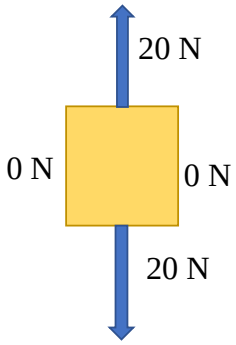
Net Force



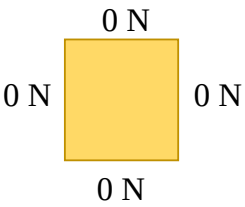
Unbalanced forces: The object in the free body diagram is affected by two forces, 20 N north and 20 N east. The two forces are NOT equal in magnitude and opposite in direction. The combination of a force pushing to the north and a force pushing to the east is to the northeast.

The **net force** is 28.3 N to the northeast, the **one non-zero force** acting upon the object. The object will accelerate to the northeast.

Free body diagram



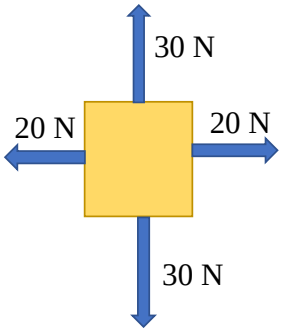
Net Force



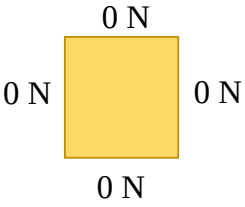
Balanced forces: The object in the free body diagram is affected by two forces, 20 N north and 20 N south. The two forces are equal in magnitude and opposite in direction. They cancel each other out.

The **net force** is 0 N. The object will not accelerate. The object will keep its current state of motion.

Free body diagram



Net Force



Balanced forces: The object in the free body diagram is affected by four forces: 30 N north and 30 N south, 20 N E and 20 N W. The forces in the north & south directions are equal in magnitude and opposite in direction. They cancel each other out. The forces in the east & west directions are equal in magnitude and opposite in direction. They cancel each other out.

The **net force** is 0 N. The object will not accelerate. The object will keep its current state of motion.