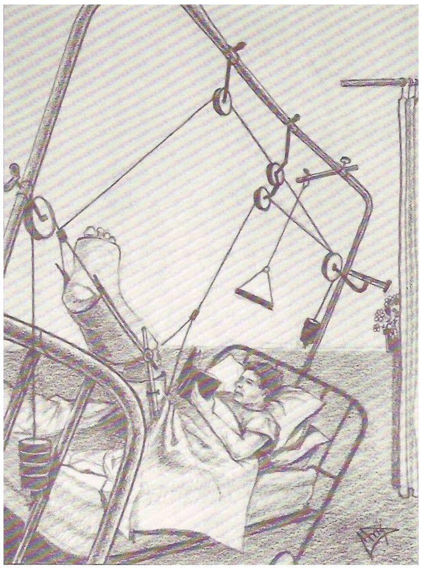
FORCE AS A VECTOR

Force as a Vector

Geometric vectors can be used to provide a mathematical model for many physical phenomena. One physical phenomenon that is effectively represented by vectors is force.



When using a vector to represent a force, the magnitude of the vector represents the magnitude of the force and the direction of the vector represents the direction in which the force is acting.

The magnitude of a force is measured in newtons, which is abbreviated as N. On Earth, this force is defined as the product between the mass of an object (in kg) and the acceleration due to gravity (9.8 m/s^2).

The **resultant** of two or more forces is the single force that has the same effect as all the forces acting together.

Example

Two horses pull a load. The chains between the horses and the load are at an angle of $60°$ to each other. One horse pulls with a force of 230 N and the other with a force of 340 N. What is the resultant force on the load (magnitude and direction)?

Equilibrium

In some cases, an object is acted upon by forces, but does not move. The object is said to be in **equilibrium.**

The **equilibrant** is the single force that holds the system in equilibrium. It is the single force that would exactly counterbalance the resultant force.

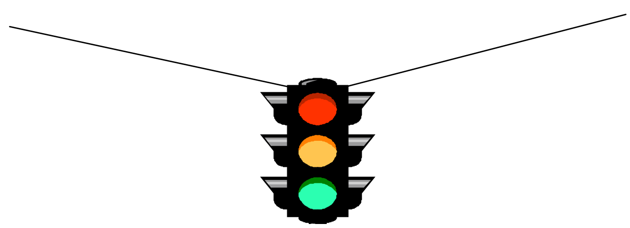
The resultant and the equilibrant have ________________ magnitudes and ________________ directions.

Example
In the previous example, what is the equilibrant?

A Little More About Equilibrium

When using vectors to model an object in equilibrium, the sum of the vectors is the zero vector.

Example
Consider a traffic light that is suspended by two cables.



There are three forces acting on the traffic light:

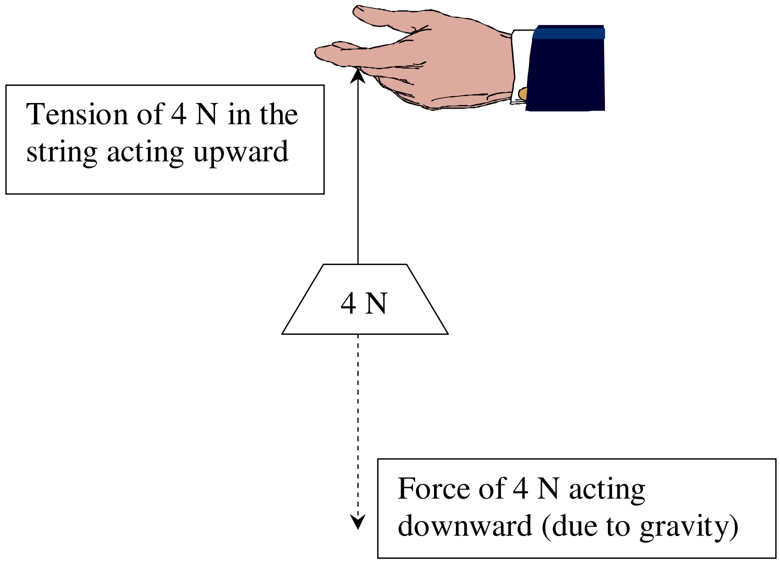
1) The downward force due to gravity.
2) The tension in one of the cables.
3) The tension in the other cable.

Since the light is being held in equilibrium (not moving), the three forces acting on the light balance each other. Therefore, if these forces were represented by vectors, the sum of the 3 vectors would be the zero vector.

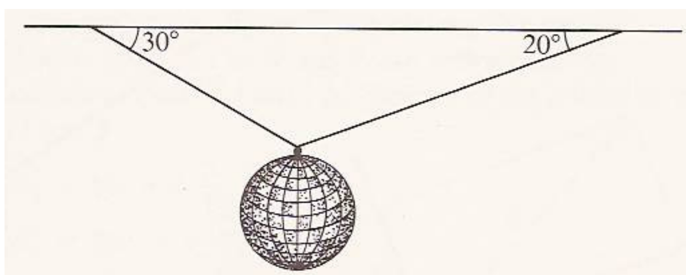
A Note About Tension

The force of tension in a rope is always in the opposite direction to the force pulling on the rope.

Example
Consider the following diagram, in which a 4 N weight is being suspended in equilibrium by a string.

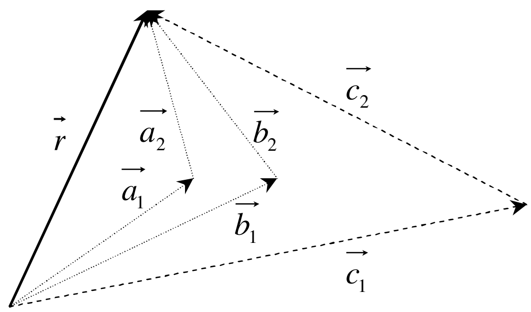


Example
At a school dance, a mirror ball is suspended from the ceiling by two wires that make angles of $30°$ and $20°$ with the ceiling. If the ball exerts a force of 123 N under gravity, find the tensions in the wires.



Resolving Vectors

When two vectors are added to produce a resultant, the original vectors are called **components**.
A single vector can have many sets of components, as shown in the diagram below.



$$\vec{r} = \vec{a_1} + \vec{a_2}$$

$$\vec{r} = \vec{b_1} + \vec{b_2}$$

$$\vec{r} = \vec{c_1} + \vec{c_2}$$

The process of expressing a vector in components is called the **resolution of a vector**.

The resolution of vectors is particularly useful when working with forces.

Example
Resolve the given force into components in the directions indicated.