Forces and Dynamics

Force is a vector quantity and the SI units for the measurement of force is the Newton (N). Forces act on masses and can produce changes in velocity or shape of an object when there is an overall net (or resultant) force acting.

Weight

The **weight** of a body is the gravitational force experienced by that body. On earth the formula give is:

$W = mg$

m - mass of the body measured in kilograms (kg)

g - the gravitational field strength of the earth which is measured in Newton's per kilogram (N kg^{-1}) or sometimes m s^{-2}. On the surface of the earth g= 9.81 N kg^{-1}.

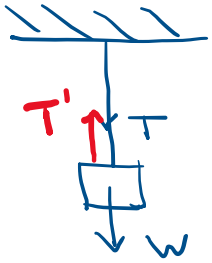
Weight can be considered as a single force acting from the centre of gravity directly down towards the centre of the Earth.

Free-body force diagrams

We can identify the forces acting on an object and represent these as arrows on a force diagram. A force diagram showing just the forces acting on a single object is known as a free-body force diagram.

Tension

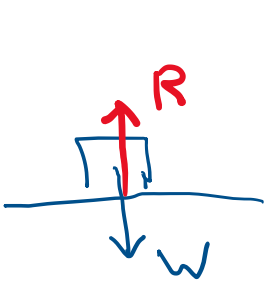
Tension is always a pull force. Tension (T) is the force in an object when it is stretched.

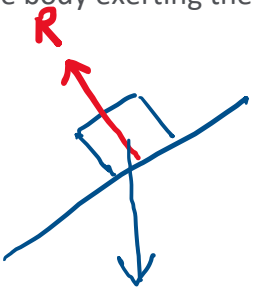


The wire is being stretched by the downwards pull of the weight. There is a tension T stretching the wire. The wire pulls back up on the block with a force T'

Normal Reaction force:

If an object is in contact with another object, there is a reaction force(R) between the two bodies. This force is perpendicular to the body exerting the force:

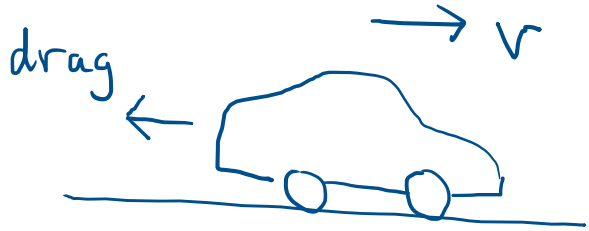




An object on a table. The reaction force R is the force that the table exerts on the object perpendicular to and pointing away from the surface

Drag Force:

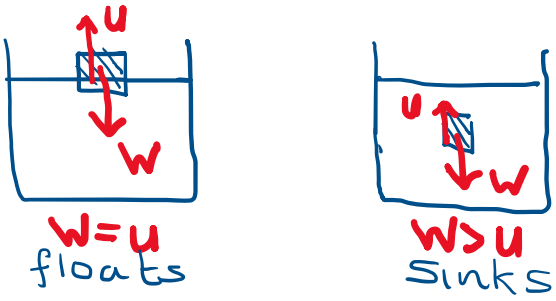
Drag forces are forces that oppose the motion of a body through a fluid (gas or liquid). They act in the opposite direction to the velocity of the body. The size of the drag force depends on the speed of the body, with a higher speed giving a higher drag force.



The drag force always opposes the motion of an object moving through a fluid.

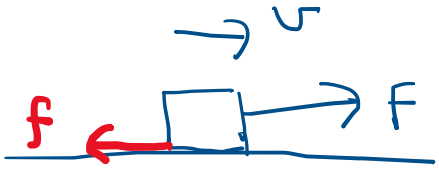
Up thrust:

An object placed in a fluid will experience upthrust. If the upthrust force on a body is equal to the weight, the body will float in the fluid.

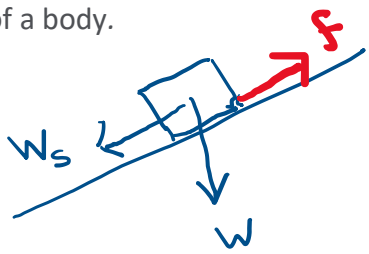


Frictional Forces:

Frictional forces (*f*) are forces that oppose the motion of a body.



A box on the floor being pulled along has a frictional force f acting to oppose the motion.



A box sliding down a slope, there is a frictional force f acting back up the slope, in the opposite direction to Ws.

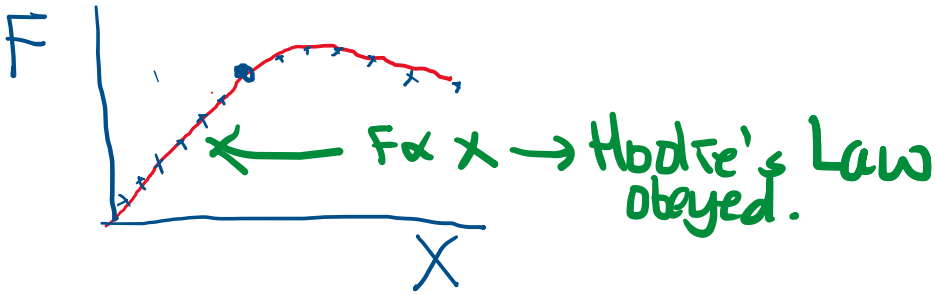
Hooke's Law:

Hooke's law states that up to the limit of proportionality, the **extension**, **x** of a spring is proportional to the **tension** force**, F**:

$F \propto x$

$F = kx$

The constant of proportionality **k** is called the **spring constant**. SI units of spring constant are $N\ m^{-1}$.

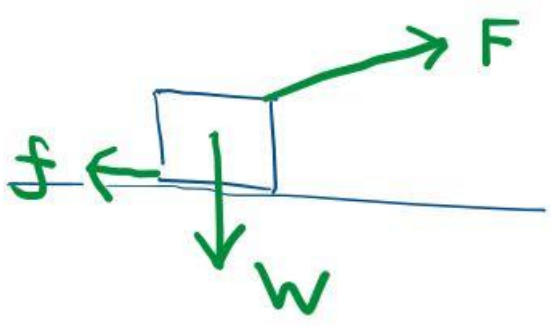


A force-extension graph for a spring, showing where the spring obeys Hooke's Law

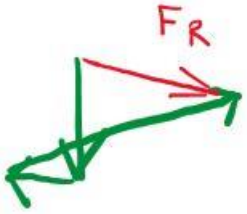
Resultant force

The resultant force is the overall force acting on an object when the effect of all the individual forces acting are added together.

To find the resultant force, we need to add the individual force vectors, considering the size and direction of each force.



a) There are 3 forces acting on an object



b) These forces are combined by vector addition to give the resultant force F_R

Solid friction

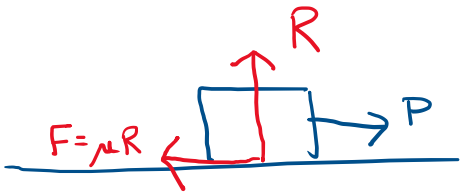
Friction is the force which acts between two surfaces in contact.

Static friction is when there is no relative movement between the surfaces. Dynamic friction is when there is movement. As pulling force increases on an object, if there is no slip, then friction is static. When pulling force exceeds the static friction, there will be a resultant force on the object and it will start to move. As the object starts to move, the friction

reduces to a lower level than the static friction – this is the dynamic friction. Both types of friction depend on the nature of the surfaces (roughness etc) in contact.

Coefficient of friction

The **coefficient of friction**, μ, is a measure of the amount of friction existing between two surfaces. A low value of coefficient of friction indicates that the force required for sliding to occur is less than the force required when the coefficient of friction is high.



R – normal reaction

P – pull force

F – frictional force

Static and dynamic friction are defined individually by their constants μ_s and μ_d respectively.

Static friction: $F_s = \mu_s R$

Dynamic friction: $F_d = \mu_d R$