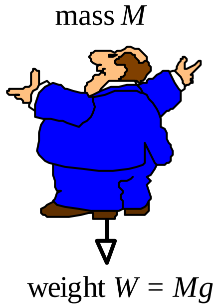
Force Diagrams

When showing forces on diagrams, it is important to show the directions in which they act as well as their magnitudes.



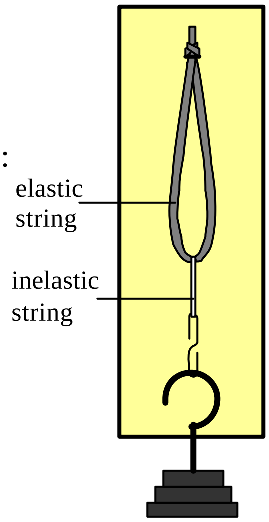
Weight
Weight, the force of attraction exerted by the Earth on an object, acts downwards.

Here are some other common forces and the direction in which they act:

Tension
Tension is an internal force in a string (or rope) that acts in the direction of the string.

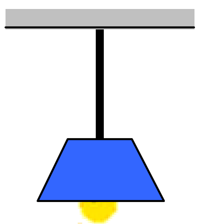
If you have made an elastoscale, you will have used two types of string:

- string which did not stretch significantly, called ***inelastic*** or ***inextensible*** string
- string which did stretch significantly, called ***elastic*** string.

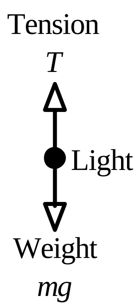


In many problems it is possible to assume that the weights of the strings or ropes involved are negligible compared to other forces. It is then said that the string or rope is ***light***.

When drawing diagrams it is not necessary to try to represent the objects in a realistic way.



For example, to represent the situation of a light hanging from a ceiling, the light is modelled as a particle and simply shown as a dot. The forces acting on the light, namely its weight and the tension in the cord, are shown as arrows.
If this system is ***in equilibrium***, $T = mg$.



In systems involving strings, pulleys are often used to change the line of action of a force. If the pulley has ***smooth*** bearings and has a small mass so that it can be considered to be ***light***, you can assume that the tension on both sides of the pulley is the same i.e. $T_1 = T_2$

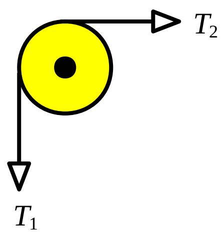
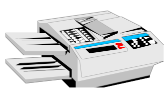
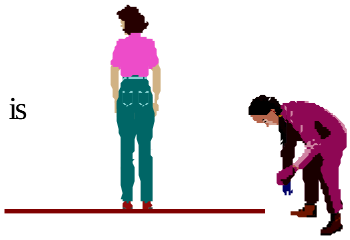


Photo-copiable



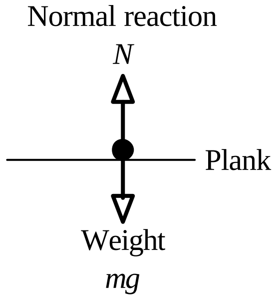
Contact Forces



Imagine you are standing on a plank of wood on horizontal ground. Someone raises one end. Assuming you remain on the plank, there is a force from the plank keeping you in contact with it. This contact force exerted by the plank is called a ***reaction***.

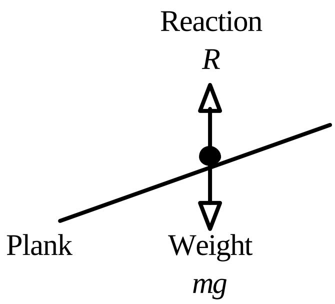
It is often convenient to consider reaction forces as consisting of two components:

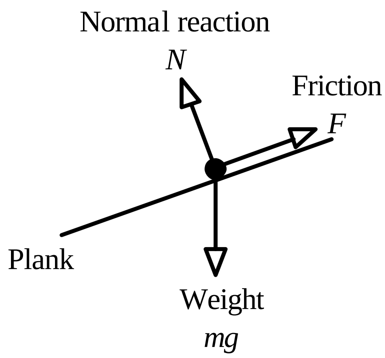
- one acting along the tangent to the two surfaces in contact, called the ***friction force***
- the other at right angles to this called the ***normal reaction***.



Throughout this situation your weight acts downwards.
Initially you were standing on the plank in equilibrium so your weight was balanced by an equal force acting in the opposite direction.
This is the normal reaction, usually represented by the symbol, N.
These forces are shown in the diagram.
As you were standing in equilibrium, $N = mg$.

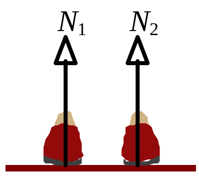
Now consider the forces that act with the plank lifted.
If you remain stationary in the new position after the lift, you are in equilibrium and your weight, mg, must again be balanced by a force of the same magnitude acting vertically upwards. These forces are shown in the first diagram below. Note that the reaction is now denoted by R, rather than N, as it is not at right angles to the two surfaces that are in contact. The second diagram shows the reaction force, R, split into two components, the friction force, F, and the normal reaction, N.





Either of these diagrams can be used to represent the situation described.
Usually the second version is more useful when working with situations of this type.

Note



It would be possible to show the normal reaction on each foot separately as shown here, but in most cases this would be an unnecessary complication. Usually the normal reaction and friction are shown as single forces even when there is more than one point of contact.

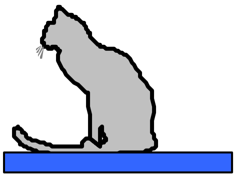
Other Common Forces

There are many other forces that could act on an object. In some cases these forces are small enough to ignore, but in other cases they may be significant. For example, a person may push an object, an engine pull it or the wind blow it. Another force due to air, called ***air resistance*** usually opposes the motion of a moving object and a similar resistance occurs if an object travels through water. Water also supplies a force upwards, often called an ***upthrust***. The force that supports an aircraft is usually called ***lift*** and ***drag*** opposes its motion.

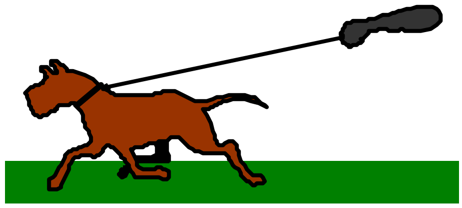
Force Diagrams

Worksheet

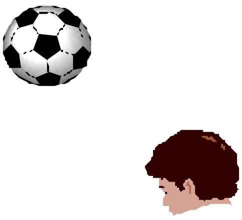
Show the forces that act on the object in each situation:



Cat on a mat

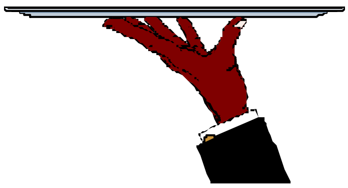


Dog pulling on a lead

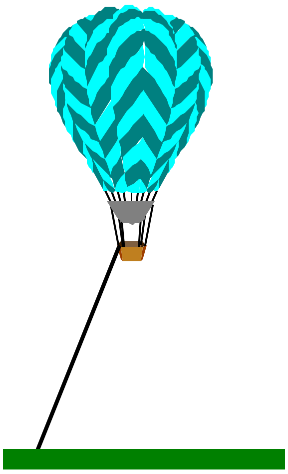


Ball after a header

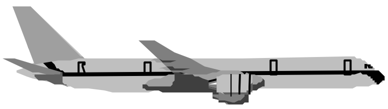
Car on a motorway



Tray on a hand



Tethered balloon



Aircraft

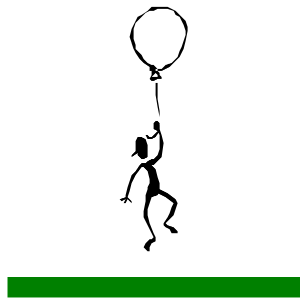
Swimmer

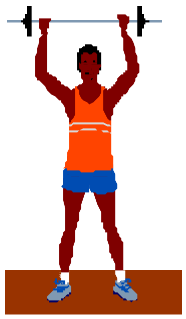
Child on pushchair

On a separate sheet of paper draw simplified sketches of the following situations.
Use dots (points) to represent the objects and arrows to represent the forces.

Mr Bean is being blown along by the wind!
Draw sketches to show

- the forces acting on the balloon
- the forces acting on Mr Bean.



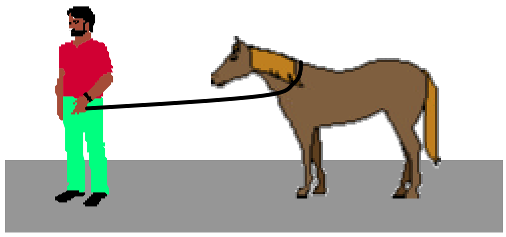


Draw sketches to show

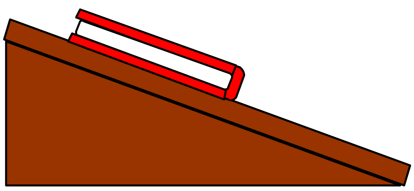
- the forces acting on the weights
- the forces acting on the weightlifter.

Draw sketches to show

- the forces acting on the man
- the forces acting on his horse.

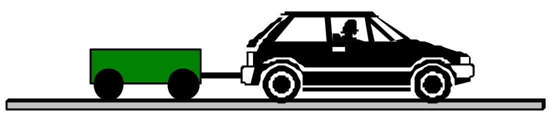


Draw a sketch to show the forces acting on a book lying on a sloping desk
Show the friction and normal reaction as separate forces.



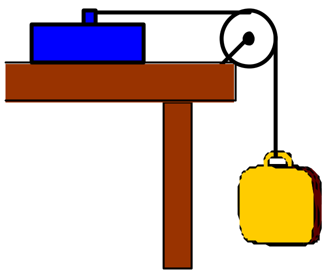
A car tows a trailer along a horizontal road.
Draw sketches to show

- the forces acting on the trailer
- the forces acting on the car.



A tool box lying on a table is attached to one end of a light inextensible string. The string passes over a smooth pulley and the other end is attached to a bag that hangs vertically as shown in the diagram.
Draw sketches to show

- the forces acting on the bag
- the forces acting on the tool box.



© The Nuffield Foundation

Photo-copiable

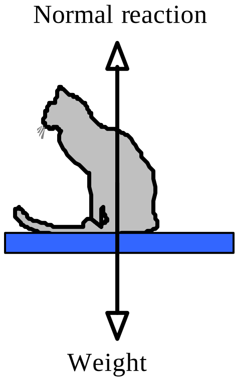
Teacher Notes

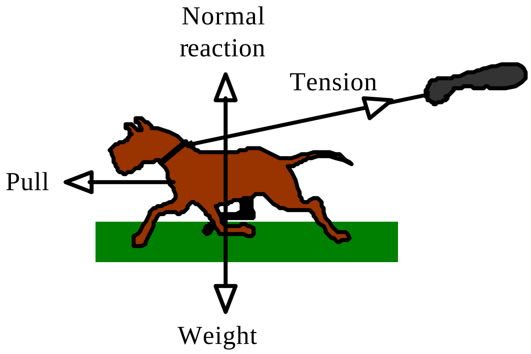
Unit Advanced Level, Dynamics

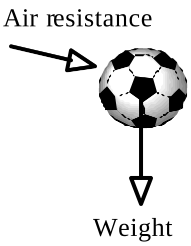
Notes on Activity

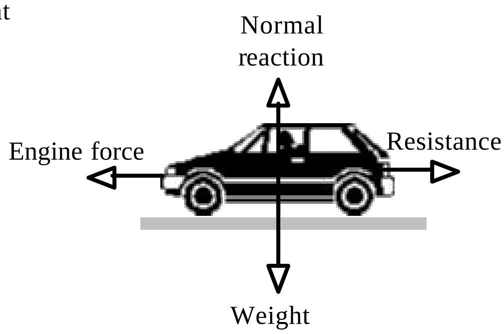
Pages 1 and 2 give a brief summary of different types of forces and some of the terms that are often used in dynamics questions. The worksheets on pages 3 and 4 give practice in showing forces on diagrams. Possible answers are given below, but some forces such as air resistance may be added/omitted depending whether or not they are considered negligible. The PowerPoint presentation includes these examples for use in class discussion which could cover equilibrium from balanced forces and acceleration from unbalanced forces.

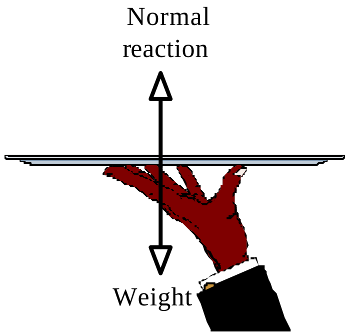
Answers

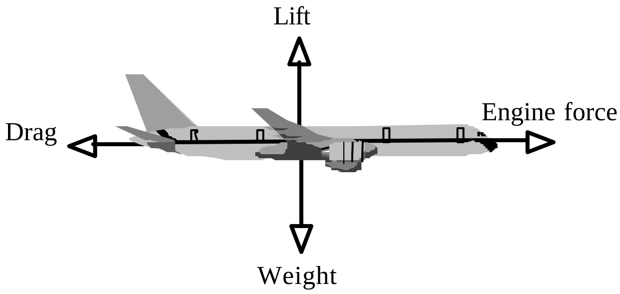


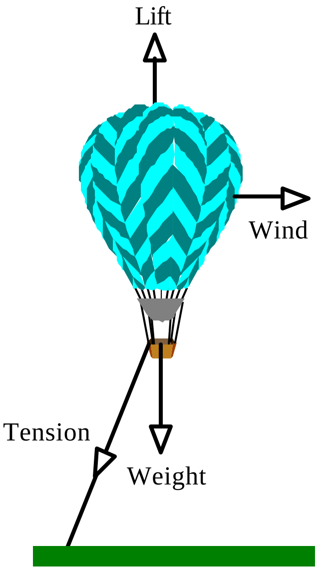


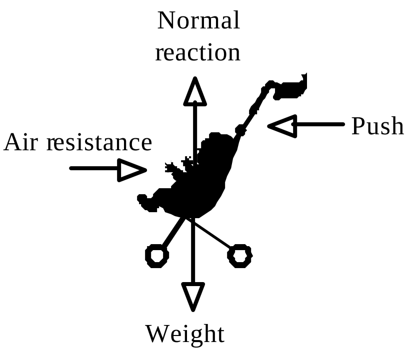


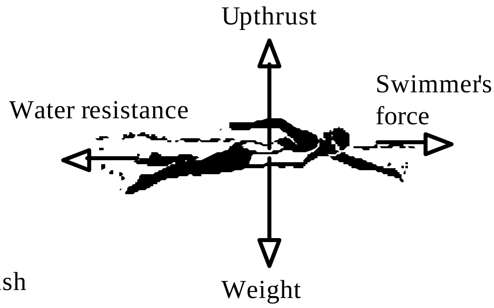




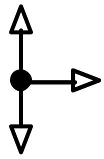




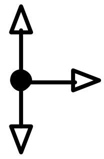




Forces on balloon



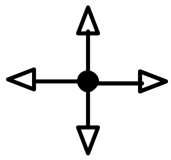
Forces on Mr Bean



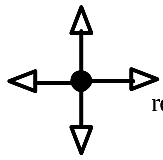
Forces on Weights

Forces on Weightlifter

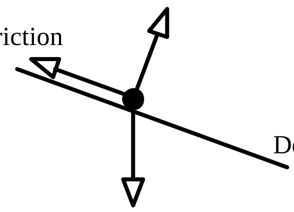
Forces on man



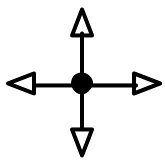
Forces on horse



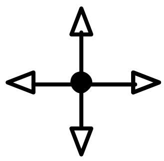
Forces on book



Forces on trailer



Forces on car



Forces on bag

Forces on tool box