Free Body Diagrams

We will need a way of organizing forces that are acting on a particular object. The easiest way to do this is by using a free body diagram.

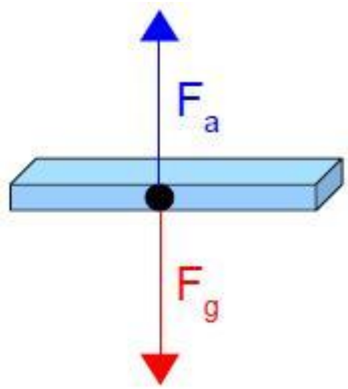
- A free body diagram is just a simple sketch of an object showing all the forces that are acting on it.
- To draw a proper free body diagram, you must follow these steps:

1. Draw a quick sketch of the object; often a simple box will do.
2. Place a dot in the centre of the object. We basically treat this as the spot that all the forces are thought to act upon.
3. For every force acting on the object, draw a vector that shows the size and direction of the force. Each vector must start from the dot and point outwards.
4. Label each vector based on the type of force it is.

Example 1

Sketch a free body diagram for a book being held up by a person.

We draw a quick sketch of the book, and then put a dot in the centre. Next, we identify that there are two forces acting on this book; the force of gravity pulling it down, and the applied force of a person holding it up. Since the book is just being held up (not accelerating up or down), we can assume that the two forces are equal, so we will draw the vectors the same size.



Common Forces

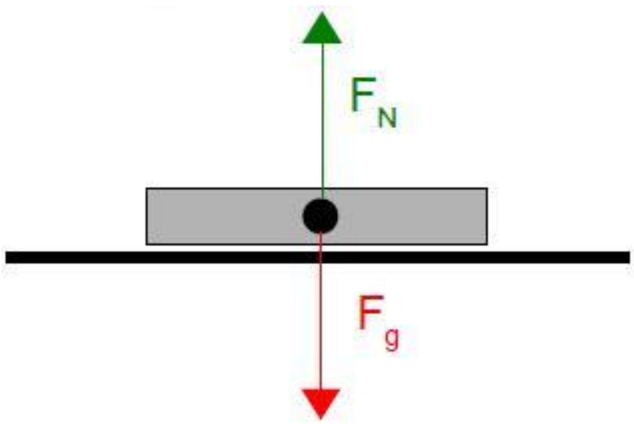
These are the common forces acting on objects that you need to memorize:
F_g = force due to gravity
F_a = applied force
F_f = force of friction
F_T = force of tension
F_N = normal force
F_{NET} = net force

Most of these forces have not been mentioned yet but we'll encounter them soon enough.

Example 2

Sketch a free body diagram of a laptop sitting on a table.

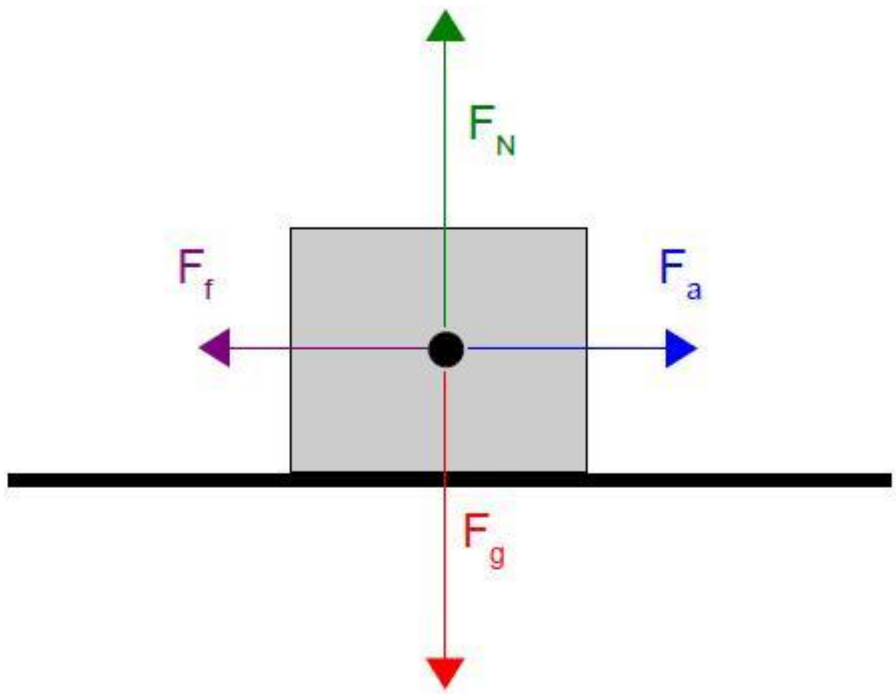
● We know that there will be a force due to gravity (F_g) pulling the laptop down, but if that was the only force it should be dropping down towards the ground.
● There must be a force acting against the force of gravity that is holding the laptop up. This is happening because the table top is strong enough to hold up the laptop.
● We call this upwards force the normal force (F_N). A normal force is exerted upwards by a surface (like a table or a floor) and is perpendicular to the surface.
● As long as the object is not breaking through the table top or flying up into the air, the force due to gravity and the normal force must be equal. This way they just cancel out and the object stays where it is.



Example 3

You are trying to push a heavy box across the floor. It's causing you some trouble because the floor is not very smooth. Sketch a free body diagram of the box.

● We still have a force due to gravity (F_g) and a normal force (F_N) since it is still an object on a surface.
● You are trying to push the box sideways, so this will be an applied force that you are exerting (F_a).
● It's tough to push because of friction between the box and the floor, so we'll also need to draw a force of friction (F_f).
● The force to friction (F_f) always opposes the motion of an object and is parallel to the surface the object is on.
● Notice that the normal force and the force due to gravity are still equal. The applied force and force due to friction are also equal to each other. This tells us that the object is moving at a constant velocity (we'll talk more about this in a different lesson).



Example 4

A sled is sliding down a sloped hill. Sketch the free body diagram of the sled.

We will have a situation similar to the one above, except the object is now on a slope and there is no applied force (you don't usually push yourself down a hill on a sled). Notice that...

- F_g still points straight down.
- F_N points upwards at an angle, since it has to be perpendicular to the surface of the slope.
- F_f points back up the hill, since friction will try to slow down the sled.