Force

A force is simply any push or pull

The unit of force is Newton (N)

It is believed there are only 4 fundamental forces:

1. Gravity	2. Strong Nuclear
3. Electromagnetic ⟷ Some	4. Weak Nuclear

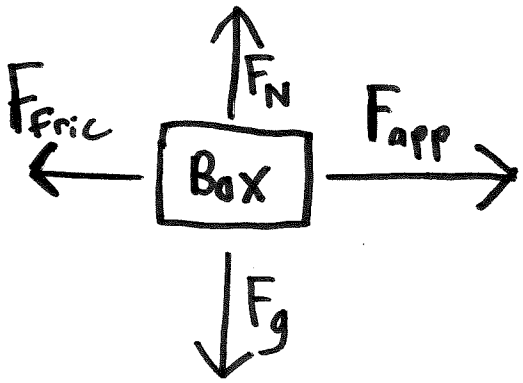
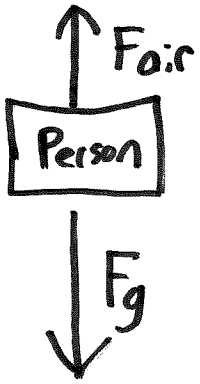
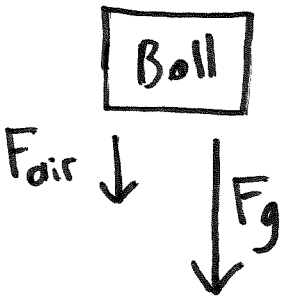
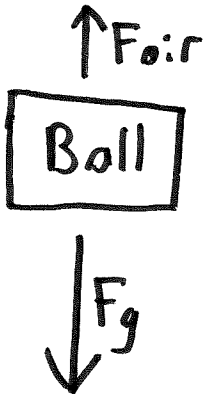
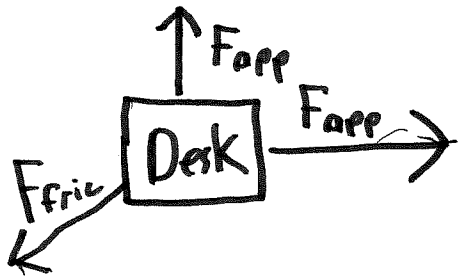
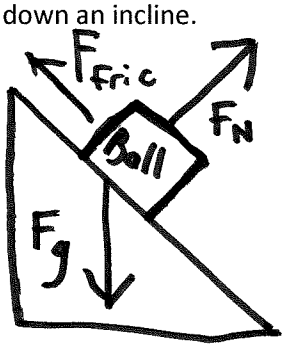
For example, if I push a chair this is really electromagnetic force at a fundamental level. In practice, it is useful to differentiate forces as we experience them.

Some forces we will deal with in this course:

Force	Description
F_g	Force of Gravity = weight
F_{app}	Applied Force
F_{fric}	Friction → Always against motion
F_N	Normal Force ↗ Prevents objects passing through each other
T	Tension → Force acting along a rope
F_E	Elastic Force → springs
F_{air}	Air resistance → like friction

Free body diagrams

Free body diagrams show the Forces which affect an object. Arrows point in the direction the force acts; length of the arrows reflects the magnitude of the force.

A box is pushed along a rough floor. 	A sky diver is falling towards to Earth. 
A ball which has just been thrown is travelling upwards 	The thrown ball falls back downwards. 
A very strong person pushes a desk East while a weaker person pushes the desk North. 	A ball rolls down an incline. 

Newton's First Law

Newton's 1st Law states: An object in motion will stay in motion and an object at rest will stay at rest unless acted upon by an external force.

This is also called the Law of inertia

Inertia: Tendency for objects to resist changes in their motion, related to mass

Another way of stating Newton's 1st law is that if an object has balanced forces acting upon it, it will have constant velocity (if it is not moving it has constant velocity of 0)

Consider a book sitting on a desk, since it is not accelerating the normal force must be equal to the force of gravity.

Consider a box being pushed at constant velocity, since it is not accelerating, the applied force must be equal to the force of friction.

Consider a book sitting on the seat of a car, you hit the breaks and the book flies forward, why?

No force acting to slow book

Newton's Second Law

Newton's second law deals with what happens when forces are unbalanced. It states that an object's acceleration will be in the direction of the net force and will depend on the mass of the object.

Heavier objects require more force to accelerate them.

Lighter objects require less force to accelerate them.

The key equation is:

$$F_{net} = ma$$

(m: mass; a: acceleration; F_{net}: sum of all forces)

This equation gives us the definition of the Newton:

$$\text{Newtons} = \text{kg} \cdot \frac{\text{m}}{\text{s}^2} = \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$$

A 5.0 kg block is pushed to the left with a force of 10.0 N. What is its acceleration?

$$F_{net} = ma$$

$$\frac{F_{net}}{m} = a \rightarrow \frac{10.0\text{ N left}}{5.0\text{ kg}} = 2.0 \frac{\text{N}}{\text{kg}} \text{ left}$$

$$= 2.0 \frac{\text{m}}{\text{s}^2} \text{ left}$$

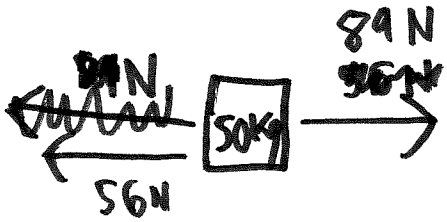
A 650 kg car accelerates at 4.0 m/s^2 South. What is the net force acting on it?

$$F_{net} = ma$$

$$= 650\text{ kg} \times 4.0 \frac{\text{m}}{\text{s}^2} \text{ South}$$

$$= 2600\text{ N South}$$

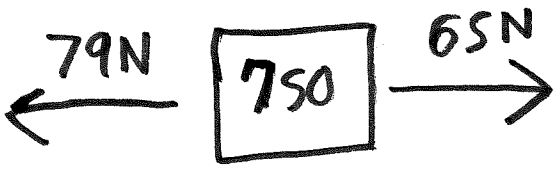
Two people push a 50.0 kg block, one pushes to the left with a force of 56 N, the other pushes to the right with a force of 89 N. What is the net force acting on the block? What is the acceleration of the block?



$$F_{net} = \text{winners} - \text{losers}$$
$$= 89N - 56N$$
$$= \boxed{33N \text{ right}}$$

$$a = \frac{F_{net}}{m} = \frac{33N}{50.0kg} = \boxed{0.66 \frac{m}{s^2} \text{ right}}$$

Two people push a 750 kg truck, one pushes with a force of 65 N right, the other with a force of 79 N left. What is the net force acting on the truck? What is the acceleration of the truck?



$$F_{net} = \text{winners} - \text{losers}$$
$$= 79N - 65N$$
$$= \boxed{14N \text{ left}}$$

$$a = \frac{F_{net}}{m} = \frac{14N}{750kg}$$
$$= \boxed{0.019 \frac{m}{s^2} \text{ left}}$$

Newton's Third Law

Every action has an equal and opposite reaction

OR

Forces come in pair, alike in type and magnitude but opposite in direction

OR

If you push something it pushes back with equal force

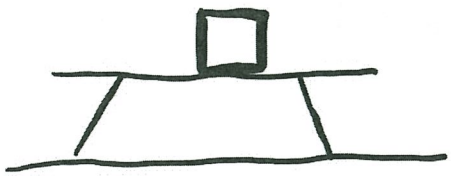
OR

$$F_{A\,on\,B} = -F_{B\,on\,A}$$

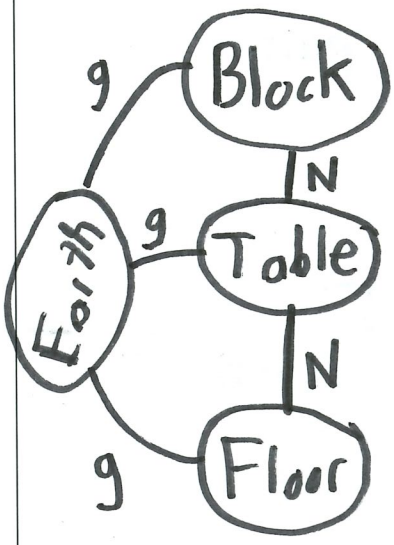
What are the force pairs in each of the following situations?

A nail is hit with a hammer:	A book rests on a table:
$F_{hammer\ on\ nail}$ $F_{nail\ on\ hammer}$	$F_{Earth\ on\ book}$ $F_{book\ on\ Earth}$ $F_{table\ on\ book}$ $F_{book\ on\ table}$

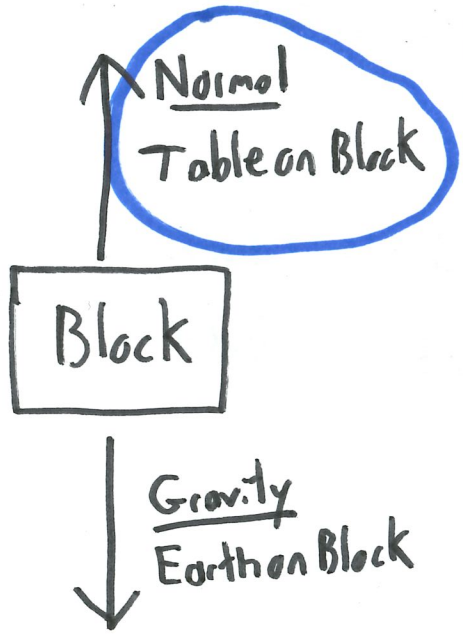
Situation: *A block sits on a table supported by the floor*



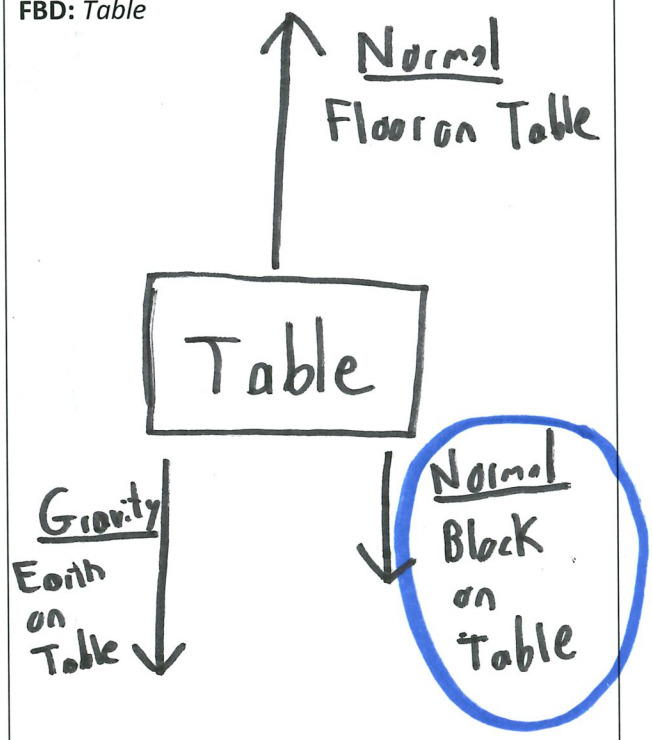
Interaction Diagram



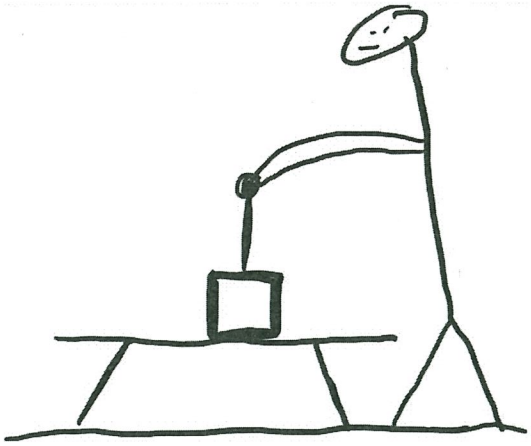
FBD: *Block*



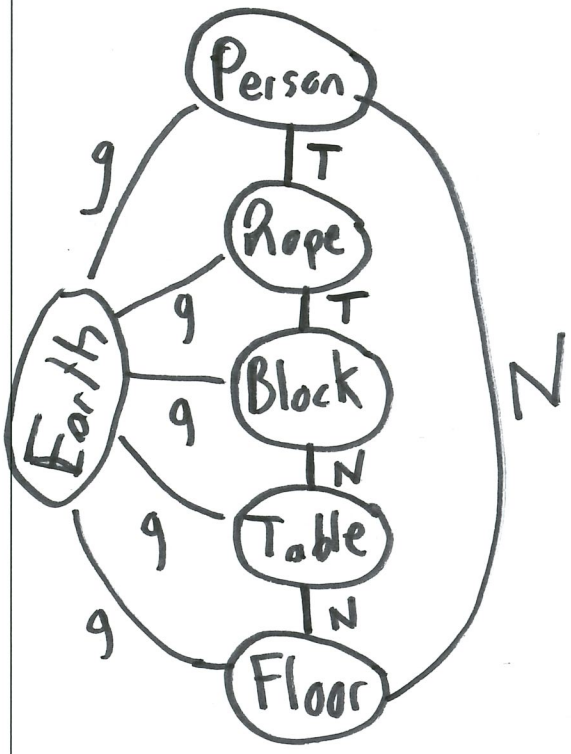
FBD: *Table*



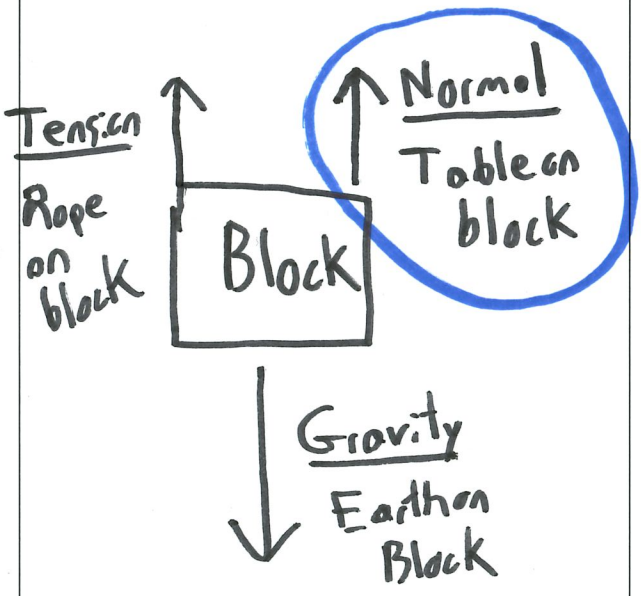
Situation: *A block sits on a table supported by the floor, a person uses a rope to pull upwards on the block but it does not lift.*



Interaction Diagram



FBD: *Block*



FBD: *Table*