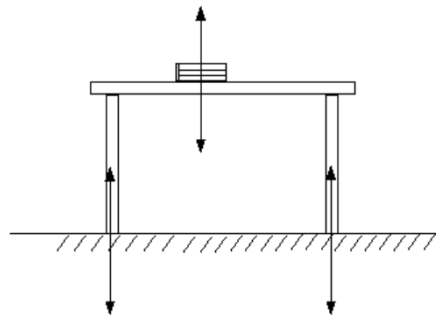


Third Newton's law

It can be simply formulated as follows: **every time one object applies force to another object, this “another” object applies force to the first object.** The forces have equal magnitudes and opposite directions.

The book lying on the table is exerting a downward force on the table, while the table is exerting an upward reaction force on the book. Because the forces are equal and opposite, the book remains at rest. Notice also that the table legs are in contact with the floor and exert a force downward on it, while the floor in turn exerts an equal and opposite force upward.

Normal force is the support force exerted by a surface that is perpendicular to the surface itself, preventing an object from passing through it



For another example, imagine that you try pushing a heavy 20 kg stone while both you and the stone are on ice. You push the stone with a force of 80N. What happens next?

Both you and the stone will slide in opposite directions. What is acceleration of the stone while you are pushing it? It is simple to calculate it:

$$a_{stone} = \frac{F}{m} = \frac{80N}{20kg} = 4 \frac{m}{s^2}$$

What about your acceleration? Assume that your mass is 40kg. But what about force which made you slide? Its magnitude is equal to the magnitude of the force you applied to the stone, but it is directed oppositely. It looks like the stone pushed you with the same force of 80N:

$$a_{you} = \frac{F}{m} = \frac{80N}{40kg} = 2 \frac{m}{s^2}$$

So, your acceleration is to be smaller, because your mass is higher and the magnitude of the forces applied to you and the stone are same.

This “picture” is universal. Whenever you apply force to something this something applies force of equal magnitude and opposite direction to you. **These forces do not compensate each other because they are applied to different objects.** We know that we can add and subtract only the forces applied to the same object.

We can write down Newton's third law as: $\vec{F}_2 = -\vec{F}_1$

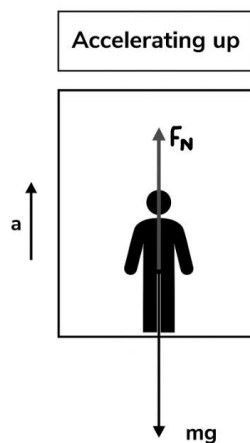
Now we learned three laws which are the base of simple mechanics:

1. The object in motion tends to stay in motion; an object at rest tends to stay at rest.
2. The total net force applied to an object is equal to the mass of the object multiplied by the acceleration of the object.
3. Any time a force is applied by one object to another, a force of same in magnitude and opposite direction is applied to the first object by the second one.

These laws are called Newton's laws of motion.

Example:

A 40 kg boy is inside the elevator. Elevator goes up with the acceleration of 2m/s^2 . Find the force which is applied to the boy by the elevator.



All the forces acting on the body written as a Second Law: $F_N - mg = ma$

$$F_N = mg + ma = 40 \text{ kg} * 9.8 \text{ m/s}^2 + 40 \text{ kg} * 2 \text{ m/s}^2 = 392 \text{ N} + 80 \text{ N} = 472 \text{ N}$$

If the boy was standing on the scale, it would show:

$$M = F_N / g = 472 \text{ N} / 9.8 \text{ m/s}^2 = 48.16 \text{ kg}$$

We actually feel heavier while standing in the elevator moving up – you can check it.

Homework:

- 1) Why can you exert greater force on the pedals of a bicycle if you pull up on the handlebars?
- 2) The gravity force on the surface of the Moon is about 6 times less than this on the Earth. What will happen with your weight and mass on the Moon?
- 3) A tiger has mass 200 kg. It jumps vertically upwards so that normal force acting on it is 3500 N. Find acceleration of the tiger at this moment.