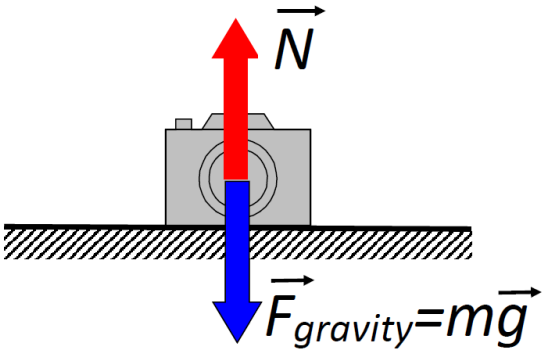
Normal force and friction force

1) Normal force.

Any time we put an object on a table, floor or any other surface this object applies to this surface. **The origin of this force may be just gravity** (the object is attracted by Earth). **We can also apply additional pressure to it**. We observe that the object does not move in vertical direction – it just lies on the table. This means that the gravity force is compensated by some other force or forces. **According to the third Newton's law the surface applies the force of equal magnitude and opposite direction to the object**. This force does not allow the object to go down through the table. We will call this force as "normal force". **Normal force is directed perpendicularly to the surface**.



As we can see in the picture, if the camera just lays on the table, the magnitude of the normal force is equal to the magnitude of the gravity force. Choosing "up" as positive direction:

$$ma = N - mg = 0$$

$$N = mg$$

If we press the camera down with a force F_{press} the normal force will increase to compensate both the gravity force and the pressure force.

$$ma = N - mg - F_{press} = 0$$

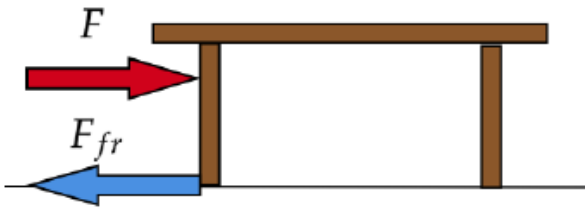
$$N = mg + F_{press}$$

2.1) Static friction force

When we try to push or **pull a heavy box standing on the floor it may not move despite a considerable pulling of pushing force applied**. If the magnitude of pushing (or pulling) force is less than certain magnitude which we will call ***static friction*** *force*, the box will not move, and friction force magnitude is equal to this of the pushing force. If we increase the pushing force, the friction force increases as well until the static friction force is reached. After that, the friction force does not increase anymore and, if we increase the pushing force just a little bit, the box will start moving.

We illustrate static friction on a figure below. The table at rest continues to stay at rest. We push the table with a force F and static friction force is:

$$\vec{F}_{fr} = -\vec{F}$$



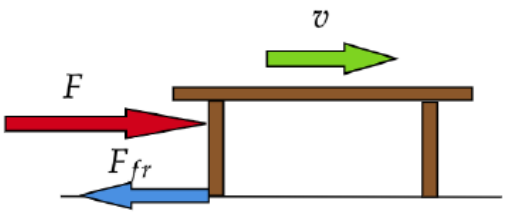
How to calculate the static friction force F_{fr}? **The magnitude of the static friction force is proportional to the magnitude of the normal force**. The heavier the box the stronger we must push to move it.

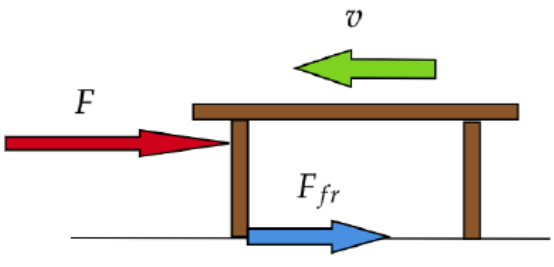
$$F_{fs} = \mu \cdot N$$

Here μ **(this Greek letter reads as "mu") is the coefficient of friction**. This is a number (it is dimensionless which means it has no units and is just a number), which depends on the roughness of the surface. **If the surfaces are rough, this number is large**, so more force is required to move the object.

2.2) Kinetic (dynamic) friction force

Now suppose the force of our push exceeds that maximum of static friction and the table is moving. Does it mean that we have overcome the friction completely, so it does not act on the table anymore? No - if you let the table move by itself it will soon stop. There is a friction force acting on the table when it is moving - this force is called **kinetic friction**.
Static friction opposes any force you push with, up to a certain limit. It is always directed oppositely to the applied force. **Direction of the kinetic friction force is always opposite to the velocity** of the moving object.





Homework:

1) 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?

2) You push a table with force 50 N to the right but it does not move. What is the magnitude and direction of the friction force acting on the table? Is it static or kinetic friction?

3) A 1 kg block lies on the floor of an elevator. When do we need to apply larger force in order to move the block horizontally with constant velocity: if the elevator is at rest of if it is accelerating upwards?

4*) A 2000kg car accelerates at 5m/s2. The friction coefficient is 1/10. Find the pulling force of the car's engine. ((optional))