Homework 6.

Equilibrium.

We learned that similar to the force which produces linear acceleration, torque is the reason for angular one. As long as there is nonzero torque with respect to certain axis – the object starts turning around this axis. From this we can conclude that **if an object is in equilibrium than both total net force and total net torque with respect to any point are zero**.

To calculate torque we have to now the position of the pivot point with respect to the position of the point to which the force is applied. For some forces it is trivial to find the point of application – for example if you push an object with your finger. For certain forces it is not that straightforward. Below we will discuss how to find the application point for the gravity force.

The point of application of the gravity force is called "center of gravity".` Here we have to clarify. Definitely, the gravity force is applied to any point of the object. But if you place the pivot point in some special place, the object will be balanced. This means that the torque produced by the gravity force is zero and the "effective" point of application of the total gravity force coincides with this pivot point.

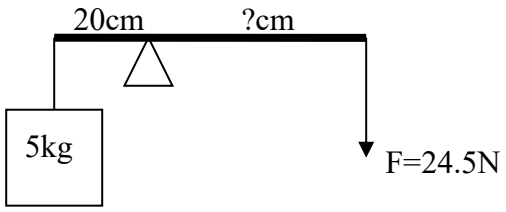
Near the Earth surface where the directions of the gravity forces applied to different parts of an object are parallel with good accuracy, the center of gravity coincides with the center of mass. To find the location of the center of gravity we can use the following property:
The center of gravity of a homogeneous symmetric body must lie on its axis of symmetry. Intuitively it is clear: again, if we will place the pivot point to the center of gravity of an object and then release the object it (the object) will not flip. That is because the gravity force in this case is applied to the pivot point and the torque of gravity force with respect to the pivot point is zero.

So if you can find at least two concurrent axes of symmetry – their intersection is the center of gravity. For simplicity, we will discuss only highly symmetrical homogeneous objects such as cylinders, parallelepipeds, spheres etc. But the center of gravity can be calculated for any object with arbitrary shape and mass distribution.

The center of gravity is unique. It is not possible for an object to have more than one center of gravity.

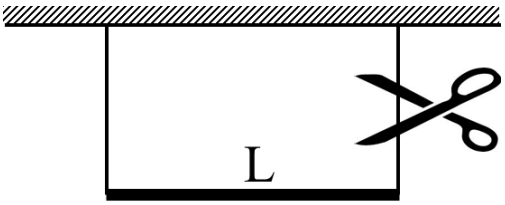
The center of gravity does not necessarily belong to the object. For example, the center of gravity of a donut is in the middle of the hole.

1. Break a match into two parts then break each part into two more parts. Why it is more difficult to break shorter parts?
2. Why the door knob is usually attached to the edge of the door rather than to the middle?
3. The system in the figure is in equilibrium. The lever is weightless. What is the length of the second arm of the lever?



4. Solve problem 1 for the case of the lever is thin rod with uniform density and the mass of 2 kg.

5. A rod of length L is suspended on two threads attached to its ends (see Figure below). We cut one of the threads. Find angular acceleration of the rod right after the thread is cut.



6. A heavy cylinder of mass ***m*** is being lifted to the step of height ***h***. The force ***F*** is applied to the center of the cylinder as it is shown in the Figure above. The radius of the cylinder is ***R*** and it is larger than the height of the step. Find minimal force we have to apply to the cylinder to roll it on the top of the step.

