Static Equilibrium and Torque

Section 1: Static Equilibrium I – Balancing Forces

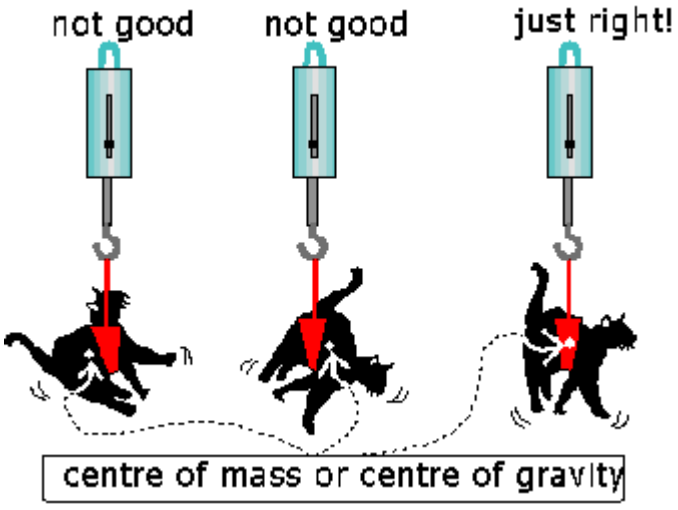
Statics -the physics of keeping objects still by applying forces on them in the appropriate places.

- An object is static equilibrium has no translational motion and no rotational motion. Hence, all applied forces lead to zero velocity and zero acceleration.

To acquire **static equilibrium**, we need to know

- what forces must be applied and
- where the force or forces must be applied.

Every object has a point where its mass and weight appear to be concentrated. This point is called the **centre of mass (CM) or the centre of gravity (CG)**. The cat in the picture is "balanced" when the supporting string falls in line with the white dot, which is its CM and CG.



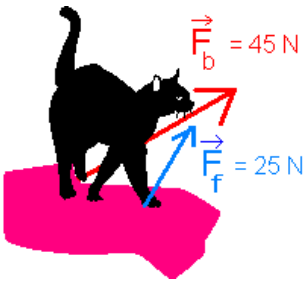
To achieve static equilibrium, 2 conditions must be met:

1 $\mathbf{F_{net} = 0}$, ie $\sum F_x = 0$, and $\sum F_y = 0$, where F_{net} is the sum of all forces acting through the cente of mass. If $F_{net} = 0$, then there is **no translational acceleration or motion.**

2 $\boldsymbol{\tau_{net} = 0}$. If $\tau_{net} = 0$, then there is **no rotational motion.**

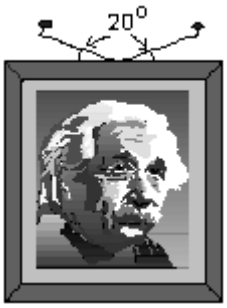
Example 1

In the picture to the right the cat is pushing with its front legs and back legs. The front legs cause a forward force of F_f = 25 N [60^o above the horizontal], and the back legs cause a forward force of F_b = 45 N [30^o above the horizontal]. What must be the magnitude and direction of the equilibrium force (F_e) applied by you in order to maintain static equilibrium?



Example 2

In the picture to the right the CG of the piece of art is directly under the point where the supporting strings are attached. The hanging picture weighs 72 N and each of the supporting strings makes an angle of 20^o with the frame. What is the tension in each string?



Example 3

In the picture to the right the CG of the piece of art is directly under the nail that supports it. The hanging picture weighs 72 N and the supporting string forms an isosceles triangle with the frame as shown. What is the tension in the string?

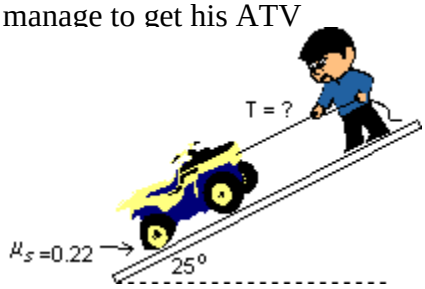
Example 4

The following set of forces act on a common point: $F_1 = 55$ N [E] and $F_2 = 45$ N [15^o W of N]
What additional force is needed to maintain static equilibrium?

Example 5

Our intrepid physics student has gotten himself in trouble again. He has manage to get his ATV halfway up a ramp and realizes that he needs help.

With the aid of friction caused by a flat tire he just manages to hold the machine steady. The coefficient of static friction is 0.22 and the ATV has a mass of 250 kg. What is the tension in the rope?



Example 6

A boom set-up for weighing very large fish is shown in the picture. The boom can withstand a compression force of 3.0×10^3 N. What is the mass of the largest fish that can be weighed?