Chapter 7
Equilibrium and Elasticity

Kittipong Siengsanoh, Ph.D.(Physics)

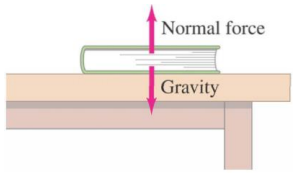
Physics, Science and Technology Department

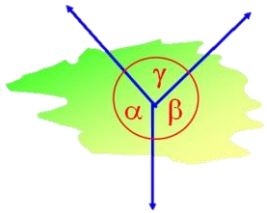
Nakhon Pathom Rajabhat University

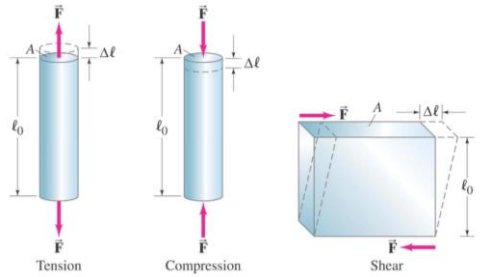
- Standard Sc 4.2
  - Understand the nature of the movement of objects in nature, the process of inquiry, knowledge and science. Communicate what is learned and bring knowledge .Take advantage.

Equilibrium and Elasticity

- Equilibrium
  - Static Equilibrium
  - Dynamic Equilibrium
- Translational Equilibrium
  - 2 Forces
  - 3 Forces
- Rotational equilibrium
  - Moment of force
  - Moment of a couple
- Equilibrium of a Deformable Body
- Centre of mass and Centre of gravity
- Stability of balance
- elasticity
  - Young's modulus
  - Stress-Strain Relationship

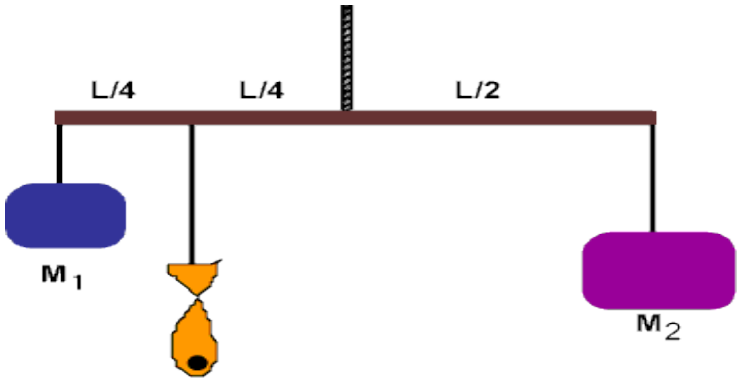


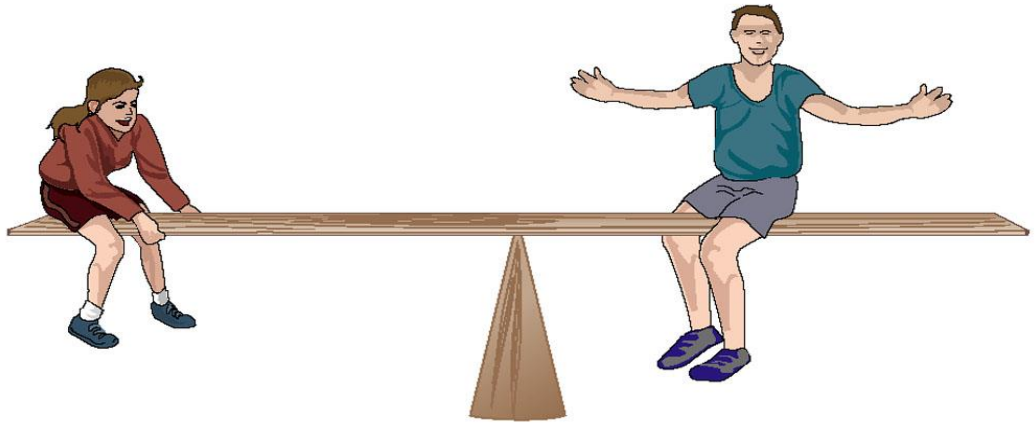


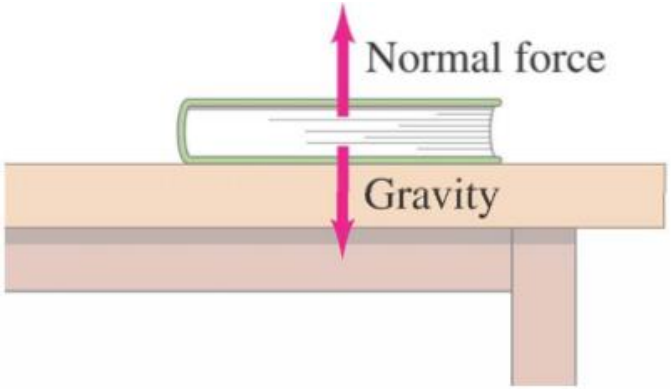


What is equilibrium ?

The condition where the object can maintain the original motion condition of the object.







Types of equilibrium :

Static Equilibrium

- The balance of a non-translating and non-rotating object with the resultant force acting on the object is zero.

Dynamic Equilibrium

- The equilibrium of a moving object with a constant velocity or rotation with a constant angular velocity.

Translational Equilibrium

- The object is stationary, not moving in a straight line. Or move in a straight line with a constant linear velocity.
- The sum of the forces acting on the object is zero. ($\sum F = 0$)

$$\sum F_x = 0 , \sum F_y = 0$$

Consider x-axis

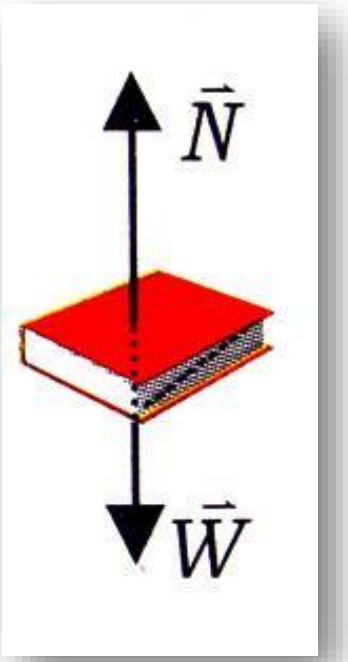
$$\sum F_x = 0$$

$$F_1 - F_2 = 0$$

$$F_1 = F_2$$

F ← = F →

Consider Y-axis



$$\sum F_y = 0$$

$$N - W = 0$$

$$N = W$$

F ↑ = F ↓

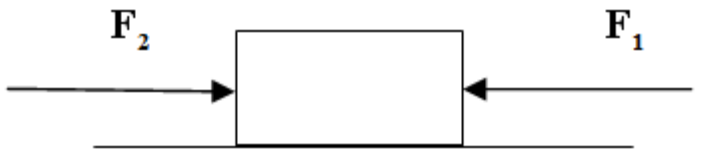
2 Forces in Equilibrium

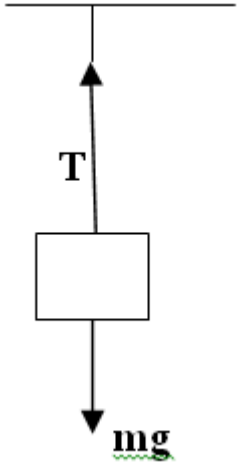
Condition

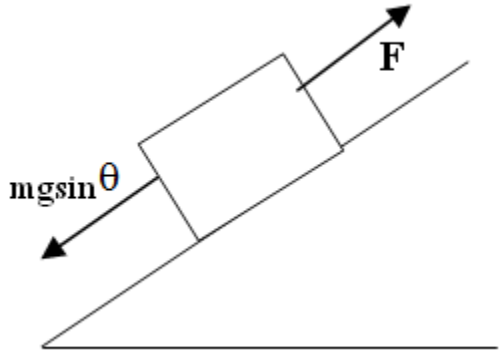
1. equal (have equal magnitudes)

2.Opposite and in the same line.

3.The force of the two forces is equal to zero.







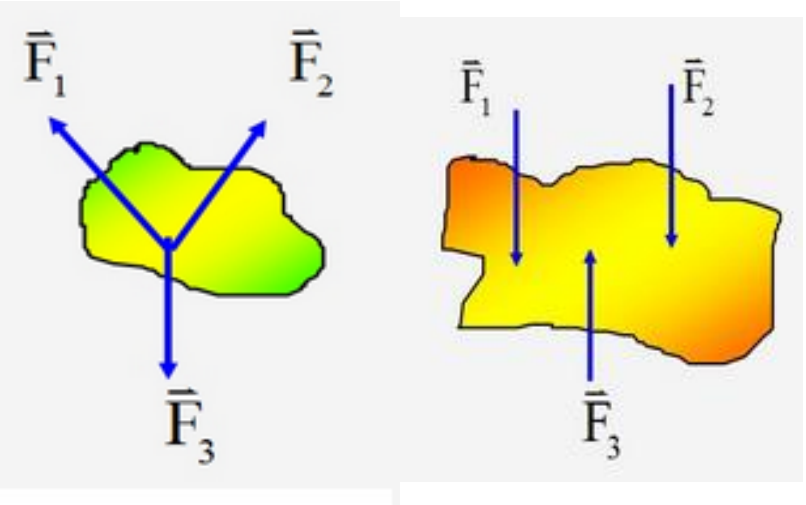
3 Forces in Equilibrium

Condition

1.The force of the three forces is equal to zero.

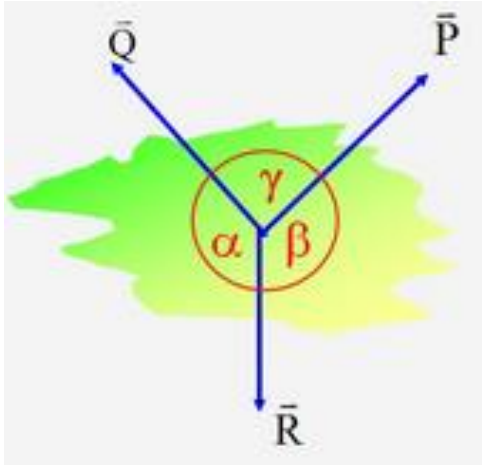
2.All three forces must be in the same plane.

3.All three must meet at the same point Or parallel.



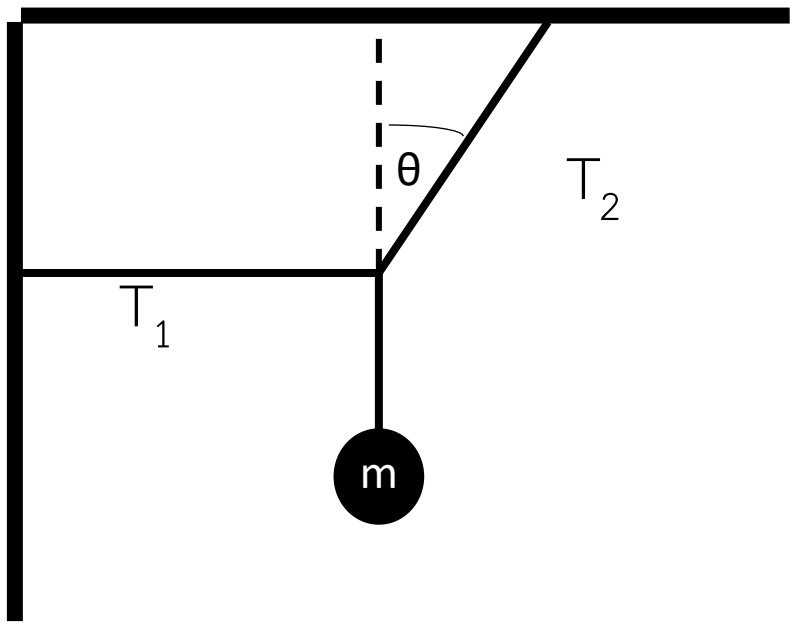
Lami's Theorem

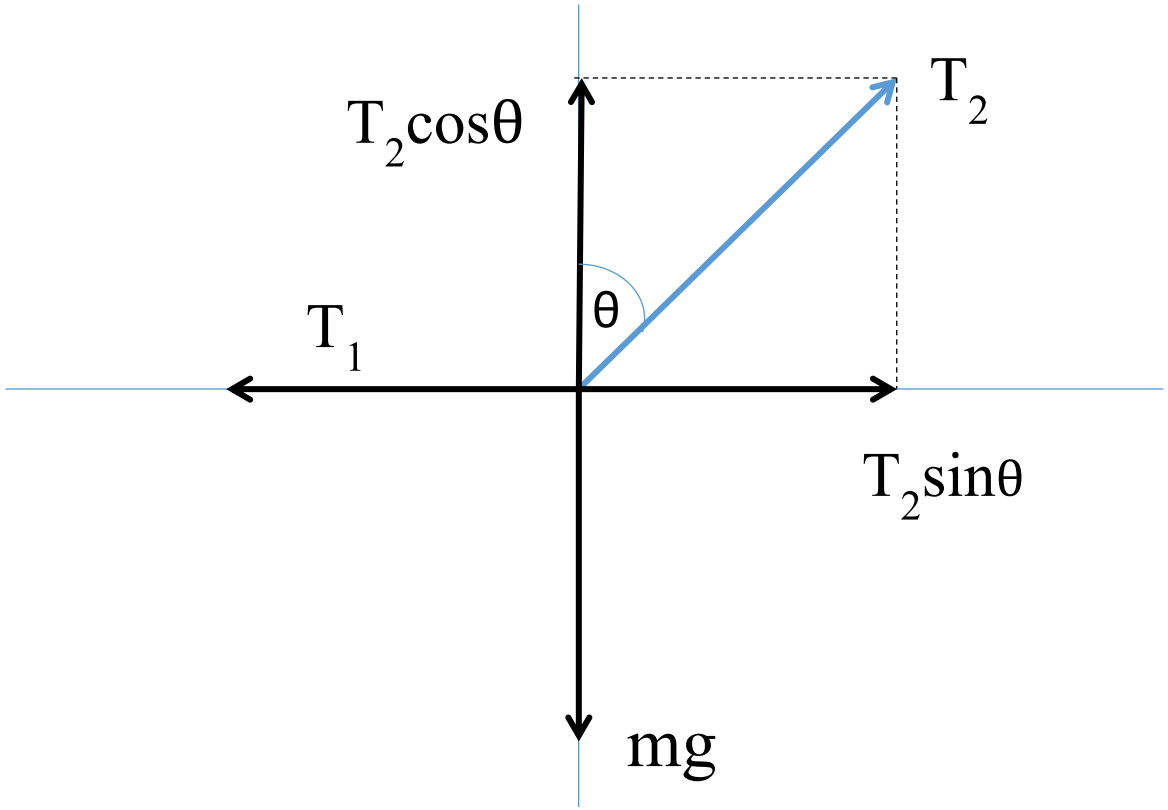
- "If there are three forces acting at one point and in a balanced state, the ratio of force to the Sin of the opposite angle. Is equal "



$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

Various forces with the object should know.

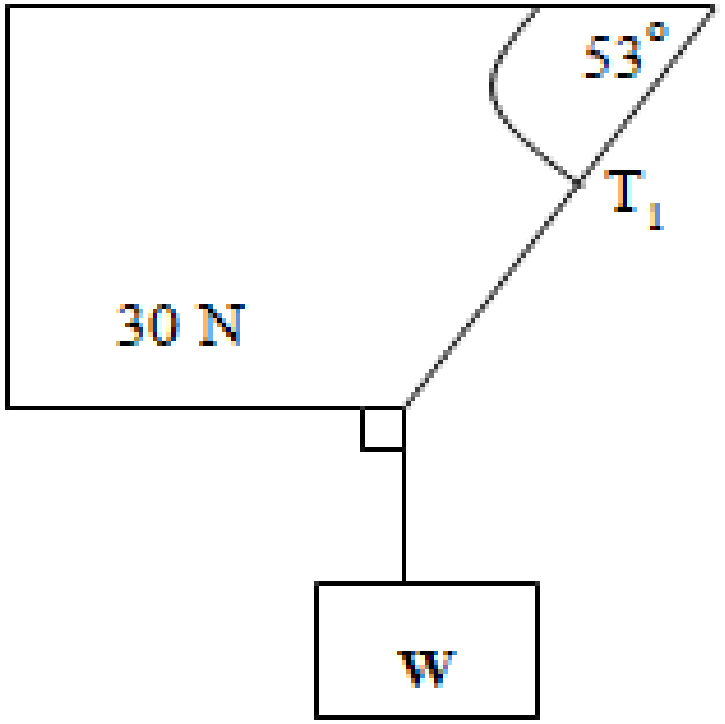


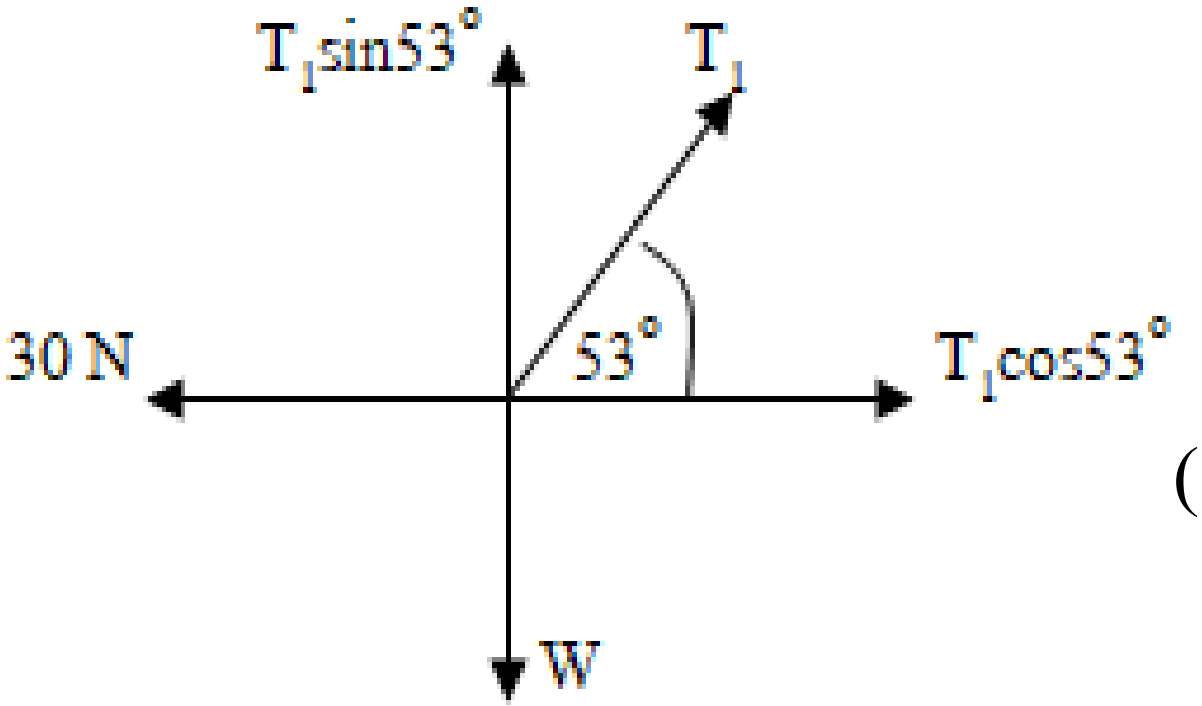


The force is in the x and y axis.

Example

Heavy objects W can be hung with the rope as shown. If the tension in the rope along the level is 30 Newton, find the weight W





$$\sum F = 0$$

$$T_1\sin53^\circ = W \quad \ldots.(1)$$

$$T_1\cos53^\circ = 30 \quad \ldots..(2)$$

$$(1)\div(2) \; ; \tan53^\circ = W/30$$

$$W = (30)(4/3)$$

$$\therefore W = 40 \text{ N}$$

Friction

- The force at the contact surface that moves the object.

$$f = \mu N$$

Kind of friction

Static friction

Friction occurs between the surface of the object. In the state where the object has been forced to stand still.

Kinetic friction

Friction occurs between the surface of the object. In the state where the object is subjected to force, the motion is constant.

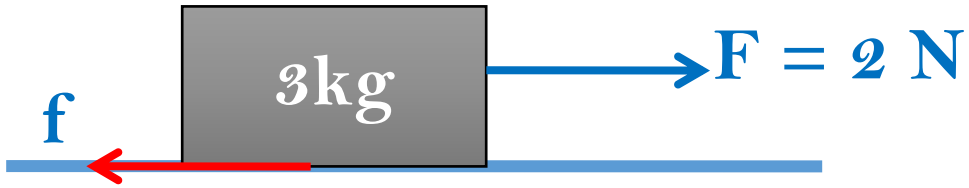
1

$\mu_s = 0.2$

f = ?

f = 0 N

2

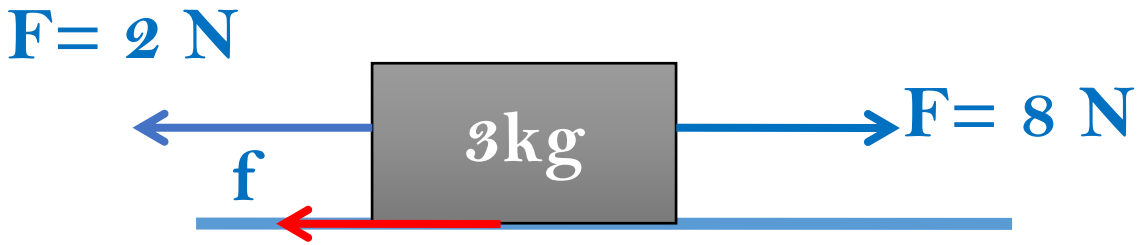


$\mu_s = 0.2$

f = ?

f = 2 N

3



$\mu_k = 0.2$

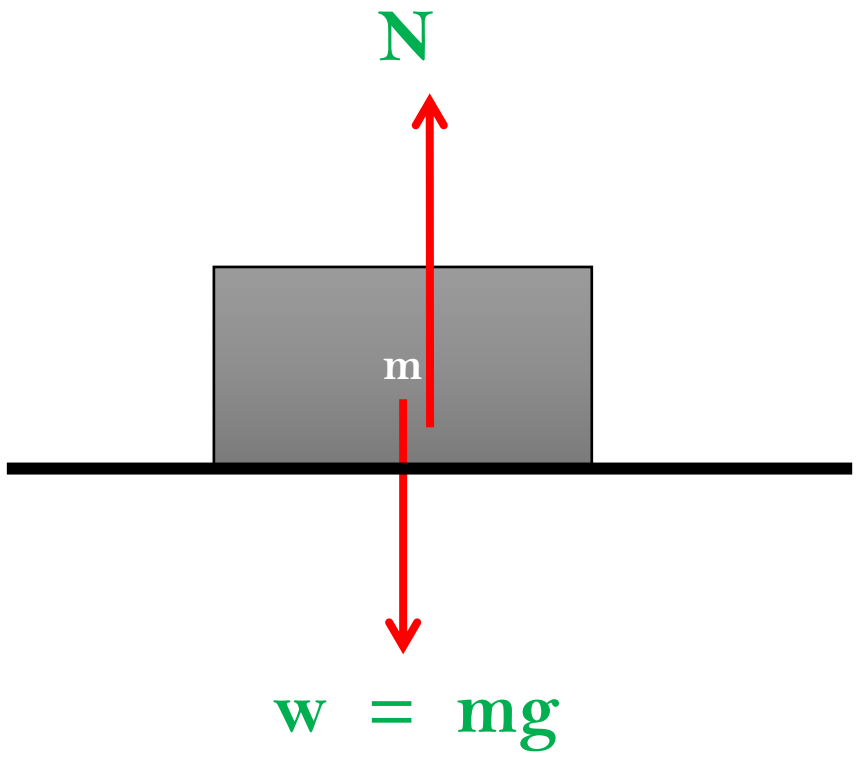
f = ?

f = 6 N

Determining the reaction force perpendicular (N)

1.Placed on a flat surface or force parallel to the ground.

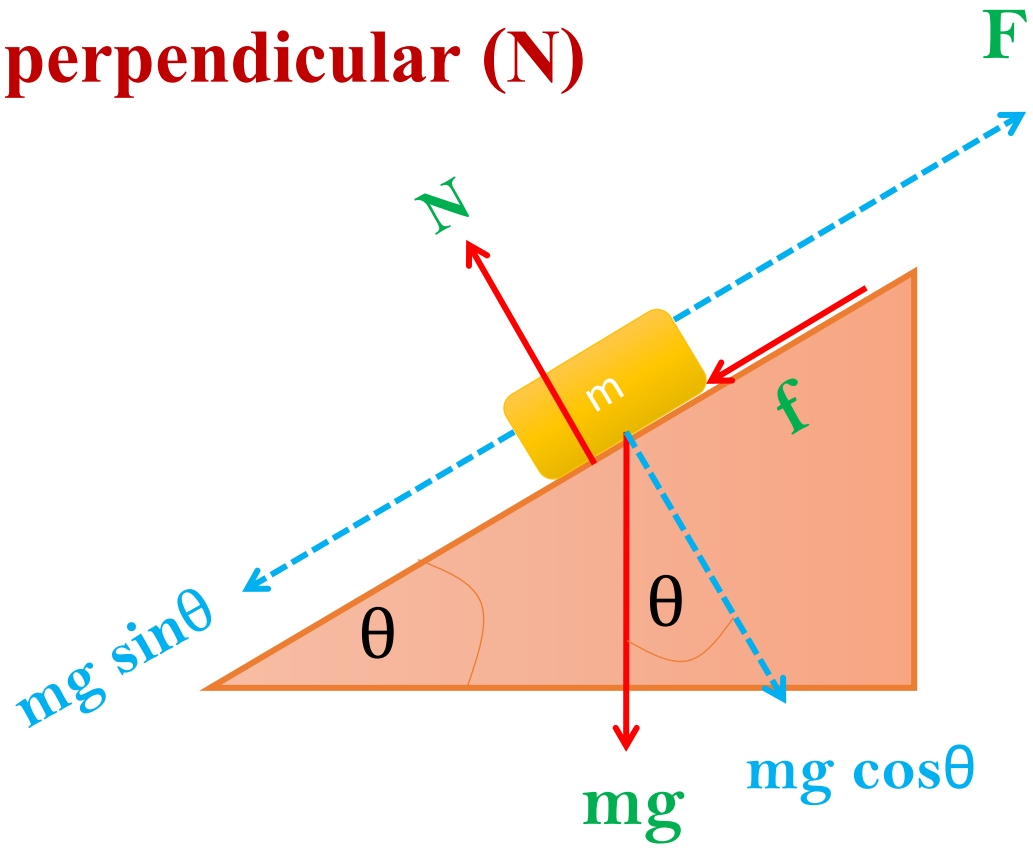
$$N = mg$$



Determining the reaction force perpendicular (N)

- 2.The object is placed on an incline or force on the tilt .

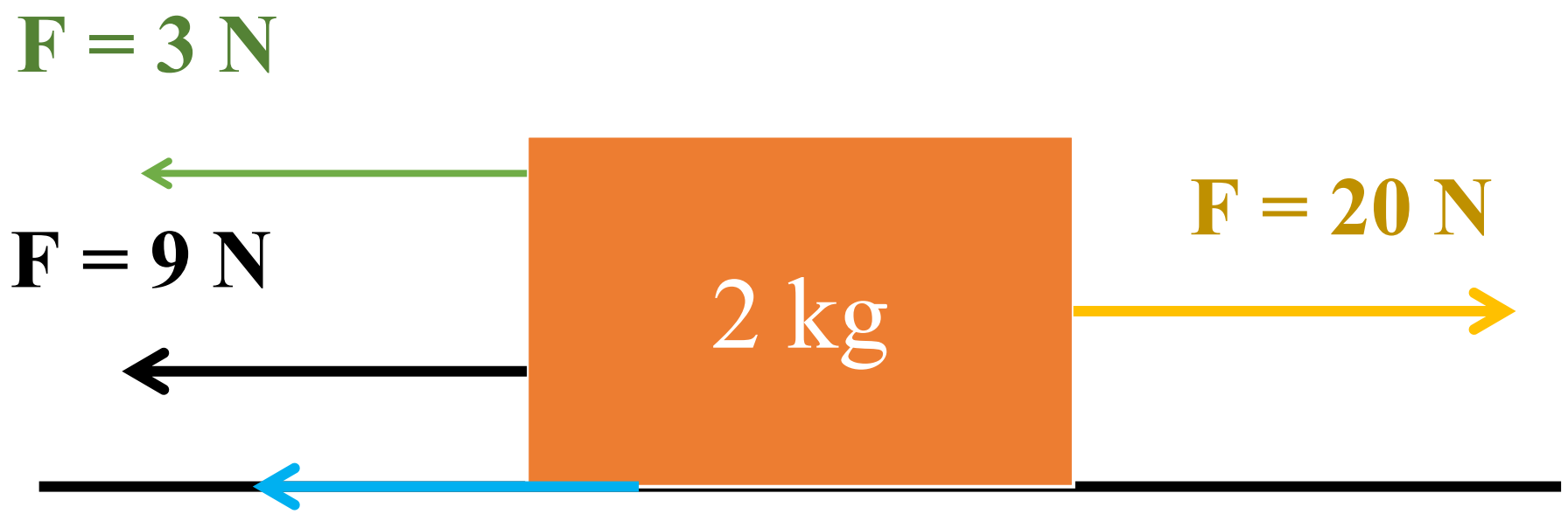
$$N = mg\cos\theta$$



Example 1

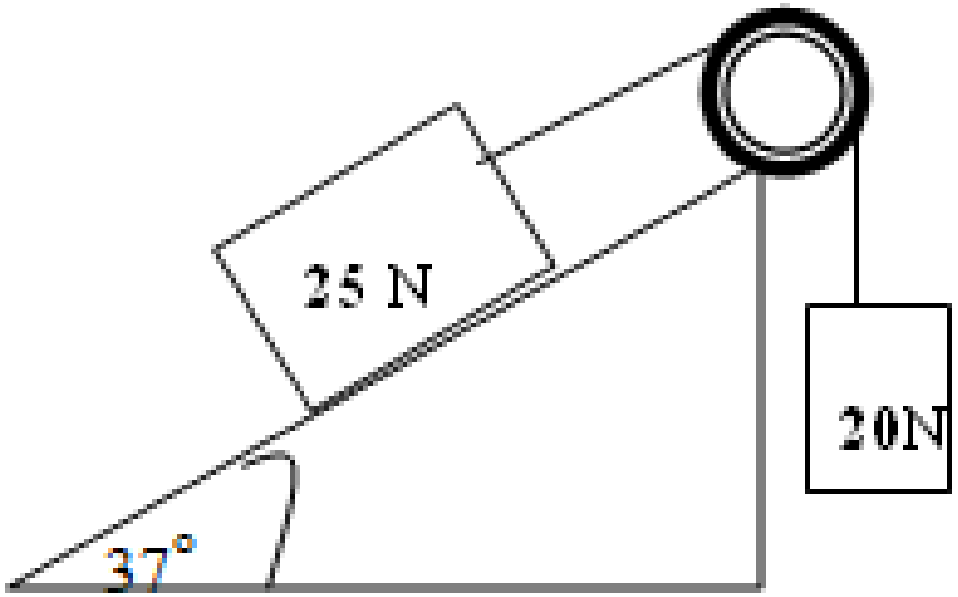
$\mu_s = 0.1$

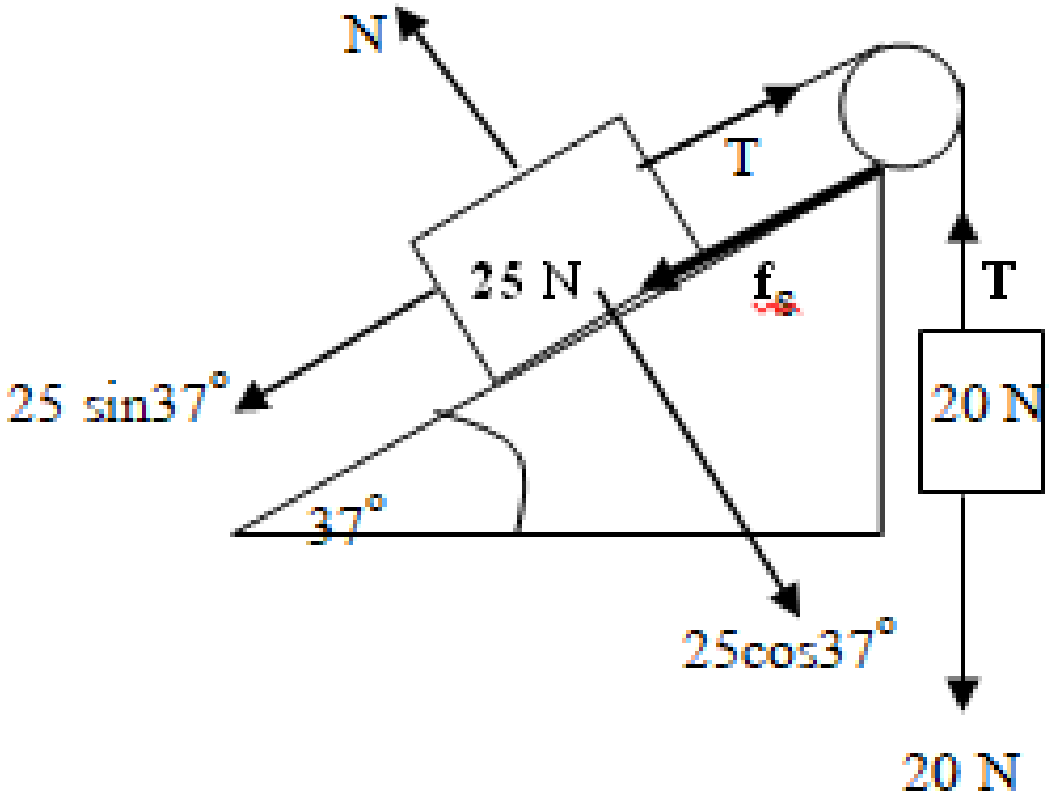
Example 2



$\mu_s = 0.4$

Heavy object, 20N, hanging with a rope through a pulley without thinking. The other side of the rope tied to 25 Newton objects are placed on the tilting surface as shown. When released independently, it turns out that the object is placed on a sloping floor. Move up the sloping floor. Find the friction coefficient between the ground and the object.





Consider a heavy object 25 Newton

$$\sum F = 0$$

$$T = 20\ N$$

Consider a heavy object 25 Newton

$$\sum F = 0$$

$$T = 25 \sin 37^\circ + f_s$$

$$T = 25 \sin 37^\circ + \mu_s N$$

$$T = 25 \sin 37^\circ + \mu_s (25 \cos 37^\circ)$$

$$20 = 25(3/5) + \mu_s (25)(4/5)$$

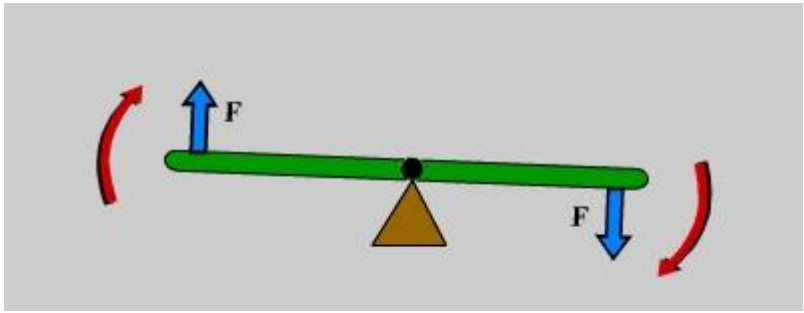
$$20 = 15 + 20\,\mu_s$$

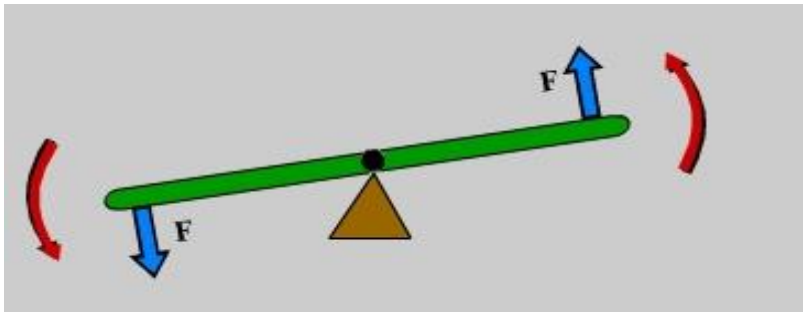
$$\mu_s = 0.25$$

Rotational equilibrium

Moment of force

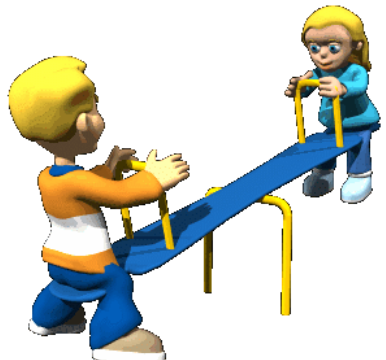
- The effect of the force on the object so that the object rotates around the pivot point.





$$M = F \times r$$

$$M_1 = M_2$$

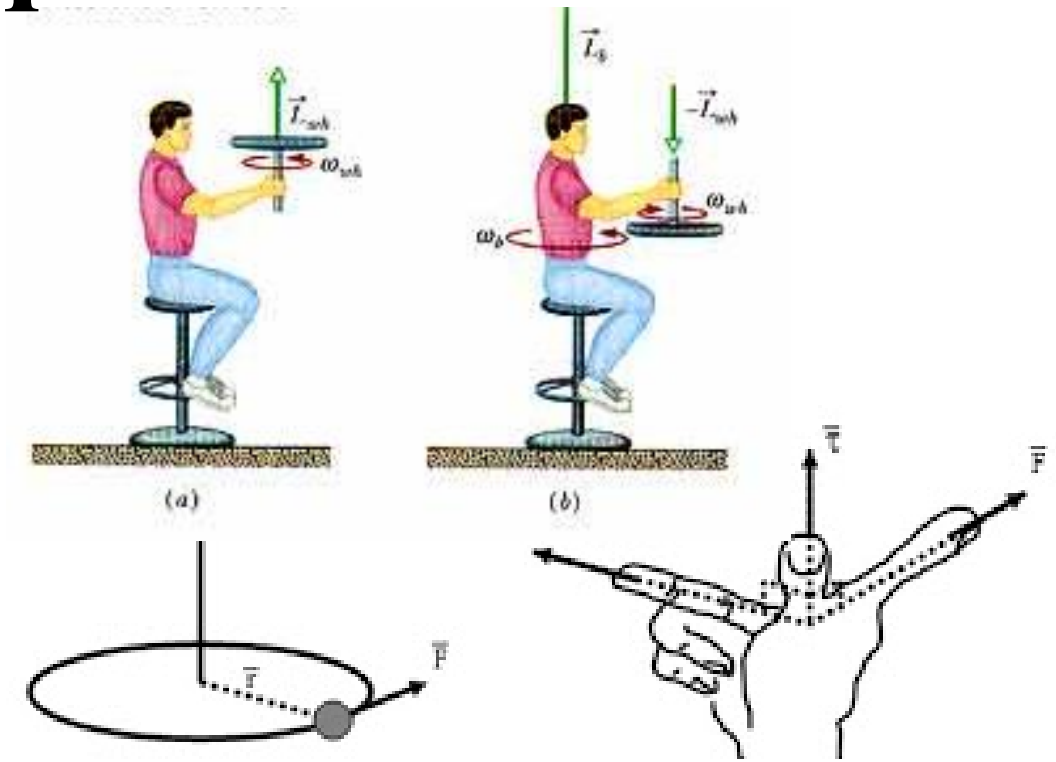


Rotational equilibrium

- **Torque**

The effort of the force to rotate the object around the axis or pivot.

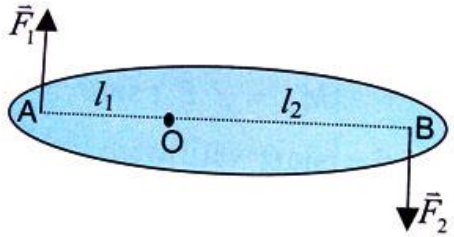
$$\tau = r \times F$$



Rotational equilibrium

Couple

- The force is the same size. Parallel force But there are opposite directions.



Moment of a couple

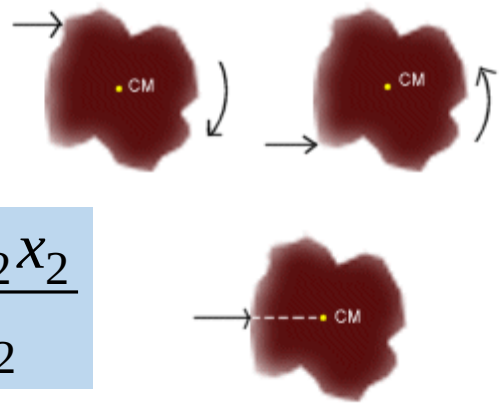
- The moment of the coupling force is equal to the force multiplied by the distance between the two forces, regardless of the rotation.

$$M_c = F \times \ell$$

Centre of mass and Centre of gravity

Center of Mass : CM

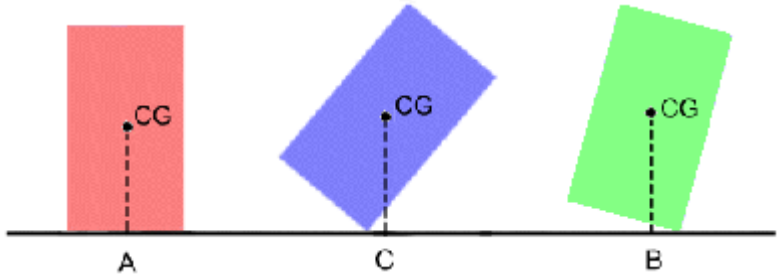
- It is the position equivalent to the total mass of the object.



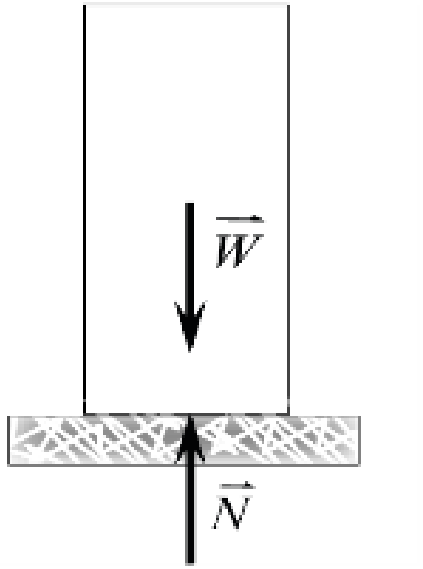
$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

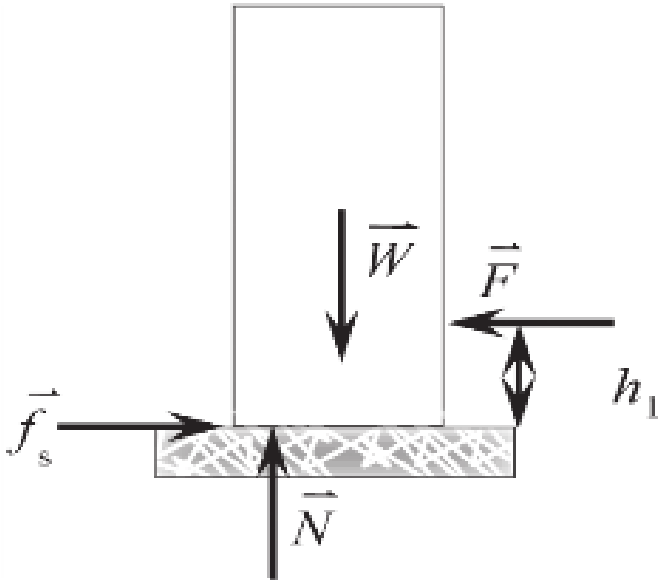
Center of Gravity : CG

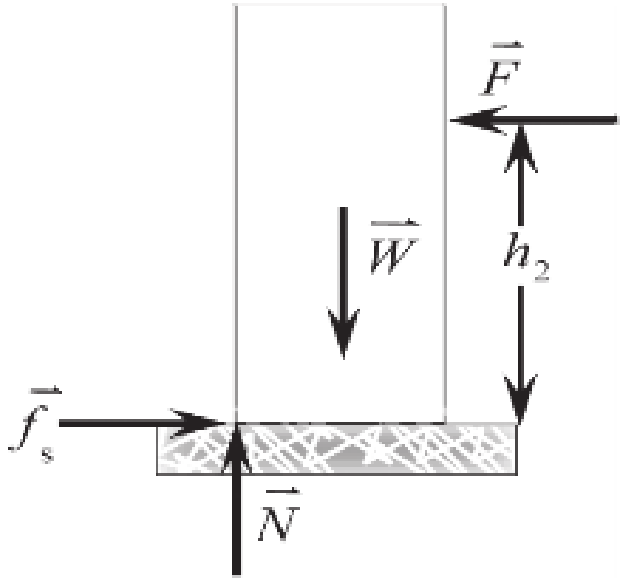
- It is the position where the force of gravity of the earth acts on the object.

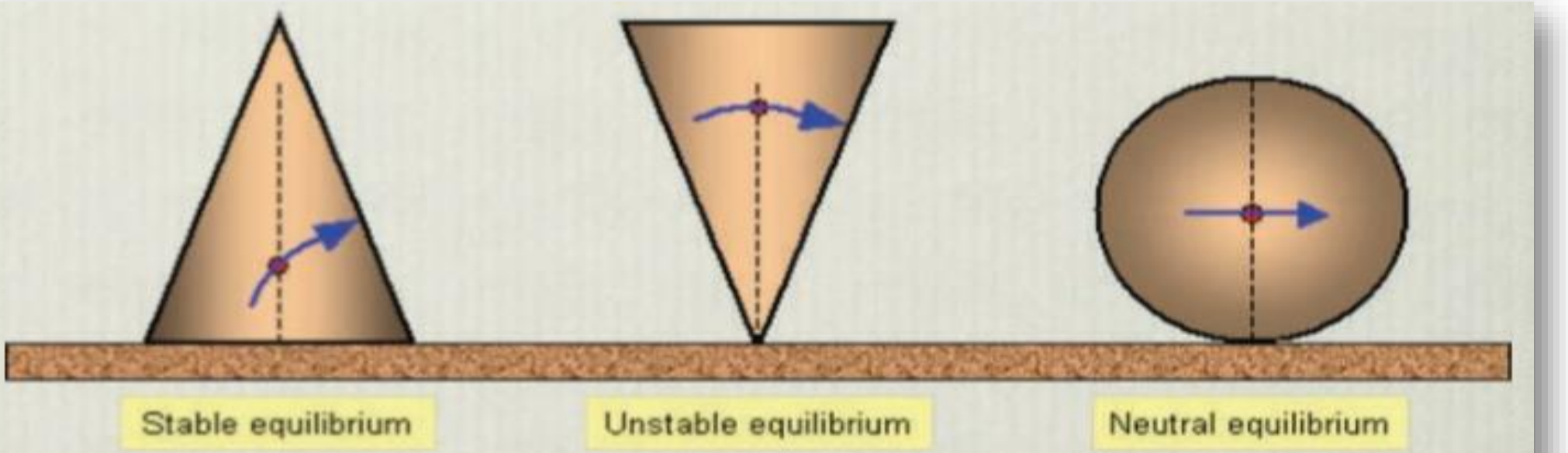


Balance of objects



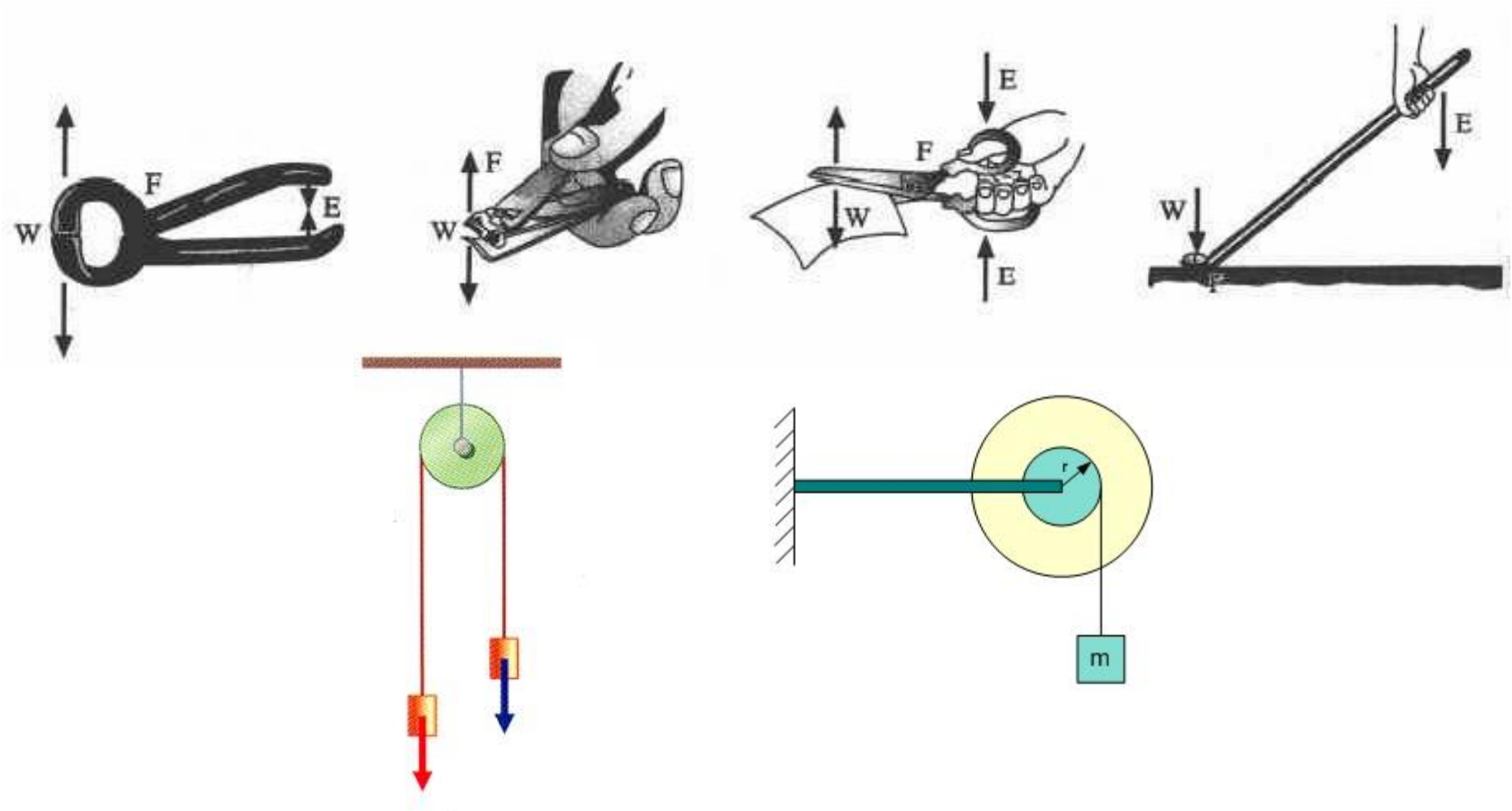





Stable equilibrium
Unstable equilibrium
Neutral equilibrium


(a) Stable
(b) Unstable
(c) Neutral

Application



Elasticity

- **Elasticity** is a condition of material that has changed shape. When the force is applied and can return to its original shape when the action is stopped.

Elasticity : Stress and Stain

Stress

- Stress is defined as the force per unit area.

$$\text{Stress} = \frac{\text{force}}{\text{area}} = \frac{F}{A}$$

Stain

- Strain is defined as the ratio of the change in length to the original length.

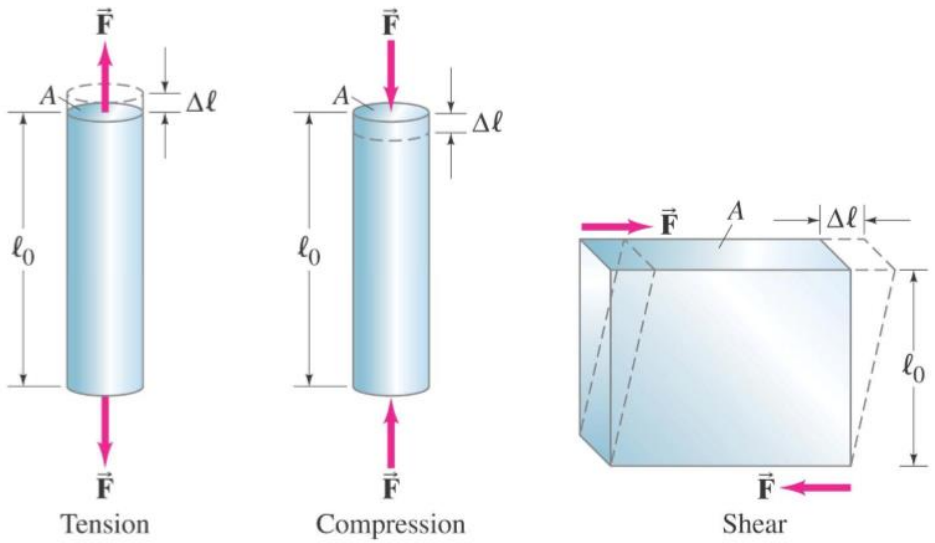
$$\text{Strain} = \frac{\text{change in length}}{\text{original length}} = \frac{\Delta l}{l_0}$$

statics_equilibriumlect.pdf | chapter09_2017.pdf | LectureCh12.pdf

file:///C:/Users/User/Desktop/LectureCh12.pdf

12-4 Elasticity; Stress and Strain

The three types of stress for rigid objects:



19:38
12/3/2561

Elasticity : Young's modulus

- The strength of the material.
- The elastic modulus is equal to the stress divided by the strain:

$$\varepsilon = \frac{F/A}{\Delta\ell/\ell_0} = \frac{\text{stress}}{\text{strain}}.$$

Reference

The Institute for the Promotion of Teaching Science and Technolog. (2556). **More Book Physics Vol. 2.** (4th edition). Bangkok

The Institute for the Promotion of Teaching Science and Technolog. (2554). **Teacher's Guide to Physics More Book 2.**(1st edition). Bangkok

Young , Hugh D. **University physics.** (10th edition)