I. Mechanics……Fundamentals Concepts…..Basic Quantities

1. Length: used to locate positions and measure sizes

الطول: ويستخدم لتحديد المواقع وللقياسات الجيومترية: مسافة، طول، مساحة، حجم.

1. Mass :quantity of matter and resistance to velocity change.

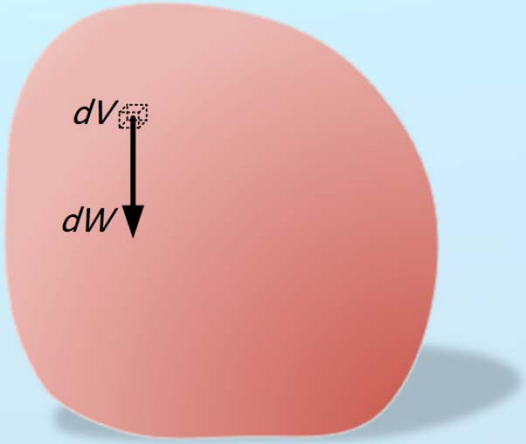
الكتلة:تستخدم لتقدير كمية المادة، ولتقدير العطالة (مقاومة تغيير السرعة)

2. Time: succession of events

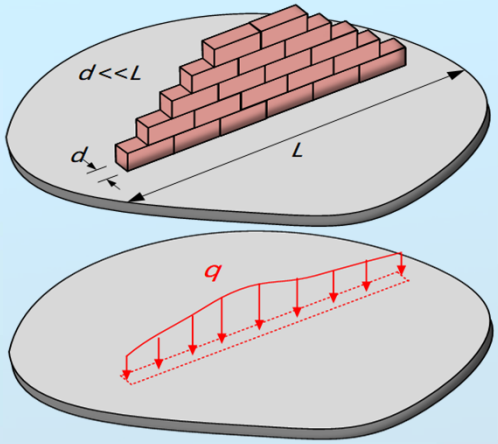
الزمن: ويحدد تتابع الأحداث

4. Force: A “push” / “pull” exerted by one body on another by direct contact or at distance بعد

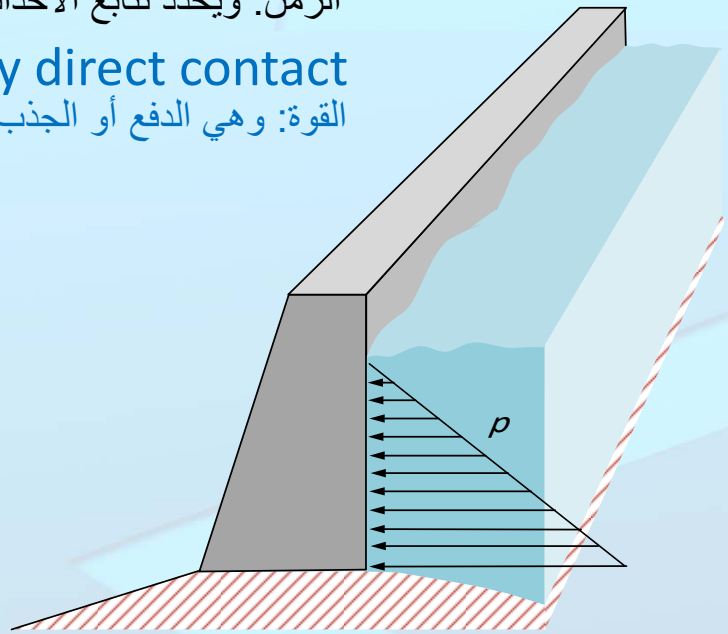
القوة: وهي الدفع أو الجذب المتبادل بين الأجسام المادية بالتماس أو عن



Volume force [F/L³]
Gravity force acting at distance



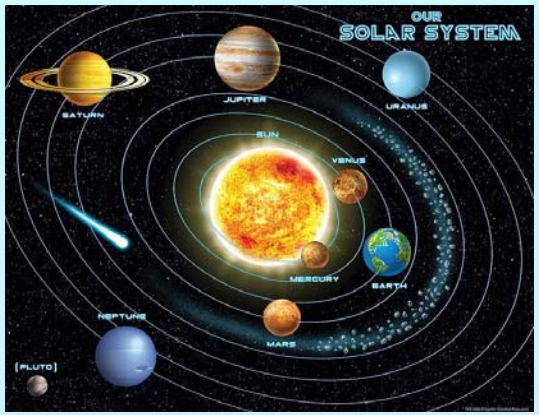
Line force [F/L]
Wall weight acting as contact force



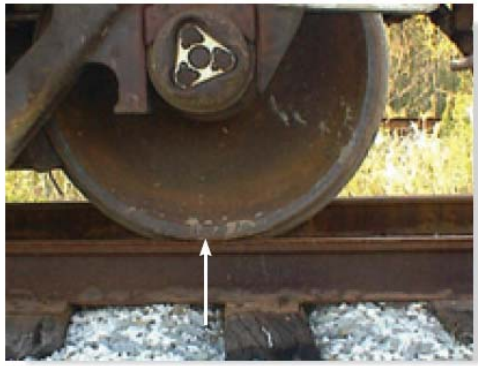
Area forces [F/L²]
Water pressure acting as contact force

II. Mechanics……Fundamentals Concepts…..Idealization

1. Particles: Has a mass but its size can be neglected



2. Rigid Body: A combination of a large number of particles fixed relative to each other.



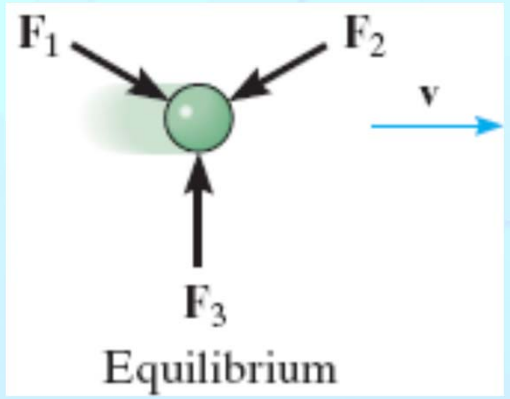
3. Concentrated Force: The effect of a loading on a small area

Fundamentals Concepts

Newton's Three Laws of Motion

First Law

"A particle originally at rest, or moving in a straight line with constant velocity, will remain in this state provided that the particle is not subjected to an unbalanced force"



Equilibrium

Second Law

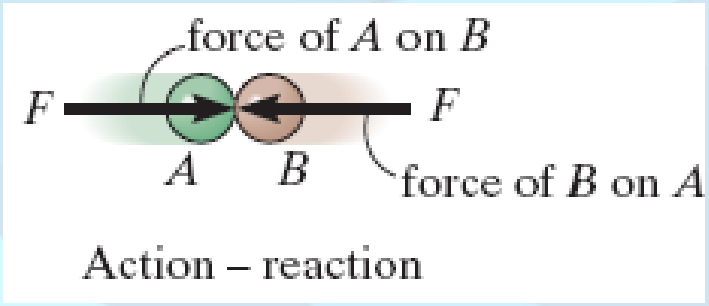
"A particle acted upon by an *unbalanced force* **F** experiences an acceleration **a** that has the same direction as the force and a magnitude that is directly proportional to the force"

Accelerated motion

$$F = ma$$

Third Law

"The mutual forces of action and reaction between two particles are equal and, opposite and collinear"



Action – reaction

III. Condition for the Equilibrium of a Particle

- **A Particle is at *equilibrium* if:**

- At rest, or
- Moving at constant velocity.

Acceleration must vanish: $\boldsymbol{a}=0$

تكون النقطة المادية متوازنة في سكون أو في حركة مستقيمة منتظمة، إذا انعدم شعاع تسارعها.

- **Newton's second law of motion:**

$\sum \boldsymbol{F} = m\boldsymbol{a}$, where $\sum \boldsymbol{F}$ is the vector sum of all the forces acting on the particle

- Condition for the Equilibrium of a Particle: $\sum \boldsymbol{F} = \boldsymbol{0}$

ونستنتج إذن من قانون نيوتن الثاني، أن شرط توازن نقطة مادية هو أن ينعدم المجموع الشعاعي للقوى المؤثرة عليها.

- Resolve into x, y and z components for equilibrium:

$$\sum \boldsymbol{F}=0 \Leftrightarrow \sum F_x = 0 \ , \ \sum F_y = 0 \ \& \ \sum F_z = 0$$

The statics of a 3D object Problem

1) Draw a free-body diagram (FBD) of the part of interest. Use knowledge of the contact conditions to draw known and unknown aspects of the forces.
2) Write equilibrium equations in terms of shown forces & couples on the **FBD**;
3) Solve the equilibrium equations for unknowns.

The brute-force approach to statically determinate problems

A problem is statically determinate when all unknown forces can be found using the Eq. Eqs. In 3D statics, this generally means that the two vector equilibrium equations

$$\sum \vec{F}_i = \vec{0} \qquad \text{and} \qquad \sum \vec{M}_{i/C} = \vec{0}$$

where C is any point that you like!!

these two vector Eq. Eqs. make up 6 independent scalar equations which can be solved for 6 unknown aspects of the applied forces