Mechanics

- Mechanics is the oldest and the most highly developed branch of physics. It is concerned with the state of rest or motion of bodies that are subjected to the action of *forces* (Mechanical Interactions, changing shape, position, velocity or acceleration).

الميكانيك أقدم فروع الفيزياء وأكثرها تطوراً. يُعنى بدراسة حالتي سكون وحركة الأجسام المادية الخاضعة لتأثير القوى أي تفاعلات غير كيميائية أو فيزيائية، بل فقط ميكانيكية: تغيير في شكل، موضع، سرعة، أوتسارع الأجسام المتفاعلة.

- Mechanics can be divided into 3 branches:

  - Rigid-body Mechanics
  - Deformable-body Mechanics
  - Fluid Mechanics

يقسم علم الميكانيك إلى: ميكانيك الجسم الصلد (مطلق الصلابة)، ميكانيك الجسم الصلب (القابل للتشوه)، ميكانيك السوائل.

- Rigid-body Mechanics deals with
- Statics: Equilibrium of bodies, at rest, or constant velocity
- Dynamics: Accelerated motion of bodies

يقسم ميكانيك الجسم الصلد إلى: (1) الستاتيك (علم السكون) ويدرس توازن القوى المؤثرة على الأجسام الساكنة أو المتحركة بسرعة ثابتة. (2) الديناميك ويدرس الأجسام المتسارعة.

Mechanics……Fundamentals Concepts…..Basic Quantities

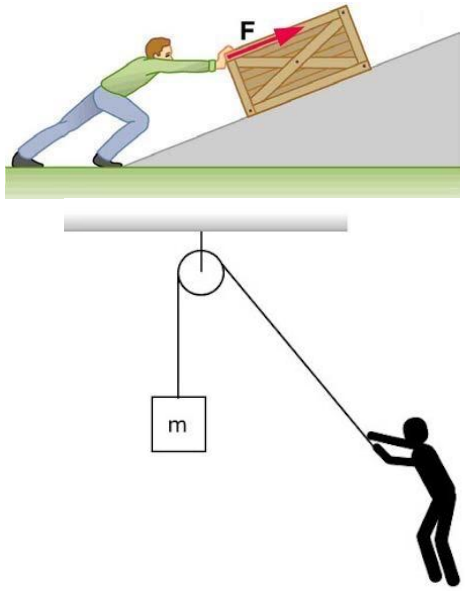
Length: used to locate positions and measure sizes الطول لتحديد المواقع وتقدير الأبعاد

Mass: quantity of matter and resistance to velocity change.

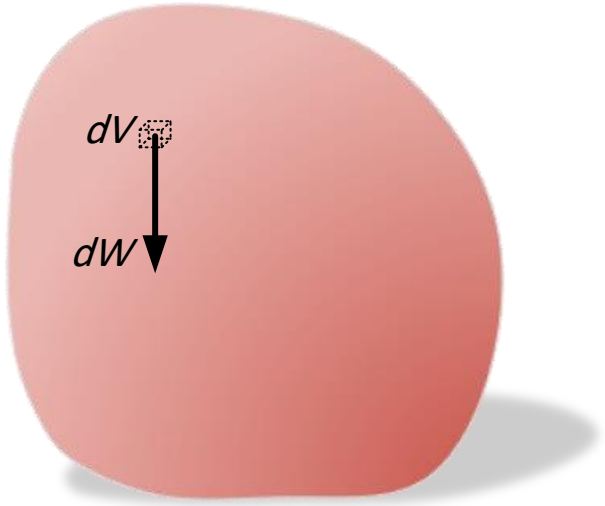
Time: succession of events

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

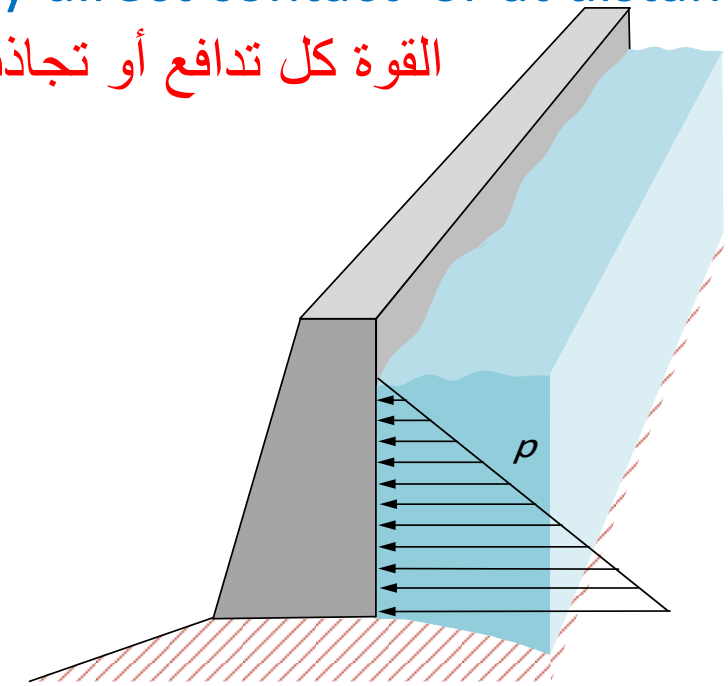
القوة كل تدافع أو تجاذب بين جسمين يؤدي إلى تغيُّر في حركتهما، وقد يكون عن بعد أو بالتماس.



Concentrated force [F]

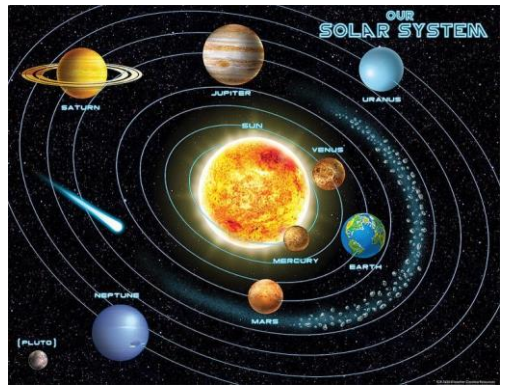


Volume force [F/L³]
Gravity force acting at distance



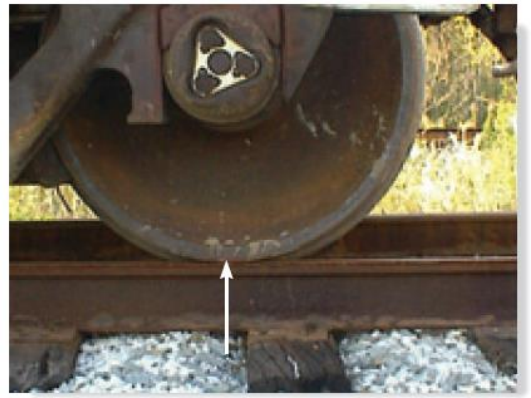
Area forces [F/L²]
Water pressure acting as contact force

1. Mechanics……Fundamentals Concepts…..Idealization استمثال



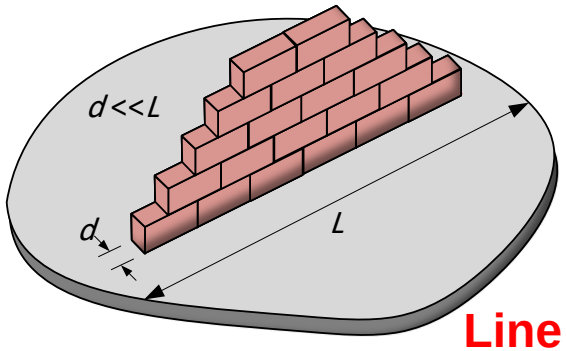
1. Particles النقطة المادية
   - has a mass but its size can be neglected

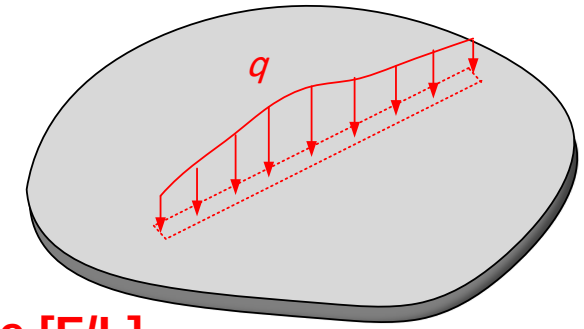
2. Rigid Body الجسم الصلد (مطلق الصلابة)
   - a combination of a large number of particles fixed relative to each other.



3. Concentrated Force القوة المركزة
   - the effect of a loading on a small area

4. Line force [F/L] القوة الطولية أو الخطية
   - Ex. Wall weight acting as contact force





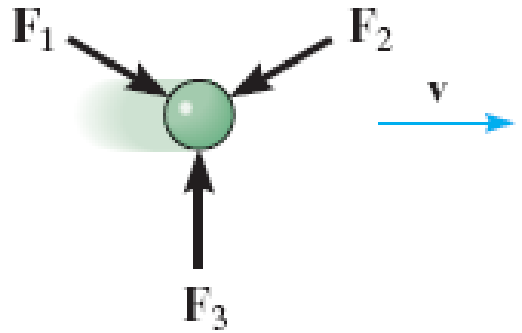
Line force [F/L]

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

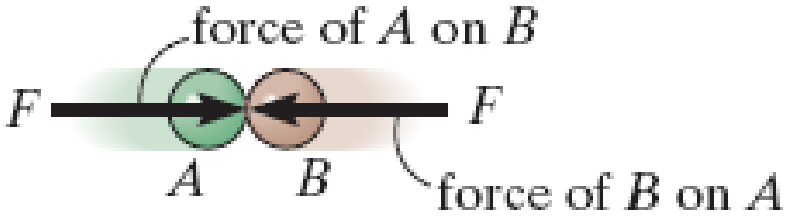
Second Law

"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"

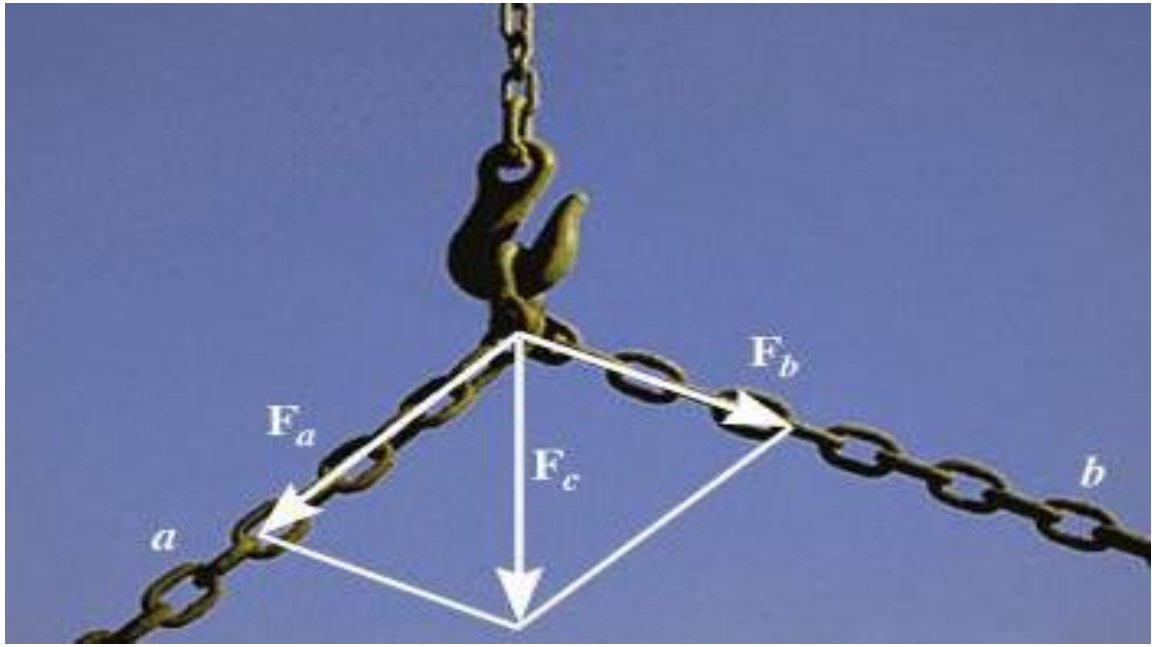


Action – reaction

SCALARS AND VECTORS

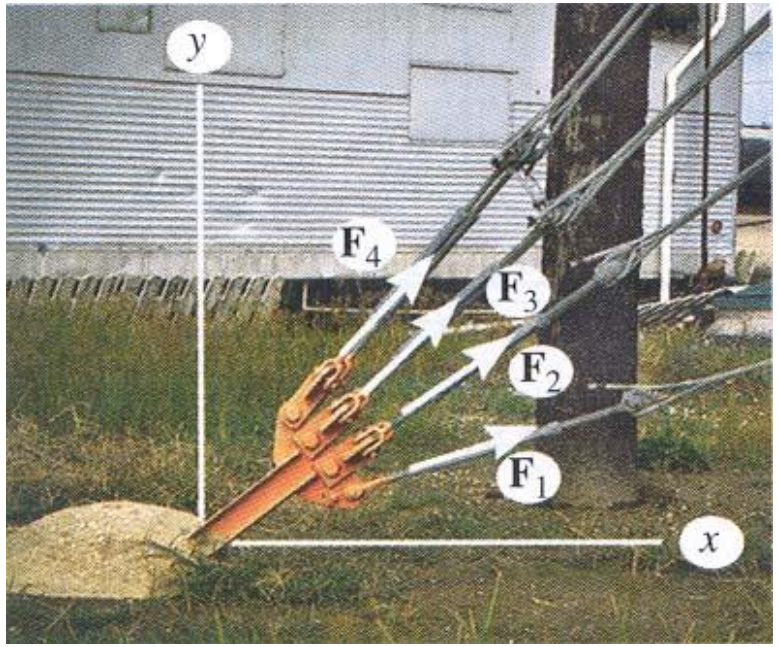
	Scalars السلميات	Vectors الأشعة
Examples أمثلة	mass, volume الكتلة، الحجم...	force, velocity القوة، السرعة،...
Characteristics المحددات	Magnitude (±) & Unit المقدار (±) وواحدة القياس	Magnitude & Direction المقدار مع الواحدة واتجاه محدد
Addition rule قاعدة الجمع	Simple arithmetic جمعاً جبرياً كأعداد حقيقية	Parallelogram law وفق قاعدة قطر متوازي الأضلاع
Special Notation الترميز	None حرف كبير أو صغير دون تمييز	Bold font, arrow (→)or a caret (^) حرف سميك، أو سهم علوي (→) أو (^)

FORCE (VECTOR) OPERATIONS & ADDITION CONCURRENT FORCES



Tow concurrent forces are additioned by the *parallelogram rule.*

The resultant of the two forces is determined by the parallelogram rule.

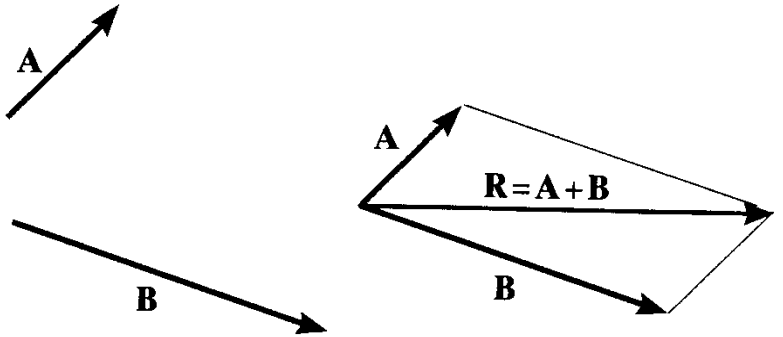


There are four concurrent cable forces acting on the bracket.

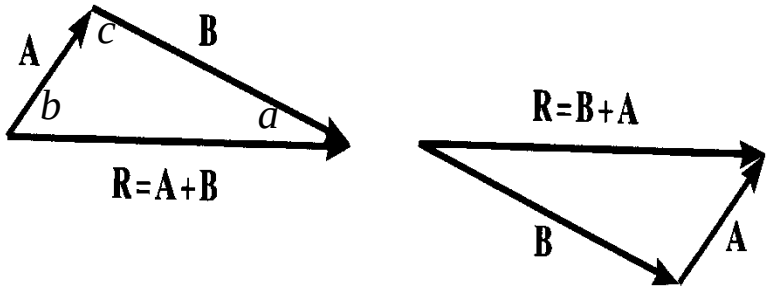
How do you deermine the resultant force acting on the bracket ?

VECTOR ADDITION USING EITHER THE PARALLELOGRAM LAW OR TRIANGLE

Parallelogram Law:



Triangle method (always 'tip to tail'):

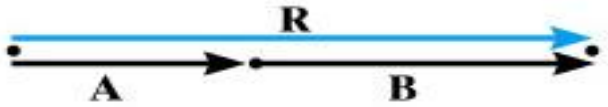


Sine law:

$$\frac{A}{\sin a} = \frac{B}{\sin b} = \frac{R}{\sin c}$$

Cosine law:

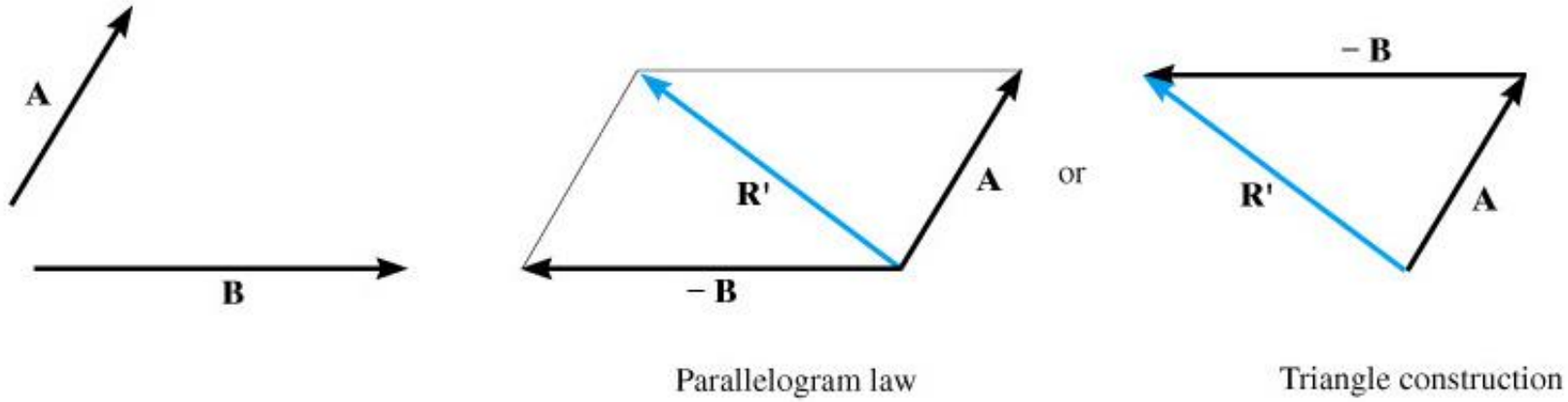
$$R = \sqrt{(A^2 + B^2 - 2AB\cos c)}$$



$R = A + B$

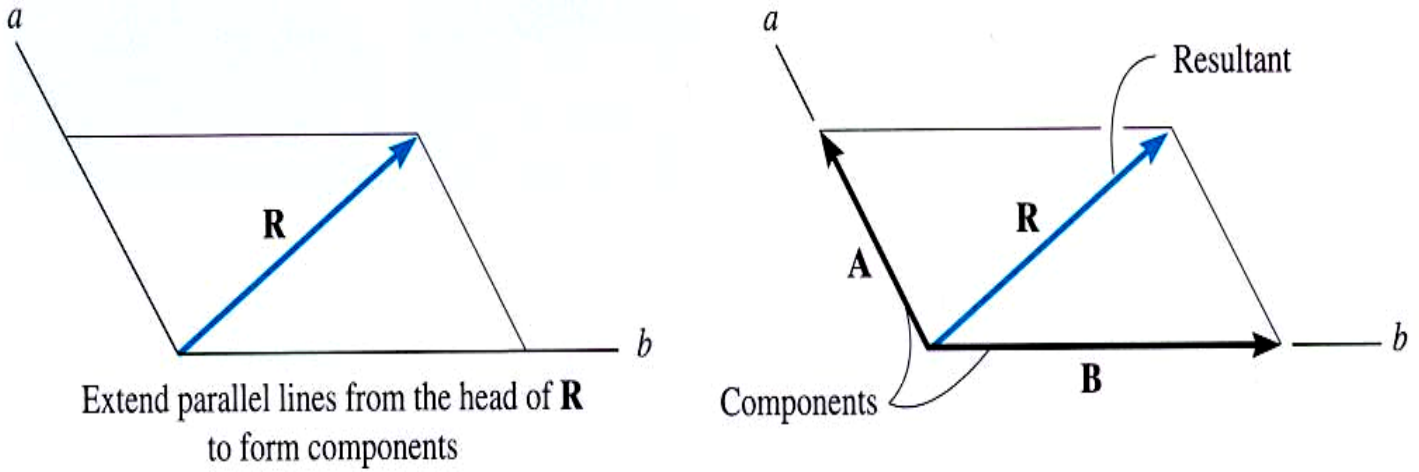
Addition of collinear vectors

VECTOR SUBTRACTION USING EITHER THE PARALLELOGRAM LAW OR TRIANGLE

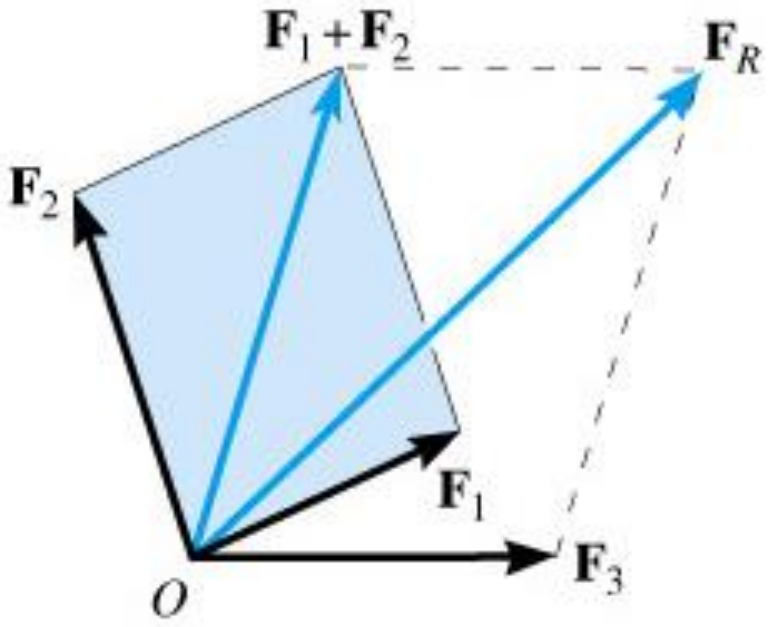


RESOLUTION OF A VECTOR

"Resolution" of a vector is breaking up a vector into components.
It is kind of like using the parallelogram law in reverse.

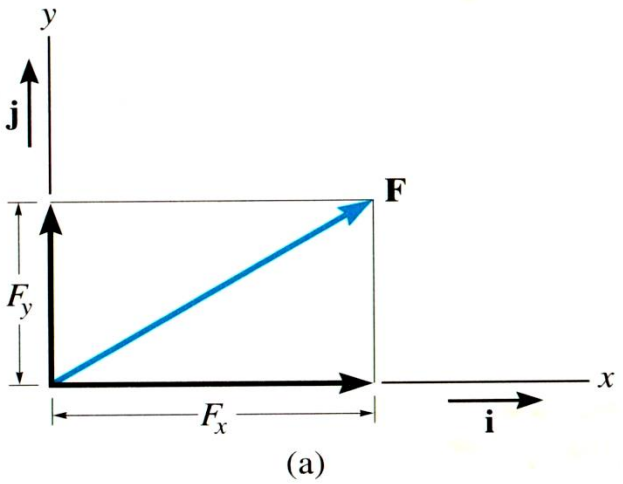


Associativity of Force Addition



Applying the parallelogram law becomes more complicated. So …. Des Carte Geometry?

CARTESIAN VECTOR NOTATION

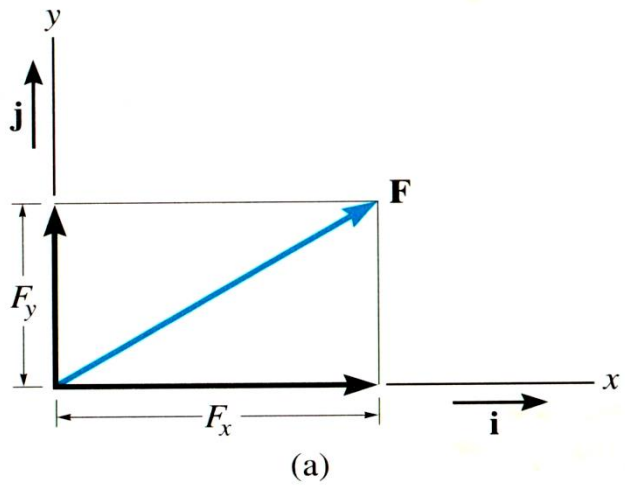


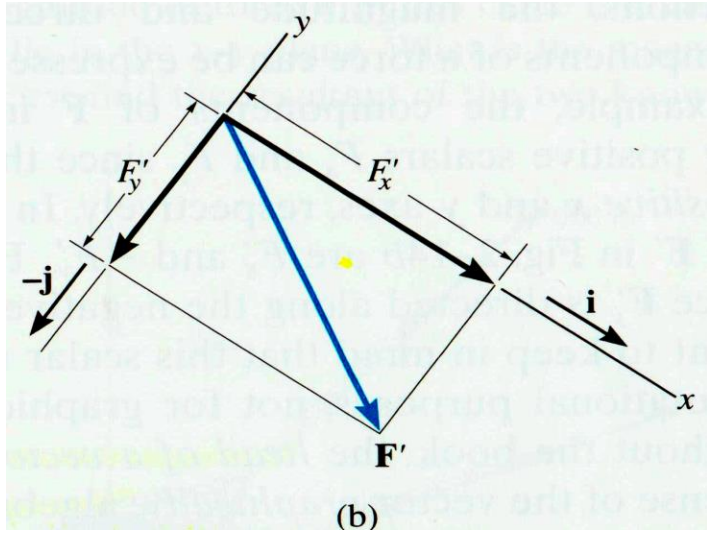
- We ‘resolve’ vectors into components using the x and y axes system.
- Each component of the vector is shown as a magnitude and a direction.

- The directions are based on the *x* and *y* axes. We use the “unit vectors” ***i*** and ***j*** to designate the *x* and *y* axes.

For example,

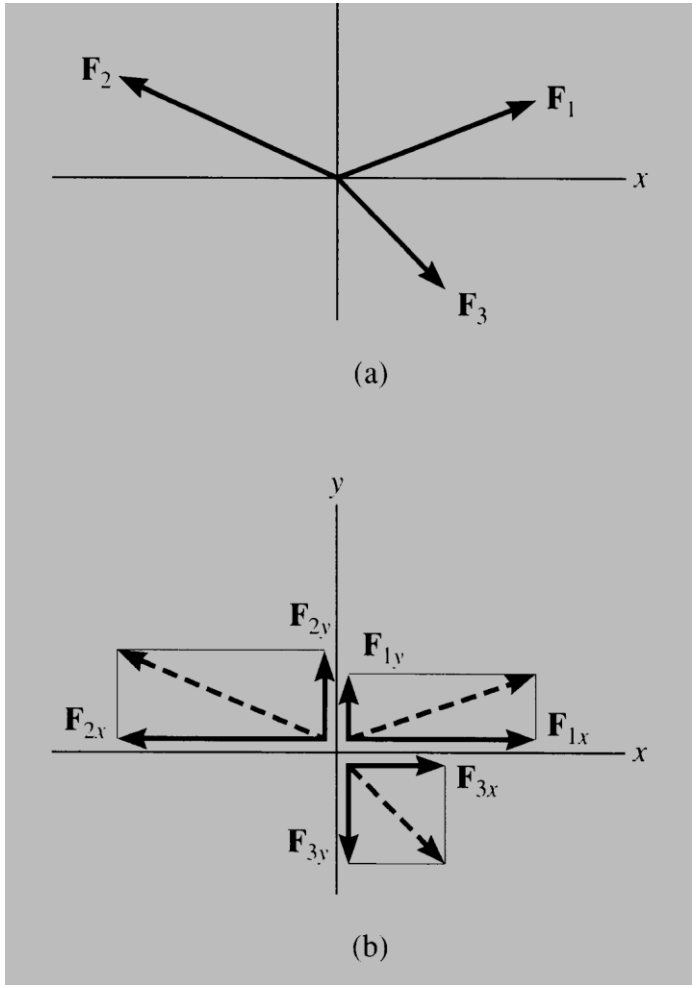
$$\boldsymbol{F} = F_x\,\boldsymbol{i} + F_y\,\boldsymbol{j} \qquad \textbf{or} \qquad \boldsymbol{F'} = F'_x\,\boldsymbol{i} - F'_y\,\boldsymbol{j}$$



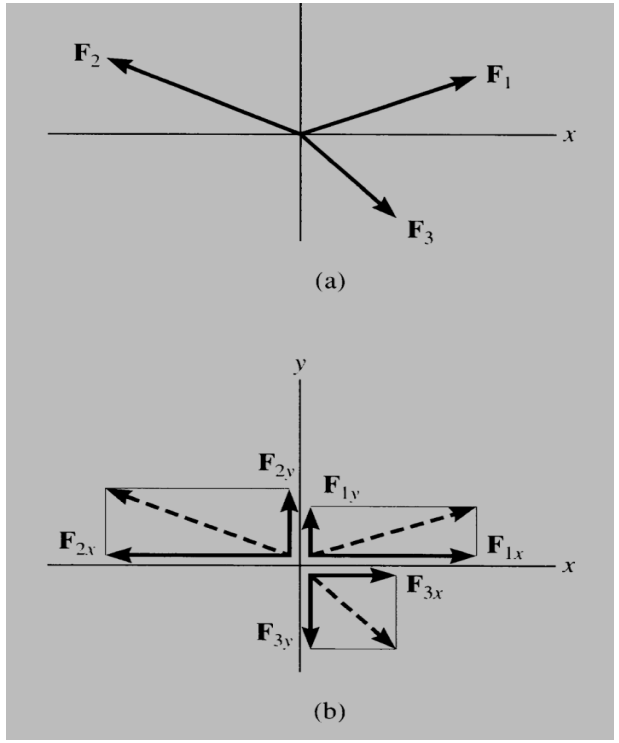


The *x* and *y* axes are always perpendicular to each other. Together, they can be directed at any inclination.

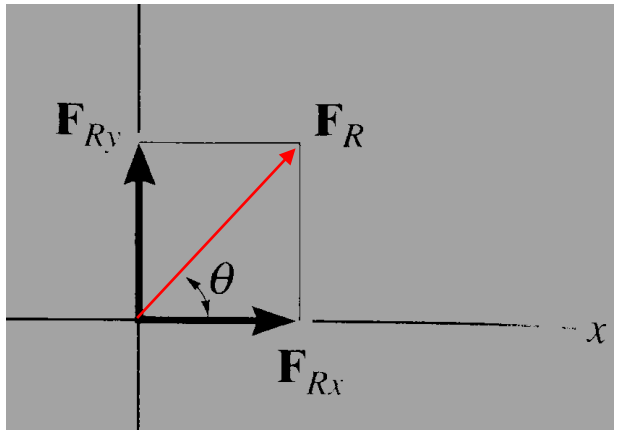
ADDITION OF SEVERAL VECTORS



- Step 1 is to resolve each force into its components
  - نحلل كل قوة إلى مركباتها
- Step 2 is to add all the *x* components together and add all the *y* components together. These two totals become the resultant vector components.
  - نوجد مجموع المركبات على المحور *x* ، كما نوجد مجموع المركبات على المحور *y* . يشكل المجموعان مركبتي محصلة القوى المتلاقية.
- Step 3 is to find the magnitude and angle of the resultant vector.
  - ثم نوجد شدة المحصة وزاوية اتجاهها مع المحور *x*.



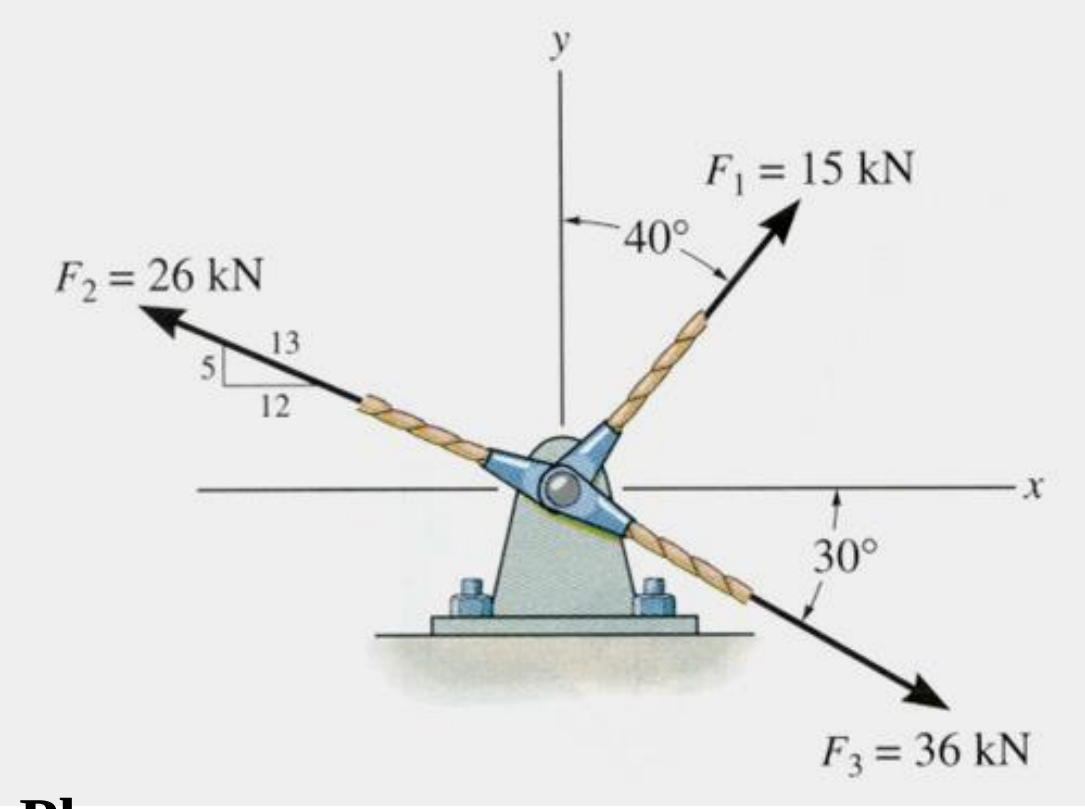
$$\begin{aligned}\mathbf{F}_R &= \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 \\ &= F_{1x}\mathbf{i} + F_{1y}\mathbf{j} - F_{2x}\mathbf{i} + F_{2y}\mathbf{j} + F_{3x}\mathbf{i} - F_{3y}\mathbf{j} \\ &= (F_{1x} - F_{2x} + F_{3x})\mathbf{i} + (F_{1y} + F_{2y} - F_{3y})\mathbf{j} \\ &= (F_{Rx})\mathbf{i} + (F_{Ry})\mathbf{j}\end{aligned}$$



$$F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2}$$

$$\theta = \tan^{-1}\left|\frac{F_{Ry}}{F_{Rx}}\right|$$

EXAMPLE



Given:

Three concurrent forces acting on a bracket.

Find:

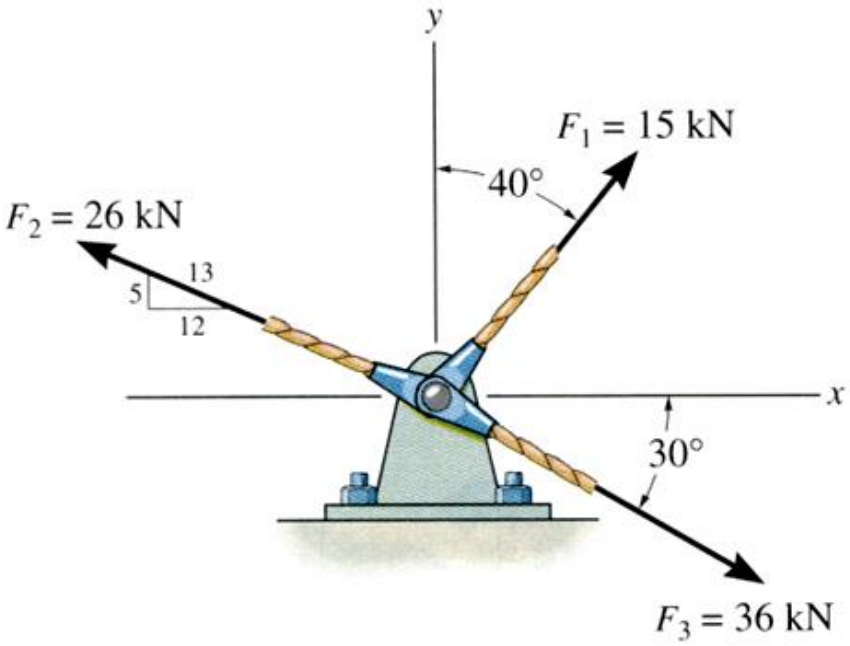
The magnitude and angle of the resultant force.

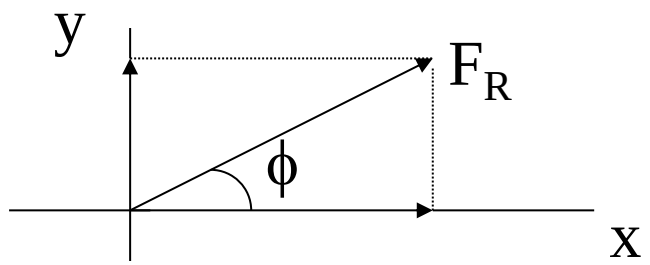
Plan:

a) Resolve the forces in their x-y components.

b) Add the respective components to get the resultant vector.

c) Find magnitude and angle from the resultant components.



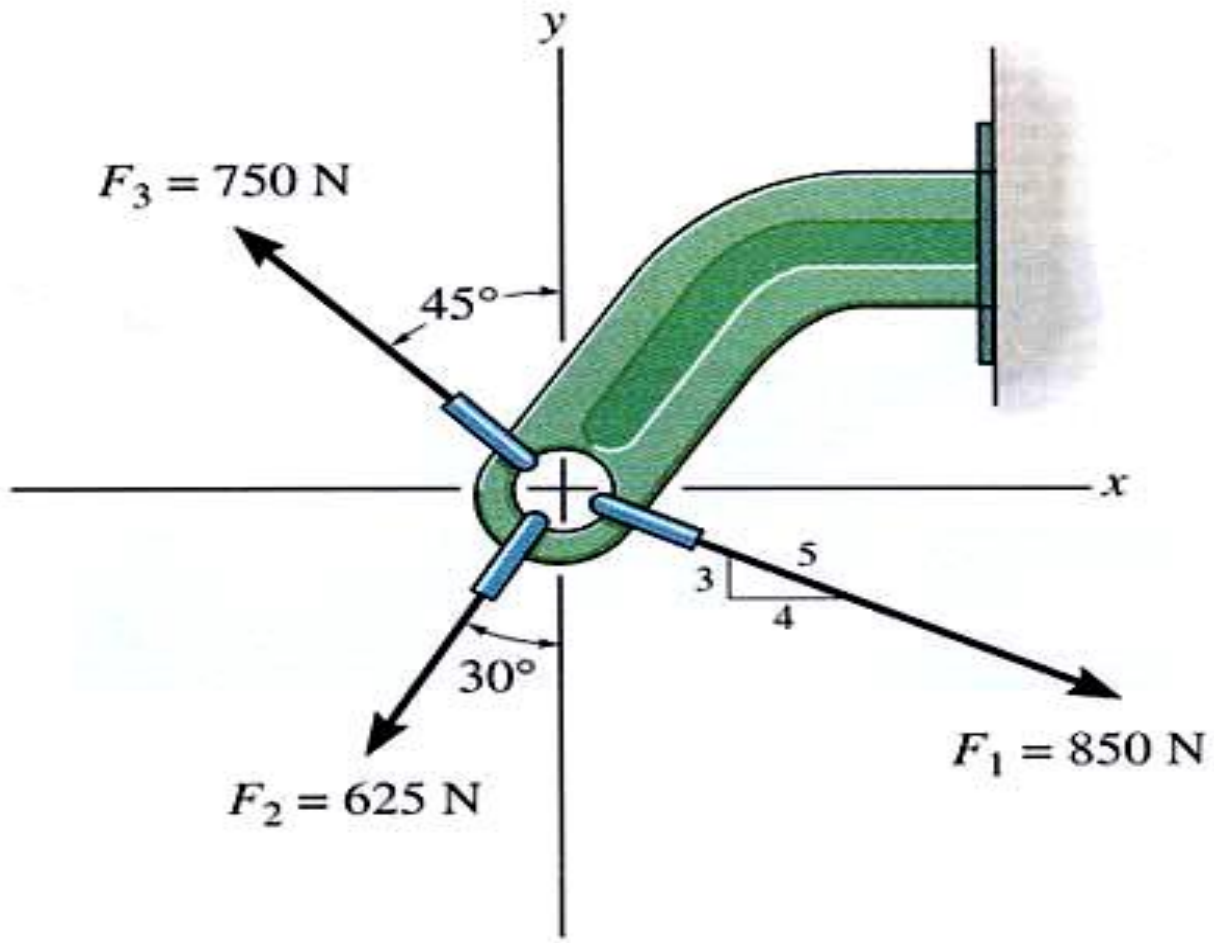


$$R_x = 16.8\ kN$$
$$R_y = 3.5\ kN$$
$$R = 17.2\ kN$$
$$\theta = 11.7°$$

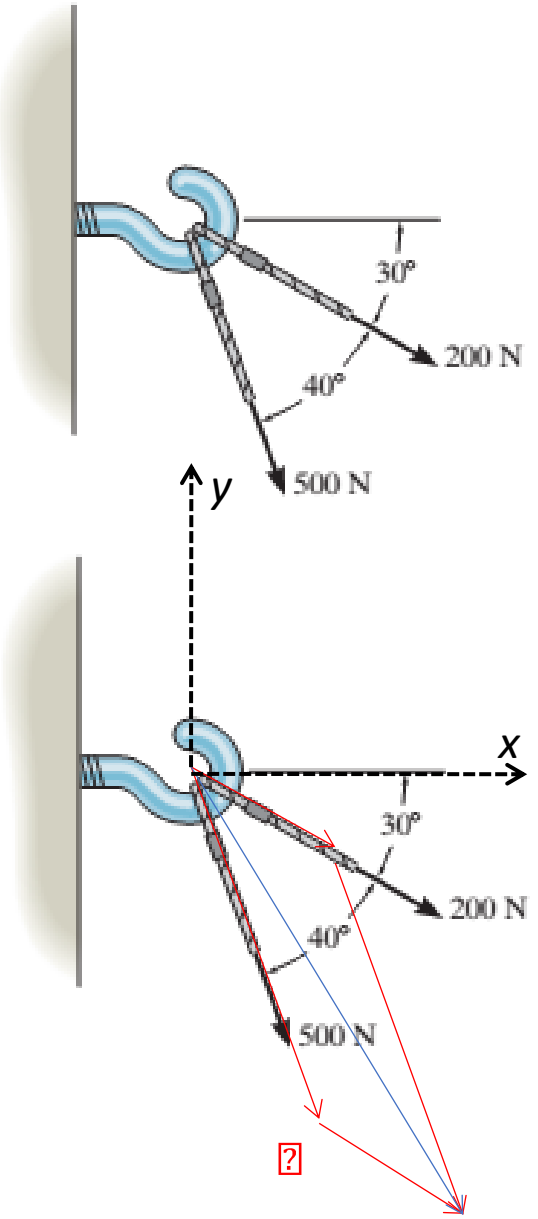
PROBLEM 1.

Given: Three concurrent forces acting on a bracket

Find: The magnitude and angle of the resultant



Problem 2. Two forces act on the hook. Determine the magnitude of the resultant force and its direction measured from the horizontal axis



$R_x = 344.215N \;\&\; Ry = -569.846N \quad R = 666N \;\&\; \theta = (-58.9)°$