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متجهات القوى

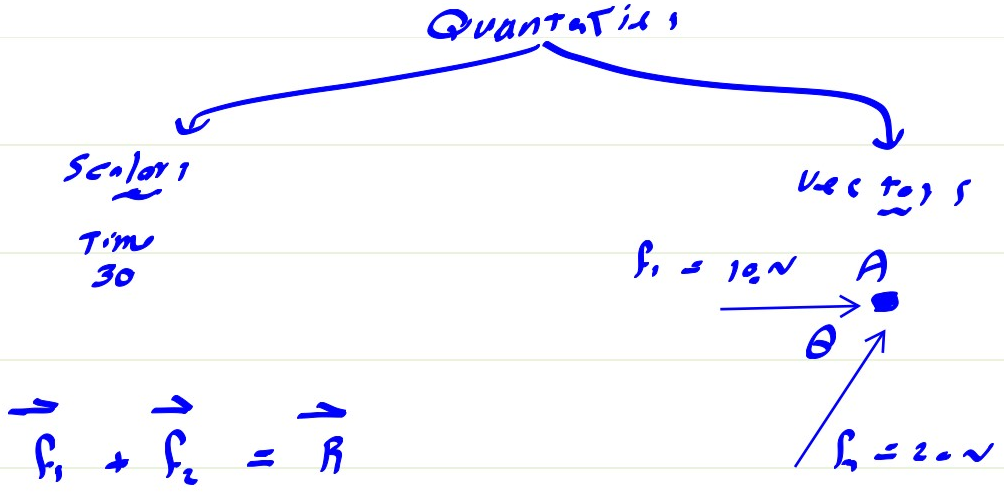
FORCE VECTORS

الكميات القياسية والكميات المتجهة

1) Scalars and Vectors

العمليات على المتجهات

2) Vector Operations



Introduction

- The objective for the current chapter is to investigate the effects of forces on particles:
  - replacing multiple forces acting on a particle with a single equivalent or *resultant* force,
  - relations between forces acting on a particle that is in a state of *equilibrium*.
- The focus on *particles* does not imply a restriction to miniscule bodies. Rather, the study is restricted to analyses in which the size and shape of the bodies is not significant so that all forces may be assumed to be applied at a single point.

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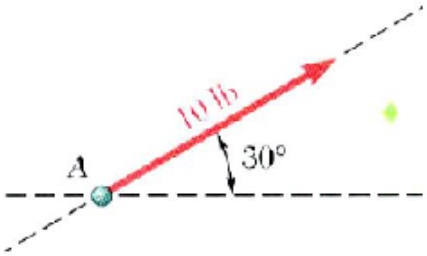
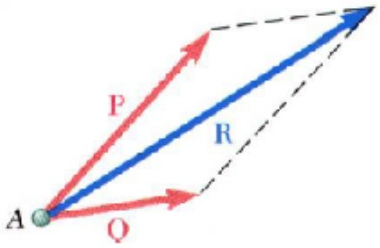
مدرسة متوسين

Resultant of Two Forces

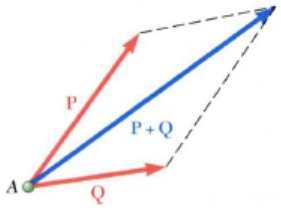


- force: action of one body on another; characterized by its *point of application*, *magnitude*, *line of action*, and *sense*.

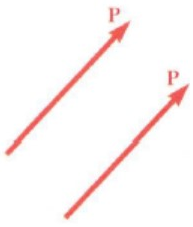


- Experimental evidence shows that the combined effect of two forces may be represented by a single *resultant* force.
- The resultant is equivalent to the diagonal of a parallelogram which contains the two forces in adjacent legs.
- Force is a *vector* quantity.

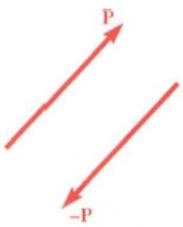
Vectors



- ***Vector***: parameters possessing magnitude and direction which add according to the parallelogram law. Examples: displacements, velocities, accelerations.
- ***Scalar***: parameters possessing magnitude but not direction. Examples: mass, volume, temperature



- Vector classifications:
  - ***Fixed* or *bound* vectors** have well defined points of application that cannot be changed without affecting an analysis.
  - ***Free* vectors** may be freely moved in space without changing their effect on an analysis.
  - *Sliding* vectors may be applied anywhere along their line of action without affecting an analysis.



- ***Equal* vectors** have the same magnitude and direction.
- ***Negative* vector** of a given vector has the same magnitude and the opposite direction.

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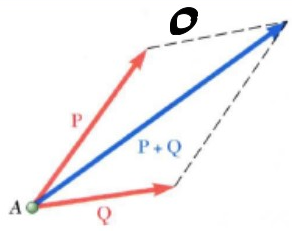
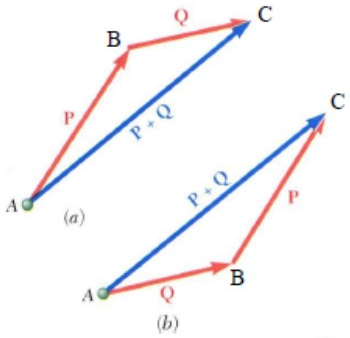
جمع المتجهات

Addition of Vectors



- Trapezoid rule for vector addition

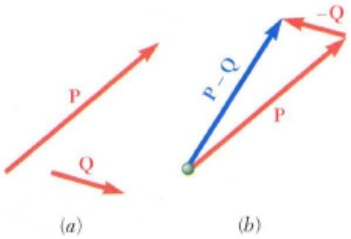


- Triangle rule for vector addition
- Law of cosines,

$$R^2 = P^2 + Q^2 - 2PQ\cos B$$
$$\vec{R} = \vec{P} + \vec{Q}$$

- Law of sines,

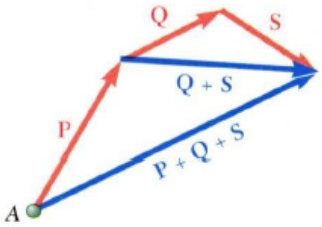
$$\frac{\sin A}{P} = \frac{\sin B}{R} = \frac{\sin C}{Q}$$



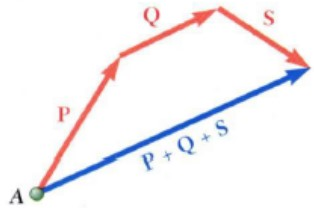
- Vector addition is commutative,

$$\vec{P} + \vec{Q} = \vec{Q} + \vec{P}$$

- Vector subtraction

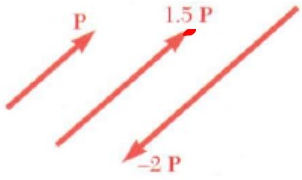


- Addition of three or more vectors through repeated application of the triangle rule



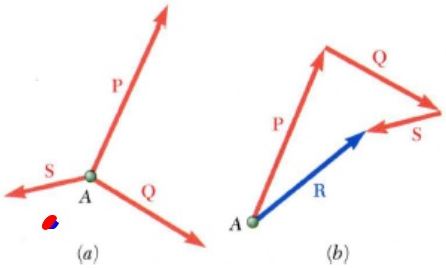
- The polygon rule for the addition of three or more vectors.
- Vector addition is associative,

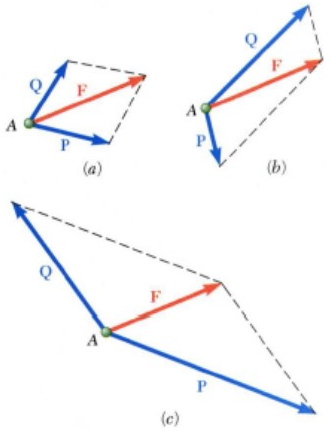
$$\vec{P} + \vec{Q} + \vec{S} = (\vec{P} + \vec{Q}) + \vec{S} = \vec{P} + (\vec{Q} + \vec{S})$$



- Multiplication of a vector by a scalar

Resultant of Several Concurrent Forces





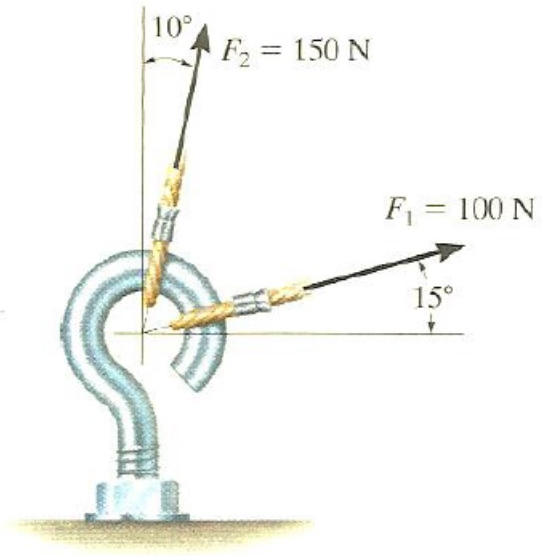
- ***Concurrent forces***: set of forces which all pass through the same point.

  A set of concurrent forces applied to a particle may be replaced by a single resultant force which is the vector sum of the applied forces.

- ***Vector force components***: two or more force vectors which, together, have the same effect as a single force vector.

Example (1)

The screw eye in Figure below is subjected to two forces, $\mathbf{F}_1$ and $\mathbf{F}_2$. Determine the magnitude and direction of the resultant force.



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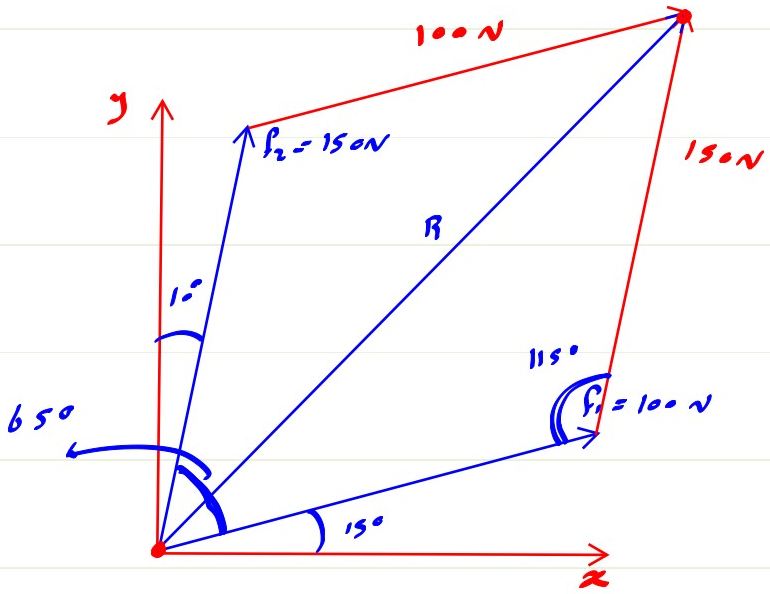
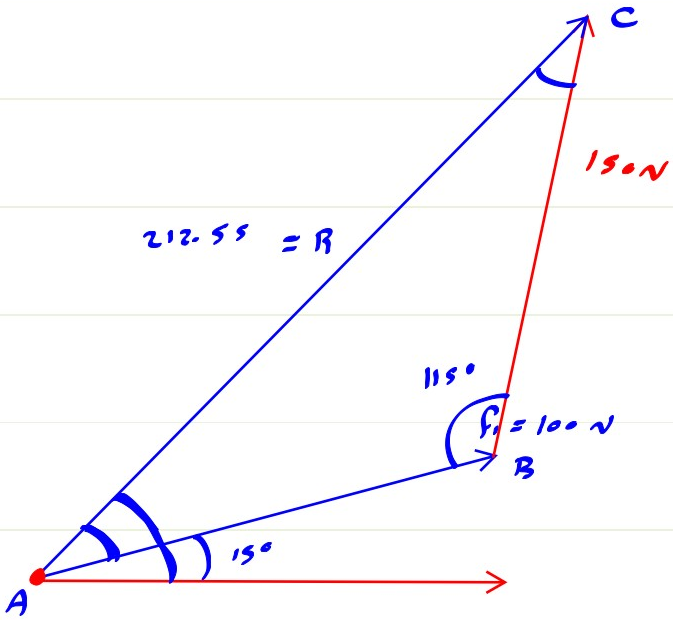


$$R^2 = P^2 + Q^2 - 2PQ\cos\theta$$

(P: f_1, Q: f_2)

$$R = \sqrt{100^2 + 150^2 - 2 \times 100 \times 150 \cos 115} = 212.55$$



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$$\frac{\sin A}{150} = \frac{\sin 115}{212.55} = \frac{\sin C}{100}$$

$$\sin A = \frac{150 \sin 115}{212.55} = 0.6396$$

$$A = 39.76$$

$$\alpha = 54.76^\circ$$