ENGINEERING MECHANICS - STATICS

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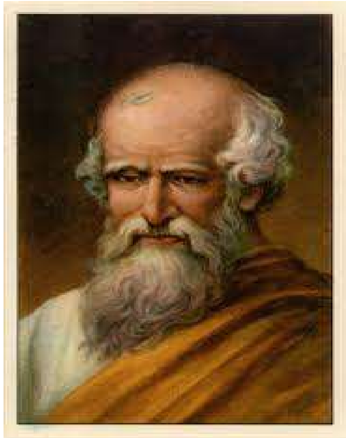
History of Mechanics



- Mechanics is the *oldest of the physical sciences.*
- The early history of this subject is synonymous with the very beginnings of engineering.
- The earliest recorded writings in mechanics are those of *Archimedes* (287 – 212 B.C.) on the principle of the lever and the *principle of buoyancy*.

- Substantial progress came later with the formulation of the *laws of vector combination of forces by Stevinus* (1548 – 1620)
- The first investigation of a *dynamics problem is credited to Galileo* (1564 – 1642) for his experiments with falling stones.

- The accurate formulation of the laws of motion, as well as the law of gravitation, was made by *Newton* (1642–1727),
- Substantial contributions to the development of mechanics were also made by *da Vinci, Varignon, Euler, D'Alembert, Lagrange, Laplace,* and Others.

- ***Space*** is the geometric region occupied by bodies whose positions are described by linear and angular measurements relative to a coordinate system.
- ***Time*** is the measure of the succession of events and is a basic quantity in dynamics
- ***Mass*** is a measure of the inertia of a body, which is its resistance to a change of velocity. Mass can also be thought of as the quantity of matter in a body.
- ***Force*** is the action of one body on another. A force tends to move a body in the direction of its action force is characterized by *its magnitude, by the direction of its action, and by its point of application*.

- ***Particle*** is a body of negligible dimensions. In the mathematical sense, a particle is a body whose dimensions are near zero so that we may analyze it as a mass concentrated at a point.
- ***Rigid body.*** *The* change in distance between any two of its points is negligible for the purpose at hand.
- Statics deals primarily with the calculation of external forces which act on *rigid bodies in equilibrium*. Determination of the internal deformations belongs to the study of the mechanics of deformable bodies.

Scalars and Vectors

A scalar quantity is a quantity that has only magnitude.

A vector quantity is a quantity that has both a magnitude and a direction.

Scalar quantities
Length, Area, Volume,
Speed,
Mass, Density
Temperature, Pressure
Energy, Entropy
Work, Power

Vector quantities
Displacement, Direction,
Velocity, Acceleration,
Momentum, Force,
Electric field, Magnetic field

Classification of Vectors

- *Free vector* is one whose action is not confined to or associated with a unique line in space.
- For example:

If a body moves without rotation, then the movement or displacement of any point in the body may be taken as a vector.

This vector describes equally well the direction and magnitude of the displacement of every point in the body. Thus, we may represent the displacement of such a body by a free vector.

Classification of Vectors

- *Sliding vector* has a unique line of action in space but not a unique point of application.
- when an external force acts on a rigid body, the force can be applied at any point along its line of action without changing its effect on the body as a whole and thus it is a sliding vector.
- *Fixed vector* is one for which a unique point of application is specified.
- The action of a force on a deformable or non-rigid body must be specified by a fixed vector at the point of application of the force

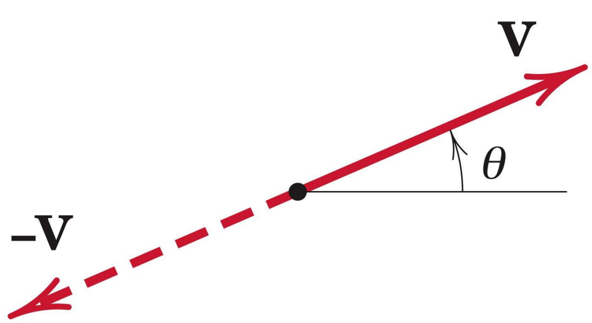


Figure 1-1

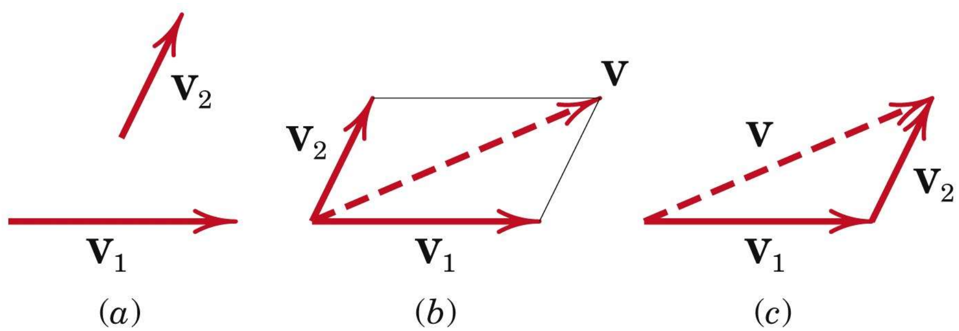


Figure 1-2

ENGINEERING MECHANICS

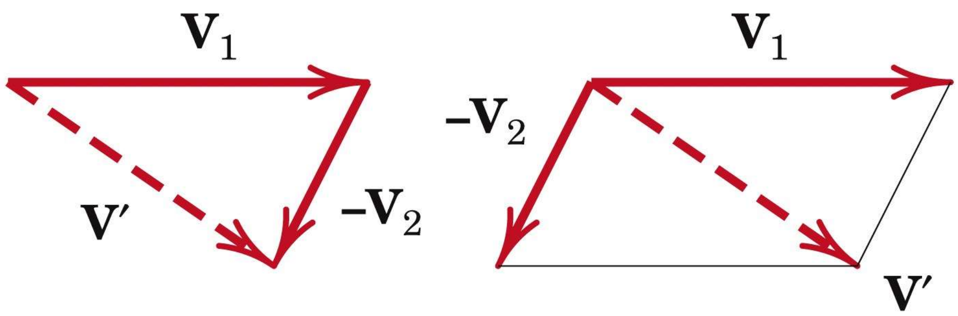


Figure 1-3

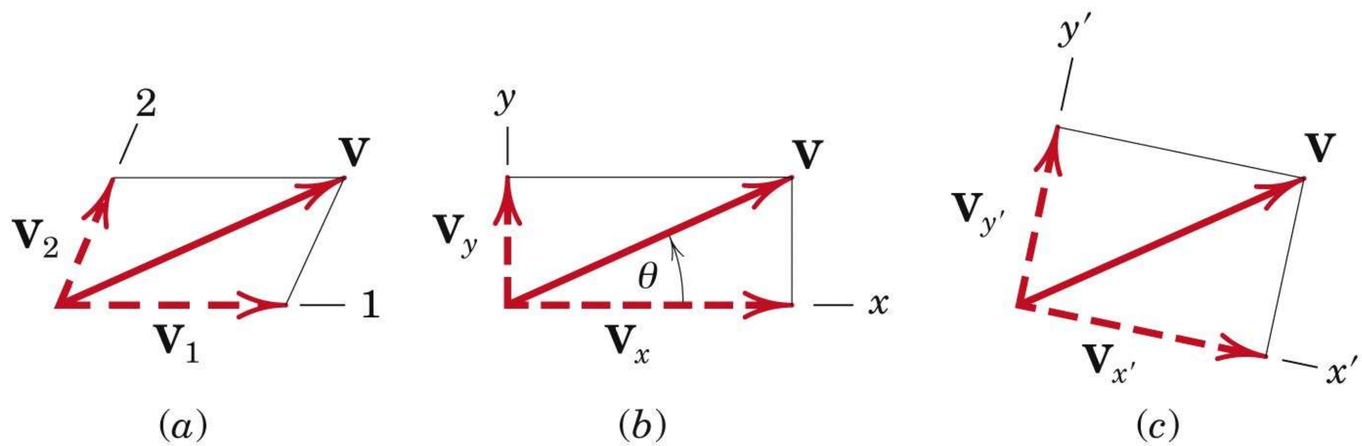


Figure 1-4

Units

- In mechanics we use four fundamental quantities called *dimensions*.
- These are length, mass, force, and time.

QUANTITY	DIMENSIONAL SYMBOL	UNIT	SYMBOL
Mass	M	kilogram	kg
Length	L	meter	m
Time	T	second	s
Force	F	newton	N

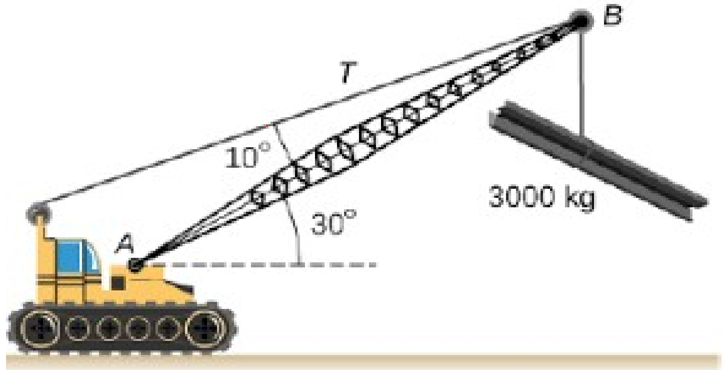
Problem solving in statics(1/2)

Making Appropriate Assumptions:

- For instance, it is often necessary to neglect small distances, angles, or forces compared with large distances, angles, or forces
- We may neglect the weight of a steel cable if the tension in the cable is many times greater than its total weight.

Using Graphics

- We use graphics to represent a physical system on paper with a sketch or diagram. Representing a problem geometrically helps us with its physical interpretation, especially when we must visualize three-dimensional problems.
- Charts or graphs are valuable aids for representing results in a form which is easy to understand.



Force systems

- In Statics a force has been defined as an action of one body on another.
- In dynamics we will see that a force is defined as an action which tends to cause acceleration of a body.
- A force is a *vector quantity, because its effect depends* on the direction as well as on the magnitude of the action.
- The characteristics of force are
  - *Magnitude*
  - *Direction*
  - *Point of application*
  - *Line of action*

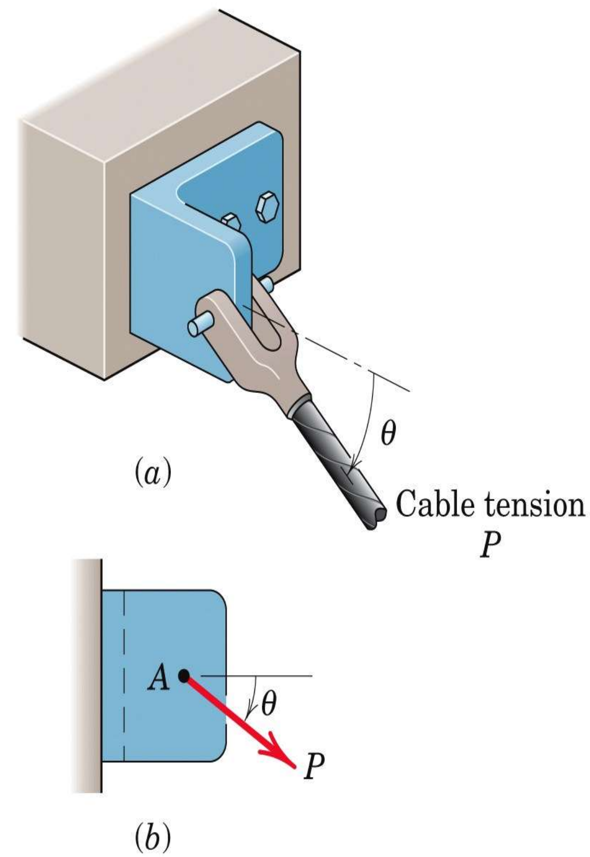


Figure 2-1

Force systems

External Forces :

- Represents the action of other bodies on the rigid body under consideration.
- They are entirely responsible for the external behavior of the rigid body.
- They will either cause it to move or ensure that it remains at rest.

Internal Forces:

- They hold together the particles forming the rigid body.

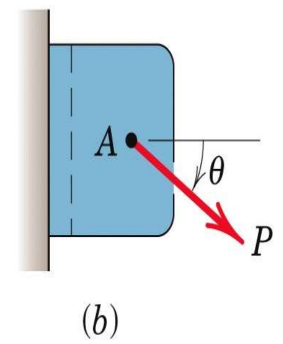


Figure 2-1

- The effects of **P external** to the bracket are the reactive forces (not shown) exerted on the bracket by the foundation and bolts because of the action of **P.**
- **Forces external** to a body can be either *applied forces or reactive forces.*
- The effects of **P internal** to the bracket are the resulting internal forces and deformations distributed throughout the material of the bracket.

Principle of Transmissibility

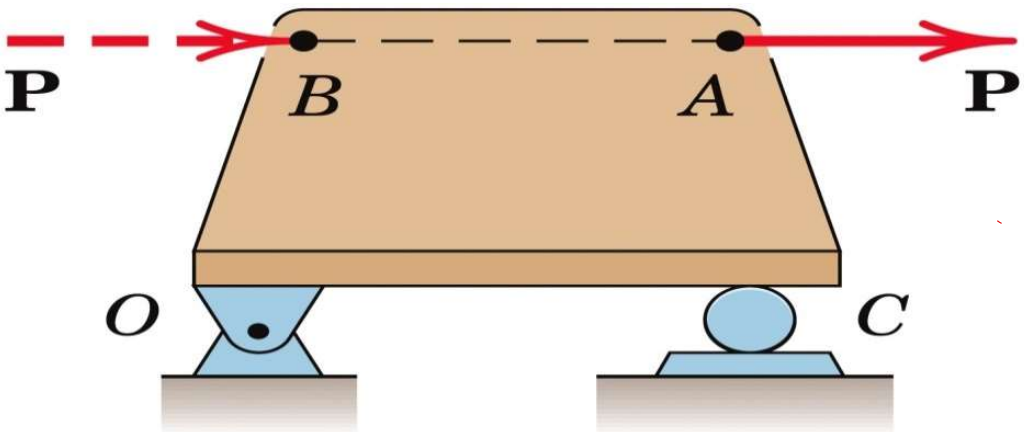
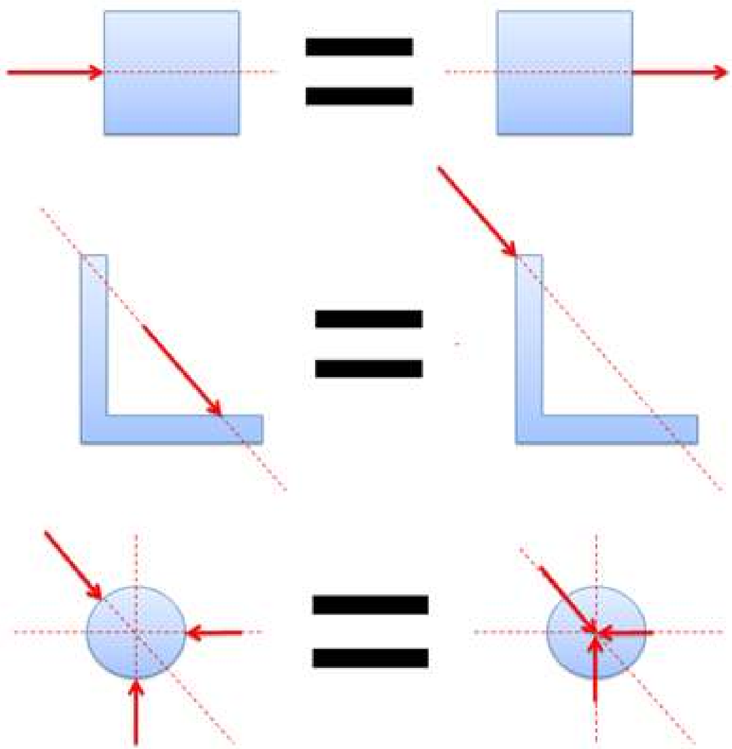


Figure 2-2



- States that "A force may be applied at any point on its given line of action without altering the resultant effects of the force external to the rigid body on which it acts".

Force Classification

1. Forces are classified as either ***contact or body forces***

- A contact force is produced by direct physical contact

  Example is the force exerted on a body by a supporting surface

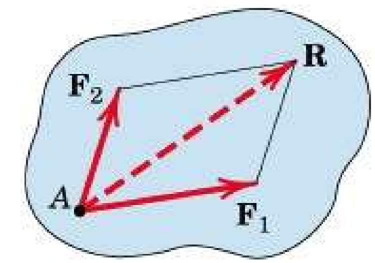
- A Body force is generated by virtue of the position of a body within a force field such as a gravitational, electric, or magnetic field.

  Example of a body force is your weight

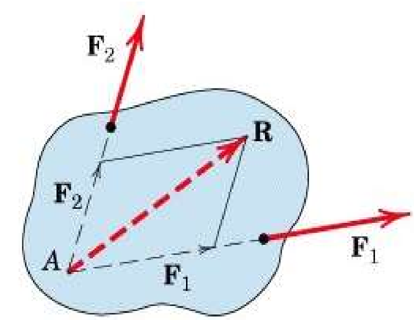
2. Forces may be further classified as either ***concentrated or distributed***

Concurrent Forces (1/3)

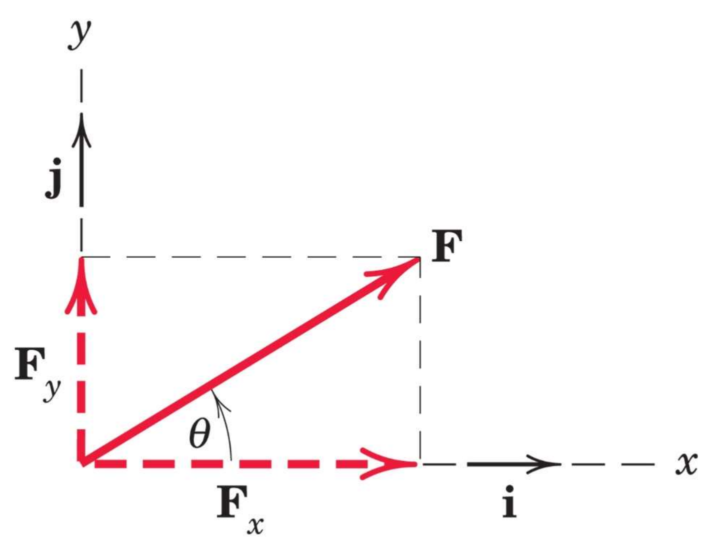
- Two or more forces are said to be *concurrent at a point if their lines* of action intersect at that point. The forces **F1 and F2 shown in Fig. (*a*)** have a common point of application and are concurrent at the point *A*.
- Thus, they can be added using the parallelogram law in their common plane to obtain their sum or *resultant* ***R, as shown in Fig. (a)***
- The resultant lies in the same plane as **F1 and F2**
- Suppose the two concurrent forces lie in the same plane but are applied at two different points as in **Fig. (*b*)** *By the principle of transmissibility,* we may move them along their lines of action and complete their vector sum **R** at the point of concurrency ***A*,** as shown in ***Fig. (b)***
- We can replace **F1 and F2** with the resultant **R** without altering the external effects on the body upon which they act.



(*a*)



(*b*)



$$\mathbf{F} = \mathbf{F}_x + \mathbf{F}_y$$

$$\mathbf{F} = F_x\mathbf{i} + F_y\mathbf{j}$$

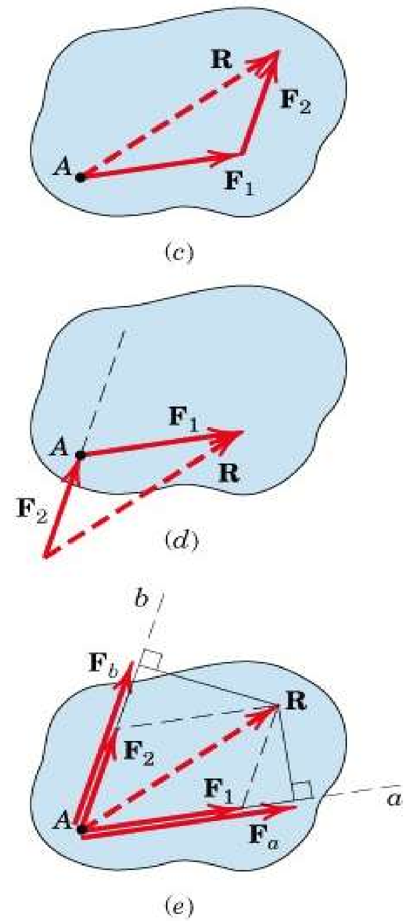
$$F_x = F\cos\theta \qquad F = \sqrt{F_x{}^2 + F_y{}^2}$$

$$F_y = F\sin\theta \qquad \theta = \tan^{-1}\frac{F_y}{F_x}$$

Concurrent Forces (3/3)

- We can also use the triangle law to obtain **R,** but we need to move the line of action of one of the forces, as shown in Fig. (*c*)
- If we add the same two forces as shown in Fig.(*d*), *we correctly preserve the magnitude and direction* of **R,** but we lose the correct line of action, because **R** obtained in this way does not pass through *A*. *Therefore this type of* combination should be avoided
- We can express the sum of the two forces mathematically by the vector equation

$$\mathbf{R = F1 + F2}$$



THANK YOU

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