Eighth Edition

CHAPTER

1

VECTOR MECHANICS FOR ENGINEERS:

STATICS

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Introduction

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Vector Mechanics for Engineers: Statics

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What is Mechanics?

- Mechanics is the science which describes and predicts the conditions of rest or motion of bodies under the action of forces.

- Categories of Mechanics:
  - Rigid bodies
    - *Statics*
    - Dynamics
  - Deformable bodies
  - Fluids

- Mechanics is an applied science - it is not an abstract or pure science but does not have the empiricism found in other engineering sciences.

- Mechanics is the foundation of most engineering sciences and is an indispensable prerequisite to their study.

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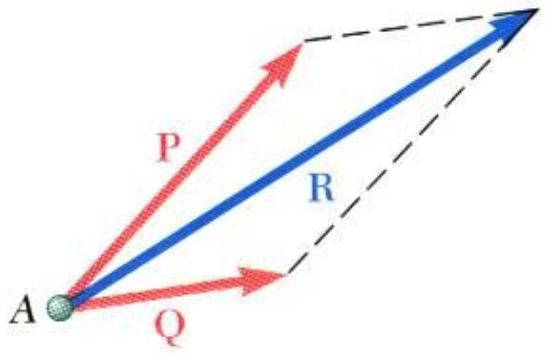
Fundamental Concepts

- *Space* - associated with the notion of the position of a point P given in terms of three coordinates measured from a reference point or origin.
- *Time* - definition of an event requires specification of the time and position at which it occurred.
- *Mass* - used to characterize and compare bodies, e.g., response to earth's gravitational attraction and resistance to changes in translational motion.
- *Force* - represents the action of one body on another. A force is characterized by its point of application, magnitude, and direction, i.e., a force is a vector quantity.

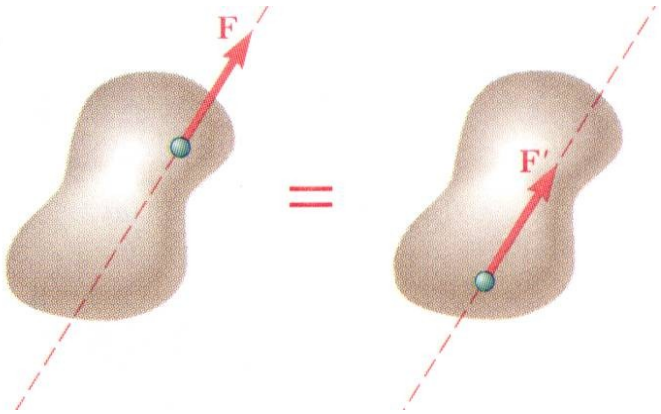
In Newtonian Mechanics, space, time, and mass are absolute concepts, independent of each other. Force, however, is not independent of the other three. The force acting on a body is related to the mass of the body and the variation of its velocity with time.

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Fundamental Principles



- *Parallelogram Law*



- *Principle of Transmissibility*

- *Newton's First Law*: If the resultant force on a particle is zero, the particle will remain at rest or continue to move in a straight line.
- *Newton's Second Law*: A particle will have an acceleration proportional to a nonzero resultant applied force.

$$F = ma$$

- *Newton's Third Law*: The forces of action and reaction between two particles have the same magnitude and line of action with opposite sense.
- *Newton's Law of Gravitation*: Two particles are attracted with equal and opposite forces,

$$F = G\frac{Mm}{r^2} \qquad W = mg, \quad g = \frac{GM}{R^2}$$

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Systems of Units

- *Kinetic Units*: length, time, mass, and force.

- Three of the kinetic units, referred to as *basic units*, may be defined arbitrarily. The fourth unit, referred to as a *derived unit*, must have a definition compatible with Newton's 2nd Law,

$$F = ma$$

- *International System of Units* (SI): The basic units are length, time, and mass which are arbitrarily defined as the meter (m), second (s), and kilogram (kg). Force is the derived unit,

$$F = ma$$

$$1\,\text{N} = (1\,\text{kg})\left(1\,\frac{\text{m}}{\text{s}^2}\right)$$

- *U.S. Customary Units*: The basic units are length, time, and force which are arbitrarily defined as the foot (ft), second (s), and pound (lb). Mass is the derived unit,

$$m = \frac{F}{a}$$

$$1\,\text{slug} = \frac{1\,\text{lb}}{1\,\text{ft/s}}$$

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Method of Problem Solution

- *Problem Statement*:
  Includes given data, specification of what is to be determined, and a figure showing all quantities involved.
- *Free-Body Diagrams*:
  Create separate diagrams for each of the bodies involved with a clear indication of all forces acting on each body.
- *Fundamental Principles*:
  The six fundamental principles are applied to express the conditions of rest or motion of each body. The rules of algebra are applied to solve the equations for the unknown quantities.
- *Solution Check*:
  - Test for errors in reasoning by verifying that the units of the computed results are correct,
  - test for errors in computation by substituting given data and computed results into previously unused equations based on the six principles,
  - **always** apply experience and physical intuition to assess whether results seem "reasonable"

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Numerical Accuracy

- The accuracy of a solution depends on 1) accuracy of the given data, and 2) accuracy of the computations performed. The solution cannot be more accurate than the less accurate of these two.
- The use of hand calculators and computers generally makes the accuracy of the computations much greater than the accuracy of the data. Hence, the solution accuracy is usually limited by the data accuracy.
- As a general rule for engineering problems, the data are seldom known with an accuracy greater than 0.2%. Therefore, it is usually appropriate to record parameters beginning with “1” with four digits and with three digits in all other cases, i.e., 40.2 lb and 15.58 lb.

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