CE 201
Statics

2
Physical Sciences

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Mechanics

Branch of physical sciences concerned with the state of **rest motion of bodies** that are subjected to the action of forces

Rigid-Body Mechanics

Deformable-Body Mechanics

Fluid Mechanics

STATICS

DYNAMICS

Branch of mechanics that deals with the equilibrium of bodies that are either at rest or moving with a constant velocity

1.6 General Procedure for Analysis

The most effective way of learning the principles of engineering mechanics is to *solve problems.* To be successful at this, it is important always to present the work in a *logical* and *orderly manner*, as suggested by the following sequence of steps.

1. Read the problem carefully and try to correlate the actual physical situation with the theory studied.

2. Draw any necessary diagrams and tabulate the problem data.

3. Apply the relevant principles, generally in mathematical form.

4. Solve the necessary equations algebraically as far as practical, then, making sure they are dimensionally homogeneous, use a consistent set of units and complete the solution numerically. Report the answer with no more significant figures than the accuracy of the given data.

5. Study the answer with technical judgment and common sense to determine whether or not it seems reasonable.

6. Once the solution has been completed, review the problem. Try to think of other ways of obtaining the same solution.

In applying this general procedure, do the work as neatly as possible. Being neat generally stimulates clear and orderly thinking, and vice versa.

Ch.1

Mechanics: Branch of physical science concerned with the state of rest or motion of bodies that are subjected to the action of forces.

Physical sciences:

→ …….
→ …….
→ Mechanics → Rigid-body mechanics → static
(particle or rigid body) → dynamics

→ deformable-body mechanics

→ fluid mechanics

Statics: deals with the equilibrium of bodies (particles/rigid bodies) that are either at rest or move with constant velocity.

- units
- significant figures
- rounding off numbers

* Reading Assignment

Read Ch. 1

* Tutorial on PC

1.2 Fundamental Concepts

* Basic Quantities
  - length
  - time
  - mass
  - force, weight $w = m.g$

$= 9.81\ m/s^2$
$= 32.2\ ft/sec^2$

* Idealizations
  - particle
  - rigid body
  - concentrated force
  - smooth

* Laws of Motion

1.3, 1.4 Units

*

1.5 Numerical Calculations

- dimensional homogeneity
- significant figures
- rounding off numbers
- calculations

1.6 General Procedure for Analysis

Ch. 2 Force Vectors

- Concept of a concentrated force

- Force is a vector quantity

- Procedures for $\rightarrow$ adding forces
  $\rightarrow$ resolving forces into components
  $\rightarrow$ projecting forces along an axis

- Rules of vector algebra

2.1 Scalar & Vectors:

- most physical quantities in mechanics can be expressed mathematically by means of scalar & vectors.

Scalar: a quantity characterized by a positive or negative number.

Ex. Mass
Volume
Length

Vectors: a quantity that has both a magnitude and direction (and sense).

Ex.
- position vector
- force vector
- moment vector

$\vec{A}$, $\mathbf{A}$

magnitude $|A|$ or A always positive.

Graphical Representation of a Vector:

Arrow is used to define vector magnitude, direction, & sense

- magnitude of vector $\equiv$ length of arrow
- direction of vector $\equiv$ angle between a reference axis and the arrow's line of action
- sense $\equiv$ arrow head

Ex. vector A has a magnitude = 4 units
direction = 20^{o} from horizontal axis
sense = upward to the right

2.2 Vector Operations:

(1) • Multiplication & Division of a vector by a scalar

Let A : vector
a : scalar

$\therefore$ $A * a = aA$ vector having – a magnitude = $|aA|$
– a sense - same as A if a (+ve)
- opposite to A if a (-ve)

$a = -1 \quad \Rightarrow \quad aA = -A$

- Division

$A/a = (\frac{1}{a}) * A \qquad a \neq 0$

(2) Vector Addition

let A & B vectors of same type

- can be added to form a resultant vector using

Parallelogram Law: (tail-to-tail)

$$\vec{R} = \vec{A} + \vec{B}$$

Procedure

1. draw vectors A & B such that they have their tails at the same point.

2. draw lines from the head of each vector parallel to the other until these lines intersect, completing the parallelogram.

3. the Resultant vector (R) is the diagonal of the parallelogram, which extends from the tails of A & B to the intersection of the two parallel lines.

Special Case of Parallelogram Law:

Triangle construction:
(head-to-tail)

1. Connect tail of B to head of A or tail of A to head of B.

2. The resultant vector R : extends from the tail of

$\vec{A}$ to head of $\vec{B}$

or $\vec{B}$ to head of $\vec{A}$.

* VECTOR Addition is commutative (vectors can be added in either order)

$$\vec{R} = \vec{A} + \vec{B} = \vec{B} + \vec{A}$$

- <u>Special Case</u>: for collinear vectors A & B
  (same line of action)

$\Rightarrow$ parallelogram law reduces to an algebraic or scalar addition

$$R = A + B$$

(3) <u>Vector Subtraction</u>: The resultant difference R' between

A & B $\Rightarrow$ $R' = A - B = A + (-B)$

(4) Resolution of a vector into two components having known lines of action

USE Parallelogram Law: to resolve vector R into Components along liens a & b.

Procedure

1. At the head of R, draw lines parallel to a & b until they intersect lines b & a.

2. The two components A & B are vectors drawn from the tail of R to the points of intersection.

2.3 Vector Addition of Forces;

Force is a vector.

It has magnitude
direction
sense

$\therefore$ it adds according to parallelogram law

* Two problems $\rightarrow$ Finding the resultant, knowing the components
  $\rightarrow$ Resolving a known force into its components

* For more than two forces: Successive (repeated) applications of the parallelogram law can be carried out in order to obtain resultant.

Ex.

$$R_{1,2} = F_1 + F_2$$

$$R = R_{1,2} + F_3$$

$$= (F_1 + F_2) + F_3$$

This method requires extensive calculations
$\Downarrow$
USE 2.4 rectangular-component method.

Procedure

Parallelogram Law

1. Make a sketch showing the vector addition using the parallelogram law.

2. Determine interior angles of the parallelogram
   - geometry of the problem
   - sum total of these angles = 360^o

3. Unknown angles & known & unknown force magnitudes should be clearly labeled on this sketch.

4. Redraw a half portion of the constructed parallelogram to illustrate the triangular head-to-tail addition of components.

Trigonometry: Using trigonometry, the two unknowns can be determined.
If no 90^o angle
USE sine & cosine laws.

Sine Law:

$$\frac{A}{\text{Sin } a} = \frac{B}{\text{Sin } b} = \frac{C}{\text{Sin } c}$$

Cosine Law:

$$C = \sqrt{A^2 + B^2 - 2AB \cos c}$$