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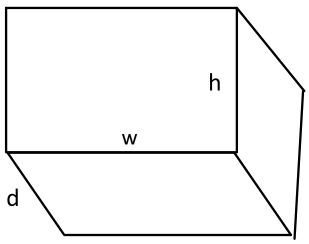
Numerical Calculations

Significant figures

The number of significant figures contained in any number determines the accuracy of the number. Use 3 significant figures for final answers. For intermediate steps, use symbolic notation, store numbers in calculators or use more significant figures, in order to maintain precision.

Example 1: If d = 3.2 in., w = 1.413 in., and h = 2.7 in., then



What is the volume of the block?

V = d * w * h
= (3.2") * (1.413") * (2.7")
= 12.208 in^3
= 12 in^3

Precision

How many sig figs should we report?

A) 1
B) 2
C) 3
D) Infinite

Inner diameter

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General procedure for analysis

1. Read the problem carefully; write it down carefully.

2. Model the problem: Draw given diagrams neatly and construct additional figures as necessary.

Free-body diagrams

3. Apply principles needed.

4. Solve problem symbolically. Make sure equations are dimensionally homogeneous.

5. Substitute numbers. Provide proper units *throughout*. Check significant figures. Box the final answer(s).

6. See if answer is reasonable.

Most effective way to learn engineering mechanics is to ***solve problems! PRACTICE!!!***

Chapter 2: Force vectors
Main goals and learning objectives

Define scalars, vectors and vector operations and use them to analyze forces acting on objects

- Add forces and resolve them into components
- Express force and position in Cartesian vector form
- Determine a vector's magnitude and direction
- Introduce the dot product and use it to find the angle between two vectors or the projection of one vector onto another

Scalars and vectors

	Scalar	Vector
Examples	Mass, Volume, Time	Force, Velocity
Characteristics	It has a magnitude	It has a magnitude and direction
Special notation used in TAM 210/211	None	Bold font or vector symbol Ex: $\boldsymbol{A}$ or $\underset{\sim}{A}$ or $\vec{A}$

(similar to $\Sigma \underset{\sim}{F} = m \cdot \underset{\sim}{a}$)

<u>Multiplication or division of a vector by a scalar</u>

$$\underset{\sim}{\boldsymbol{B}} = \alpha \underset{\sim}{\boldsymbol{A}}$$

$\underset{\sim}{A}$

if $\alpha = 2$, then $\underset{\sim}{B} =$ (change magnitude)

if $\alpha = -1$, then $\underset{\sim}{B} =$ (change direction by 180°)

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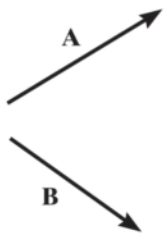
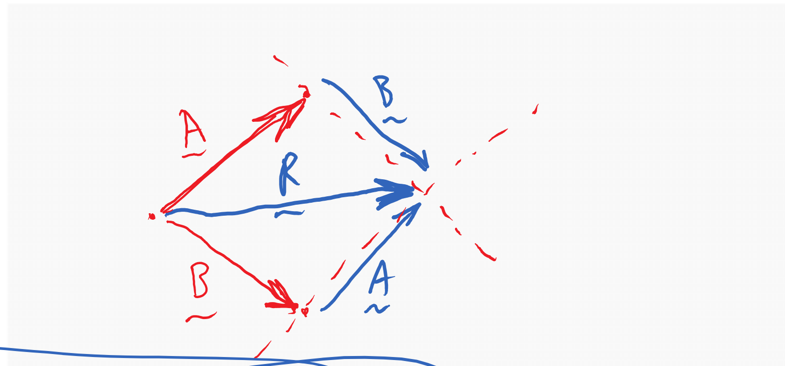
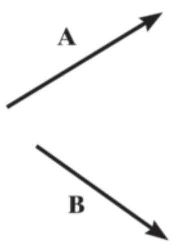
Vector addition

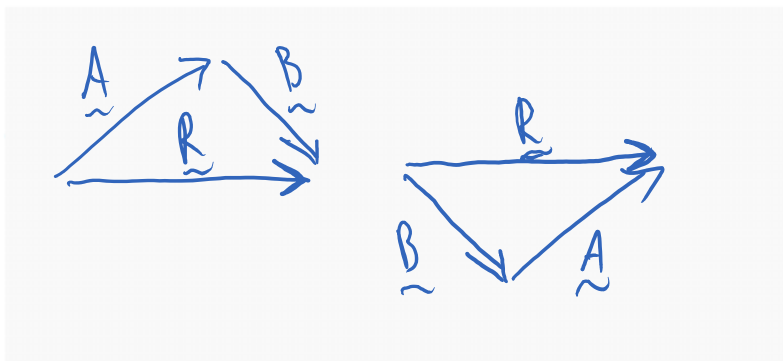
All vector quantities obey the parallelogram law of addition $\boldsymbol{R} = \boldsymbol{A} + \boldsymbol{B}$





Commutative law: $\boldsymbol{R} = \boldsymbol{A} + \boldsymbol{B} = \boldsymbol{B} + \boldsymbol{A}$





Associative law: $\boldsymbol{A} + (\boldsymbol{B} + \boldsymbol{C}) = (\boldsymbol{A} + \boldsymbol{B}) + \boldsymbol{C}$

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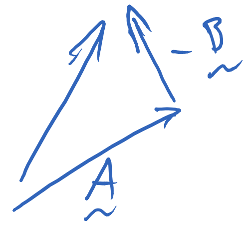
Vector subtraction:

$$\boldsymbol{R} = \boldsymbol{A} - \boldsymbol{B} = \boldsymbol{A} + (-\boldsymbol{B})$$

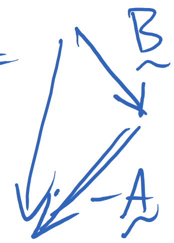
Note: $\underset{\sim}{A} - \underset{\sim}{B} \neq \underset{\sim}{B} - \underset{\sim}{A}$

$(-\boldsymbol{B})$ has the same magnitude as $\boldsymbol{B}$ but is in opposite direction.

$\underset{\sim}{A} - \underset{\sim}{B} =$



$\underset{\sim}{B} - \underset{\sim}{A} =$



Scalar/Vector multiplication:

$$\alpha(\boldsymbol{A} + \boldsymbol{B}) = \alpha \underset{\sim}{A} + \alpha \underset{\sim}{B}$$

$$(\alpha + \beta)\boldsymbol{A} = \alpha \underset{\sim}{A} + \beta \cdot \underset{\sim}{A}$$

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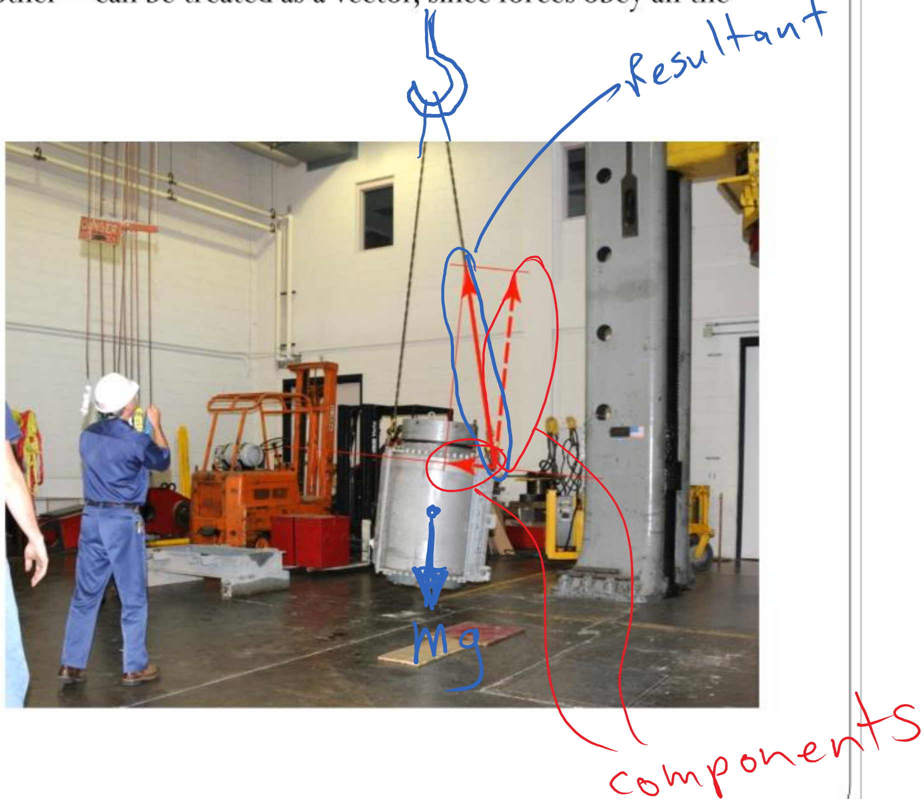
Force vectors

A force—the action of one body on another—can be treated as a vector, since forces obey all the rules that vectors do.



Generally, in Statics, we do two types of problems:

- Determine a resultant force (mag. & direction)
- Resolve a force into components

Cartesian vectors

Rectangular coordinate system: formed by 3 mutually perpendicular axes, the x, y, z axes, with unit vectors $\hat{i}$, $\hat{j}$, $\hat{k}$ in these directions.

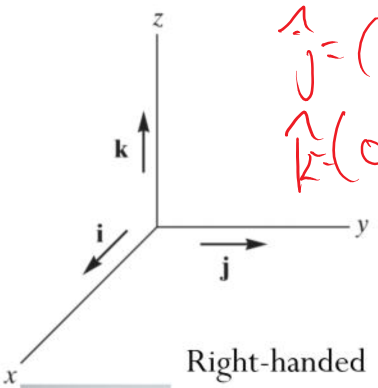
Note that we use the special notation "^" to identify *basis vectors* (instead of the "~" notation)

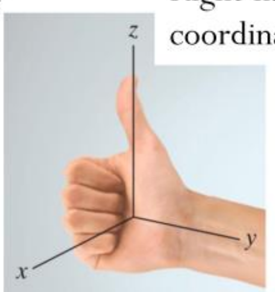
$(\hat{i}, \hat{j}, \hat{k})$ or $(\boldsymbol{i}, \boldsymbol{j}, \boldsymbol{k})$

$\hat{i} = (1, 0, 0)$ No units!

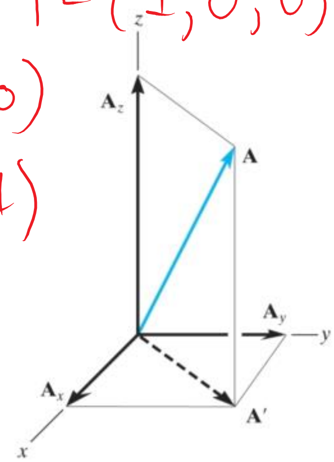
$\hat{j} = (0, 1, 0)$

$\hat{k} = (0, 0, 1)$

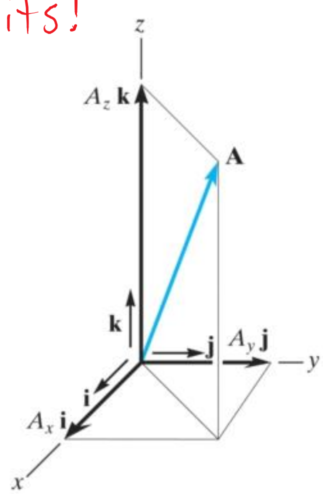




Right-handed coordinate system



Rectangular components of a vector



Cartesian vector representation

$\underset{\sim}{A} = \underset{\sim}{A}_x + \underset{\sim}{A}_y + \underset{\sim}{A}_z$

$\mathbf{A} = A_x \hat{i} + A_y \hat{j} + A_z \hat{k}$

what are the dimensions of a unit vector?

A) length

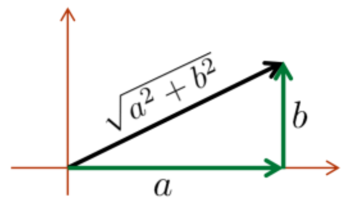
B) dim'less

C) force

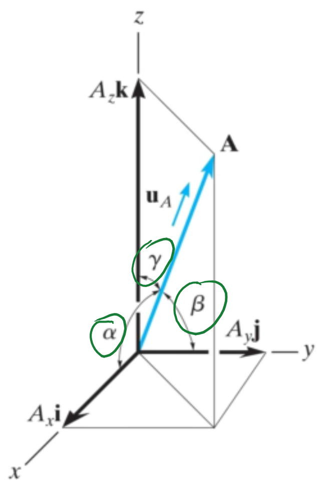
D) velocity

Magnitude of Cartesian vectors

$$A = |\underset{\sim}{\mathbf{A}}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$



Direction of Cartesian vectors



Expressing the direction using a unit vector:

$$\hat{\mathbf{u}}_A = \frac{\mathbf{A}}{A}$$

vector

scalar

unit vector

Direction cosines are the components of the unit vector:

dimensionless vector of magnitude $|\hat{u}_A| = 1$

Direction cosines

$$\frac{\underset{\sim}{A}}{A} = \frac{A_x}{A}\hat{i} + \frac{A_y}{A}\hat{j} + \frac{A_z}{A}\hat{k}$$

$$= \cos\alpha\,\hat{i} + \cos\beta\,\hat{j} + \cos\gamma\,\hat{k}$$

Addition of Cartesian vectors

$$\boldsymbol{R} = \mathbf{A} + \boldsymbol{B} = (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j} + (A_z + B_z)\hat{k}$$