CE30 – Discussion 1

Vector Operations & Forces

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Vectors

Quantities of a Vector

1. Magnitude
2. Direction

Quantities of a Force

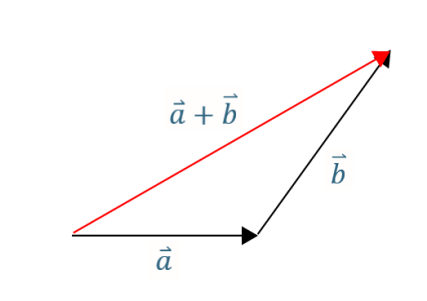
1. Magnitude
2. Direction
3. Point of application

Vector Operations

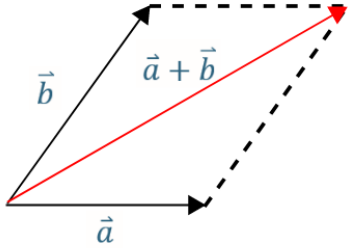
- $\vec{a} + \vec{b} = \vec{b} + \vec{a}$
- $\vec{a} + \vec{b} + \vec{c} = \vec{a} + (\vec{b} + \vec{c})$
- $\vec{a} - \vec{b} = \vec{a} + (-\vec{b})$
- $\vec{a} - \vec{a} = \vec{0}$

Geometrical Representation of Vector Operations

- Triangle Method



- Parallelogram Method



Vector Addition

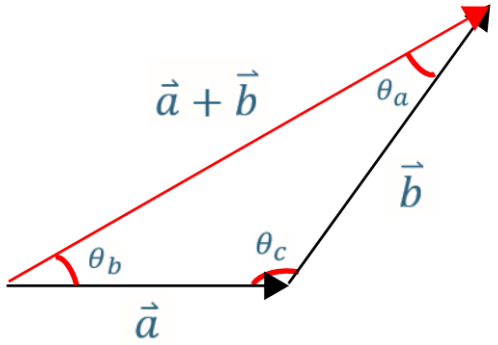
How to Calculate $|\vec{a} + \vec{b}|$?

- Law of Sine

$$\frac{|\vec{a}|}{sin\theta_a} = \frac{|\vec{b}|}{sin\theta_b} = \frac{|\vec{a}+\vec{b}|}{sin\theta_c}$$

- Law of Cosine

$$|\vec{a} + \vec{b}| = |\vec{a}|^2 + |\vec{b}|^2 - 2\vec{a}\vec{b}cos\theta_c$$



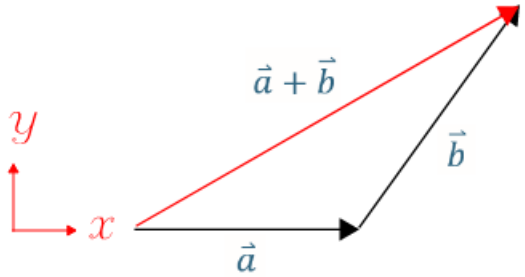
Vector Addition

Component Representation

$\vec{a} = (x_a,\ y_a)$
$\vec{b} = (x_b,\ y_b)$

$\vec{a} + \vec{b} = (x_a + x_b,\quad y_a + y_b)$

Applies to 1D, 2D and 3D



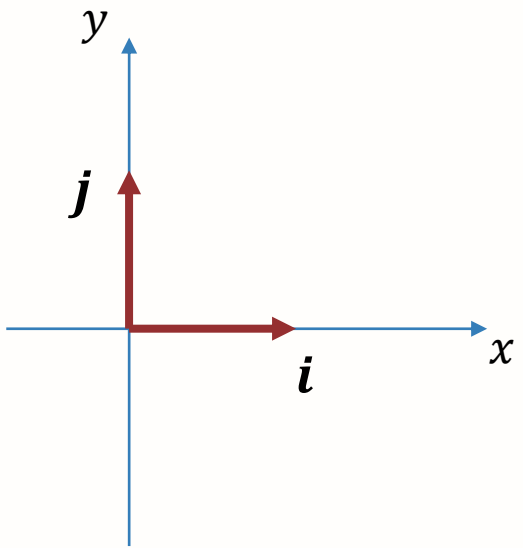
Component of vectors

Unit vectors

- Magnitude 1
- Directions aligned with coordinate system

- Typically denoted as $\boldsymbol{i}, \boldsymbol{j}$

$$|\boldsymbol{i}| = 1 \quad and \quad |\boldsymbol{j}| = 1$$



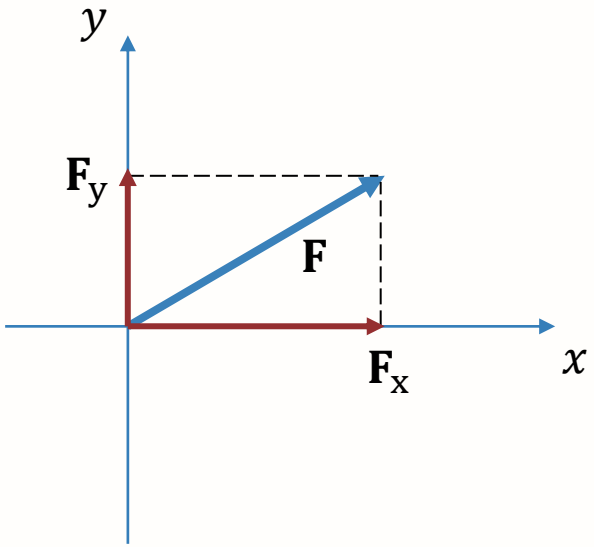
Component of vectors

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

or in terms of unit vectors

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

where F_x and F_y are scalar components



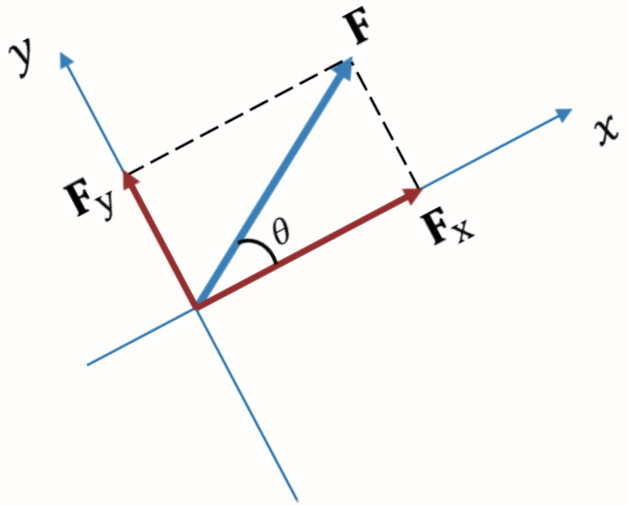
Component of vectors

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

$$F_x = F\cos(\theta)$$

$$F_y = F\sin(\theta)$$

$$F = |\mathbf{F}|$$



Forces

- Properties:

  1. Magnitude
  2. Direction
  3. Point of application

- A vector quantity, follows all the operations of a vector

- Sum of the two forces can be represented by a single **resultant force**

Forces

How to Solve a Statics Problem?

1. Draw coordinate system
2. Draw free body diagram
3. Set up equilibrium equations
4. Identify unknown forces
5. Solve equilibrium equations

Homework 1

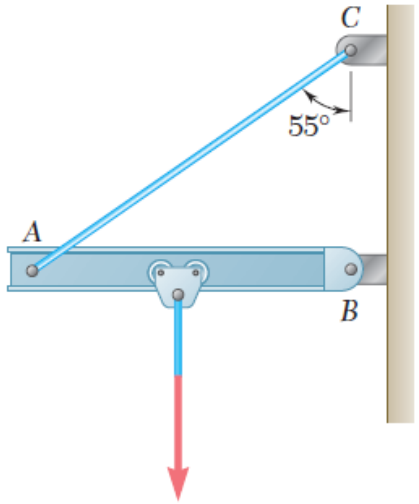
- Problems from the textbook:

  2.1, 2.2, 2.7, 2.18, 2.21, and 2.28.

- Due 01/26 (Friday) midnight
- Use engineering paper (hardcopy or electronic)
- Submit to **Gradescope** (not to bCourses!)

Example

2.22 Cable AC exerts on beam AB a force $\mathbf{P}$ directed along line AC. Knowing that $\mathbf{P}$ must have a 350-lb vertical component, determine (a) the magnitude of the force $\mathbf{P}$, (b) its horizontal component.



Example

2.29 A hoist trolley is subjected to the three forces shown. Knowing that $\alpha = 40°$, determine (a) the magnitude of the force **P** for which the resultant of the three forces is vertical, (b) the corresponding magnitude of the resultant.