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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

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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!!!***

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# 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

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# 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<br>Ex: $\boldsymbol{A}$ or $\underset{\sim}{A}$ |

**Multiplication or division of a vector by a scalar**

$$\boldsymbol{B} = \alpha\, \boldsymbol{A}$$

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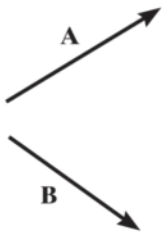
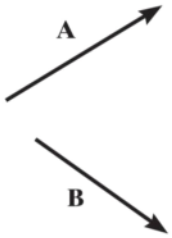
**Vector addition**

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:**

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

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

**Scalar/Vector multiplication:**

$$\alpha(\boldsymbol{A} + \boldsymbol{B})$$

$$(\alpha + \beta)\boldsymbol{A}$$

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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.

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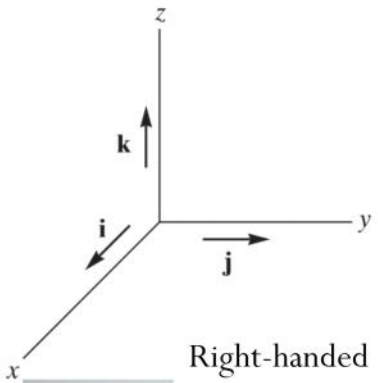
# Cartesian vectors

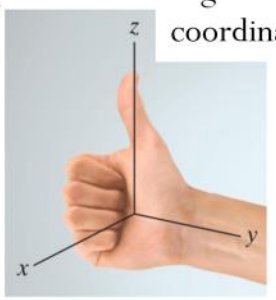
Rectangular coordinate system: formed by 3 mutually perpendicular axes, the $x$, $y$, $z$ axes, with unit vectors $\hat{i}$, $\hat{j}$, $\hat{k}$ in these directions.

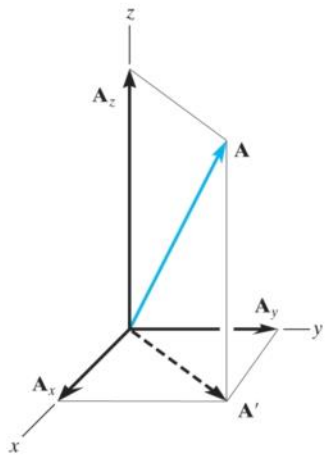
Note that we use the special notation "^" to identify *basis vectors* (instead of the "~" notation)

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

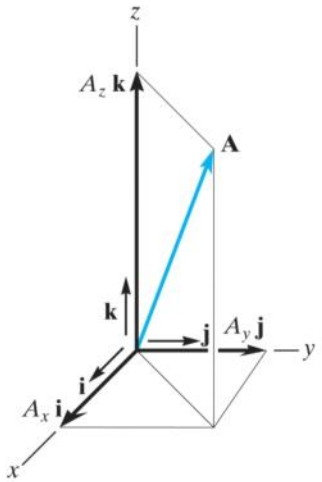



Right-handed coordinate system




Rectangular components of a vector




Cartesian vector representation

$\boldsymbol{A} =$ $\boldsymbol{A} =$

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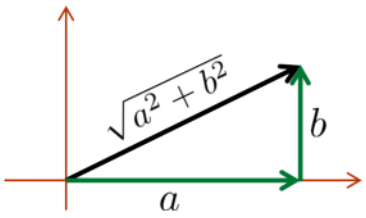
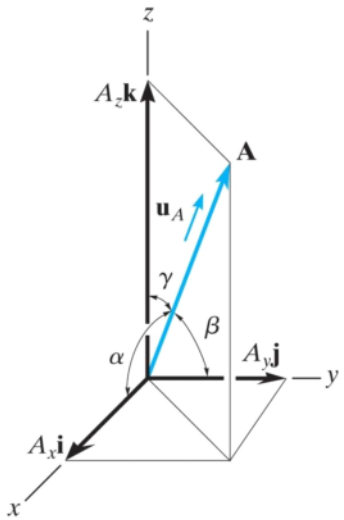
## Magnitude of Cartesian vectors

$$A = |\boldsymbol{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$$




## Direction of Cartesian vectors




Expressing the direction using a unit vector:

$$\boldsymbol{u}_A = \frac{\boldsymbol{A}}{A}$$

Direction cosines are the components of the unit vector:

## Addition of Cartesian vectors

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

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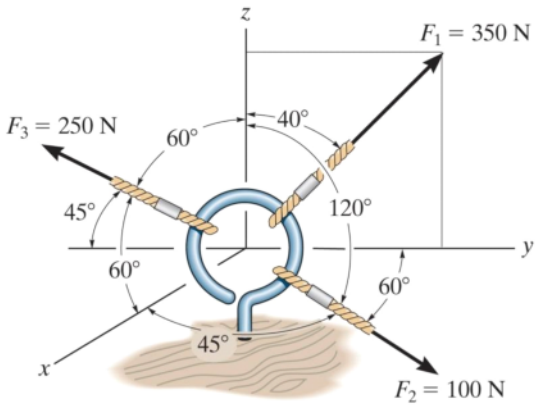
# Example




The cables attached to the screw eye are subjected to the three forces shown.

(a) Express each force vector using the Cartesian vector form (components form).

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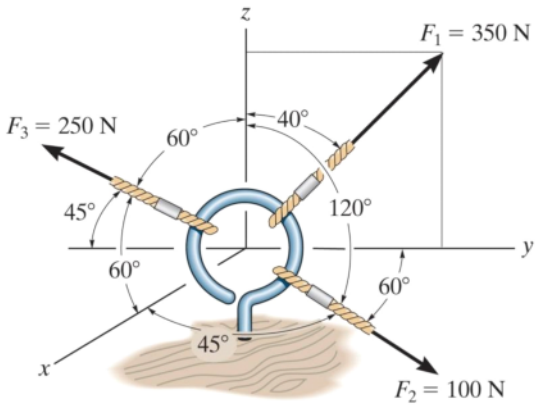
# Example




The cables attached to the screw eye are subjected to the three forces shown.

(a) Express each force vector using the Cartesian vector form (components form).

(b) Determine the magnitude of the resultant force vector

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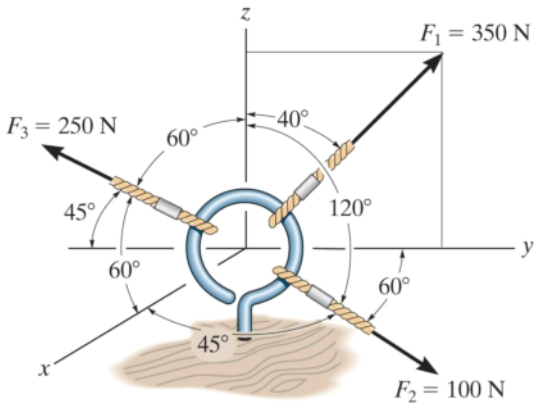
# Example




The cables attached to the screw eye are subjected to the three forces shown.

(a) Express each force vector using the Cartesian vector form (components form).

(b) Determine the magnitude of the resultant force vector

(c) Determine the direction cosines of the resultant force vector