Statics - TAM 211

Lecture 2

September 12, 2018

Announcements

- Go through course website (policies, info, schedule, references)
- MATLAB training sessions TBA (next 2 weeks)
- Upcoming deadlines:
- Tuesday (Sept 18 – due by 11:59 pm)
  - PrairieLearn HW1
  - Take practice Quiz 0 on PrairieLearn (not graded)
  - If you have difficulty logging into PrairieLearn pleases post comment in Blackboard Discussion Board

expedia.com

Chapter 1: General Principles
Main goals and learning objectives

- Introduce the basic ideas of *Mechanics*
- Give a concise statement of Newton's laws of motion and gravitation
- Review the principles for applying the SI system of units
- Examine standard procedures for performing numerical calculations
- Outline a general guide for solving problems

Numerical Calculations

Dimensional Homogeneity

Equations ***must*** be dimensionally homogeneous, i.e., each term must be expressed in the same units.

Work problems in the units given unless otherwise instructed!

Numerical Calculations

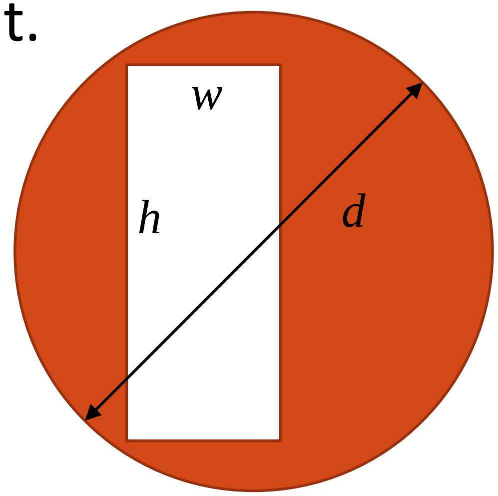
Significant figures

Number of significant figures contained in any number determines 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, to maintain precision.

Example: Find area of circle with rectangular cut-out.

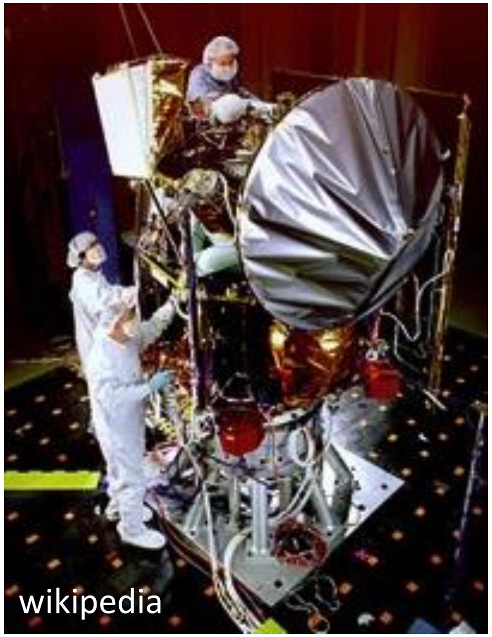
$$A = \frac{\pi d^2}{4} - wh$$

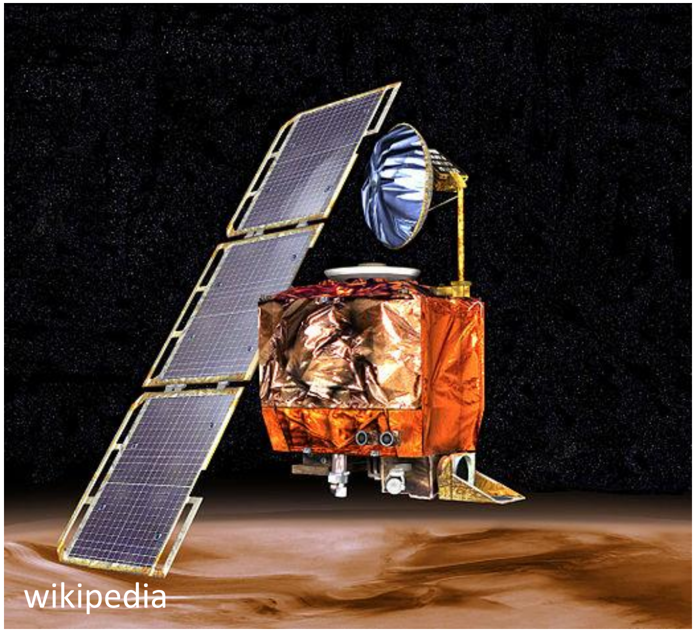
Given: *d* = 3.2 in., *w* = 1.413 in., and *h* = 2.7 in.



Why so picky? Units matter…

- A national power company mixed up prices quoted in kilo-Watt-hour (kWh) and therms.
  - Actual price = $50,000
  - Paid while trading on the market: $800,000
- In Canada, plane ran out of fuel because pilot mistook liters for gallons!





Mars climate orbiter – $327.6 million

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.
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!***

Chapter 2: Force Vectors

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

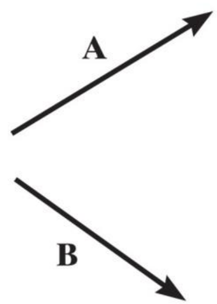
	Scalar	**Vector**
Examples	Mass, Volume, Time	Force, Velocity
Characteristics	It has a magnitude	It has a magnitude and direction
Special notation used in TAM 210/211	No special font A	Bold font or symbols ($\sim$ or $\rightharpoonup$) Ex: $\mathbf{A}$, $\tilde{\mathbf{A}}$, $\vec{\mathbf{A}}$

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

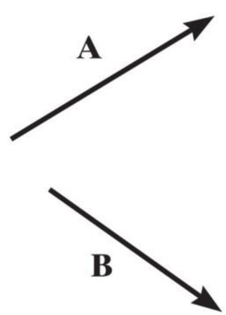
$$\boldsymbol{B} = \alpha\, \boldsymbol{A}$$

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

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.

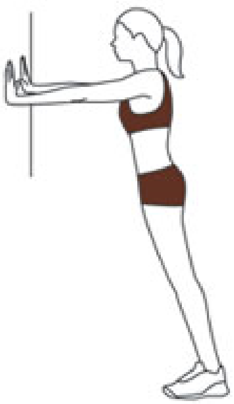
Scalar/Vector multiplication:

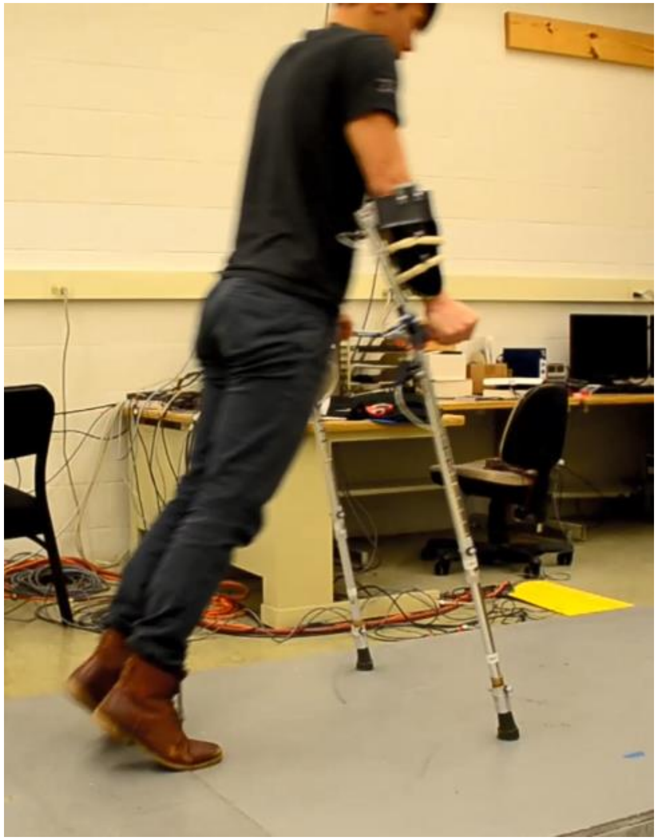
$$\alpha(\boldsymbol{A} + \boldsymbol{B})$$

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

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.





Human Dynamics & Controls Lab

www.altramotion.com

Generally asked to solve two types of problems.

1. Find the resultant force.

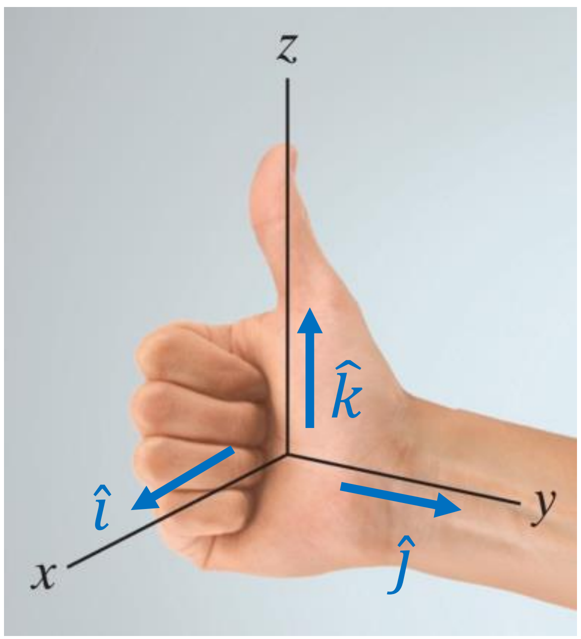
2. Resolve the force into components

Cartesian vectors

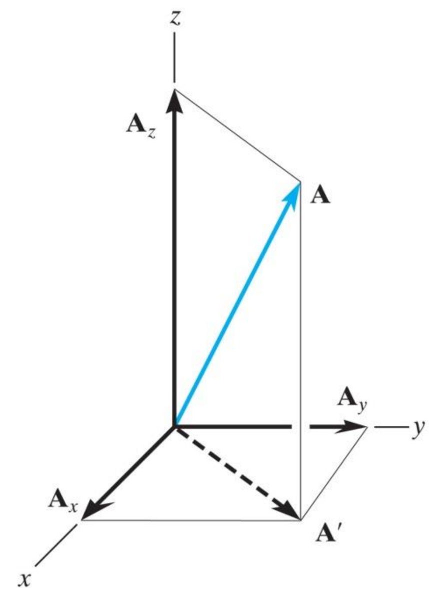
Rectangular coordinate system: formed by 3 mutually perpendicular axes, the *x*, *y*, *z* axes with unit vectors $\hat{\imath}, \hat{\jmath}, \hat{k}$ in these directions.

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

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

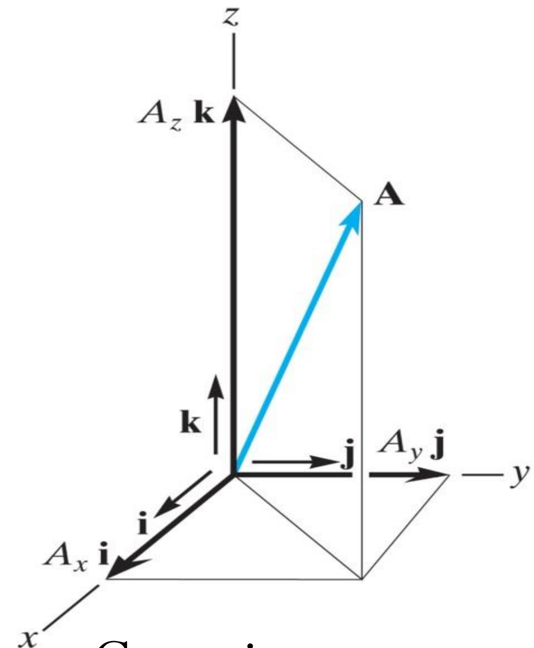


Right-handed coordinate system



Rectangular components of a vector

$$\boldsymbol{A} = \boldsymbol{A}_x + \boldsymbol{A}_y + \boldsymbol{A}_z$$

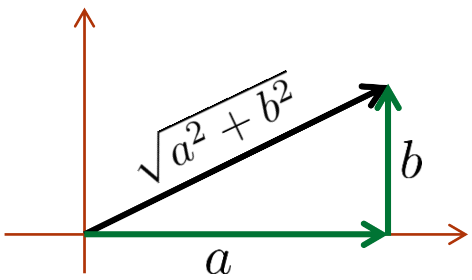


Cartesian vector representation

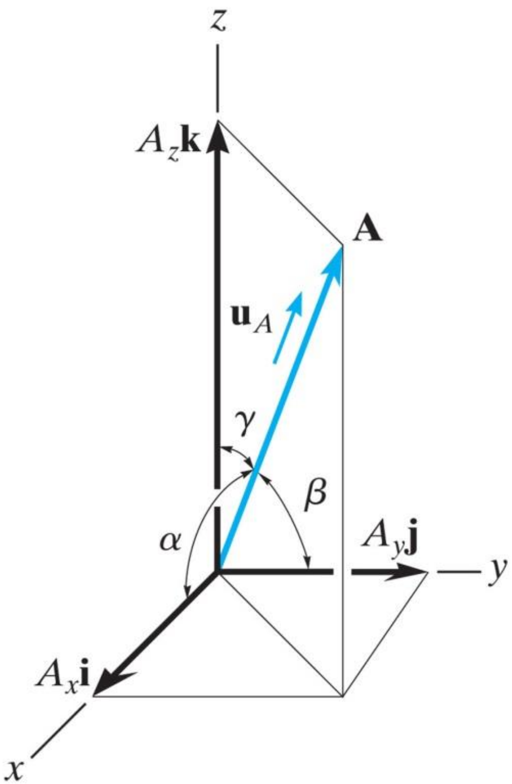
$$\boldsymbol{A} =$$

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

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

Example

The cables attached to the screw eye are subjected to 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