Lecture 1 — Introductory Dynamics

Ray Essick
PhD Student (Geir Dullerud)

- Hybrid and switched systems
- Computational tools

Where does TAM 212 fit in?

TAM 210/211: Statics
- Don't move
- Don't change shape

TAM 212
- Move
- Don't change shape

TAM 251
- Don't move
- Change shape

300/400
- Move
- Change shape

Finite Element Models
"Real world"

How we structure TAM 212

- Learning Time

  Lectures
  "Discussion" activities
  Piazza
  Office Hours
  Homeworks

  Project Checkpoints

- Testing Time

  CBTF Quizzes
  Final Exam

  (Final Project Report)

My goal: Everyone succeeds

Learning time is work

Testing time is easy

Logistics

Lecture: MWF 1pm - 3pm

Ask questions! Tell me what's making sense and what isn't

"Discussion": F 2-3pm (in lecture)

Group activities → apply class tools to engineering problems

Project: With your discussion group, over the semester

Details coming on Friday

Piazza: Open 24-7

Xian and I will check and respond

Office Hours:

	M	T	W	R	F
AM		○			
PM	○ After Class	○			

Homework: PrairieLearn

Available Wed morning, due end of Wed one week later

More questions than points
- Answer some for HW points
- Answer more for quiz prep

Quiz: CBTF

One quiz / week, schedule coming soon

Positions and Vectors

Talk about where we are in two ways

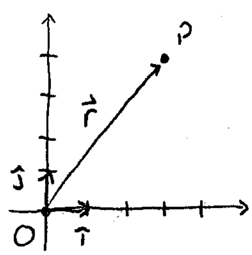
Position → coordinates → coordinate system ↗ origin $(0\,m, 0\,m)$; ↘ axes

$x = 3\,m, \; y = 4\,m$

(Position) Vector → components → basis $\hat{\imath}, \hat{\jmath}$

$\vec{v} = 3\hat{\imath} + 4\hat{\jmath}$

Cartesian Coordinates and Basis (and notation)



position of P is $x = 3\,m$
$y = 4\,m$ $(= 400\,cm = 4000\,mm = 13.1\,ft)$

P has coordinates $(x, y) = (3\,m, 4\,m)$

$\boxed{Q}$ Does x have units? $\boxed{NO}$

Values have units (and depend on units) - Keep calculations clean

$x = 3(\ )t^2 = \left(3\,\frac{m}{s^2}\right)t^2$

$= (3t^2)\,m, \; t$ in seconds

Position vector of P $\vec{r} = (3\,m)\hat{\imath} + (4\,m)\hat{\jmath}$ (units go with values, not unit vectors)

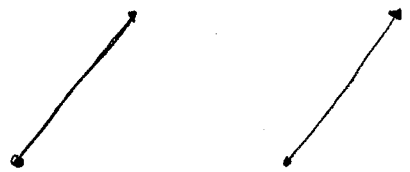
$\vec{r}_P$ to distinguish from other points $\quad \vec{r} = [3\,m, 4\,m]$

$\vec{r}_{OP}$ to explicitly identify an origin $\quad = [r_x, r_y] = r_x\hat{\imath} + r_y\hat{\jmath}$

! Avoid $\langle r_x, r_y \rangle$ this notation often means dot product

Properties of Vectors

Vectors have direction and magnitude, but not position



These have the same direction and same magnitude

Vectors don't ~~not~~ have position (e.g. $\hat{\imath}$ is $\hat{\imath}$ all over the blackboard)

Physical meaning can distinguish vectors : $\vec{r} = [3\,m, 4\,m]$ Not the same

$\vec{v} = [3\,m/s, 4\,m/s]$

Separating direction and magnitude

$\vec{r} = (3m)\,\hat{\imath} + (4m)\,\hat{\jmath}$

Magnitude is a scalar $\quad r = \|\vec{r}\| = \sqrt{r_x^2 + r_y^2}$

Direction is a unit vector $\quad \hat{r} = \dfrac{\vec{r}}{r}$

$$\hat{r} = \frac{(3m)\,\hat{\imath} + (4m)\,\hat{\jmath}}{(5m)} = 0.6\,\hat{\imath} + 0.8\,\hat{\jmath}$$

* Magnitude of $\hat{r}$ $\quad \|\hat{r}\| = 1$
* Units of components : None

$$\vec{r} = \underbrace{r}_{\text{Scalar magnitude}}\ \underbrace{\hat{r}}_{\text{Unit vector direction}}$$

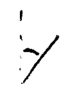
Example

Walking along a field

- You go 3 m east every time you go 4 m north

$$\vec{v} = (3\,\text{m/s})\,\hat{\imath} + (4\,\text{m/s})\,\hat{\jmath}$$

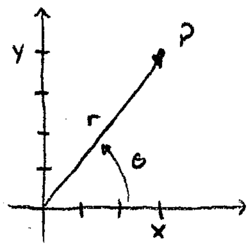
- You are facing compass heading 36.87° and speed (5 m/s)



$$\vec{v} = (5\,\text{m/s})\,\hat{v} = (5\,\text{m/s})\left[\sin(36.87^\circ)\,\hat{\imath} + \cos(36.87^\circ)\,\hat{\jmath}\right]$$

What you write depends on what you know (or want to find out)

Polar Coordinates



P has position $x = 3$ m

$y = 4$ m

or

$r = 5$ m

$\theta = 53.2^\circ \approx 0.927$ rad

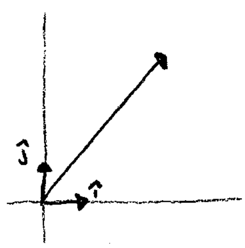
! Magnitude
Direction

Geometry provides transform: $x = r\cos\theta$, $y = r\sin\theta$

$r = \sqrt{x^2+y^2}$

$$\boxed{\theta = \mathrm{atan2}(y, x) \neq \mathrm{atan}\left(\frac{y}{x}\right)}$$

Polar Basis



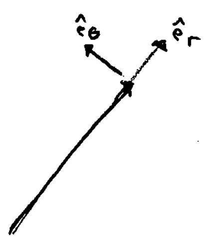
$\hat{\imath}$: Direction to increase x leaving y constant

$\hat{\jmath}$: Direction to increase y leaving x constant

$\boxed{\hat{e}_r}$: Direction to increase r leaving θ constant

$\boxed{\hat{e}_\theta}$ $\qquad\qquad\qquad\qquad \theta \qquad\qquad r$

Graphically



Algebraically

$$\vec{r} = r\cos\theta\,\hat{\imath} + r\sin\theta\,\hat{\jmath}$$

$$\frac{\partial\vec{r}}{\partial r} = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$$ ✓ unit vector?

$$\frac{\partial\vec{r}}{\partial\theta} = -r\sin\theta\,\hat{\imath} + r\cos\theta\,\hat{\jmath}$$ X unit vector?

Not normalized

$\hat{e}_r = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$

$\hat{e}_\theta = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$

Find $\hat{\imath}, \hat{\jmath}$ in terms of $\hat{e}_r, \hat{e}_\theta$

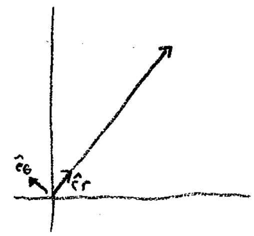
$\hat{\imath} = \cos\theta\,\hat{e}_r - \sin\theta\,\hat{e}_\theta$

$\hat{\jmath} = \sin\theta\,\hat{e}_r + \cos$

Position Vector in Polar basis

$$\vec{r}_{op} = (3m)\hat{i} + (4m)\hat{j}$$

$$\vec{r}_{op} = (\underline{\ r\ })\hat{e}_r + (\theta)\hat{e}_\theta$$



Cartesian <u>coordinates</u> and Cartesian <u>position components</u> are the same

Polar coordinates and Polar position components <u>do not agree</u> $\cancel{\vec{r} \neq r\hat{e}_r + \theta\hat{e}_\theta}$