TAM 212 – Introductory Dynamics

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Summer 2019

Outline

- Course Policy
- Course Resources
- Course Elements
- Tools for Success
- Intro to Dynamics – Course Overview

Course Websites

https://courses.engr.illinois.edu/tam212/su2019/index.html

How to Succeed in TAM 212

- We want everyone to succeed
- Show up
- Participate: lecture, homework, discussion
- Get help as soon as you need it
- Slow and steady does it

Time/Activities

- Learning Time
- Testing Time

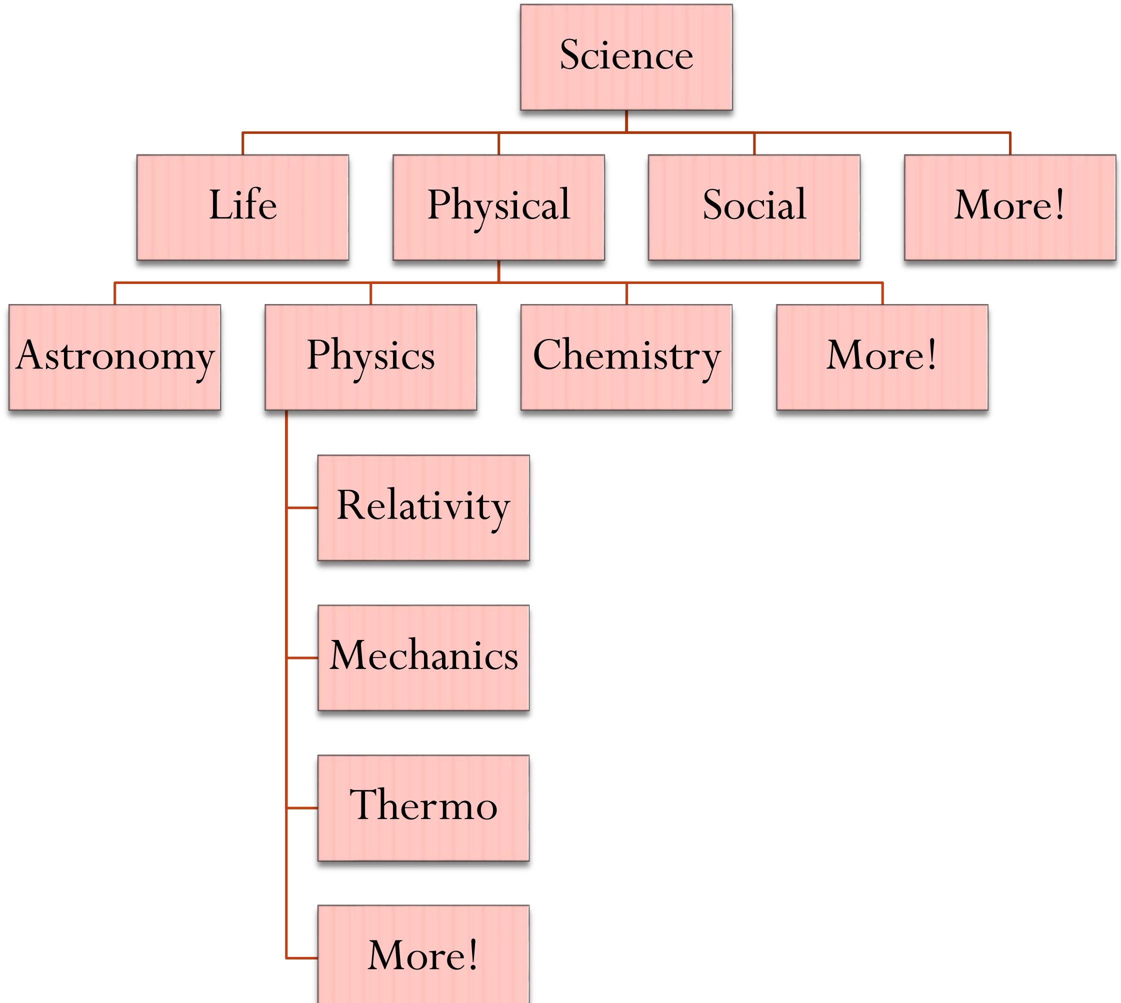
TAM 212: Introductory Dynamics

Introduction

https://www.youtube.com/watch?v=dEYEn_fpv-4

The bike has only 2 gears (one just for start only & another for the rest of race) w/ single-piston engine (Suzuki provides it as one make). No brake installed for both front & rear wheel. No mechanic allowed by the regulation, thus rider have to manage everything. They wear iron made slipper over their left boots.

What is "dynamics"?



Mechanics

Mechanics is a branch of the physical sciences that is concerned with the **state of rest or motion of bodies that are subjected to the action of forces**

Rigid Bodies

Statics

Dynamics

Deformable Bodies

Solid Mechanics

Fluids

Compressible and incompressible

Goal

Develop relevant fundamental knowledge to understand dynamic processes and to use mathematical tools to analyze them.

Where does TAM 212 fit?

TAM 210/211: Statics - don't move, don't bend

TAM 212: Dynamics - move, don't bend

TAM 251: Solid Mechanics - don't move, bend

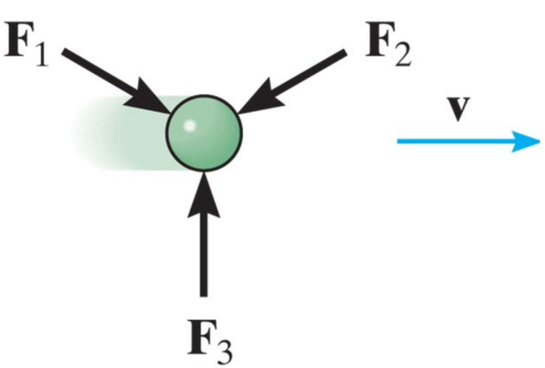
300s, 400s classes, e.g., FEM - move + bend

ME 200 - Thermodynamics

ME 310 - Fluid Dynamics

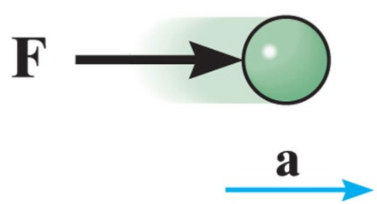
Newton's laws of motion

First law:
Particle at rest (or moving in a straight line with constant velocity) stays that way unless another force comes in.

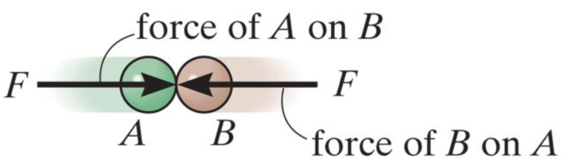


Second law: a particle acted upon by an unbalanced force **F** experiences an acceleration **a** that is proportional to the particle mass *m*:

$$F = ma$$



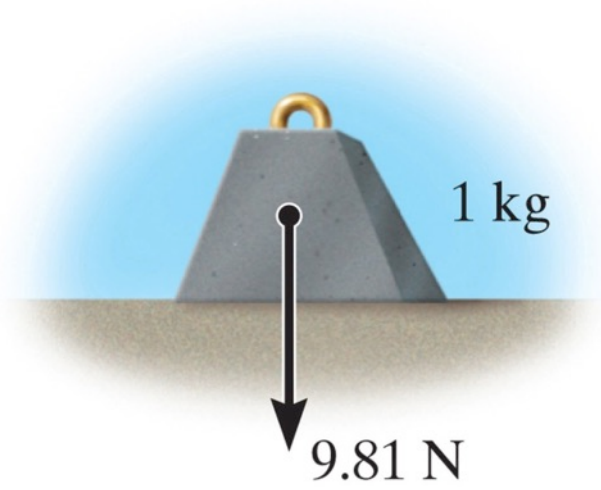
Third law: the mutual forces of action and reaction between two particles are ____equal____, ___opposite___ and ____collinear____.

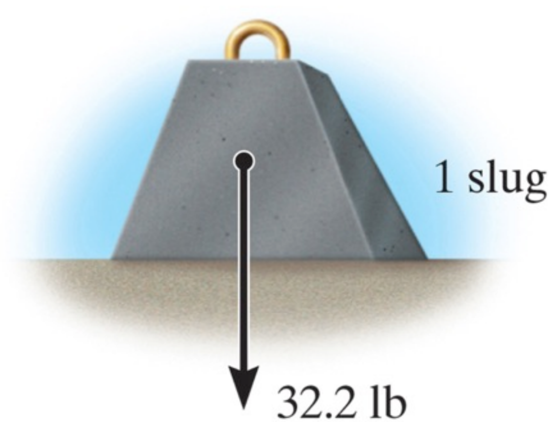


Units

TABLE 1–1 Systems of Units				
Name	Length	Time	Mass	Force
International System of Units SI	meter m	second s	kilogram kg	newton* N $\left(\frac{kg \cdot m}{s^2}\right)$
U.S. Customary FPS	foot ft	second s	slug* $\left(\frac{lb \cdot s^2}{ft}\right)$	pound lb

*Derived unit.



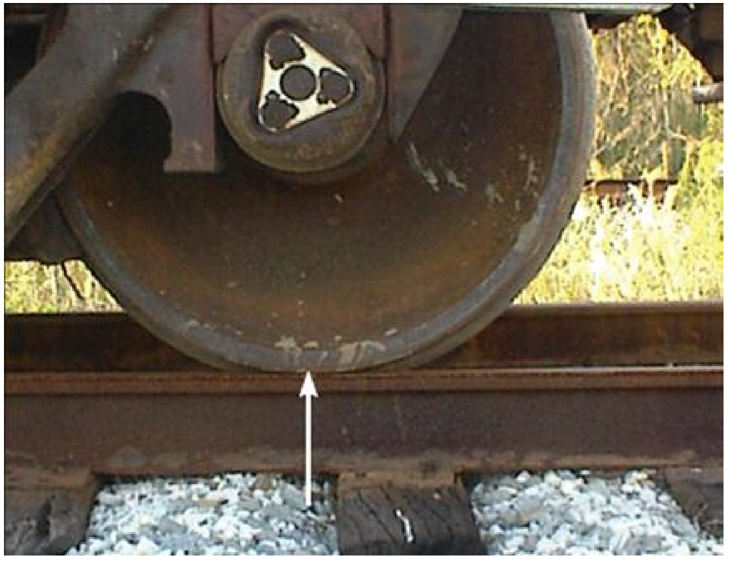


$$G = 66.73 \times 10^{-12} \frac{m^3}{kg \cdot s^2}$$

$$g = 9.81 \frac{m}{s^2}$$

$$g = 32.2 \frac{ft}{s^2}$$

Fundamental concepts



Basic quantities:

- Length
- Time
- Volume
- Mass

Idealizations:

- Particle:

  Has mass but neglect size (no geometry)

- Rigid Body:

  A combination of particles at a fixed distance, no deformation

- Concentrated Force:

  Loading acting at a point

Understanding and applying these things allows for amazing achievements in engineering! (planes, robotics, etc)

Dynamics Roadmap

Kinematics: the motion of objects

Kinetics: the forces acting on particle/rigid body

Momentum: the quantity of motion of a moving body

Work and energy: the exertion of force overcoming resistance

Lecture Objectives

- Position vs. Vector

- Vector Operations
  - unit vector
  - dot product
  - cross product
  - Vector projection

Positions and Vectors in Cartesian Coordinate System

Position

Vector

Position of P is $x = 4\text{m}$

$y = 3\text{ m}$

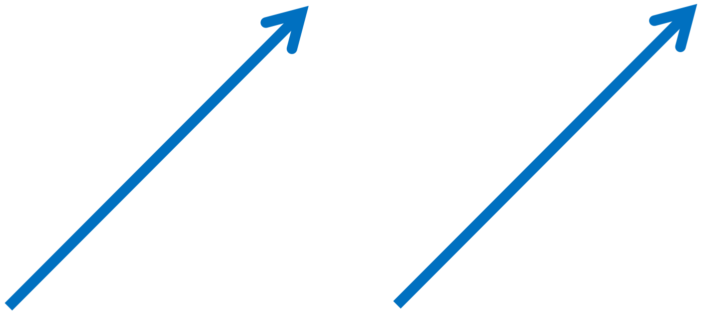
(x, y)

Position vector P

Which of these things is not like the others?

A. Meter
B. Second
C. Length
D. Lightyear
E. Foot

Are these the same vector? A. Yes   B. No



Do vectors have positions? A. Yes   B. No

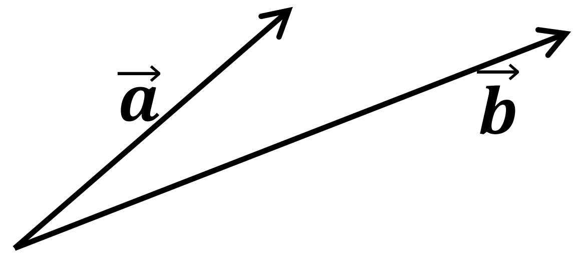
Vector

Unit Vector

Dot Product

Cross Product

Projections & complementary projections of vectors



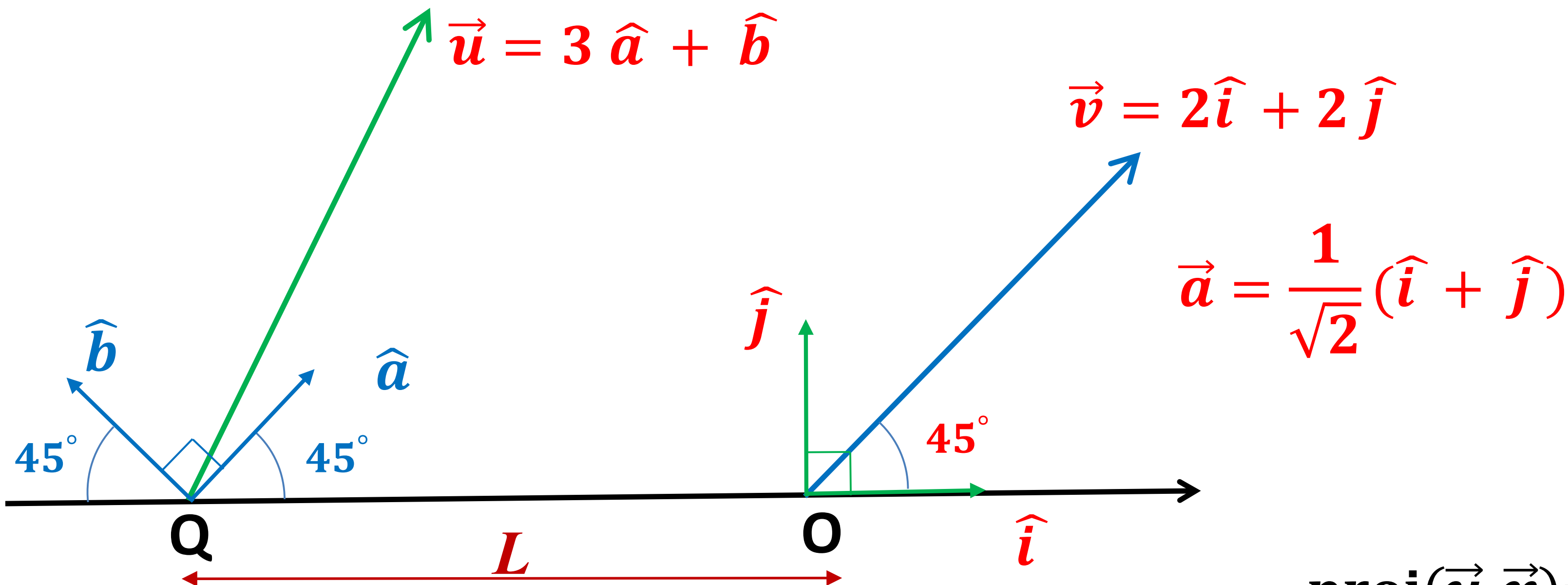
$\vec{p} = \mathbf{proj}\left(\vec{a}, \vec{b}\right)$

$=$ vector projection of $\vec{a}$ in the direction of $\vec{b}$

$\vec{c} = \mathbf{comp}\left(\vec{a}, \vec{b}\right)$

$=$ complementary projection of $\vec{a}$ in the direction of $\vec{b}$

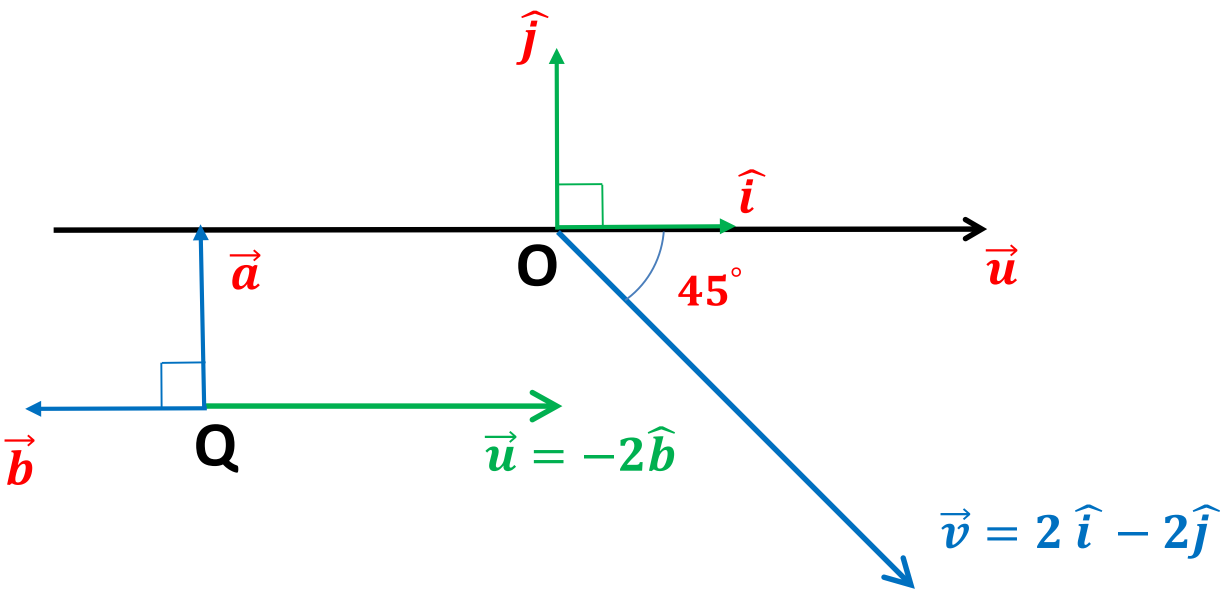
Example



proj$(\vec{u}, \vec{v})$=

A. 3
B. $3\hat{a}$
C. $\frac{1}{\sqrt{2}}(3i + 3j)$
D. 6
E. Need to know L

Example



$\text{proj}(\vec{u}, \vec{v})$=

A. $\hat{i} + \hat{a}$
B. $-\hat{i} + \hat{j}$
C. $\hat{a} + \hat{b}$
D. $\hat{j} - \hat{a}$
E. $-\hat{j} - \hat{b}$

Homework for Tonight

- Check out Piazza
- Check out CBTF website for quiz/exam sign-up
- First PL homework due Thursday, June 13
- First quiz starts <u>this</u> Thursday (June 13)!