Dynamics, MAE 2030 ①

Wed Jan 23, 2019

Today *Intro.
*1D dynamics
(Please do not sit in last 3 rows)

What is Mechanics?

Given a system (suggests a model)
" some info. about the forces (dir., mag, loc.)
" some inf. about distortion & motion

Find? Other info. about forces, distortion & motion.

How?

Write "true" equations that involve known & unknown quantities.

Then: solve eqs for vars or fns. of interest.

Main Eqn:

think about sending 2 different ways

"Let $X = X$" - Laurie Anderson

What are these eqns.?

3 general types of Eqns.

"pillars"

I. Constitutive Laws or Force Laws or Material properties

Ex: $F = k(\Delta \ell)$ spring

ex) $F_{12} = \frac{G m_1 m_2}{r_{12}^2}$ central force gravity

ex) $F = g m$ near earth gravity

ex a) $\vec{F}_D = -C\vec{v}$ ← linear drag

ex b) $\vec{F}_D = -c|\vec{v}|^2 \frac{\vec{v}}{|\vec{v}|}$ ← quadratic drag

ex) $F_f = \mu N$ friction

ex) $v^+ = -e v^-$ collision

ex) $\sigma = E\varepsilon$ Hook's laws (3)

All bad; All good enough

$F = mg$ typical error 1/4 % or 2 %

best

$\Rightarrow (g = 10\ m/s^2)$ ↑ Andy likes

worst. $F = \mu N$ typical errors

const. law; 10% – 50%

Friction; Jaeger's 3rd law: "A friction exp. will make a monkey out of you."

II. Geometry & time

Geometry in motion

Kinematics ~~Kinetics~~

Lengths, angles, time

no forces

ex) $v = \dot{x}$

ex) $a = \dot{v} = \ddot{x}$

ex) $\epsilon = \frac{\Delta l}{l}$

ex $\epsilon = \frac{-y}{\rho}$

ex) $c^2 = a^2 + b^2 - 2ab\cos\theta$

ex) $\vec{v} = \vec{\omega} \times \vec{r}$

ex) $\vec{a}_P = \vec{a}_{O'} + \vec{a}_{rel} + \vec{\omega} \times (\vec{\omega} \times \vec{r}_{P/O'})$ "5 term acceleration formula"

$$+ \dot{\vec{\omega}} \times \vec{r}_{rel} \times 2\vec{\omega} \times \vec{v}_{rel}$$

III. Laws of Mechanics

Linear Momentum Balance

LMB

$$\vec{F}^{ext}_{Tot} = m \vec{a}_{G_{Tot}}$$

Angular Momentum Balance

AMB

$$\sum \vec{r}_{i/C} \times \vec{F}_i^{ext} = \dot{\vec{H}}_{/C} = \sum \vec{r}_{j/C} \times m_j \vec{a}_j$$

$$= \int \vec{r}_{/C} \times \vec{a}\, dm$$

What for?

It describes how world works.

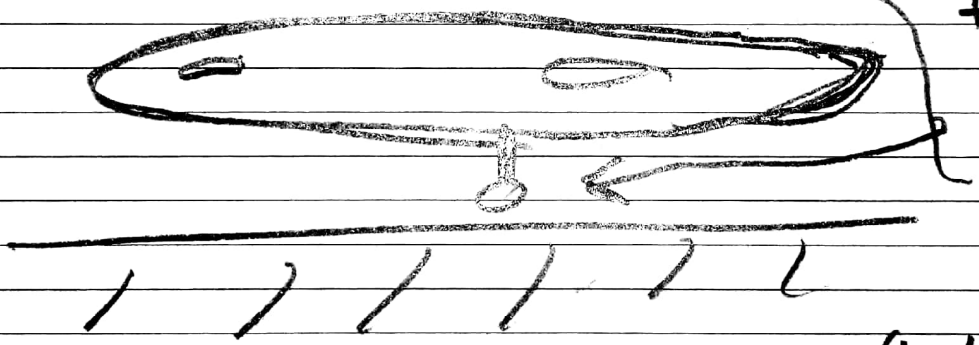
It's useful sometimes.

It builds useful skills.

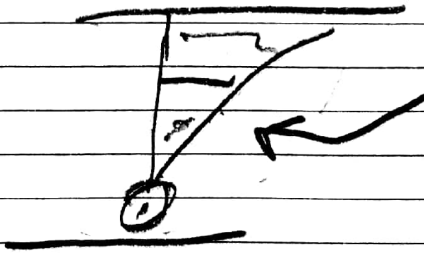
$m\vec{a} \approx \vec{0} \Rightarrow$ statics

much more useful than dynamics

Airplane landing:



Easy to estimate force on gear from Dynamics



Lots of Statics & Strength of materials to design the gear

Some people really use dynamics. (Like me)

↑ Prof. ANDY

Skills have useful

* you will get better at statics
* " " build probl. solv skills
* " " get good at Matlab
* " " gain an understading of vibrations

Matlab Question Plot is ?

A) Straight line

B) Circle

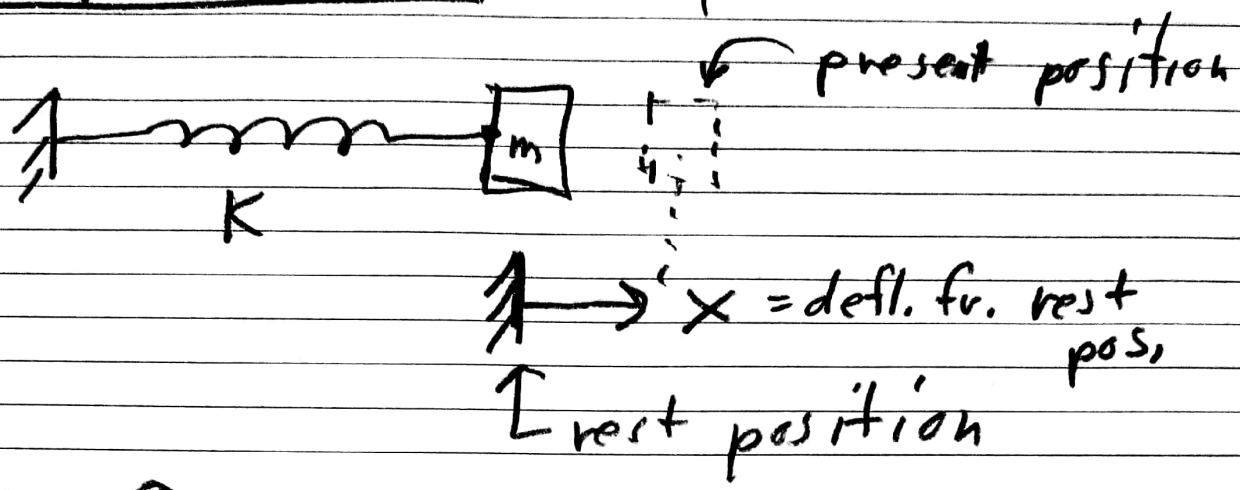
C) elipse

d) parabola

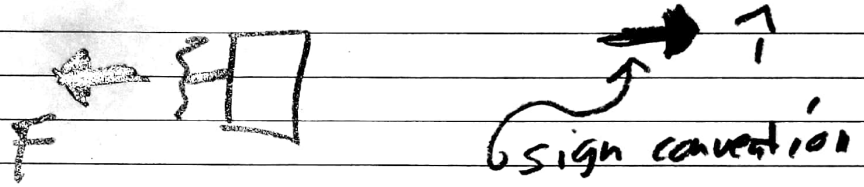
e) sine wave

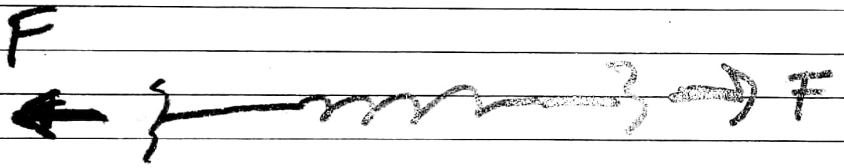
(see matlab code for lecture 1)

Spring & mass: 1D



FBD !





$$F = kx$$

LMB $\{\sum \vec{F} = m\vec{a}\} \cdot \hat{\imath}$

$\dot{v}$

$$-F = m\ddot{x}$$

$$\boxed{-kx = m\ddot{x}}$$

or $$m\ddot{x} + kx = 0$$

or $$\ddot{x} + \frac{k}{m}x = 0$$

used in matlab code $\rightarrow$

$$\begin{cases} \dot{v} = -\frac{k}{m}x \\ \dot{x} = v \end{cases}$$

1st order form (natural)

Soln: Euler's method

$$x_{new} = x_{old} + \dot{x} \cdot \Delta t$$

$$v_{new} = v_{old} + \dot{v} \cdot \Delta t$$

$\dot{v} = -\frac{k}{m} x$

Solve numerically on computer

(1st lecture code)