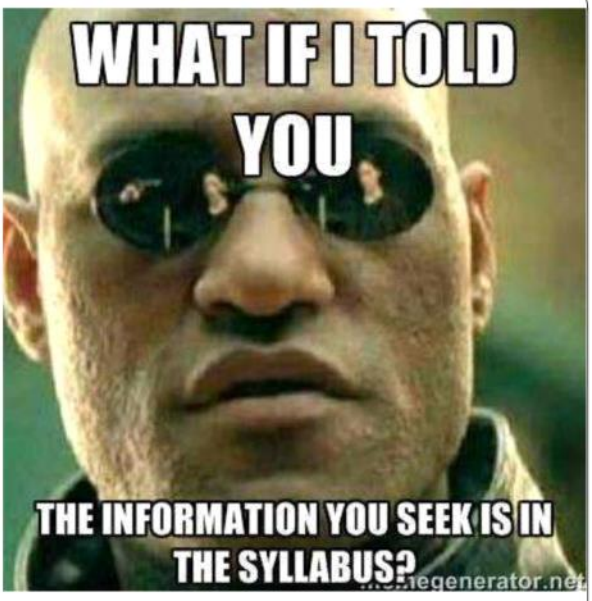
Lecture 02

Wednesday, August 30, 2017 11:48

To do...

- Register i>clicker (Compass)
- MATLAB office hours
  - WED/FRI 9-5 pm in MEL 1001
- Mastering Engineering office hours
  - WED/THURS
  - 4-6 pm in Grainger 429
- HW 0 (PrairieLearn) due FRI
- HW 1 (Mastering Engineering) due SUN
- HW 2 (PL) due TUES

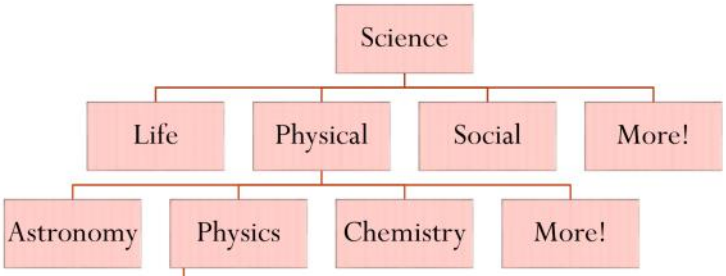


Main goals and learning objectives

- 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

Wednesday, August 24, 2016 10:48

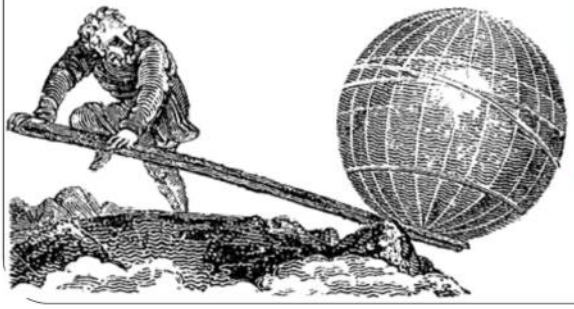
What is "statics"?



- Mechanics: Study of what happens to a "thing" when forces are applied to it

Bill Nye
Mech Eng

Archimedes



"Give me a lever long enough and A place to stand And I will move the Earth."

Q: What is statics?

Analysis of loads on Physical Systems in equilibrium.

Wednesday, August 24, 2016 10:48

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**

* Design objects with the intention that they remain in equilibrium

Rigid Bodies

Statics

Dynamics

Deformable Bodies

Solid Mechanics

Fluids

Compressible and incompressible

* Mechanics Important At many length SCALES

* Close link with materials.


victorstuff.com

Which forces?


www.ashvegas.com

Contact vs. field forces.

- Mechanics: State of rest or motion of bodies subjected to forces

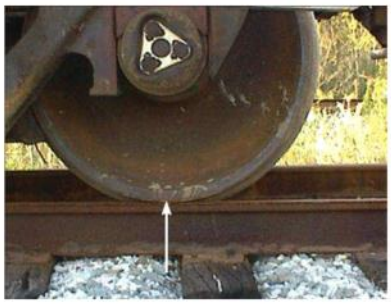
Q: # of fundamental forces in nature?

4!

- Gravity
- Electromagnetic
- Strong
- Weak

} Action at a distance { → Attraction; → Attraction / repulsion

Fundamental concepts



Basic quantities:

- length
- time
- Mass
- force

Idealizations:

- Particle:
  → has mass but size is neglected
- Rigid Body:
  → Shape of body does not change before/after Applied force
- Concentrated Force:
  → force Applied over small Area compared to body

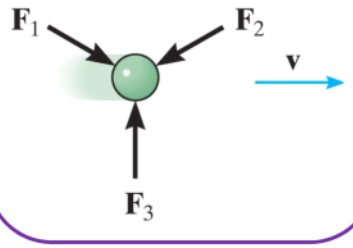
Understanding and applying these things allows for amazing achievements in engineering! (planes, robotics, etc)

* Length - locate And describe the size of A physical system
* mass – measure of A quantity of matter, should not change in space
* time - succession of events
* force - action exerted by one body on Another.

Wednesday, August 24, 2016 10:48

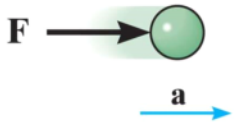
Newton's laws of motion

First law: An object remains at rest or moves w/ constant velocity in a straight line unless acted upon by a net force

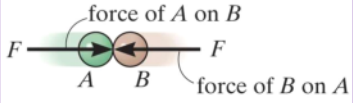


Second law: a particle acted upon by an unbalanced force **F** experiences an acceleration **a** that is proportional to the particle mass *m*:

$$F = ma$$



Third law: the mutual forces of action and reaction between two particles are Equal, opposite and colinear.



Principia 1687 Newton

WOW!

Newton's law of gravitational attraction

The mutual **force F of gravitation** between two particles of mass m_1 and m_2 is given by:

$$F = \frac{G m_1 m_2}{r^2}$$

G is the universal constant of gravitation (small number)
r is the distance between the two particles

Figure: 01_PH003
The astronaut's weight is diminished, since she is far removed from the gravitational field of the earth.

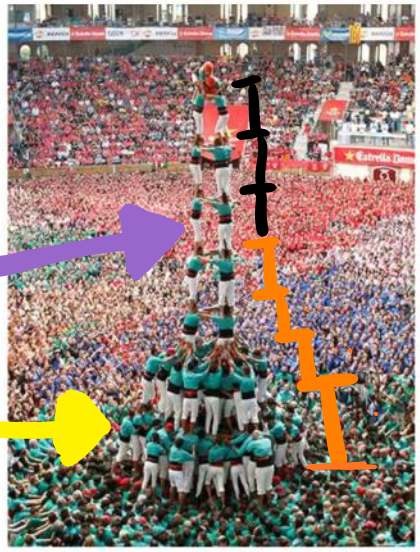
Weight is the force exerted by the earth on a particle at the earth's surface:

$$W = m\frac{G M_e}{r_e^2} = mg \quad \therefore \quad g = \frac{G M_e}{r_e^2}$$

M_e is the mass of the earth
r_e is the distance between the earth's center and the particle near the surface
g is the acceleration due to the gravity

Castells of Catalonia

* What is the force experienced here or here



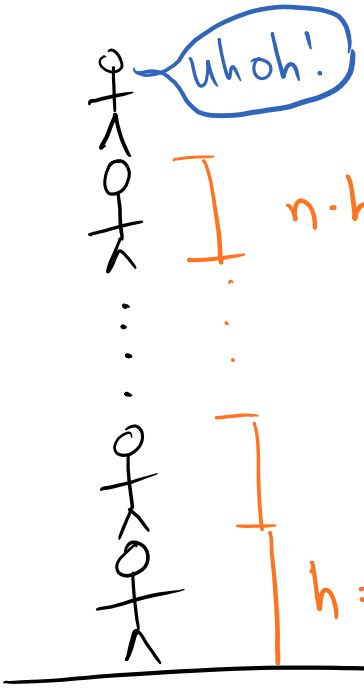
*forces of NATure PBS

7 level tower!

$W_{AVG} = 140\ lb$

What if you fall?

you statics doesn't work !!



$$PE = KE$$

$$mg\Delta y = \frac{1}{2}mv^2$$

$$\sqrt{2g\Delta y} = v$$

$$v = \sqrt{2gnh}$$

for $n = 7$,

$$\sqrt{2 \cdot 7 \cdot 1} = \sqrt{14\left(9.81 \frac{m}{s^2}\right)\cdot(1.7\ m)} = 15.3\ m/s$$

$$v = \sqrt{2g7h} = \sqrt{14\left(9.81\ \frac{m}{s^2}\right)\cdot(1.7\ m)} = 15.3\ m/s$$

or

33.6 mph!

(ouch!)

Wednesday, August 24, 2016 10:48

Units

TABLE 1–1 Systems of Units

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

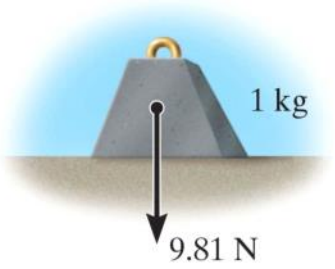
*Derived unit.

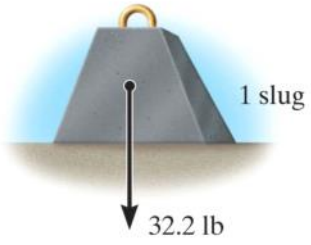
REMEMBER

DIMENSIONS

units

units





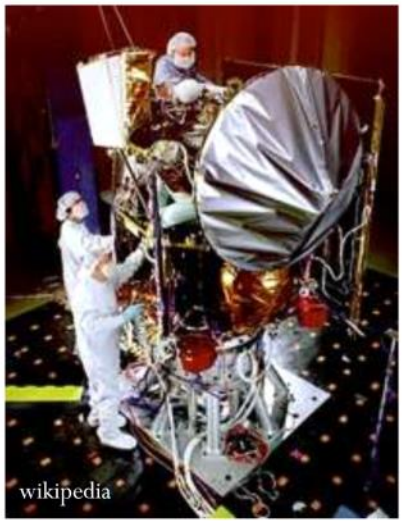
$$G = 66.73 \times 10^{-12} \frac{m^3}{kg \cdot s^2}$$

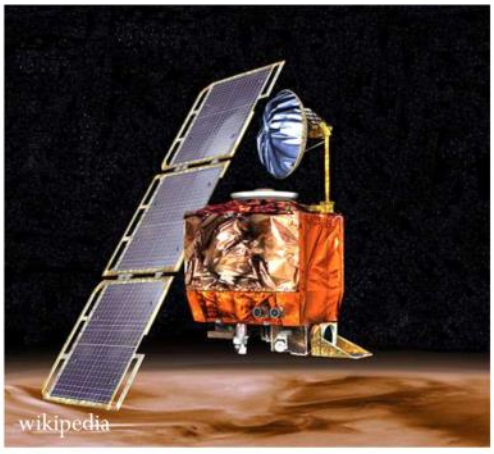
$$g = 9.81 \frac{m}{s^2}$$

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

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, a plane ran out of fuel because the pilot mistook liters for gallons!. He landed the plane safely without power on an emergency airstrip.





Mars climate orbiter -- $327.6 million

doh!!

CNN STYLE FASHION DESIGN ARCHITECTURE ARTS AUTOS LUXURY

The 'super-tall' age is here: World welcomes 100th mammoth skyscraper

~1400 ft tall

Approx 4-5 football fields tall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menu
Could this detachable plane cabin really save lives? ... hmmm...

Wednesday, August 24, 2016 10:48

Numerical Calculations

Dimensional Homogeneity

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

the Kinematic eqn.

$$x = vt + \frac{1}{2}at^2$$

length = velocity · time + acceleration · (time)^2

$$= \frac{\text{length}}{\text{time}} \cdot \text{time} + \frac{\text{length}}{\text{time}^2} \cdot \text{time}^2$$

length = length + length

O.K. ☑

Remember

Dimension ↗

unit → meter

feet

mile

Wednesday, August 24, 2016 10:48

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

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

for the #'s

4.227 in

becomes

4.23 in

if >5 round up

if <5 do not round up

if =5 if odd Round up

if even do not Round up

EXAMPLES:

0.5896 becomes 0.590

0.3762 → 0.376

75.25 → 75.2

0.1275 → 0.128

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. *check units ; magnitude

Most effective way to learn engineering mechanics is to ***solve problems!***
PRACTICE!!!

Step 1
Interpret:
* Read and determine what is given and what to be found
* make assumptions

Step 2
Plan:
* think about major steps (Road map)
* think about alternative and creative solutions

Step 3
Execute:
* carry out steps
* Appropriate diagrams/eqns.
* estimate, reflect, revise