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
- Use Illinois netid/email
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
What is “statics”?

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

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

[Images: Yoda, astronaut in space, and Earth from space]
Fundamental concepts

Basic quantities:

Idealizations:

• Particle:

• Rigid Body:

• Concentrated Force:

Understanding and applying these things allows for amazing achievements in engineering! (planes, robotics, etc)
Newton’s laws of motion

First law:

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

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

$F_1$ $F_2$ $F_3$ $v$ $F$ $a$
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:

$$G \text{ is the universal constant of gravitation (small number)}$$

$$r \text{ is the distance between the two particles}$$

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

$$M_e \text{ is the mass of the earth}$$

$$r_e \text{ is the distance between the earth’s center and the particle near the surface}$$

$$g \text{ is the acceleration due to the gravity}$$
Castells of Catalonia
### TABLE 1–1  Systems of Units

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Time</th>
<th>Mass</th>
<th>Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>International System of Units (SI)</td>
<td>meter</td>
<td>second</td>
<td>kilogram</td>
<td>newton* (N)</td>
</tr>
<tr>
<td>U.S. Customary FPS</td>
<td>foot</td>
<td>second</td>
<td>slug*</td>
<td>pound</td>
</tr>
</tbody>
</table>

*Derived unit.

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

\[ g = 9.81 \frac{m}{s^2} \]

\[ g = 32.2 \frac{ft}{s^2} \]

1 kg → 9.81 N

1 slug → 32.2 lb
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
The 'super-tall' age is here: World welcomes 100th mammoth skyscraper
Could this detachable plane cabin really save lives?
Numerical Calculations

Dimensional Homogeneity

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