******* WEEK 9 *******

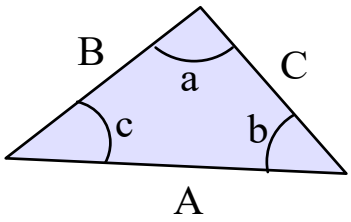
WEEK 9 - EE PROJ & TRIG (:20)

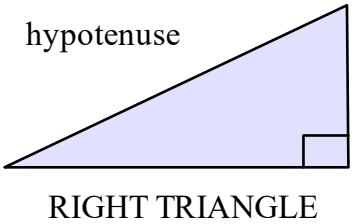
9.1 BASIC TRIGONOMETRY

Trigonometry is the math of **triangles**.

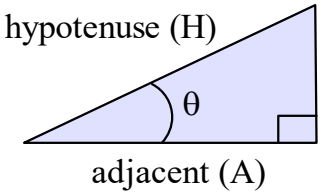
A triangle is a 3-sided polygon (a closed shape made from 3 straight edges and 3 vertices). Triangles have 3 interior angles (a, b, c) and 3 sides (lengths A, B, C). Triangles have an interesting property that the interior angles must add up to **180 degrees** (a + b + c = 180 degrees).

Right triangles have one of the angles is 90 degrees. The side opposite the 90 degree angle is the **hypotenuse**.

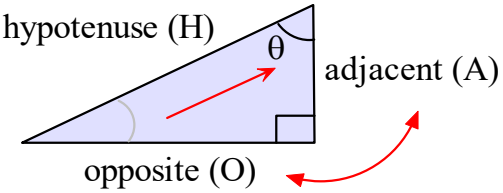




Sine and cosine of an angle are trig functions. The angle is one of the 2 angles that is NOT the 90-degree angle. These functions are simply ratios of 2 sides of the right triangle.



opposite (O)



$$\sin(\theta) = \frac{opposite}{hypoteneus} = \frac{O}{H}$$

$$\sin\theta = \frac{O}{H}$$

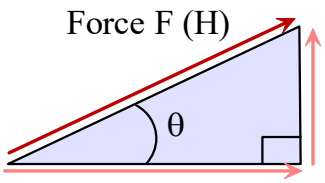
$$O = H\sin\theta$$

$$\cos(\theta) = \frac{adjacent}{hypoteneus} = \frac{A}{H}$$

$$\cos\theta = \frac{A}{H}$$

$$A = H\cos\theta$$

Sine and cosine are used all the time in engineering. We use these trig functions to PROJECT (or break up) forces. Forces are arrows (they have magnitude and direction). A force that is inclined above the horizontal by angle θ has horizontal and vertical projections as shown below.



Force in y direction (Fy) (O)
Fy = F sin θ

Force in x direction (Fx) (A)
Fx = F cos θ

ARDUINO PROJECT (go over exercise 5, code)

9.2 TECHNICAL ACTIVITY

WORK ON EE PROJECT (exercises 4, 5)

DO EXAM 3

******* WEEK 10 *******

WEEK 10 - MECHANICAL ENGINEERING (0.5h)

10.1 PRELIMs

(CT brings – 4-bar mechanism, vids of convertible, pins, films, wind-up toy)
Make up teams for ME project

10.2 MECHANICAL ENGINEERING

WHO ARE MECHANICAL ENGINEERS?

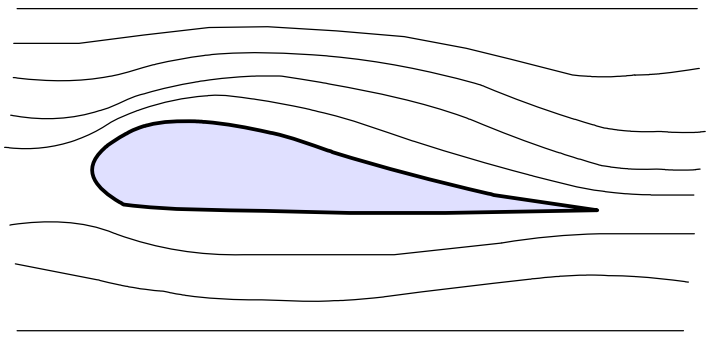
Mechanical engineers work with & design **mechanical systems**.
Examples of mechanical systems are: **machines**, mechanisms, heating & cooling systems.
Examples of products designed by ME's are: cars, planes, engines, HVAC systems, robots, machinery, etc.





SUB-DISCIPLINES OF ME

1. Design – kinematics (study of motion), machines (mechanisms, transmissions, etc.)
2. Robotics/ controls systems – computer-controlled machines (robots, industrial automation)
3. Fluids – physics of gases & liquids (wings, fuselages, flow thru pipes)
4. Thermal/energy – heat transfer; heating, refrigeration , & energy systems (engines)
5. Materials – material construction & failure. (alloys, composites)



LIFT ON AN AIRFOIL

$$L = C\rho V^2 A/2$$

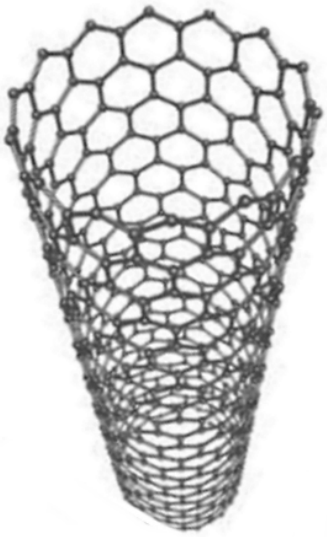
WHERE DO ME's WORK?

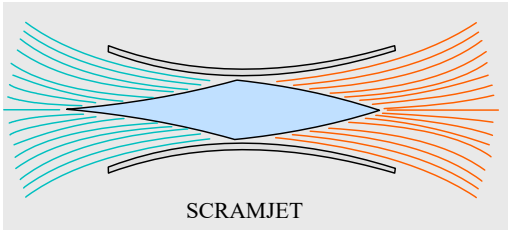
1. Manufacturing firms – aerospace (NASA, JPL, Raytheon, Boeing, Airbus),
   automotive (Honda, Ford, GM), biomedical firms (Alcon, Stryker, Baxter, St Jude, Siemens), etc.
2. Materials firms – 3M, ALCOA, General Electric, Hewlett-Packard

PROFESSIONAL SOCIETY
   ASME (American Society of Mechanical Engineers, founded 1880)

CHALLENGES FOR ME's (UPDATE THIS!!)
1. Energy – new, alternative energy systems (fuel cells, fusion, etc.), improved machine efficiency
2. MEMS/nanotechnology – tiny & molecular-sized mechanisms & machines,
3. Materials – advanced or intelligent materials, carbon nanotubes
4. Advanced robotics – intelligent, autonomous machines/robots, advanced controls
5. Aerospace – advanced space exploration technologies, new propulsion systems (scramjet)
6. Other – reduce carbon footprint in manufacturing,

Show vids (Honda robot, MEMS, X-43A scramjet)





10.3 ME PROJECT

CLASSICAL MECHANICAL COMPONENTS - gears, shafts, gussets, levers, cams, etc.

10.4 ENERGY

Machines are devices that convert energy. Engineers must think about how efficiently a machines converts this energy. But first we must understand ENERGY.

- Energy (E) – force times distance (exerting force over a distance, called "work")

- There are different types of energy: kinetic energy (KE), potential energy (PE), & heat energy
- Energy is "conserved" – it is not created or destroyed. (it is not "used up")
  It only changes from one form to another

KINETIC ENERGY (KE) - the energy of a mass in motion.

$$KE = \frac{1}{2}mv^2$$

POTENTIAL ENERGY (PE) - "stored" energy (different types).

1. Gravitational

$$PE = mgh$$

2. Compressed (or stretched) spring

$$PE = \frac{1}{2}kx^2$$

3. Other - chemical bonds (gasoline, TNT, plastic explosives), pressure (compressed air or liquids)

HEAT ENERGY

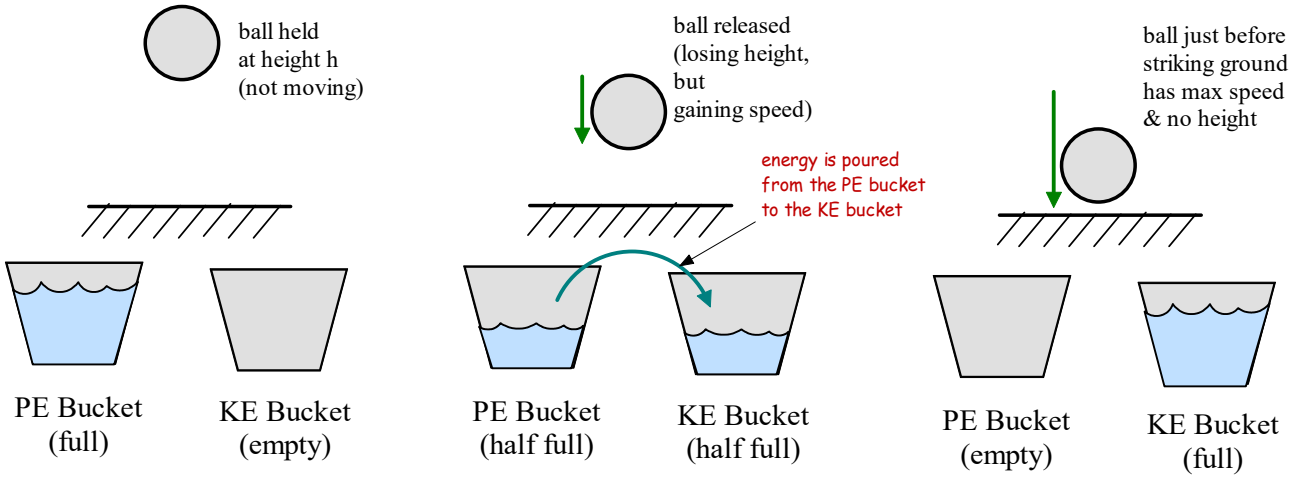
Warm objects have more E than cool objects

FRICTION

Friction converts KE into heat energy.

Friction occurs whenever objects rubs against one another object, or when a fluid is moved, or when an object flexes (particles rub against each other internally). Examples - block sliding on surface, flexing object, drag in fluid

EXAMPLE – mass/spring or bouncing ball



Think of energy as water in a bucket. As the ball bounces, energy is exchanged between the KE and PE buckets.

Energy Loss to Friction (think of water buckets!)

Think of friction as the spilling of water out of the buckets. Once spilled, you can't get it back. Every time you pour water back and forth, you spill some water. Less water in the buckets means less energy. Eventually there is more water in the buckets (no energy).

MACHINES CONVERTING ENERGY

TREBUCHETS are medieval siege machines. They were **catapult**-like devices that were the dominant military weapon for over 200 YEARS. It is believed that could launch stones up to 1500 kg about 300 meters. These devices work by converting the PE of a **counterweight** into KE of a projectile.

Gasoline AUTOMOBILES convert the chemical energy of gasoline into the KE of the vehicle. Electric cars convert the chemical energy stored in its battery to KE of vehicle.

10.5 TECHNICAL / PROJECT

EE PROJECT DEMOS

******* WEEK 11 *******

WEEK 11 - MACHINE PERFORMANCE (:40)

11.1 MACHINE EFFICIENCY

Machines are devices that convert energy. One key performance measure for a machine is its MACHINE EFFICIENCY (denoted by the Greek letter "eta", η, which is like a Greek "h"). Machine efficiency is the energy OUTPUT divided by the energy INPUT.

$$\eta = \frac{E_{OUT}}{E_{IN}}$$

η is a number between 0 and 1 (1 means 100% efficient), where η = 1 is a perfectly efficient machine. In reality, virtually NO machine can be 100% efficient.

For example in trebuchets, E_{IN} is the potential energy of gravity of the counterweight.

$$E_{IN} = m_1 g h$$

E_{OUT} is the KE of the projectile.

$$E_{OUT} = \frac{1}{2} m_2 v^2$$

GASOLINE CAR THERMAL EFFICIENCY

Gasoline cars have ~15-35% thermal efficiency.
Gas has an energy content of 122 MJ/gallon (about 100x the energy density of Li-ion battery).
Thus a 10-gallon gas tank has 1,220 MJ of energy (60 lb gas + 20 lb tank = 80 lb)
(for reference a 70kWh Tesla battery = 252MJ of energy, & weighs 1000 lbs)

11.2 LAB/TECHNICAL TOPICS (above)

START ME PROJECT - Arduino ME Project (exercises 1, 2)

EXAM 4 REVIEW

TECHNICAL TOPICS (TRIG)
What is trig? Right triangles? Sum of angles of triangle – YES
Identify hypotenuse, opposite, adjacent – YES
Sine, cosine of angle YES

ME & ME PROJECT (WK 10)
Definition, things worked on, (YES)
Sub-disciplines – (YES, name 3 of 5)
Where you work – no
Professional society – (YES, & what "ASME" stands for)
Branch emerging technologies – no
Types of energy (KE, PE) & what are they? (YES)
Friction & what is does to energy (YES)

MACHINE PERFORMANCE (WK 11)
What is machine efficiency (output over input, possible values)? YES
Energy – do simple calculations (eg – compute KE & PE given all values & equations) (YES)
Note – equations will be provided, so don't memorize them
Identify types of energy in various mechanical systems – YES.
Simple computation – compute machine efficiency, unit conversion – YES.