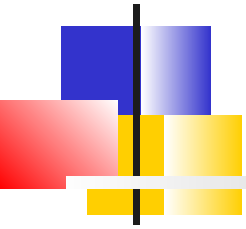


Forces

- 9-22-08

Forces

Force

Newton (N)

- A push or a pull with size and direction Ex: 5N →
- Unit used to measure force

(equivalent to 0.22 lbs of force, or 1N can accelerate a mass of 1kg at the rate of 1m/s/s)

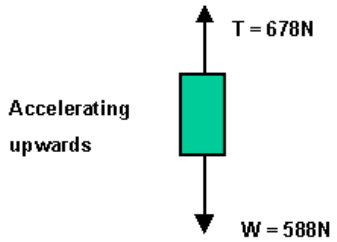
Force and Motion

- Balanced Force
- When 2 equal forces are exerted on an object and no change in motion results (this can mean no motion or constant velocity)
- Ex:

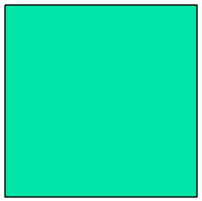
←200 N 200 N→

- Unbalanced Force

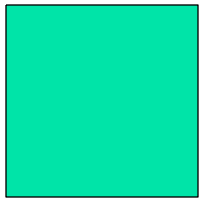
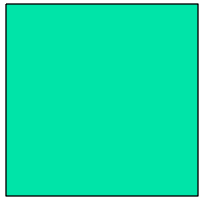
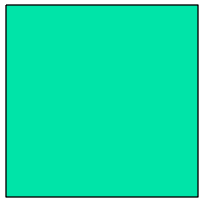
- When 2 unequal forces are exerted on an object and a change in velocity (acceleration) results. This could mean a change in direction or speed.



Net force

- The combination of forces. When forces are going in the same direction they are added, when they are opposing directions they are subtracted. (The net force will tell you if an object is in motion)
- Ex: 5N→  ← 2N
- Net force =3N to the right

Try these:

- 1. 10 N→  15 N→
- 2. 4N →  ←3N
- 3. 5N ↑  2N→ ← 2N

Newton's 3 laws of motion

- Newton's First Law of Motion
- An object at rest will stay at rest, and an object in motion will stay in motion; unless acted upon by an outside force

Inertia

- Inertia
- The tendency of an object to resist a change in motion.

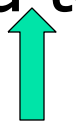
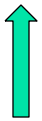
  This is mass related.

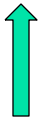
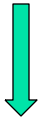
  ↑ mass, ↑ inertia

Newton's 2nd law of motion

- $a = \frac{F}{m}$

  The acceleration of an object depends on the mass of the object and the amount of force applied to it.

As Force  acceleration  w/constant mass

As mass  acceleration  w/constant force

Note: 1N = 1kg x m/s/s

Newton's 3rd law

- For every action there is an equal and opposite reaction
- Forces come in pairs: action, reaction
- Forces are acting on 2 different objects
- Forces are equal in size
- Forces are immediate interaction

Examples

- 1. You push against the wall

Action: You push on the wall

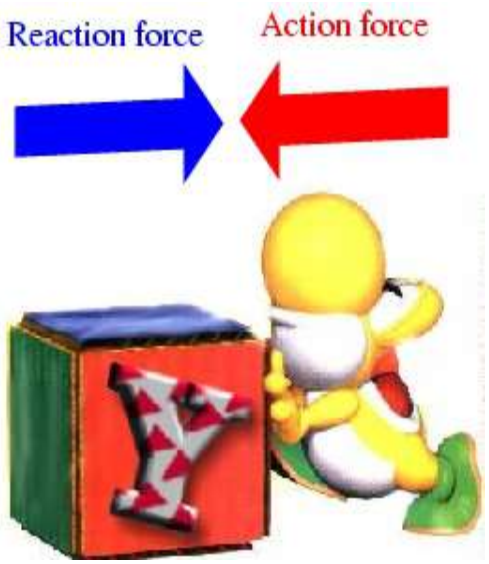
Reaction: The wall pushes on you

2. You sit on your seat

Action: You sit on the seat

Reaction: The seat sits on you (ha ha)

The seat pushes back up on you



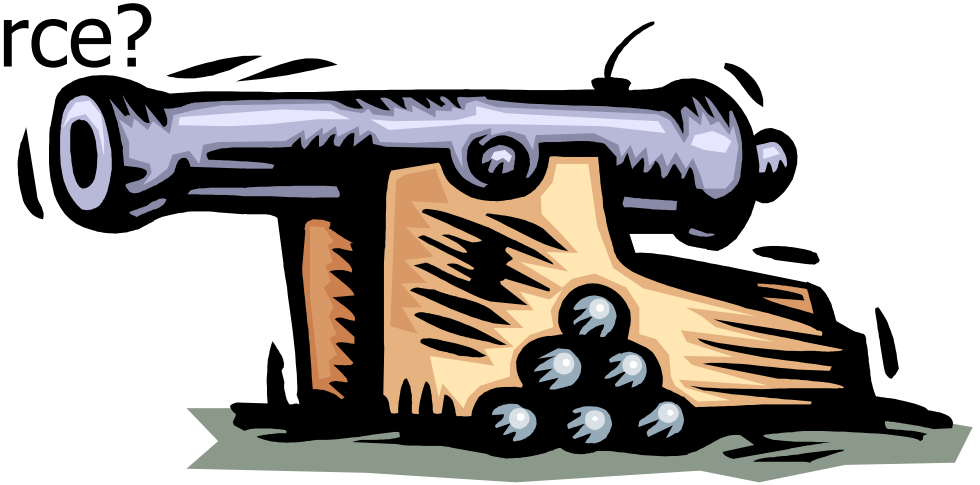
Examples of the 3rd law

- 1. A high speed bus and an unfortunate bug have a head-on collision. The force of the bus on the bug splatters it all over the windshield. Is the corresponding force of the bus greater than, less than, or the same as the force of the bug on the bus? IS the resulting deceleration of the bus the same as the bug?

Last one together…..

- A cannon recoils a few feet after shooting a cannonball 300 ft. What is the action, reaction?

  Do the cannon and cannonball interact with equal force?

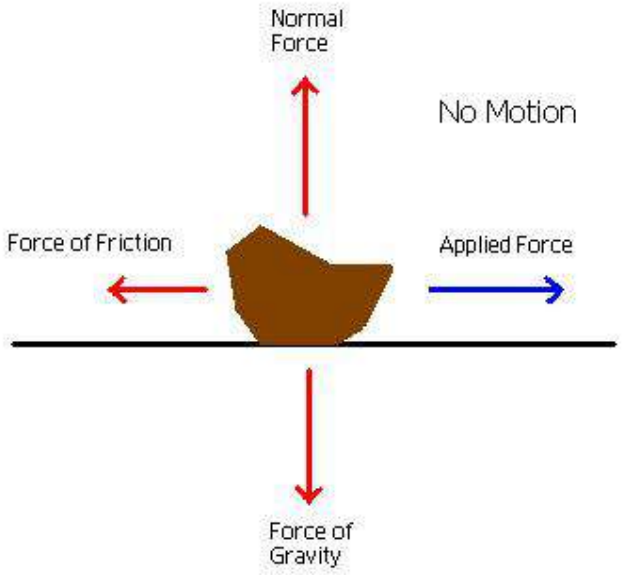


Friction

- Friction

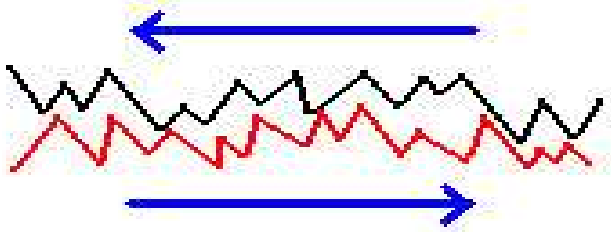
- A force that opposes motion

  (It always goes in the OPPOSITE direction of motion)



Causes of friction

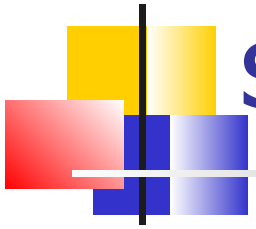
- Friction is caused by microscopic hills and valleys of one surface that catch onto the hills and valleys of another surface



Types of friction

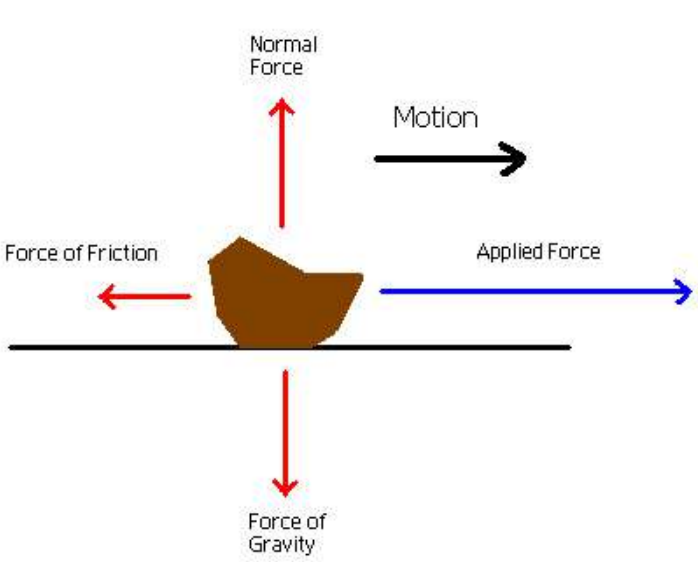
Sliding	■ Occurs between 2 objects that rub surfaces
Static	■ Occurs between 2 surfaces in contact and keeps an object in place
Rolling	■ Occurs between the wheels of an object and a surface or when an object rolls
Fluid	■ Gas or liquid friction, air resistance

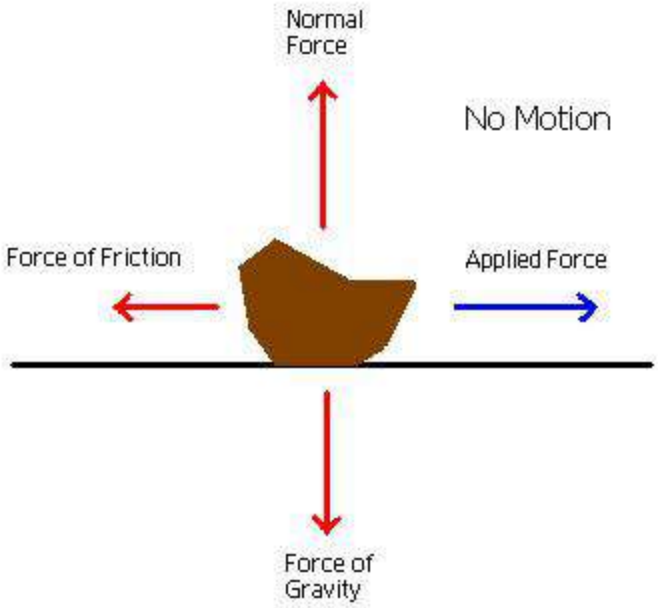
Friction between different surfaces



- The level of friction that different materials exhibit is measured by the coefficient of friction.
- The formula is $\mu = f / N$
- μ=coefficient of friction (how much friction occurs between 2 surfaces, ratio
- f = force of friction, N = normal force
- (N= mg)

What type of friction is the rock experiencing in each picture?





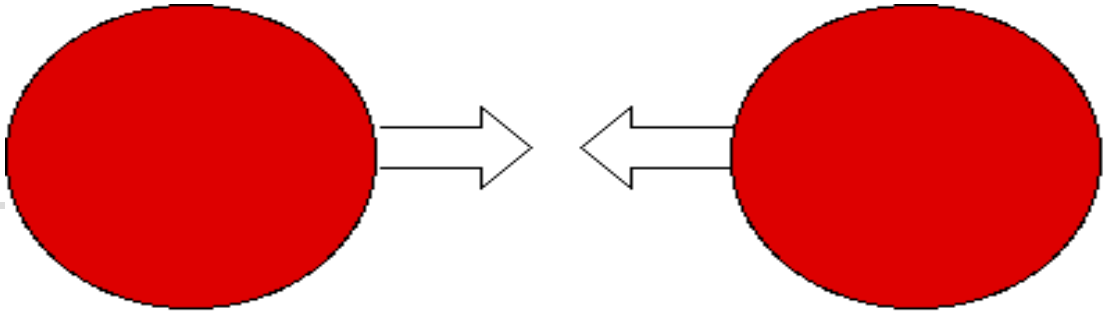
What type of friction is present ?

- On a person's skateboard and the road
- On a sofa resting on the carpet
- On a person parachuting from a plane
- On a box being pushed along the ground

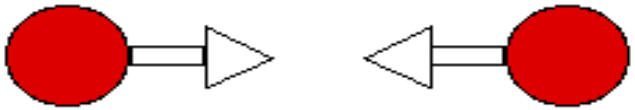
Gravity

- The force of attraction between 2 masses (anything with mass pulls on each other)
- Gravitational force increases as mass increases
- Gravitational force decreases as distance between objects increase

  $F=1/d^2$



Gravitational force between two objects depends on their masses.
and the distance between them.



Eventhough the distance is the same the gravitational pull
is less because the object's mass is less.

What would happen if we moved the balls farther
apart?

The farther away you get from the center of the earth the less you weight
up to the point of weightlessness in outer space.

Mass vs. Weight

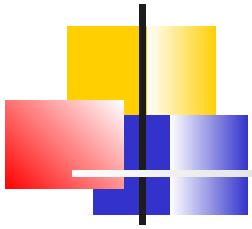
- Mass – the measure of the amount of matter in an object
- Weight – The measure of gravitational force of an object
- w= m*g, measured in Newtons
- Weight changes, mass does not

Determine your weight on earth

- w=m*g
- m=your mass in kg
- g= 9.81m/s/s
- Example

60 kg * 9.81m/s/s = 600 N

Your weight on other planets



- If the g-force is 1.0 on the surface of Earth, the g-forces on the surfaces of the planets are:
- Mercury = 0.38
- Venus = 0.91
- Earth = 1.0
- Mars = 0.38
- Jupiter = 2.6
- Saturn = 1.1
- Uranus = 0.90
- Neptune = 1.1
- Pluto = 0.07

Multiply your weight by one of the factors above.

Force of gravity

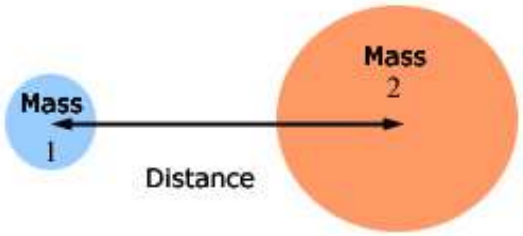
Longhand:

$$\text{Force}_{\text{of gravity}} = \text{Gravitational constant} \times \frac{\text{Mass}_1 \times \text{Mass}_2}{\text{Distance}^2}$$

Shorthand:

$$F_g = G \times \frac{m_1 \times m_2}{D^2}$$

Picture:



M. Yasuda 2002

- Universal Gravitational constant =
- 6.67×10^{-11}
- If masses are large the force of gravity is large
- If the distances between objects are large the force of gravity weakens

Example problem

- Here is a problem which envisions an unfortunate astronaut stranded exactly half way between the earth and moon. What is the gravitational force of the earth acting on him? The data we need are
- The mass of the astronaut: *m1* = 100 kg
- The mass of the earth: *m*2 = 6 x 10^{24}kg
- The distance between earth and moon: *r* = 3.8 x 10^{8} m
- The universal gravitational constant: *G* = 6.67 x 10^{-11} N kg m2/kg2
-

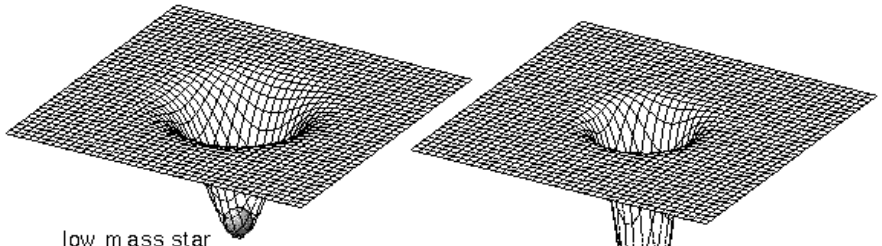
$$F_g = Gm_1m_2\frac{1}{r^2}$$

$$= (0.667\times10^{-10}\mathrm{Nm^2/kg^2})(100\mathrm{kg})(6\times10^{24}\mathrm{kg})\frac{1}{(\frac{1}{2}\times3.8\times10^{8}\mathrm{m})^2}$$

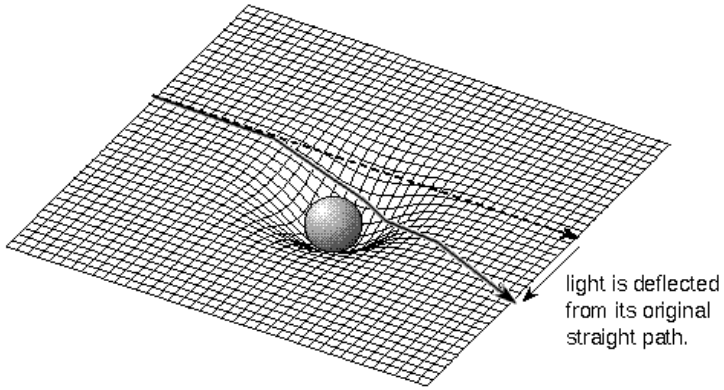
$$= \frac{(0.667)(100)(6)}{1.9^2}\times10^{-10}10^{24}(10^{-8})^2\,\frac{[\mathrm{Nm^2/kg^2}][\mathrm{kg}][\mathrm{kg}]}{[\mathrm{m^2}]}$$

$$= 1.10\times10^{-10+24-16}\,\mathrm{N} = 1.1\,\mathrm{N}$$

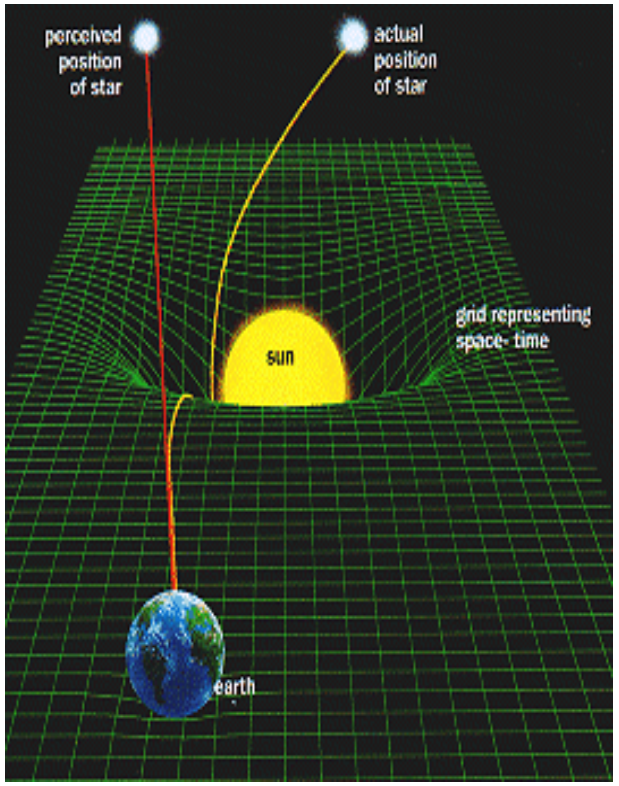
How does gravity "work" ?



General Relativity: Einstein described gravity as a warping of space-time around a massive object. The stronger the gravity, the more space-time is warped.



General Relativity: Light travels along the curved space taking the shortest path between two points. Therefore, light is deflected toward a massive object! The stronger the local gravity is, the greater the light path is bent.

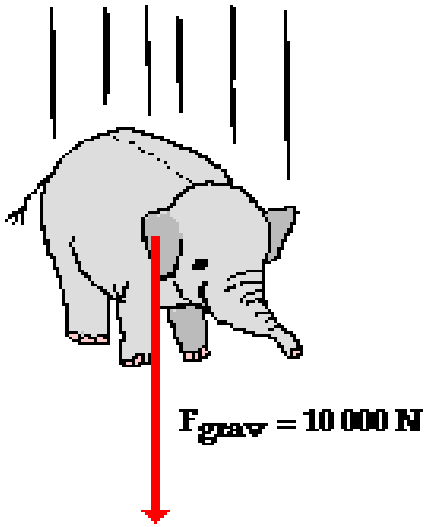


Acceleration due to gravity

- On earth it is 9.81m/s/s
- In free fall (no air resistance) all things will fall at the same acceleration
- Because of air resistance things will not fall at the same rate
- Objects that are bigger (more mass) will fall at the same rate as small objects due to Newton's 2nd law- more force

2nd law explains same acceleration

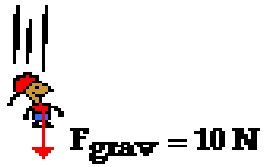
$m = 1000\ kg$



$$a = \frac{F_{net}}{m} = \frac{10\,000\ N}{1000\ kg}$$

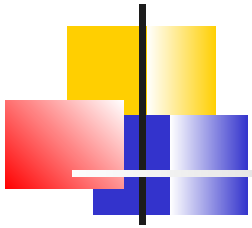
$a = 10\ m/s/s$

$m = 1\ kg$



$$a = \frac{F_{net}}{m} = \frac{10\ N}{1\ kg}$$

$a = 10\ m/s/s$



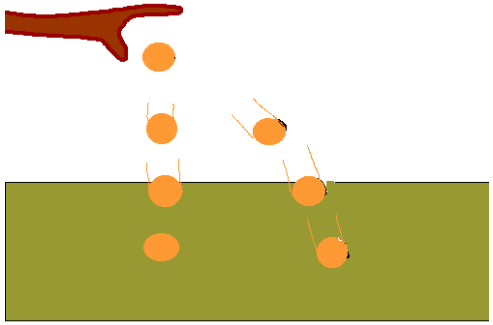
- Terminal velocity – As acceleration increases so does air resistance, until both forces are equal and the object is falling at constant velocity
- v = g*t

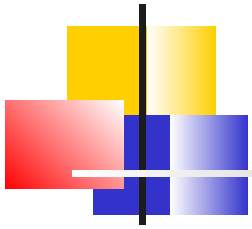
V = g x t

- v = velocity
- g = 9.81 m/s/s
- t = time
- Example : A boy looking out a window from his apartment on the 4^{th} floor of the building decides to drop a water balloon on an unsuspecting person below. Four seconds later he hears a splat. How fast was the balloon going when it hit the pavement below?

Projectile motion

- Question: Will gravity accelerate 2 balls that are released at the same time at the same rate (9.81 m/s/s) if one is released down and the other is thrown out?





- $v = g \times t$
- $v = 9.81\ m/s/s \times 4s$
- $v = 39.24\ m/s$

Projectile motion

- A projectile (anything that is thrown or launched) has 2 motion components that are independent of each other
- 1. Vertical motion – gravity pulls on all objects with the same rate of acceleration 9.81 m/s/s
- Horizontal motion – constant velocity if no air resistance

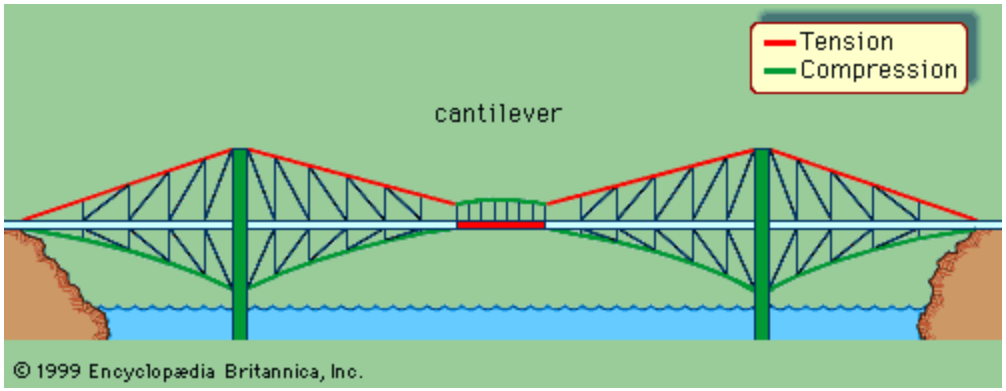
What would happen?

- A hunter spies a monkey in a tree, takes aim, and fires. At the moment the bullet leaves the gun the monkey lets go of the tree branch and drops straight down. How should the hunter aim to hit the monkey?
- Aim directly at the monkey
- Aim high (over the monkey's head)
- Aim low (below the monkey)

Elastic Forces

- Tension – Force that stretches (Like stretching a slinky)
- Compression – Force that squeezes (like squeezing a sponge)

- Cantilever


Tension
Compression
cantilever
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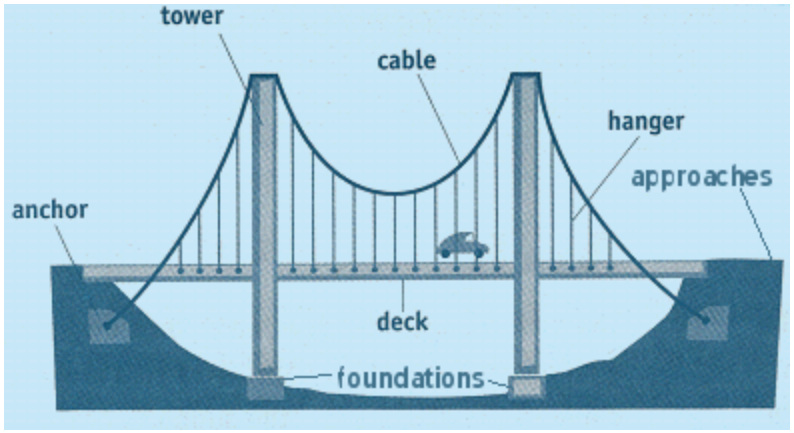
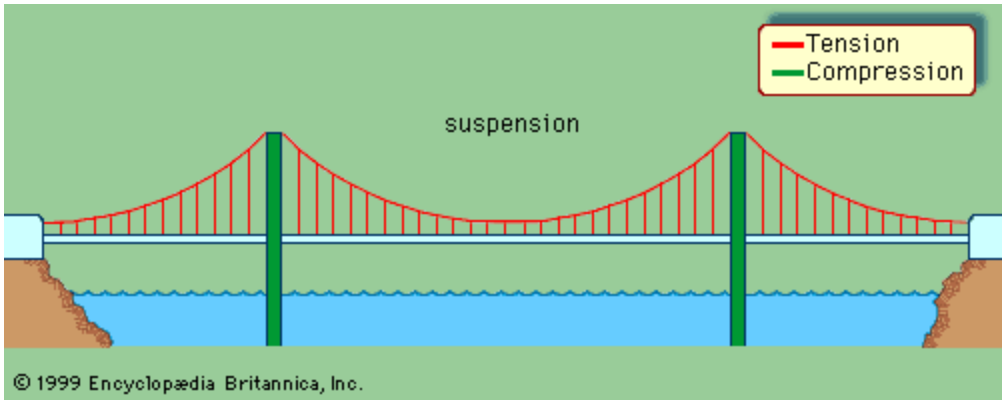
Bridges

- Bridges operate using forces of tension and compression
- Ex: Suspension Bridge





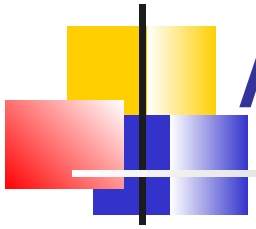
Longest bridge

Momentum

- A characteristic of a moving object that has to do with its mass and velocity
- The quantity of motion
- Law of conservation of momentum says that momentum is conserved in the absence of outside forces (it can be transferred)
- Momentum = mass x velocity

What is the momentum?

- Which has more momentum? A 3kg sledgehammer swung at 1.5m/s or a 4kg sledgehammer swung at 0.9m/s?
- What is the momentum of a bird with a mass of 0.018kg flying at 15m/s?
- Which has more momentum? A golf ball travels at 16m/s while a baseball moves at 7m/s. The mass of the golf ball is 0.045kg and the baseball is 0.14kg.



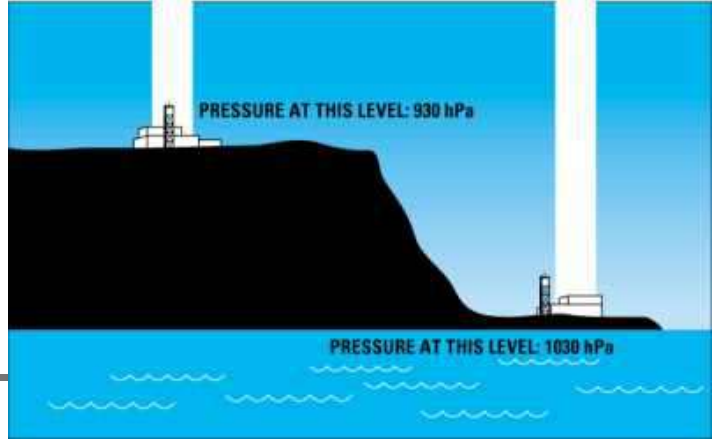
Angular momentum

Pressure!!!!!

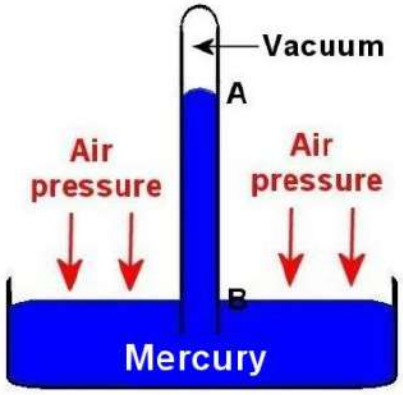
- Pressure is how much force is applied over a certain area
- Pressure = $\frac{\text{Force}}{\text{Area}}$

Unit = pascal or N/m^2

Fluid Pressure



- Fluids – Liquids or gases
- Fluid pressure is caused by the force of particles colliding with a surface
- Air pressure – Depends on elevation
- Sea level pressure is 14.7 lbf per square inch on your body



Pressure

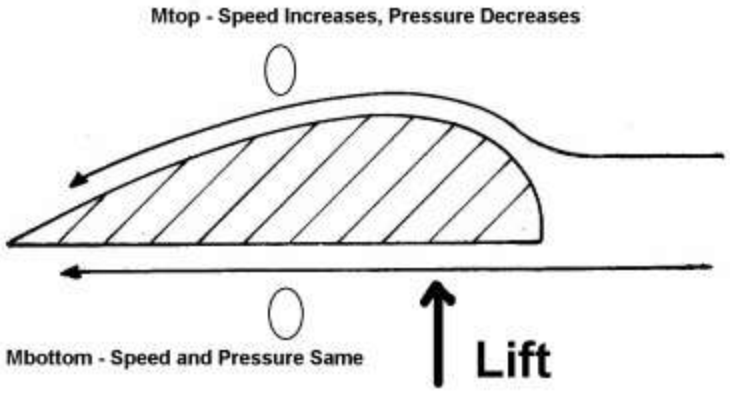
- Fluids will move from an area of higher pressure to lower pressure to achieve equilibrium

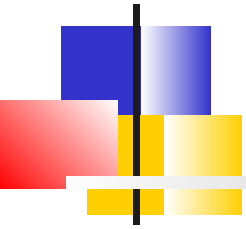
Bernoulli's Principle

- Fast moving fluids exert less (static) pressure than do slow moving fluids
- http://home.earthlink.net/~mmc1919/venturi.html
- Fast moving fluids exert less pressure since the molecules are "skimming" the surface

Lift

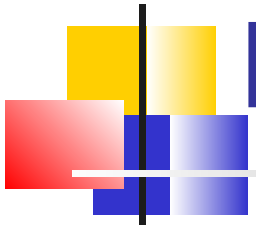
- Lift is an upward force on a solid object in a fluid
- Lift is created by differences in air velocities and pressure





Energy

- 1-21-09



Energy

- What is energy and how is it different from matter?
- Matter is substance and energy the mover of substance
- Energy is the capacity to do work
- Energy cannot be created or destroyed (law of conservation of energy)
- Energy can change form

Types of energy

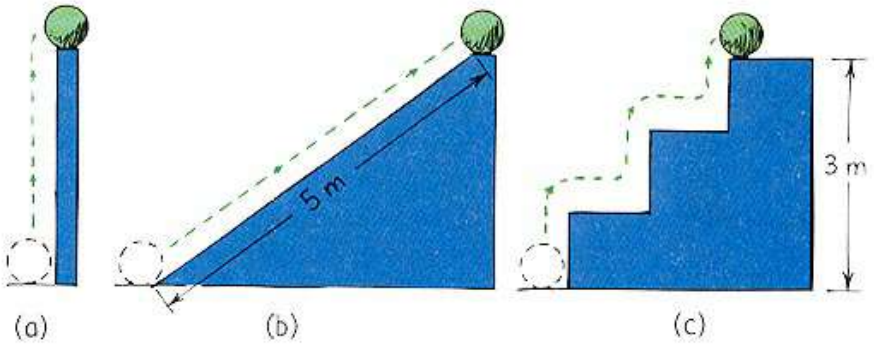
- Chemical energy – in bonds between atoms and molecules
- Thermal energy or heat
- Electrical energy
- Potential energy
- Kinetic energy

Potential Energy

- The energy in matter due to position or arrangement of parts. This is stored energy, because it has the potential to do work.

Gravitational potential energy

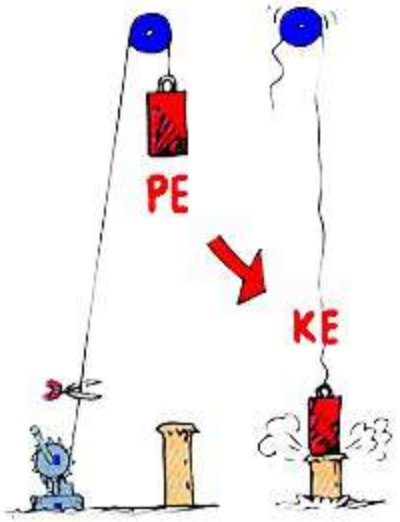
- Work is done to elevate objects against the gravity of the earth. Energy is transferred from the person and stored in the ball



The work done on the ball gives the ball *gravitational potential* energy.
Gravitational potential energy = mgh Ball =1kg, g=9.81m/s/s h=3m
Potential Energy = 30 Joules

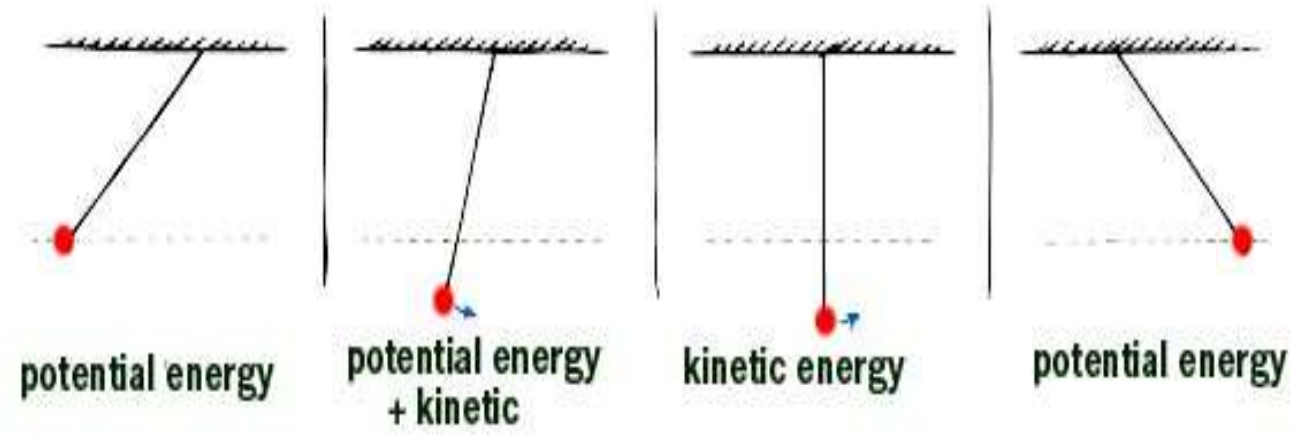
Kinetic Energy

- The energy of motion. Potential energy changes form to kinetic energy.
- The work done in lifting the mass gave the mass gravitational potential energy. Potential energy then becomes kinetic energy.
- Kinetic energy then does work to push stake into ground.



Kinetic Energy continued…

- Kinetic Energy = ½ mass x speed^2



Sample Problem

What is the kinetic energy of a 45 kg object moving at 13 m/sec?

1. First we identify the information we are given in the problem:

- mass = 45 kg • velocity = 13 m/sec

2. Next, we place this information into the kinetic energy formula:

- $KE = 1/2\ mv^2$
- $KE = 1/2\ (45\ kg)(13\ m/sec)^2$

3. Solving the equation gives a kinetic energy value of 3802.5 Joules

Roller Coasters, PE and KE

http://www.teachersdomain.org/resource/hew06.sci.phys.maf.rollercoaster/

http://www.teachersdomain.org/resource/phy03.sci.phys.mfe.zcoaster/