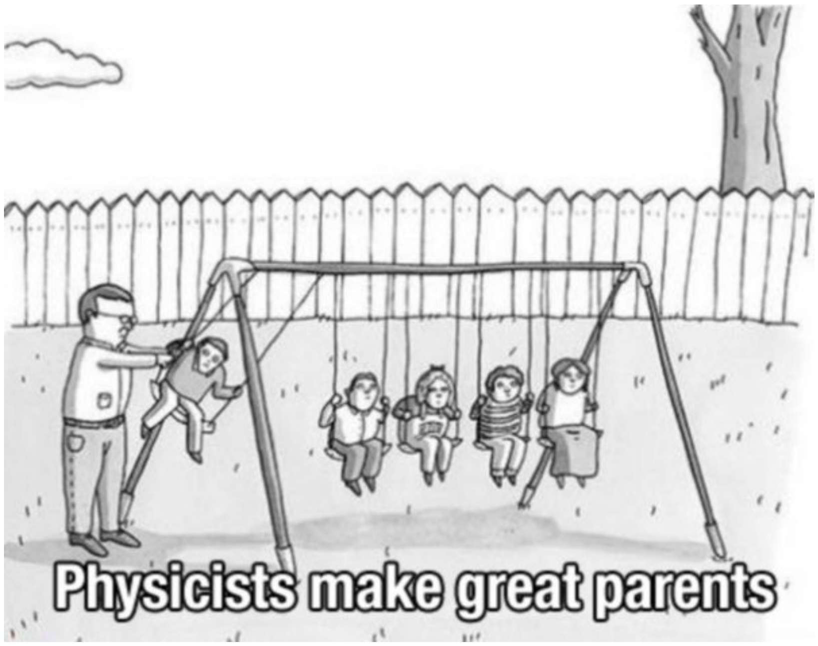
Ye' Ole Great Physics Chapter Review Marathon

(Chapter reviews as submitted by PHSN AP Physics students as of 4/17/16)

A.P. Physics - 2016



Effort is *everything*

The Physicist's Bill of Rights

We hold these postulates to be intuitively obvious, that all physicists are born equal, to a first approximation, and are endowed by their creator with certain discrete privileges, among them a mean rest life, n degrees of freedom, and the following rights which are invariant under all linear transformations:

1. To approximate all problems to ideal cases.
2. To use order of magnitude calculations whenever deemed necessary (i.e. whenever one can get away with it).
3. To use the rigorous method of "squinting" for solving problems more complex than the addition of positive real integers.
4. To dismiss all functions which diverge as "nasty" and "unphysical".
5. To invoke the uncertainty principle when confronted by confused mathematicians, chemists, engineers, psychologists, dramatists, and other lower scientists.
6. When pressed by non-physicists for an explanation of (4) to mumble in a sneering tone of voice something about physically naive mathematicians.
7. To equate two sides of an equation which are dimensionally inconsistent, with a suitable comment to the effect of, "Well, we are interested in the order of magnitude anyway".
8. To the extensive use of "bastard notations" where conventional mathematics will not work.
9. To invent fictitious forces to delude the general public.
10. To justify shaky reasoning on the basis that it gives the right answer.
11. To cleverly choose convenient initial conditions, using the principle of general triviality.
12. To use plausible arguments in place of proofs, and thenceforth refer to these arguments as proofs.
13. To take on faith any principle which seems right but cannot be proved.

Ch.1 Handout (Skylan Gaston)

Important things to know-

Motion Diagrams- There is four basic types of motions. Linear motion, Circular motion, Projectile motion, and Rotational motion. The trajectory or path the object takes defines its motion. Although Rotational is a bit different in that it's a change in its angular position.

Making a Motion Diagram- Showing an object's position at several equally spaced instants of time, is called a motion diagram. (see pic)

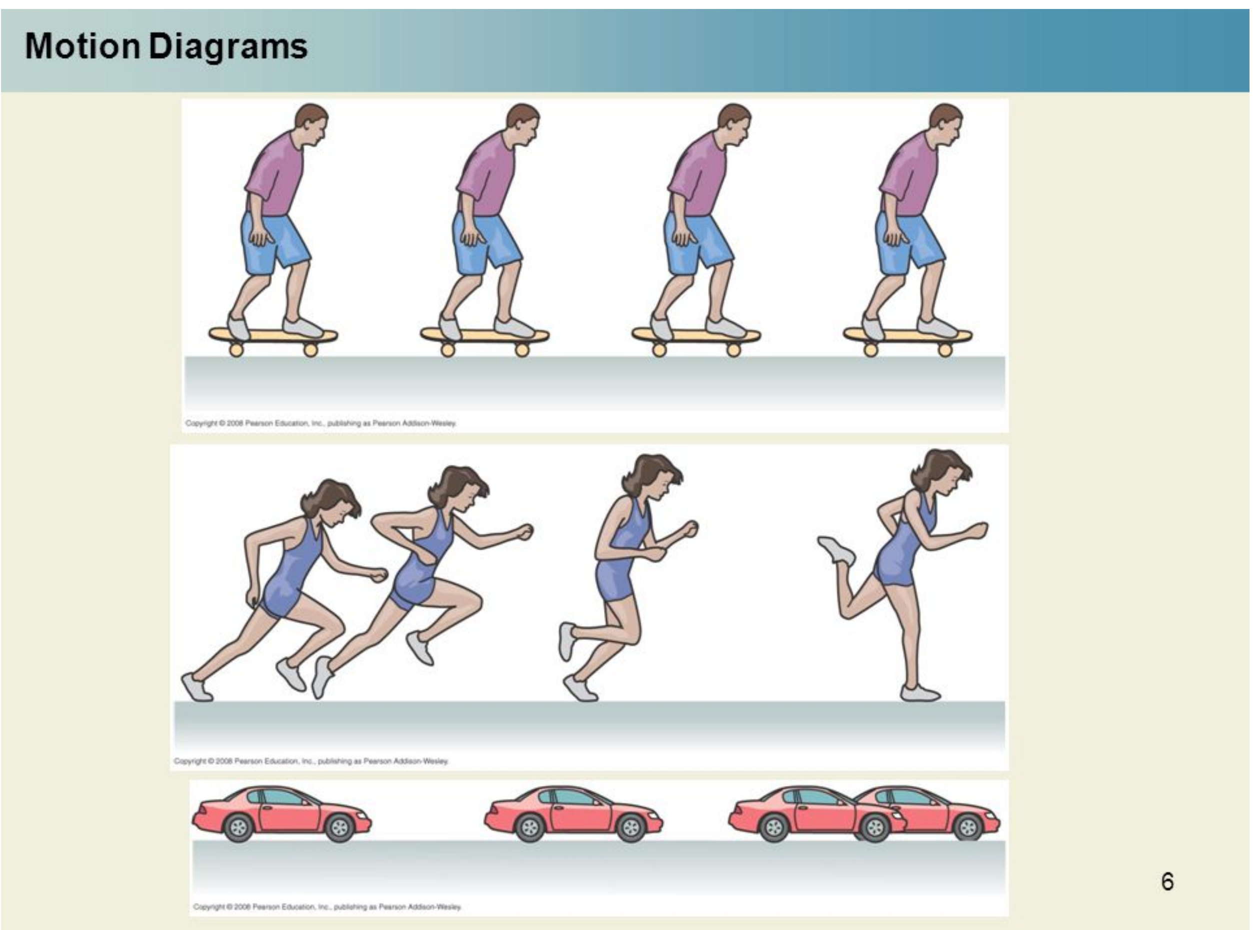
An object that can be represented as a mass at a single point in space is called a **particle.** This helps you understand the particle model of motion. This is like in earlier labs with the ticker tapes. It can tell you if the object is moving at a constant speed or acceleration, the direction, and motion.

The direction of a quantity is also important. We use **vectors** to represent quantities, such as velocity, that have both a size and direction.

- Displacement- change of position

For example if I walked 15ft forward and 20 ft backwards… My total displacement for my original position would be -5 ft because I ended up 5 more feet backwards from my starting position.

- Average speed= distance traveled/ time interval traveling
- The length of a velocity vetor represents the avg speed w which the object moves between 2 points.
- An object is speeding up if only v and a point in the same direction. An object is slowing down if only v and a point in the opp directions. Constant if a=0
- Calculations in physics are most commonly done using SI units known more formally as the metric system. Meter,second, and kilogram are the most commonly used,



Chapter 2 – Kinematics (Liya Amanuel)

2.1 Uniform Motion

Uniform motion- a straight line of motion in which equal displacements occur during any successive equal-time intervals

-An object's motion is uniform if its position vs time graph is a straight line

Final definition of uniform motion- an object's motion is uniform if its velocity doesn't change

-There is no need to specify the average for a velocity that doesn't change, so average velocity is V_x or V_y

Speed- how fast an object is going independent if direction

-absolute value of velocity

-scalar not vector ≡

V_s= rise/run=$\Delta s/\Delta t=s_f-s_i/t_f-t_i$

$S_f=S_i+V_s\Delta t$ (uniform motion) w/ constant velocity

2.2 Instantaneous Velocity

Instantaneous velocity- velocity (speed and direction) at a single instant of time

$V_s\equiv\Delta s/\Delta t=ds/dt$ (instantaneous velocity)

V_s= slope of the position vs time graph at time t

2.4 Motion with Constant Acceleration

rate of velocity change = $\Delta V_s/\Delta t$=30m/s/6.0s= 5.0 (m/s)/s

$a_{avg}=\Delta V_s/\Delta t$ (average acceleration)

Acceleration- "the rate of change of velocity" measures how quickly or slowly an object's velocity changes

a_{avg}= slope of the velocity vs time graph

$S_f=S_i$ + area under velocity curve V_s between t_i and t_f (object's final position)

Kinematic equations for motion with constant accelerations:

$V_{fs}=V_{is}+ a_s\Delta t$

$S_f=S_i+V_{is}\Delta t + 1/2a_s(\Delta t)^2$

$V_f^2=V_i^2+ 2ad$

2.5 Free Fall

Free fall- object moving under influence of gravity only

-occurs only in vacuum

Galileo model of motion- 2 objects dropped from same height will, if air resistance can be neglected, hit the ground at same time with the same speed

-consequently, any 2 objects in free fall, regardless of mass, have the same acceleration

-free fall acceleration is known as symbol g

g= 9.8m/s^2 (free-fall acceleration)

2.6 Motion on an Inclined Plane

a_s= +/- gsinθ (acceleration along incline)

Practice Problem

1)Mr. Forrest is approaching a stoplight moving with a velocity of +30.0 m/s. The light turns yellow, and he applies the brakes and skids to a stop. If Mr. Forrest's acceleration is -8.00 m/s^2, then determine the displacement of the car during the skidding process. (physics classroom)

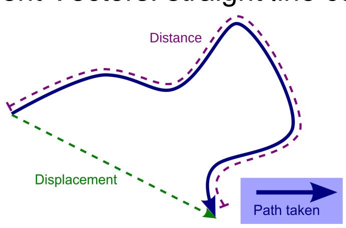
Given:V_i= +30.0 m/s V_i= 0 m/s a= -8.00 m/s^2
Equation: $V_f^2=V_i^2+ 2ad$
d= 56.3m So, the car will skid a distance of 56.3 meters

Helpful Places to go for Help:
5 Steps to a 5 book~ short and simple
Physicsclassroom.com ~ so many practice problems to help a student out
Science360.gov ~ has videos showing kinematics in action in real life, pretty cool stuff

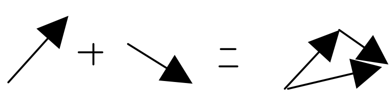
Chapter 3, Vectors and Coordinate systems (Kaitlin Macfarlane)

Notes/Key Ideas:
Scalar Quantities: a quantity fully described with a number and units (no direction)
Vector Quantities: a quantity described with a magnitude and a direction
Magnitude: size of a vector (scalar quantity) (cannot be negative)
Displacement Vectors: straight line connection from start to finish, (must include magnitude and direction)

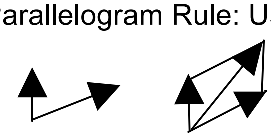
Example:



*vectors with equal magnitude and direction are equal (starting point doesn't matter)
Net Displacement: Sum of displacement vectors creating a resultant vector (C=A+B)
Graphical Addition: "tip-to-tail"



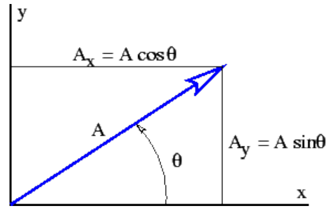
Magnitude/Length of C=$\sqrt{A^2 + B^2}$
Angle θ=$\tan^{-1}$(B/A)
Parallelogram Rule: Use when tails are together, find the diagonal of a parallelogram



Component Vectors: components of a vector parallel to the axes ($A=A_x+A_y$)

- -Decomposition: the process of breaking up the vectors components
- -Vectors pointing left or down are negative, right or up are positive

Unit Vectors: î= (1, +x-direction)
ĵ= (1, +y-direction)



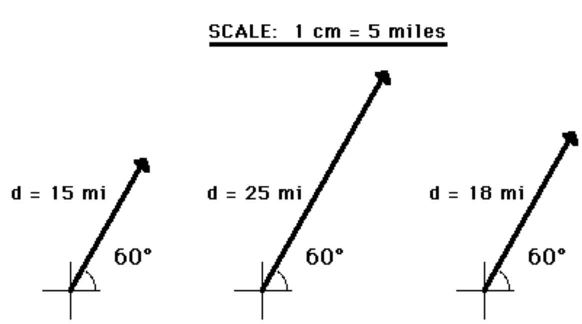
Algebraic Addition/Subtraction:

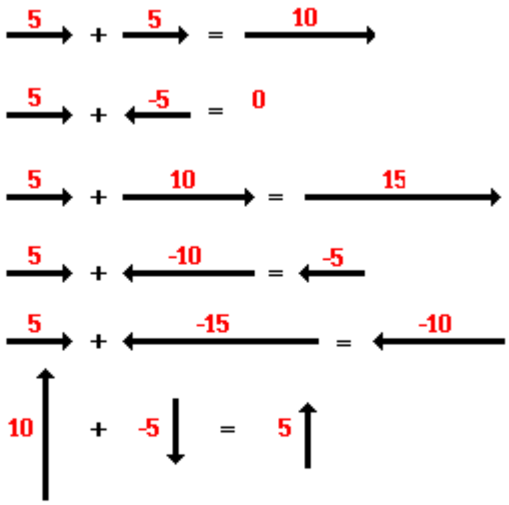
$$\vec{a} = a_x\hat{i} + a_y\hat{j}$$
$$\vec{b} = b_x\hat{i} + b_y\hat{j}$$
$$\vec{a} - \vec{b} = \vec{a} + \left(-\vec{b}\right) = a_x\hat{i} + a_y\hat{j} + \left(-b_x\hat{i} - b_y\hat{j}\right)$$
$$= \left(a_x - b_x\right)\hat{i} + \left(a_y - b_y\right)\hat{j}$$

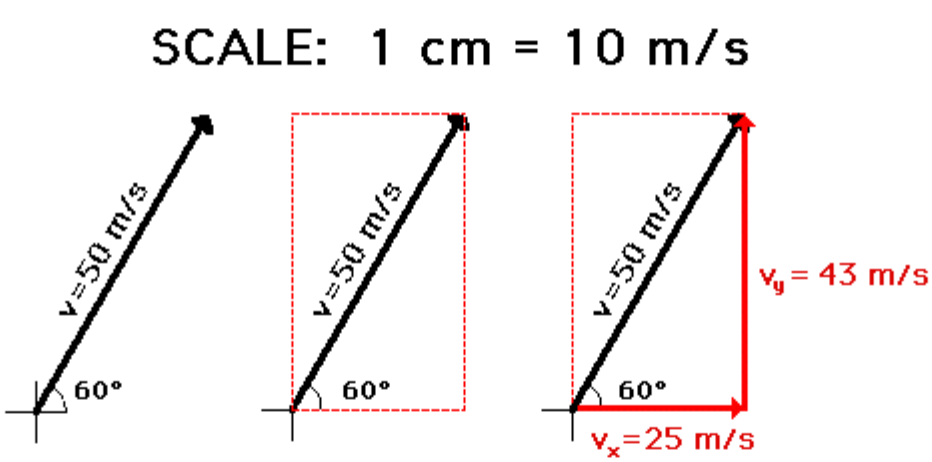
Problems to rework:
Ch. 3 #'s 11,13,19,30,43
These problems practice finding the magnitude of vectors along with direction. They are also good practice for using i-hat and j-hat

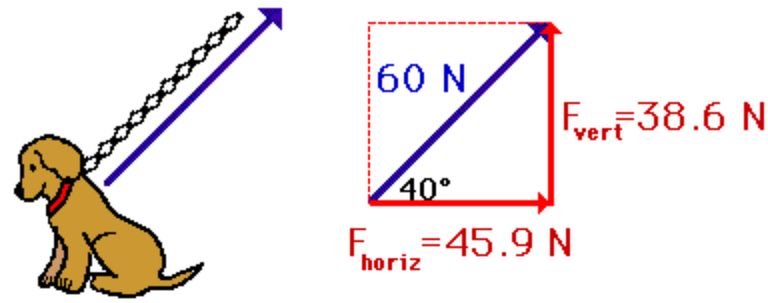
Chapter 4 Kinematics in 2 Dimensions (Ian M^{C}Teague)

- Object moving in two dimensions follows a trajectory
- Projectile motion is under influence of only gravity
- Uniform circular motion has constant velocity
- Acceleration points in the same direction as the change in velocity
- Uses Vector diagrams
- Vectors have both magnitude and direction
- Vector quantities are often represented by scaled vector diagrams. Vector diagrams depict a vector by use of an arrow drawn to scale in a specific direction
- Vectors are due north, east, south, and west. Or northwest etc. Ex: 45* north of east.
- The direction of a vector is often expressed as an angle of rotation of the vector about its "tail" from east, west, north, or south
- Magnitude of vector is depicted by length of arrow
- Vectors are added to find total distance. Uses the same rules as free body diagrams.



- 

- Resultant is the combination of two or more single vectors
- Pyhtagorean theorem is used to find resultant of two vectors that create 90* angle.
- Can also use trig functions. Sin Cos Tan
- The magnitude and direction of the sum of two or more vectors can also be determined by use of an accurately drawn scaled vector diagram. Using a scaled diagram, the head-to-tail method is employed to determine the vector sum or resultant
- Angled vector components: if a chain is pulled up and to the right at an angle its components are right and up
- The process of determining the magnitude of a vector is known as **vector resolution**. The two methods of vector resolution that we will examine are
    - the parallelogram method
    - the trigonometric method
- Parallelogram method: 



$$\sin 40° = \frac{F_{vert}}{60\ N} \qquad \cos 40° = \frac{F_{horiz}}{60\ N}$$

$$F_{vert} = 60\ N \times \sin 40° \qquad F_{horiz} = 60\ N \times \cos 40°$$

$$F_{vert} = 38.6\ N \qquad F_{horiz} = 45.9\ N$$

- Trigonometric method:
- Youtube links to help w projectile motion: https://www.youtube.com/watch?v=RcSadoSQhdA
- Youtube link to help with drawing vectors and vector addition: https://www.youtube.com/watch?v=RcSadoSQhdA

Chapter 5: Force and Motion (Oliver Mitchell)

A **force** is …

- A push or a pull
- An action on an object
- A vector quantity
- Can be a contact force or a long-range force

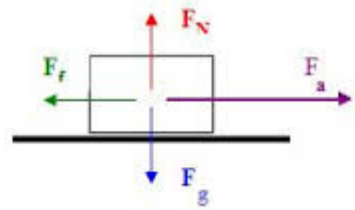
Examples of forces are …

- Gravity
- Tension
- Friction
- Drag
- Spring

Force causes an object to **accelerate.**
If there is **no net force,** there is no **acceleration** of an object.

Newton's second law states: **Force net on an object is the product of an object's mass and its acceleration. (Fnet = M*a)**

Force can be represented by a **free-body diagram.**
Example of a free-body diagram:



An object pulled with a **constant force** moves with a **constant acceleration.**

Acceleration is **directly proportional** with force.
Acceleration is **inversely proportional** with an object's mass.
An object only responds to the forces acting on it **at that instant.**
(This is known as **Newton's zeroth law)**

An object at rest is in **static equilibrium.**
An object moving in a straight line with constant velocity is **dynamic equilibrium.**

Newton's first law:
An object at rest will remain at rest until acted upon by an outside force.+

Chapter 6 Review (Jamie McLaughlin)

Key Ideas:

- An object on which the net force is zero is in equilibrium.
- An object can be at rest in static equilibrium, or it could be moving along a straight line with constant velocity in dynamic equilibrium.
- The forces acting on an object determine its acceleration.
- Mass is an intrinsic property of an object, whereas weight is not. Mass is the amount of matter in an object, and it is the same everywhere. Weight is the result of weighing an object on a scale, and it depends on gravity and acceleration.
- Gravity is an attractive, long-range force between any two objects.
- Force gets weaker as the distance between two objects increases.
- Flat earth approximation: if the height above the surface is very small in comparison with the size of the planet, then the curvature of the surface is not noticeable and there's virtually no difference between r and the planet's radius R.
- All objects on the same planet, regardless of mass, have the same free-fall acceleration.
- An object is weightless if it is in free fall.
- Static friction is a force on an object that keeps it from slipping. The force points in whichever direction that would prevent motion.

- Once an object starts to move, static friction force is replaced by kinetic friction force. The direction is always opposite to the direction in which an object slides across the surface.
- Molecular bonds are quickly established where a wheel presses against a surface, and the effort needed to break them as the wheel rolls forward causes rolling friction.
- Drag force is opposite in direction to velocity and increases in magnitude as the object's speed increases.
- Drag is more complex than ordinary friction because drag depends on the object's speed, the object's shape, and on the density of the medium through which it moves.
- If an object falls for long enough, it will eventually reach a speed at which the drag force will be equal and opposite to the gravitational force. The net force at this speed is 0, so there is no further acceleration and the object falls with a constant speed.
- The speed at which the exact balance between the upward drag force and the downward gravitational force causes an object to fall without acceleration is called terminal speed. Once an object reaches this point, it will continue falling at that speed until it hits the ground.

Important Formulas:

- Newton's Second Law: $F=ma$
  - Use when wanting to find the net force on an object, an object's acceleration, or an object's mass if the other two variables are already known.
- Newton's Law of Gravity: $F=Gm_1m_2/r^2$
  - G is the gravitational constant, and is equal to $6.67x10^{-11}$
  - Use when wanting to find the gravitational force between two objects.
- Flat Earth Approximation: $F=mg$
  - Pretty much the same as Newton's Second Law, but can be used to find the force of gravity when close to a planet's surface and the other two variables are known.
- Force of friction: $\mu = Ffric/Fnorm$
  - Use when wanting to find the coefficient of friction, the force of friction, or the normal force when the other two variables are known.
- An object remains at rest as long as $F_s > F_{smax}$
- An object slips when $F_s = F_{smax}$
- It is not possible to have $F_s > F_{smax}$
- $F_k < F_{smax}$, which explains why it is easier to keep an object moving than it is to start its motion.
- Drag Force: $D=1/2CpAv^2$
  - C=drag coefficent
  - p=density of air, 1.2 kg/m^3
  - A=cross section area of object as it faces into the wind
  - Can be used if the object is moving through the air near the earth's surface, the object's size (diameter) is between a few millimeters and a few meters, and the object's speed is less than a few hundred meters per second.
- Terminal Velocity: $V_{term}=\sqrt{2mg/CpA}$
  - Variables are same as above.
  - Use when wanting to solve for an object's terminal velocity.

Suggested Problems to Re-work:

- Conceptual #10, 11, 18
- Problems #31, 33, 55
    - This is the entire assigned chapter 6 book homework other than one problem, and since it was a smaller assignment, all of these problems are relevant and important for understanding. The three conceptual questions check your understanding about the difference between mass and weight, the force of gravity, acceleration, and air resistance.
    - The three problems all touch on important mathematical concepts from the chapter, including applying Newton's second law, calculating net force at an angle, and an understanding of static and kinetic friction.

Chapter 7 - Newton's Third Law (Brian Fissel & Raymon Chen)

1. Key Ideas

- The mutual influence of two objects on each other is called an **interaction**

- If object A exerts a force on object B, then object B will exert a force on object A that is **equal in magnitude and opposite in direction**, this pair of forces is called an **action/reaction pair**. The two members of an action/reaction pair act on **two different objects**

- The forces of an action/reaction pair are **equal**, but the **accelerations are not**. In an interaction between two objects of different mass, the lighter mass will do essentially all of the accelerating even though the forces exerted on the two objects are equal

- An action/reaction pair of forces exist as a pair, or not at all

- Long-range action/reaction pairs exist, the two objects don't have to be in contact with each other. For example, the force of the moon on the earth, and the force of the earth on the moon (this is how waves are created)

- **Propulsion** is a force that a system with an internal source of energy uses to drive itself forward. The friction force on a person is an example of propulsion

- The friction that prevents slipping is called **static friction**, it points in the direction that prevents slipping

- If two objects move together, their accelerations are constrained to be equal. A well defined relationship between the accelerations of two or more objects is called an **acceleration constraint.** A common example is two objects connected to a pulley

- **Tension** is a force that is exerted on an object by a rope or string. It is the force within the rope that pulls up to prevent an object from falling. An example is an object hanging from a rope from the ceiling

- Tension pulls equally in both directions. This means when it is being pulled by two objects, it remains at rest

- If two objects are pulling on each other via a massless string, the string can be ignored along with that the tension is constant and it can be treated as a force reaction pair, the force on string is equal to the force of the other object on string. This is called the **massless string approximation**

- Tension in massless string remains constant as it passes over a massless, frictionless pulley

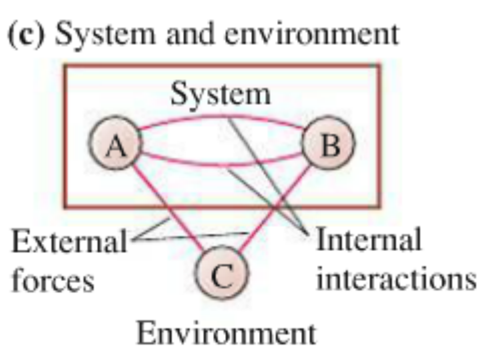
2. Important Equations

Acceleration: a = Fnet/m (acceleration is equal to net force divided by mass)

Use this formula when trying to calculate any of the three variables for a given situation (most situations in which you would use this formula are mostly, but not limited to, problems with pulleys and blocks)

3. General Information

Interaction Diagrams: The system consists of objects whose motion we want to analyze. The environment consists of objects external to the system. Interactions with objects in the environment are called external forces

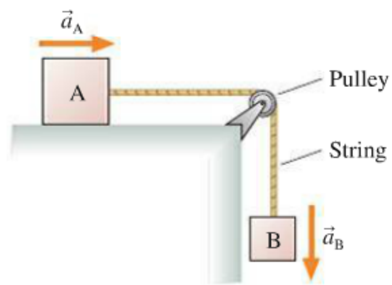


This is an *interaction diagram*.

Preparing for the A.P. test: The main idea to take away from this section in regards to the A.P. test is that action/reaction pair forces must act on different objects. Also, it is very helpful to start each problem with a free-body diagram. To prepare for the test, I would recommend doing the practice problems on page 126 in the 5 Steps To A 5 book, and also revisiting the A.P. physics problem(s) of the day for this section . These problems are similar to A.P. questions

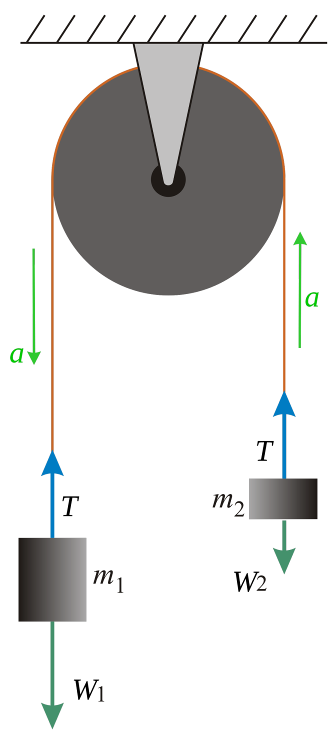
Acceleration Constraints: Though the accelerations are equal, don't assume that the accelerations will always have the same sign, in the example below block A has a positive

FIGURE 7.16 The string constrains the two objects to accelerate together.



acceleration, while block B has a negative acceleration

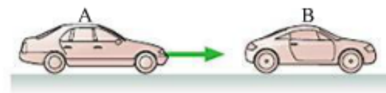
Ropes and Pulleys: Ropes or cables or strings allow two objects to interact with each other. If the rope or string is modeled as massless and the pulley is modeled as frictionless, the tension is constant throughout. All objects connected together must also
have the same acceleration



4. <u>Questions</u> (Answer key on next page)

1.

STOP TO THINK 7.2 Car B is stopped for a red light. Car A, which has the same mass as car B, doesn't see the red light and runs into the back of B. Which of the following statements is true?



a. B exerts a force on A, but A doesn't exert a force on B.
b. B exerts a larger force on A than A exerts on B.
c. B exerts the same amount of force on A as A exerts on B.
d. A exerts a larger force on B than B exerts on A.
e. A exerts a force on B, but B doesn't exert a force on A.

12. ‖ What is the tension in the rope of FIGURE EX7.12?

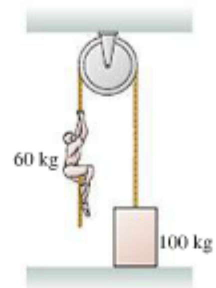
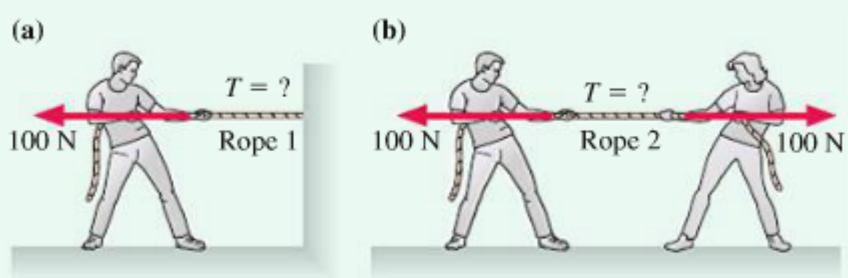


FIGURE EX7.12

2.

______**3.**

FIGURE 7.19 Pulling on a rope. Which produces a larger tension?



4. Assume a massless string and a frictionless pulley. On the right end of the hanging rope is a 10.0 kg block (Block B). On the other end there is a 5.0 kg block (Block A). What is the acceleration of the 10.0 kg block?

5. **Answer Key (Ch. 7)**

1. C - the force of A on B is equal and opposite to the force of B on A, this is always true, the speed of the objects is irrelevant

2. (60kg)(9.8m/s/s) = 590 N

3. They are the same, the wall exerts an equal force to the person pulling the first rope.

4.

mg - T = Fnet	Fnet of Block B
T - mg = Fnet	Fnet of Block A
Fnet = m * a	
(10 kg)(9.8 m/s/s) - T = 10 kg * a	10 kg block (Block B)
T - (5 kg)(9.8 m/s/s) = 5 kg * a	5 kg block (Block A)
98 N - (49N + 5 kg * a) = 10 kg * a	Substitute T, *Tension*
a = 3.26 m/s/s	

Chapter 8: Motion in a Plane (Owen Moore)

Formulas to know:

- $a = \frac{Fnet}{mass}$ - acceleration
- $a = \frac{v^2}{r} = w^2 r$ - centripetal acceleration
- $v = wr$ - rotational velocity
- $f_s = u_s n$ - static friction
- $v - orbit = \sqrt{rg}$ - orbital velocity
- $T = \frac{2\pi r}{v-orbit}$ - period of orbit
- $a = r\alpha$ - tangential and angular acceleration

The r or radial axis points from the particle to the center of the circle.
The t or tangential axis runs tangent to the circle, in the counterclockwise direction.
The z axis is perpendicular to the plane of motion.
These three axes are all mutually perpendicular, just like x, y, and z axes.

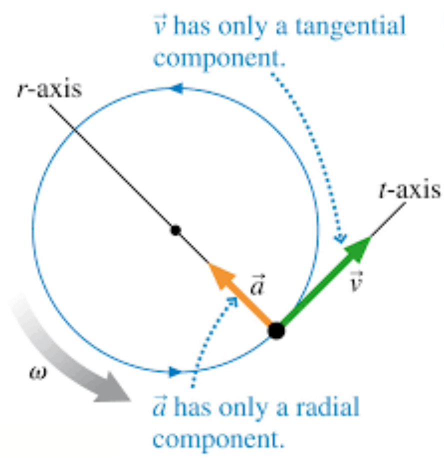
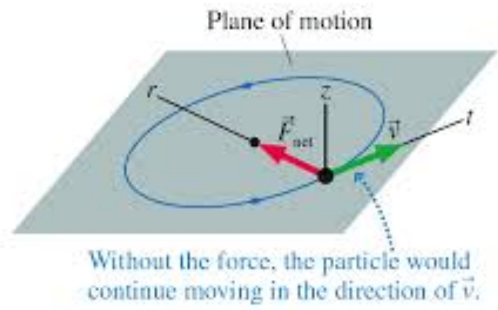
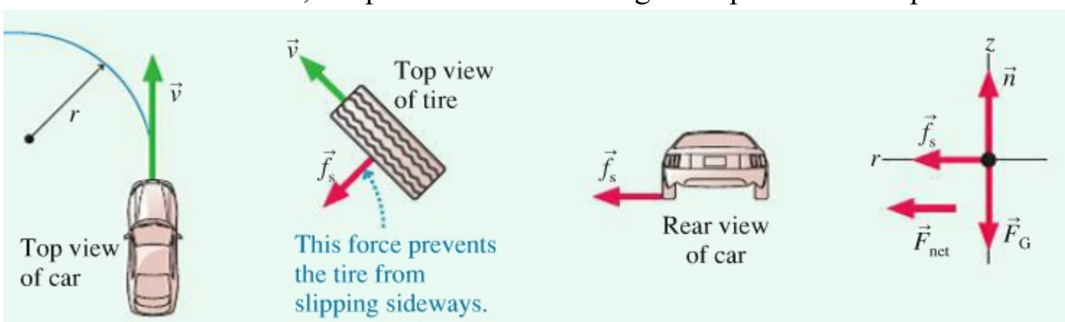


FIGURE 8.6 The net force points in the radial direction, toward the center of the circle.

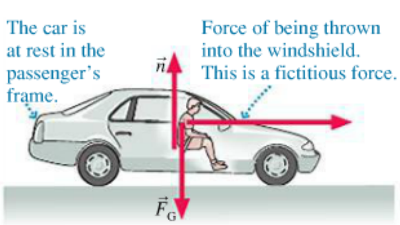


Angular velocity is measured in radians/second.
The velocity vector only has a tangential component,
The acceleration vector only has a radial component.
ω is positive when counterclockwise, negative when clockwise.

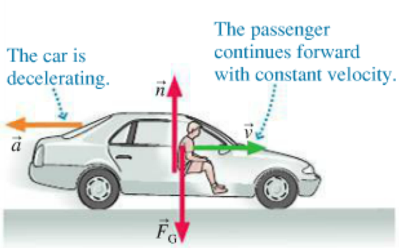
Acceleration is a net force.
A constant acceleration or net force inward is required for a centripetal force.
If this force is removed, the particle travels in tangential path from the point where it stopped.



True gravitational force is always directed at the center of the planet, but our flat-earth approximation is always vertically downward.
AN ORBITING PROJECTILE IS IN FREE FALL.



Noninertial reference frame of passenger



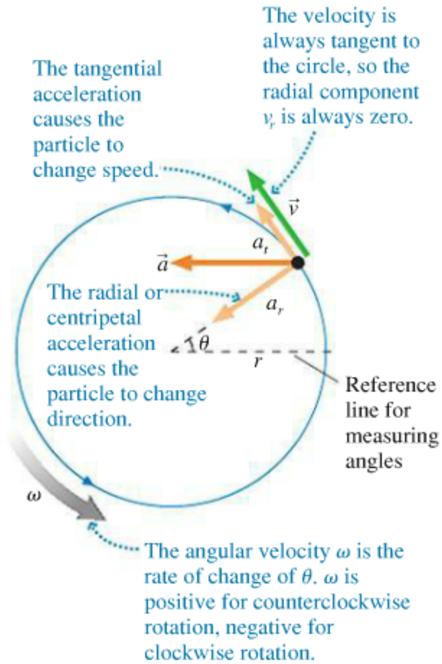
Forces are only identified properly in inertial reference frames. These reference frames create movements that are received as forces, but frame of reference is in actuality the only thing changing.
Centrifugal force is one of these "forces" in a noninertial reference frame. In reality, the reference frame is changing while the object experiencing the centrifugal force is only traveling with its tangential velocity, causing it to experience a "force" as it comes into contention with the frame.

Newton's laws always apply in inertial reference frames.

n(normal force) must be greater than Fg in order for object in circular motion (roller-coaster loop/bucket of paint.)

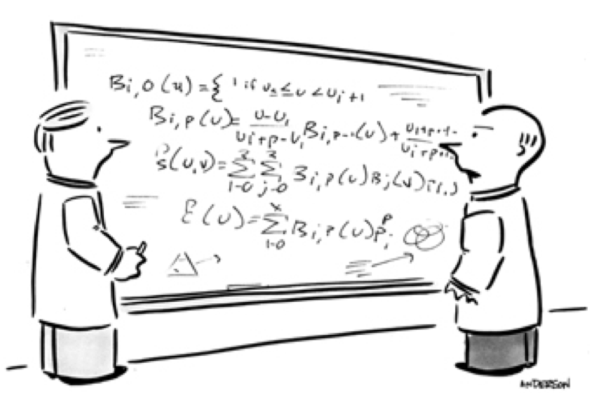
Critical speed is the *slowest speed possible* for an object (roller-coaster car) to still complete a circle.

Net force is applied to a particle moving in a circle, bisecting the line of centripetal force and the tangent line.



Resources to consult:
Five Steps to a 5: Pages
http://www.varsitytutors.com/ap_physics_1-help/centripetal-force-and-acceleration
http://bowlesphysics.com/images/12AP_Physics_C_-_Circular_Motion.ppt

Practice problems:
http://www.lghs.net/ourpages/auto/2012/1/2/64335036/CircularPracticeTest.pdf
https://d3jc3ahdjad7x7.cloudfront.net/osIWIcvHhkuYq77iu3le1m5XduN1nEn2WnUGW3B9HG1Js4CW.pdf
http://teachersites.schoolworld.com/webpages/KSeabolt/files/apb_mc07_circularmotion.pdf



"What the hell is that supposed to mean?!"

Chapter 9: Momentum and Impulse → By: Grace Gibson

9.1

- Impulse Force – a large force exerted for a short period of time
- Momentum – product of mass and velocity
  - The momentum vector is parallel to the velocity vector
- Newton's second law, F = ma, is a way of saying that *force is the rate of change of momentum*
- Impulse is proportional to force
- Impulse momentum theorem – an impulse delivered to a particle changes the particle's momentum
  - Impulse transfers momentum to an object as well. So, if an object has a momentum of 2 kg m/s and an impulse of 1 kg m/s acts on it, its new momentum is 3 kg m/s

9.2

- Impulse Approximation – allows for the neglect of small forces that happen during the brief time of the impulsive force

9.3

- The momentum before the collision will equal the momentum after the collision, but only in an isolated system
- Isolated system – a system for which the net external force is zero
  - In other words, the system has no external forces or has balanced external forces so they add up to zero
  - So, the total momentum of an isolated system doesn't change

9.4

- Perfectly inelastic collision – a collision in which the two objects stick together and move with a common final velocity
  - Ex: a bullet embedding itself in the wood
  - Mechanical energy is not conserved
- Elastic collision – a collision in which two objects bounce apart
  - Mechanical energy is conserved

For understanding:
If a 10 kg cart is going 2 m/s to the left before the collision and 1m/s to the right after the collision, what is its change in moment?

$P_1 = -20\ kg\ m/s$ $\quad\quad \Delta P = \left(10\ kg\frac{m}{s}\right) - \left(-20\ kg\frac{m}{s}\right) = 30\ kg\ m/s$

$P_f = 10\ kg\ m/s$

Suggested problems in textbook:
#1, #9, #11 (think Pythagorean Theorem), #15, #17 (see example 9.5 for help)
1, 15, and 17 are strictly momentum problems, but as the student goes through them, the complexity of the problem increases. They serve the same purpose in regards to what they teach the student, but they let he/she approach the concept of momentum from different points of view. 9 and 15 contain momentum concepts but the point of the problems are to get the student to connect momentum with impulse.

The three equations you will use the most are…

$$J = \int F dt = \Delta p$$

Impulse = force x the change in time = the change in power
*be aware that there is an integral. It may end up significantly effecting the answer.

$$p = mv$$

Momentum = mass x velocity

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f$$

To find final velocity of an inelastic equation (typically, although you may need to find one of the other variables instead).

Chapter 10: Energy (Review) by Julien Turner

3 fundamental forms of energy:

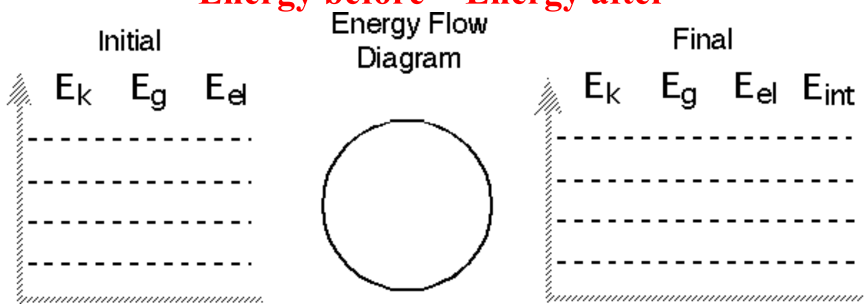
1. Kinetic Energy: Energy of motion.
• The more massive an object or the faster it moves, the larger its kinetic energy.
• Kinetic Energy (KE) = (1/2)(mass)(velocity)^2
• Kinetic Energy cannot be negative.
PRACTICE Q'S:
- pg 271 Exercises #1 & 3
- pg 276 #62

2. Potential Energy: Energy associated with an object's position.
• Gravitational potential, spring potential, etc.
• Gravitational potential (U_g) = (mass)(acceleration due to gravity [g])(change in height)
Earths gravitational constant= g= 9.8m/s^2
• Spring potential (U_s) = (1/2)(spring constant[k])(change in position)^2

3. Thermal Energy: Sum of the microscopic kinetic and potential energies of all the atoms and bonds that make up the object.
• Higher the temperature = Higher the thermal energy

Units of energy = Joules = 1 J = 1 kgm^2/s^2

Law of conservation of energy: Energy cannot be created nor destroyed.
Energy before = Energy after



Energy Bar Charts:
Visual representation of transformation of energy
•Remember any additional work done to the system goes into the middle circle

Gravitational Potential Energy:

•Net force of an object in freefall

F_{net}=-(mass)(g)

• Velocity of an object in freefall

$v_x^2 = v_i^2 + 2a_x(x-x_i)$

Current Velocity

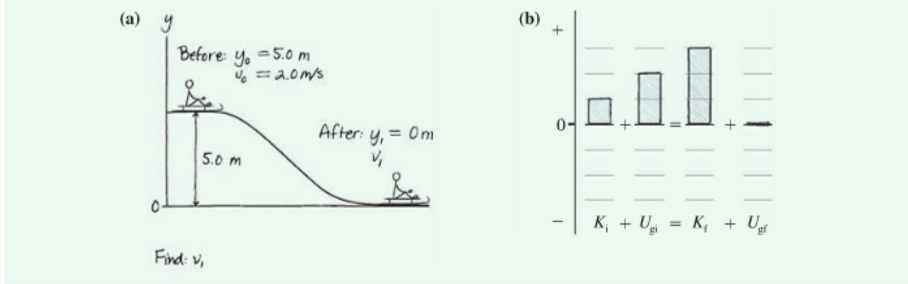
Initial Velocity

Acceleration

Current Position

Initial Position

FIGURE 10.11 Pictorial representation and energy bar chart of Christine sliding down the hill.



• The sum of KE + U_g is not changed by free fall

• Gravitational potential can be negative because position is relative to where you set the 0 position (Possibility of negative value).

• When dealing with a slanted slope, take the horizontal vector that applies to the specific variable you are looking for

PRACTICE Q'S:

- pg 272 #4 & 9

- pg 273 #33

Momentum of a system is constant if there are no external forces on the system

$$P_i = P_f$$

$$M_1V_1 = M_2V_2$$

Mechanical Energy is conserved only if two requirements are met:

1. **The system is isolated, no external force.**
2. **No friction/drag**

$$\mu_k = F_k / N$$

Elastic/Spring Energy:

• **Restoring forces:** The force of a spring trying to return back to equilibrium (L_0).

• **FORCE OF SPRING**

$F_s = k(\Delta x)^2$

Force of spring (N)

Spring constant

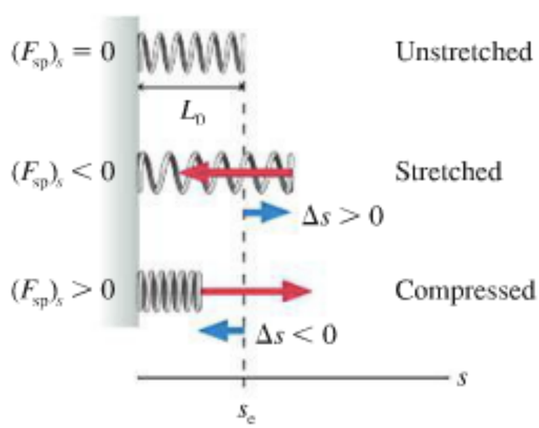
Change in position

PRACTICE Q'S:

- pg. 271 #10,11,12

- pg 273 #40

FIGURE 10.15 The direction of $\vec{F}_{sp}$ is always opposite the displacement $\Delta\vec{s}$.



Hooke's Law: The force needed to extend or compress a spring by the same distance is proportional to that distance.

Put it all together?

EXAMPLE 10.7 A spring-launched projectile

Your lab assignment for the week is to devise a method to determine the spring constant of a spring. You notice several small blocks of different mass lying around, so you decide to measure how high the compressed spring will launch each of the blocks. You and your lab partners quickly realize that you need to compress the spring the same amount each time, so that only the mass is varying, and you choose to use a compression of 4.0 cm. Measuring the height from where you place the mass on the compressed spring generates the following data:

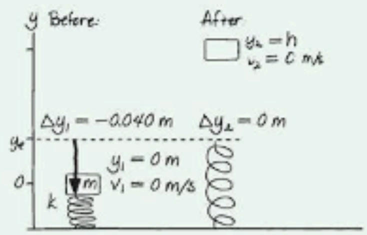
Mass (g)	Height (m)
50	2.07
100	1.11
150	0.65
200	0.51

What value will you report for the spring constant?

MODEL Assume an ideal spring that obeys Hooke's law. There's no friction, and we'll assume no drag; hence the mechanical energy $K + U$ is conserved. However, this system has both elastic *and* gravitational potential energy—two distinct ways of storing energy—and we need to include them both. Thus $U = U_g + U_s$.

VISUALIZE FIGURE 10.21 is a before-and-after pictorial representation. We've chosen to place the origin of the coordinate system at the point of launch, so in this problem the equilibrium position of the spring is *not* $y_e = 0$. The projectile reaches height $y_2 = h$, at which point $v_2 = 0$ m/s.

FIGURE 10.21 Pictorial representation of a spring-launched projectile.



SOLVE Mechanical energy is now $K + U_g + U_s$, so the conservation equation is

$$\frac{1}{2}mv_2^2 + mgy_2 + \frac{1}{2}k(\Delta y_2)^2 = \frac{1}{2}mv_1^2 + mgy_1 + \frac{1}{2}k(\Delta y_1)^2$$

It is important to distinguish between the *position* of the projectile and the *compression* of the spring. While the projectile moves to position y_2, the end of the spring stops at y_e. Thus $\Delta y_2 = 0$, not $\Delta y_2 = y_2$. The initial and final speeds are zero, as is the initial position, so the equation simplifies to

$$mgh = \frac{1}{2}k(\Delta y_1)^2$$

Continued

Collisions:

- **Perfectly Elastic Collision:**
  - Mechanical energy is conserved.
  - Momentum is conserved.
- $\mathbf{m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}}$
- **Sample problems to work on!**

PRACTICE Q'S:

- pg 273 #29, 30, 31

What's likely to be on the test?

• Energy Bar chart interpretation
• Collision or Momentum Problem
• Spring/Kinetic Transformation Problem
• Spring/Gravitational Transformation Problem
• Kinetic/Gravitational Transformation Problem

Chapter 11 Key Concepts (Christian Popovski) --> sections 1-5

- Total energy in an isolated system is conserved
- Two types of energy transfers
  - One dealing with forces
  - Heat
- A force does work only if the particle is displaced
- Work is force x distance only if the force is constant and parallel to the displacement
- Whenever a force is perpendicular to the motion, no work is being done
- Conservative and Non-conservative Forces
  - A conservative force is a force for which work is done on a particle as it moves from an initial to a final position and is independent of the path followed. An example of a conservative force is Potential Energy
  - A non-conservative force is a force for which the work is not independent on the path. No potential can be transformed into kinetic energy

Equations

- $\Delta E\ system = \Delta K + \Delta U + \Delta E\ thermal$
- $\Delta K = net\ work$
- Kinetic energy in terms of momentum

K= 1/2mv^2 = (mv^2)/2m= p^2/2m

.

Good Problems To Review and Strategies to Know

1. A 20 g particle is moving to the left at 30m/s. How much net work must be done on the particle to cause it to move to the right at 30m/s.

2.Know what the slope and trapped area on a Newton/ meter *graph (Whu??? - Note from Forrest)*

Chapter 11 sections 6-10 NOT complete as of April 17 at 7:00 PM → NOT COOL to the person who was supposed to do those!

Chapter 12 (Kyle Moesle, Fred Tocco)

Rotational motion is described in radians while linear motion is described in meters.

$v = r\omega$ $a = r\alpha$ $\qquad \omega = \frac{d\theta}{dt} \qquad \alpha = \frac{d\omega}{dt}$

Comparisons to assist understanding

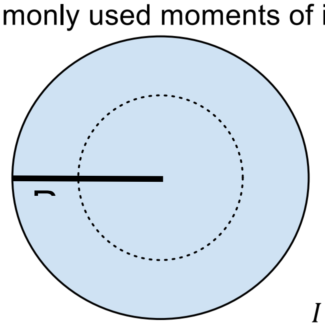
Rotational	Linear
$\omega_f = \omega_i + \alpha t$	$v_f = v_i + at$
$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$	$x_f = x_i + v_i t + \frac{1}{2}at^2$
I	m
τ	F
$\alpha = \tau_{net}/I$	$a = F/m$
L	p
$L = I\omega$	$p = mv$
ω	v
θ	x
α	a
$KE = \frac{1}{2}I\omega^2$	$KE = \frac{1}{2}mv^2$

Moment of Inertia

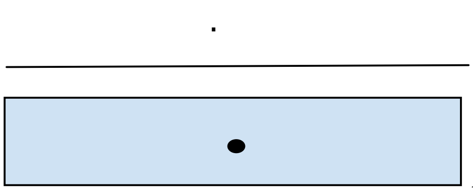
a) $$I = \sum mr^2$$

b) depends on the axis of rotation.

c) commonly used moments of inertia



$I = \frac{1}{2}mr^2$for a uniformly distributed mass in a circle



$I = \frac{1}{12}mL^2$ for a thin rod rotated abou t its center

Center of mass

$$x = \frac{1}{M}\sum mx = \frac{m_1x_1 + m_2x_2 \ldots}{m_1 + m_2 \ldots}$$

Torque

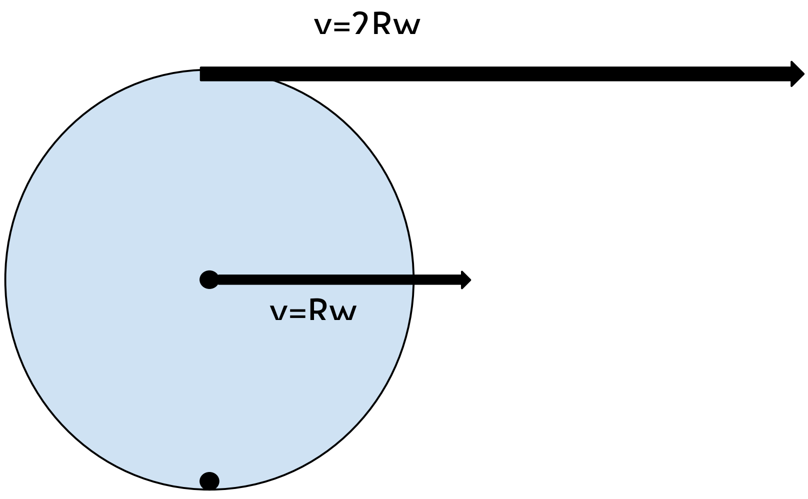
$\tau = rF\sin\theta$ (θ is the angle between force vector and radial line)

Torque due to gravity = $-Mgx_{center\ of\ mass}$

Torque causes angular acceleration

Velocity of a rolling object

a) Acceleration of a rolling object is less than the acceleration of a particle because rolling objects have a greater moment of inertia
b) Velocity at different points of a rolling object:



Angular Velocity

a) Right-hand rule: Curve fingers of your **right hand** with the direction of the spinning of the object. The direction your thumb is pointing is the direction of the angular velocity vector.

Practice

A baseball player swings his bat with his arms fully extended. If the arms are pulled in closer to the body, in which of the following is true about the angular momentum and kinetic energy of the swing affected?

(multiple choice answers on next page)

Angular Momentum	Kinetic Energy
(A) Increases	(A) Increases
(B) Increases	(B) Remains Constant
(C) Remains Constant	(C) Increases
(D) Remains Constant	(D) Remains Constant
(E) Decreases	(E) Remains Constant

Answer is written on the back of the first page of the review.

Materials you can use for practice – Ch. 12

a) https://www.crashwhite.com/apphysics/materials/practicetests/practice_test-6-rotation-angular_momentum.pdf (includes multiple choice and free response with answers)
b) http://www.smusd.org/cms/lib3/CA01000805/Centricity/Domain/2309/rotational%20dynamics%20MC%20Practice%20w%20sol.pdf (includes multiple choice and answers)
c) http://apcentral.collegeboard.com/apc/members/exam/exam_information/8039.html (Question 3 on many old exams includes rotational dynamics. Practicing these would be helpful.)

Chapter 13- Newton's theory of Gravity (Keller, Ayers)

Kepler's Laws:
1. The planets move in elliptical orbits.
2. The planets "sweep out" equal areas in equal times.
3. The square of the period is proportional to the cube of the orbit's radius.

Newton reasoned that the moon's circular motion is due to the earth's pull of gravity, and this must mean that the moon is in *free fall* with the free fall acceleration.
- *See figure 13.3 on page 356*

The centripetal acceleration of an object in uniform motion is
- Vm^2/ Rm

Newton proposed that every object in the universe attracts every other object with a force that is….
- Inversely proportional to the square of the distance between the objects
- Directly proportional to the product of the masses of the two objects.
- *See figure 13.4 on page 357*

Newton's Law of Gravity:
- Gm1m2/ r^2
- The constant "G" is the value of 6.67 x10^-11 N m^2/kg^2

No matter how far away two objects are, there is always a gravitational force between them.

Inertial mass = F/a
Gravitational mass = r^2Fm on m/ GM
- Inertial mass = Gravitational mass
- This is called the principle of equivalence

Answer question 13.2 on page 359

Newton's law of gravity is for a Universal force that exists between all objects.

g of the surface = GM/ R^2

Answer question 13.3 on page 361
Gravitational Potential energy = Ug

- Ug = - Gm1m2/ r
- The asymptote as r approaches infinity is 0.
- *See figure 13.10 for a pictoral representation.*

Kepler's Third Law
A satellite is a celestial body that orbits around the earth or another planet.

The speed of a satellite in a circular orbit is

- $\sqrt{GM/r}$

The relationship between the speed, radius, and period is

- $v=2\pi r/T$

The relationship between a satellite's period and the radius of its orbit is

- $v=2\pi r/T=\sqrt{GM/r}$

Squaring both sides of the equation above and solving for T gives $T^2 = (4\pi^2/GM)\, r^3$

Kepler's Second Law
The angular momentum $L=mrv\sin\beta$ remains constant throughout the orbit.

Orbital energetics
A satellite's mechanical energy Emech=K+Ug is conserved, where the gravitational potential energy is Ug= -GM*m*/r

For circular orbits, K= -1/2Ug and Emech=1/2Ug

Negative total energy is characteristic of a bound system.

A bound system is a system in which the satellite is bound to the central mass by the gravitational force and cannot get away.

Look at conceptual questions on page 372
to check if you have a full understanding

Conspiracy theory of relativity

Chapter 14: Oscillations (Cole Losoncy and Erin Peine)

1. Simple Harmonic Motion occurs when a linear restoring force acts to return a system to an equilibrium position.
2. Energy is always conserved in oscillation.
3. Period: time to complete one full cycle, or one oscillation.
4. Frequency: number of cycles per second.
5. Amplitude: maximum displacement from equilibrium.
    a. The speed is zero when $x=\pm$□(position/time graph)
    b. Speed is maximum when passing through X=0(position/time graph)
6. Phase Constant (θ): Species initial conditions of oscillator.
7. The period and frequency do not depend on amplitude.
8. On a pendulum the frequency and period are independent of the mass.

Formulas:

$f = 1 \div T$	-Frequency (f), period (T) This is used to calculate the frequency when you already have the period.
$x(t) = A\cos((2 \cdot \pi \cdot t)/T)$	-Object's position When you have the given time, period, and amplitude of the oscillation you can calculate the position of the object that's oscillating at any given time. You can also rework the equation to solve for any of the other variables provided you have the other necessary information.
$\omega = 2\pi f = 2\pi/T$	-Angular Frequency If you're looking to calculate the rate at which an object completes one full oscillation this is the formula that you would use.
$\omega = d\theta \div dt$	-Angular velocity This is used to find the velocity of an object that is oscillating.
$E = K + U = 1/2m \cdot v \cdot v + 1/2 \cdot k \cdot x \cdot x$	-Mechanical Energy in SHM This is the fundamental principle of energy being conserved in an oscillating object. It can be rearranged provided you have the necessary information.
$\tau = m/b$	-Time Constant This is the formula used to find time constant of an oscillating object.

Ch. 14 Problems to re-work:

Page 402, Section 14.1, Problem 2

An air-track glider attached to a spring oscillates between the 10 cm mark and the 60 cm mark on the track. The glider completes 10 oscillations in 33 seconds. What are the (a) period, (b) frequency, (c) angular frequency, (d) amplitude, and (e) maximum speed of the glider?

-Good to rework because it requires you to find each piece of information that comes with an oscillation, and you get a feel for working the different equations. It's a fairly simple question, but it helps jog your memory on this section.

Page 402, Section 14.4, Problem 13

A 200 gram mass attached to a horizontal spring oscillates at a frequency of 2.0 Hz. At t = 0 seconds, the mass is at x = 5.0 cm and has v_x = -30 cm/s. Determine: (a) the period, (b) the angular velocity, (c) the amplitude, (d) the phase constant, (e) the maximum speed, (f) the maximum acceleration, (g) the total energy, (h) the position at t = 0.40 seconds.

-We thought this one would be a good problem to review because it's similar to the first one that we suggested, however, it goes more indepth with working the formulas and building off of previous parts of the problem that you calculated. Overall, it's fairly indepth and it definitely helps you review the majority of the chapter in one problem.

Page 404, Problem 41

A 300g oscillator has a speed of 95.4cm/s when its displacement is 3.0cm and 71.4cm/s when its displacement is 6.0cm. What is the oscillator's maximum speed?

-We thought this problem would be a good problem to review because it incorporates the fundamental principle that energy is conserved. It also still involves an oscillator, it just pertains to a different area of oscillations.

Chapter 25: Electric Charges and Forces (Daniel Ceculski)

Important big ideas and concepts to know for AP testing:

---25.1: Developing a Charge Model

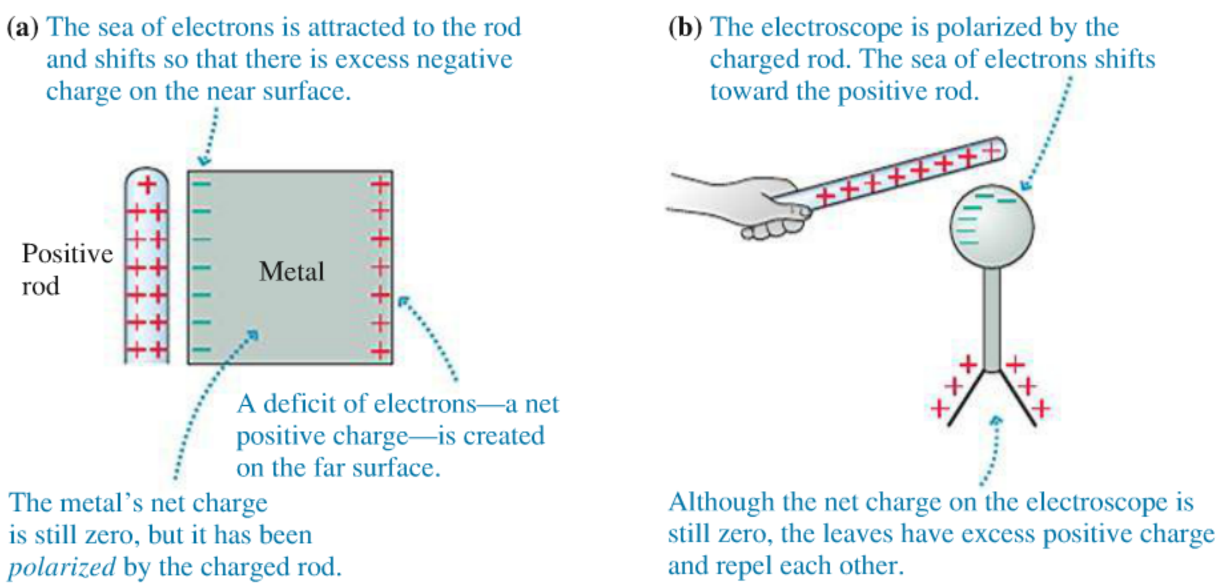
- Three types of charges: positive (proton), neutral (neutron), and negative (electron) (coined by Benjamin Franklin)
  - Opposite charges attract, same charges repel
  - A charged object attracts neutral objects, also
    - To determine if an object has a charge, try to pick paper up with it.
- An object can be charged or discharged by contact. Charges on these objects can be transferred.

---25.2: Charge

- Two types of charges: positive (proton) and negative (electron) (Coined by Benjamin Franklin)
  - Opposite charges attract and same charges repel
- A glass rod rubbed with silk is positively charged, while a plastic rod rubbed with wool is negatively charged
- The nucleus of an atom is about $10^{□1□}$ m, and the size of an electron cloud is about $10^{□1□}$ m.
- Charge and mass are properties of protons and electrons
- e is the fundamental unit of charge
  - 1 coulomb = 6.25 x $10^{1□}$ fundamental charges
- Mass of a proton = 1.67 x $10^{□2□}$ kg, mass of an electron = 9.11 x $10^{□31}$ kg
- Q is the symbol used to symbolize charge
- Law of Conservation of Charge: No charges are created or destroyed

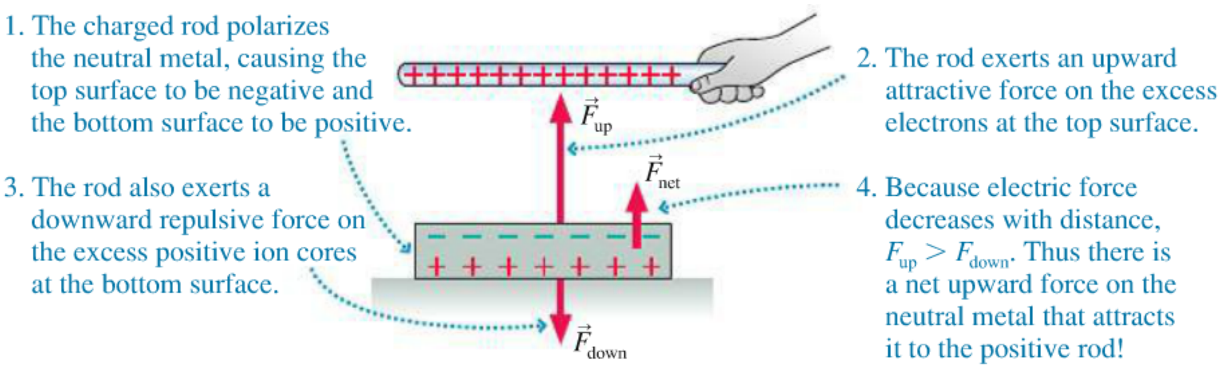
---25.3: Insulators and Conductors

- Conductors: charge easily moves
- Insulators: charge remains immobile
- Electrostatic equilibrium: charges are at rest and there are no forces acting on them
- In an isolated conductor, any excess charge is located on the surface of the conductor
- Charge Polarization: A slight separation of positive and negative charges in a neutral object



A couple of diagrams depicting charge polarization. The metal and the electroscope are both neutral, but when a charge comes near a neutral object, the objects stays neutral, but charges shift in the neutral object (making contact can be a different story and charges can actually be transferred between objects, then.)

- Polarization Force: Net force exerted toward a charged rod from a neutral object.
  - Occurs because the charges in a neutral object are shifted, NOT because the rod and the metal are oppositely charged.



- A dipole is when this happens with atoms within a material
- Charging by Induction: Occurs when a rod is near an electroscope and a person is in contact with it.
  - Let's say that a rod is positive and the person has a positive charge. When the person lets go and then the rod is taken away, the electroscope will be negatively charged.

---25.4: Coulomb's Law

- **Formula: $F = K q_1 q_2 / r^2$, where $K = 9.0 \times 10^9$ Nm²/ C² or $1 / 4\pi \varepsilon_0$, where $\varepsilon_0 = 8.85 \times 10^{-12}$ C² / Nm²**
- Describes the force between charged particles, or point charges.

---25.5: The Field Model

- Michael Faraday came up with the idea of a particle altering a space around another particle to interact with it (a field). Newton suggested that the particles interacted with each other directly.
  - An electric field is very similar to a gravitational field, affecting the surrounding area with a field. Many of the same principles still apply, such as interactive force pairs
  - The field itself exerts a force
- **Electric Field Strength can be found with the formula $E = F/q$ (gravity is similar, using $g = F/m$)**
- **Derived from the electric force equation, it can be concluded that $E = kq / r^2$**
- Electric Fields can be represented by arrows since they are vector quantities, like gravity
  - When drawing electric fields, arrows always leave positive particles and point toward negative particles

FIGURE 25.27 The electric field of a positive point charge.

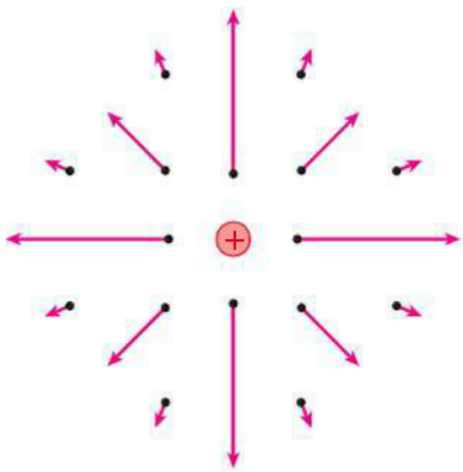
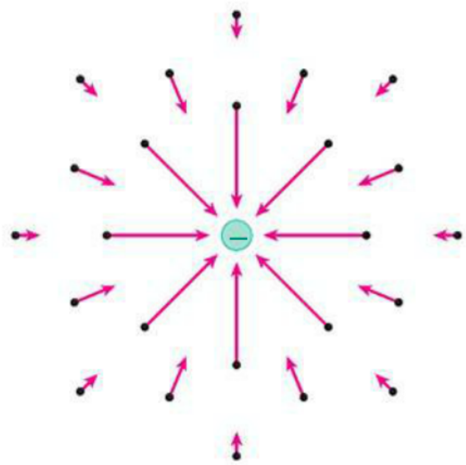


FIGURE 25.29 The electric field of a negative point charge.



The AP Test

This chapter is an introduction to electricity, and isn't too mathy, but rather very conceptual. All of these principles are the foundations for future chapters and must be known to succeed on the Electricity and Magnetism test.

To be prepared for these types of questions on the test, you can find questions relating to this chapter in the book. A good idea would be to rework and then review the ones in your composition notebook done for homework when this chapter was covered in class (Conceptual questions 3, 5, 7, 10, 12, 13 and problems 3,17,21,27, 33, 37, 49, 53, 59, and 66). The summary on page 743 can also be a very quick review of this.

Another good way to review for the test is to refer to your "5 Steps to a 5" study book. There is a quick review on pages 179-183 of some of the topics covered in this chapter. Also, pages 186-190 teach you how to use equations and concepts from this chapter on general AP problems. Also, on page 192, there is a set of practice problems on pages 192-193 (#1, #4, #5, and #6). Answers are also on page 193. Page 194 also contains a very short review of things contained in chapter 18 of the "5 Steps to a 5" book. Although not all of this is over this chapter, but electrostatics in general.

One person I like to watch when it comes to learning physics is Walter Lewin, a physics professor at MIT who has many lectures available on Youtube. There is a lecture on Electric Field and Dipoles that may be helpful for this chapter, but this professor and youtube channel may be very helpful for studying for the AP exam in general:

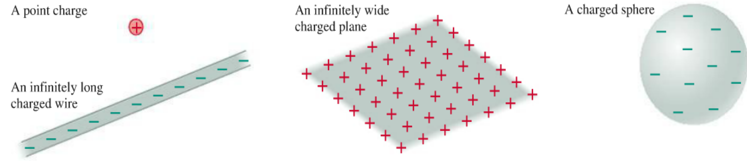
Electric Field and Dipole lecture: https://www.youtube.com/watch?v=JSa7_pEVdpA

Youtube channel: https://www.youtube.com/channel/UCliSRiiRVQuDfgxI_QN_Fmw

GOOD LUCK!

Ch 26 Review: The Electric Field (Becca Lubow and Makenna Spence)

There are four common models for sources of charge that create electric field:



We show electric field as pointing toward negative charges and away from positive charges. Electric field lines point in the direction of electric field. The closer together they are, the stronger the magnitude of electric field is.

Electric Field of a Point Charge:

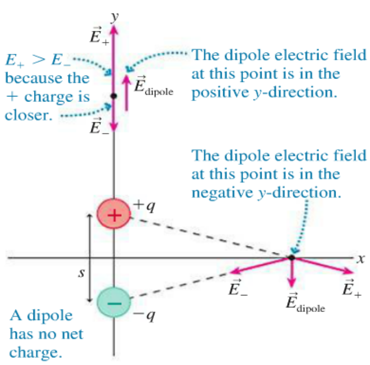
The formula for the electric field of a point charge q is: $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$ where r̂ is a unit vector pointing away from q, and $\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N\,m^2}$ is the permittivity constant.

For multiple point charges, the net force on q due to electric field is a vector sum: $\vec{F}_{\text{on } q} = \vec{F}_{1 \text{ on } q} + \vec{F}_{2 \text{ on } q} + \cdots$

The net electric field is the vector sum of all the electric fields due to charge. This is the principle of superposition:

$$\vec{E}_{\text{net}} = \frac{\vec{F}_{\text{on } q}}{q} = \frac{\vec{F}_{1 \text{ on } q}}{q} + \frac{\vec{F}_{2 \text{ on } q}}{q} + \cdots = \vec{E}_1 + \vec{E}_2 + \cdots = \sum_i \vec{E}_i$$

The net electric field can be written as a magnitude and direction, or in component form.



Electric Field of a Dipole

-Two equal but opposite charges separated by a small distance form an electric dipole. Dipoles have no net charge, but they do have electric fields.

-In a nonuniform electric field, a dipole has a net force in the direction of increasing field strength.

-Electric field exerts a torque on a dipole that tends to align the dipoles with the field: *T= pE sinØ* where p is dipole moment, and *p=qs* with direction from negative to positive charge

Electric Field of a Continuous Charge Distribution

To find the net electric field of a continuous distribution of charge:

1. Divide the total charge Q into many small point-like charges *Δ*Q
2. Find the electric field of each *Δ*Q as if it were a point charge
3. Calculate net field by adding all the fields as components

Electric Field of an Infinite Line of Charge

The electric field of an infinite line of charge points straight away from the line. The field gets weaker as distance from the line increases.

$$E_{\text{line}} = \frac{1}{4\pi\epsilon_0}\frac{2|\lambda|}{r}$$

where $|\lambda| = |Q|/L$ is the magnitude of the charge density on the line.

Electric Field of an Infinite Plane of Charge

$$\vec{E} = \left(\frac{\eta}{2\epsilon_0}, \text{perpendicular to plane}\right)$$

For an infinite plate of charge with surface density η = Q/A the electric field is:
The field is always perpendicular to the plane.

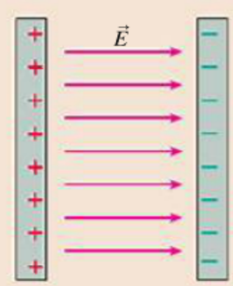
Electric Field of a Charged Sphere

For conducting spheres, all charge is distributed on the outside surface of the sphere.
-**There is no electric field inside a charged conducting sphere.**
-For all points outside a charged conducting sphere, the field acts like a point source with the origin at the center of the sphere.

Electric Field of a Capacitor

A parallel-plate capacitor is made of two parallel infinite plates of charge.
The points between them are in a **uniform electric field**.
Field inside a capacitor is:

$$\vec{E} = \left(\frac{\eta}{\epsilon_0}, \text{from positive to negative}\right)$$



Problems:

-Use conceptual question 2 to practice using the principle of superposition to calculate the net electric field of multiple point charges. Problems 2, 3, and 29 also practice this skill.
-Try problem 7 to practice infinitely charged wires and finding electric field strength.
-Problems 21, 22, 23 help apply electric field to motion of charged particles. These might be the most helpful problems because you have to apply previous knowledge of kinematics to determine motion after you figure out force due to electric field.
-Try problem 50. It also applies electric field to determine motion, but it gives you practice with field inside capacitors instead of point or line sources.

Good Luck!!! Make Sure You Study!!

Chapter 27 Review: Gauss's Law and Electric Flux

Courtesy of: Jack Riordan and JJ Starrett

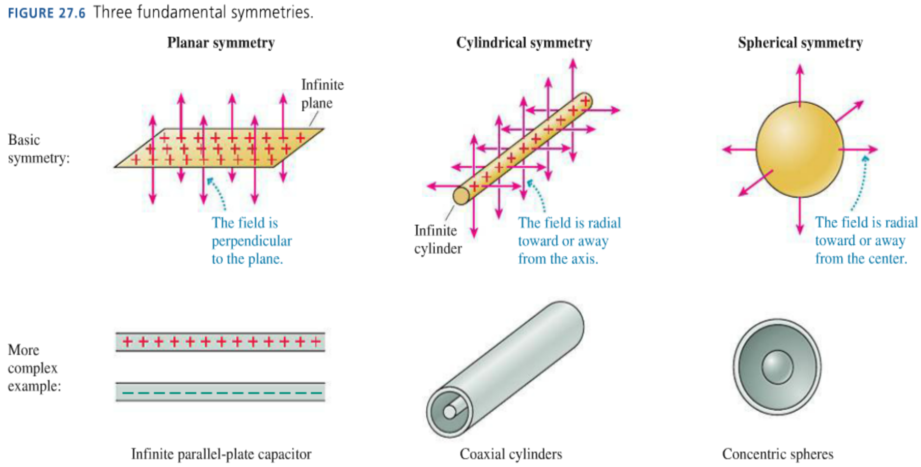
Key Concepts:

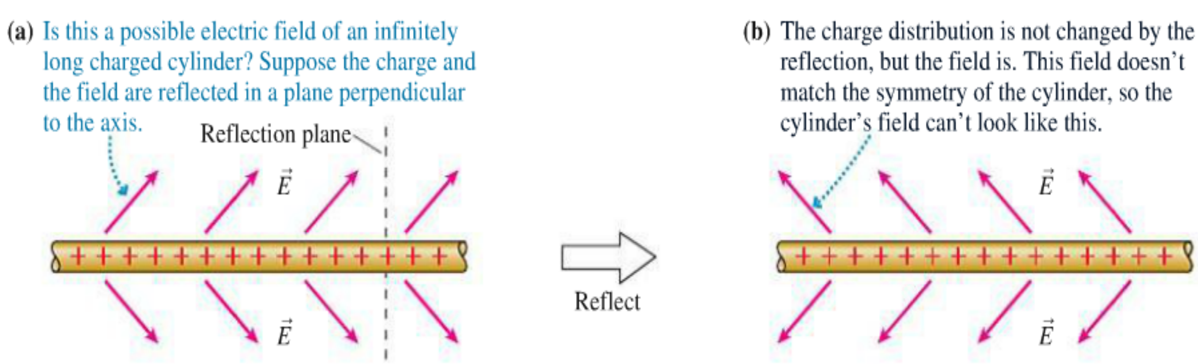
Gauss's Law: -The electric flux through a closed surface is proportional to charge "Q' enclosed within the surface (Formula: Q/ε_0)

Symmetry: -An object is symmetric if it can be translated, rotated, and reflected without visually changing the charge distribution

-The electric field must match the charge distribution when this happens

FIGURE 27.6 Three fundamental symmetries.

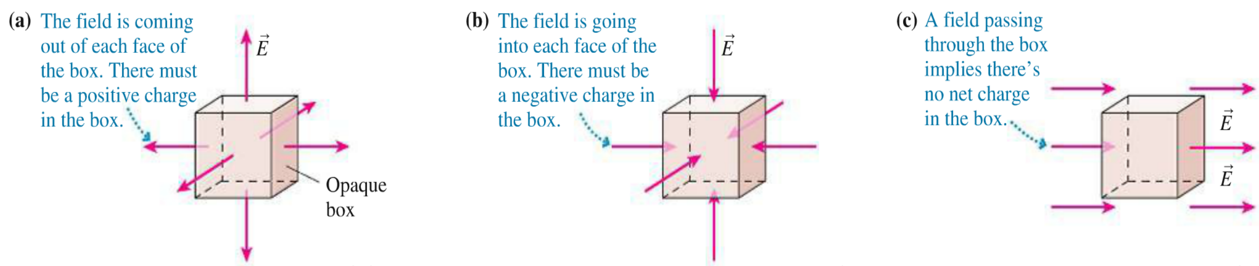




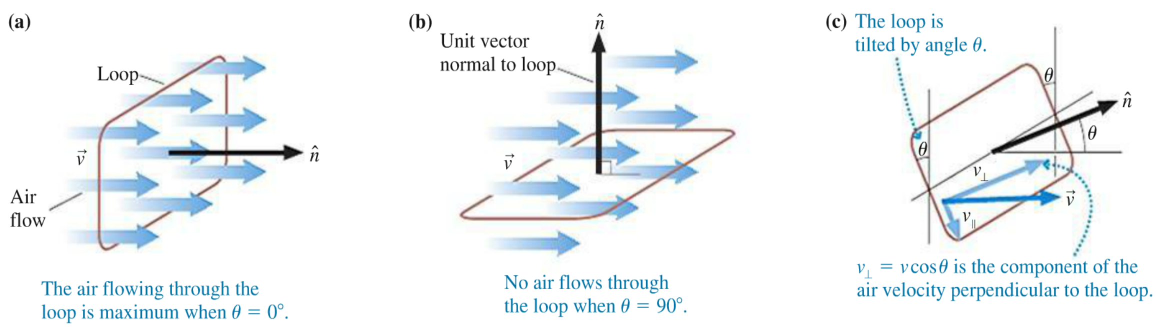
Gaussian Surface: -A closed, imaginary surface around charge "Q"

Electric Flux: -The amount of electric field passing through a Gaussian surface

-Flux flowing out of a Gaussian surface is positive, while flux flowing in is Negative. Equal flux going both ways indicates a flux of zero



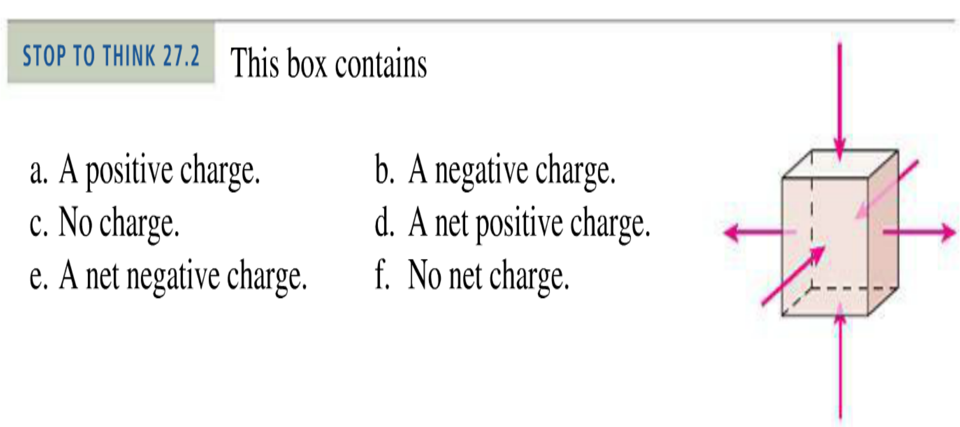
-The maximum amount of flux is obtained when the electric field is perpendicular to the Gaussian Surface (Formula: EAcosθ)



Electrostatic Equilibrium: -The electric field within a charged conductor is zero at all points within the conductor as the charges reside on the outside of the conductor (flux is zero inside)-The electric field is perpendicular to the conductor at all points on the exterior of the conductor (Formula: $\eta A / \varepsilon_0$)

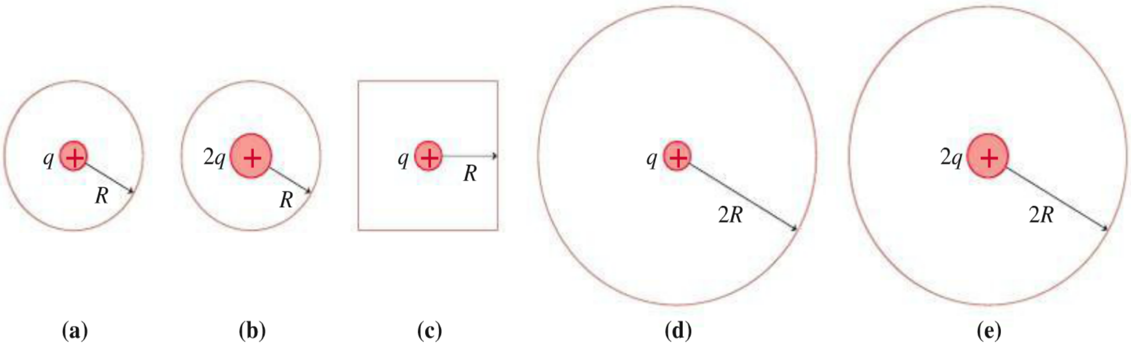
Questions:

Question 27.2: This question covers the basics of flux and helps to introduce the idea of net flux.



Question 27.4: Flux depends on relatively few variables. This question should test your knowledge of these variables.

STOP TO THINK 27.4 These are two-dimensional cross sections through three-dimensional closed spheres and a cube. Rank in order, from largest to smallest, the electric fluxes Φ_a to Φ_e through surfaces a to e.



Question 16: This question brings to light the idea that flux depends on the location and shape of the Gaussian surface it is contained in.

16. | What is the net electric flux through the two cylinders shown in FIGURE EX27.16? Give your answer in terms of R and E.

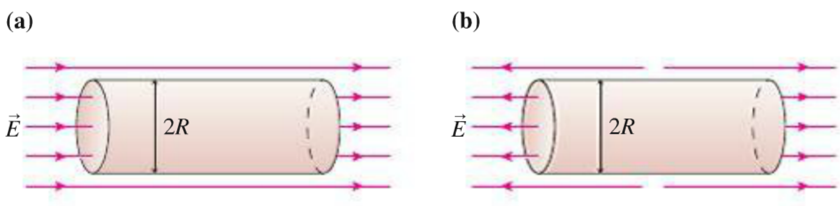


FIGURE EX27.16

Question 28: The question here draws upon the idea of electrostatic equilibrium to answer an unorthodox flux problem.

28. || FIGURE EX27.28 shows a hollow cavity within a neutral conductor. A point charge Q is inside the cavity. What is the net electric flux through the closed surface that surrounds the conductor?

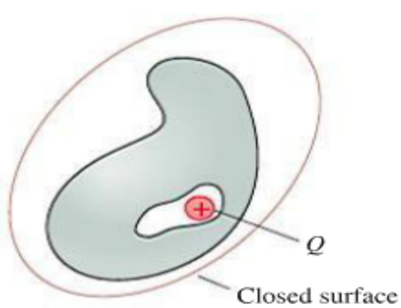


FIGURE EX27.28

CHAPTER 28 PHYSICS CHAPTER REVIEW Rebecca Arp & Jacob Wilmer

(Bolded problems represent challenge problems)

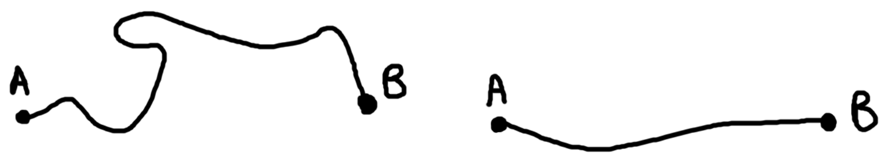
28.1)

Electrical Potential Energy

Mechanical Energy = Kinetic Energy + Electric Potential Energy

$E_{mech} = \Delta K + \Delta U$

-Electric force is a *conservative force*, meaning that work done as a particle moves from point A to point B is not changed by the path taken. Both paths below have the same amount of work.



Relevant Problems: #1, 4 conceptuals

Uniform Fields

-Electric field works similarly to gravity. Charges "fall" in the parallel plate capacitor because of the electric field. As a positive charge falls toward the negatively charged plate, it speeds up, gains kinetic energy, and loses potential energy.

$\Delta U_{elec} = qEs$, where "s" is distance from negative plate.

Relevant Problems: #1, 3

28.2)

The Potential Energy of Point Charges

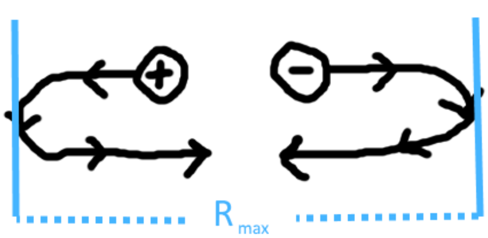
$$\Delta U_{elec} = \frac{Kq_1q_2}{r}$$

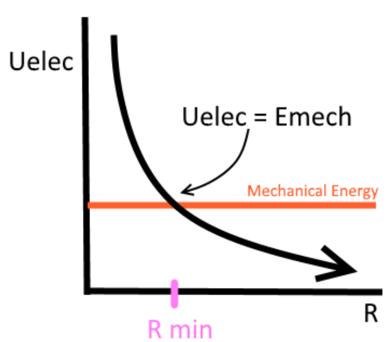
-Potential energy for like charges is positive, potential energy for opposite charges is negative.

-Charged spheres act like point sources in these situations, where r would be the distance between their centers.

-Two oppositely charged particles shot away from each other CAN escape, but only if $E_{mech} > 0$

-The initial speed that gives $E_{mech} = 0$ is called the escape speed.





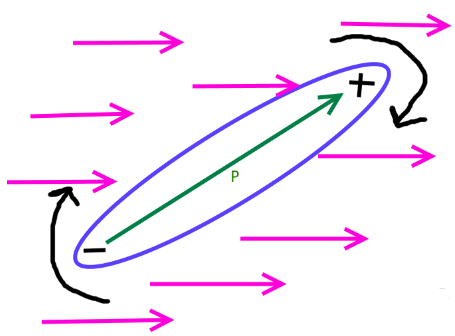
-If more than two charges are present, the potential energy is the *sum* of the potential energies at all of the points.

Relevant Problems: problems #6, 7, 26, 31, 35, **74**

28.3)

The Potential Energy of a Dipole

-Electric field exerts a torque on a dipole, shown below.



P=qs , where P is the dipole moment.

U_{dipole}=-pEcosθ

Relevant Problems: #8, **48**

28.4) Electric Potential

$V = U_{q+sources} / q$

-Electric Potential is a property of the source charges. A positive charge slows down as it moves into a region of higher electric potential.

Potential Difference

$\Delta V = V_f - V_i$

-Potential difference between two points is called the voltage.

-Source Charges alter the space around them by creating an electric potential.

-If a particle moves through a potential difference, its electric potential energy changes by U = qΔV

Electric Potential

	Increasing (ΔV>0)	Decreasing (ΔV<0)
Positive Charge	Slows Down	Speeds Up
Negative Charge	Speeds Up	Slows Down

Relevant Problems: #11, 13, 15

28.5)

Electric Potential Inside a Parallel Plate Capacitor

-Electric Potential inside a parallel plate capacitor: V = E * s ,Where "s" is the distance from the negative electrode.

-Electric potential exists at all points inside the capacitor. Electric potential is created by the source charges on the capacitor plates.

-Electric field vectors are perpendicular to the equipotential surface

-The Electric field points in the direction of decreasing potential.

Relevant Problems: # 17, 19, **78**

28.6)

Electric Potential of a Point Charge

V = K * q / r

-Potential is scalar whereas field is a vector

-Potential outside a sphere:

$V = R/r * V_0$

Relevant Problems: 21, 23, 49

28.7)

Electric Potential of Many charges

$$V = \sum 1/4\pi\varepsilon_0 * q_i / r_i$$

-Electric potential, like electric field, obeys the principle of superposition.

-Add the potentials of many charges to get the total potential.

Relevant Problems: 6, 37,63

Chapter 29: Potential and Field (by Zach Beretich and Lindsay Koenig)

Electric Potential: Potential energy provided by an electric field per unit charge - this can also be thought of as Potential Energy over Charge Q.

- Electric potential is also voltage (measured in volts or Joules per coulomb)
- Electric potential is a scalar quantity

Equipotential Surfaces: Surfaces that maintain a constant scalar potential

- Equipotential surfaces are illustrated with equipotential lines, in which the potential across the lines are all equal (also can be thought of as equal altitude across each line)
- Electric Field is perpendicular to an equipotential surface and points downhill in the direction of decreasing potential

Kirchhoff's Loop Law: While moving across a loop or closed path, the sum of all potential differences will always be zero.

Capacitance: the storing of an electric charge (measured in Farads or Coulombs per Volt)

- A capacitor has two plates that are charged by a battery
- A voltage is created across the plates, but charges are unable to cross the plates or else the capacitor will become discharged
- Measuring equivalent capacitance will differ depending on whether it is hooked up in series or parallel with others (see Formulas)
- A dielectric may be added to a circuit to insulate the electric field in order to stop charge from moving through

*The energy stored in a capacitor can also be found using a formula similar to the electric potential energy formula

Extras:

- When in electrostatic equilibrium, the potential inside a conductor is the same
- A material's maximum sustainable electric field is called its dielectric strength

Important Formulas

Electric Potential: $V \equiv \frac{U_{q + sources}}{q}$

Electric Field: $E_s = \frac{dV}{ds}$

Kirchhoff's Loop Law: $V_{loop} = \Sigma (\Delta V)_i = 0$

Capacitance: $C = \frac{Q}{\Delta V_c}$

Parallel-Plate Capacitor: $C = \frac{\varepsilon_0 A}{d}$

Parallel Capacitor: $C_{eq} = C_1 + C_2 + C_3 + \ldots$

Series Capacitor: $C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\right)^{-1}$

Electric Field inside capacitor: $\Delta V = Ed$

Energy stored in a capacitor: $u_c = \frac{1}{2} C(\Delta V_c)^2$

AP Multiple Choice Practice

For examples 1, 2 and 3
http://www.learnapphysics.com/apphysicsc/capacitance.php
Problems to revisit in Ch. 29!
16, 35, 55, and 59

Practice FRQ

https://secure-media.collegeboard.org/digitalServices/pdf/ap/ap15_frq_physics_c-e-m.pdf

Parts B-D all apply to Chapter 29

Answers to Parts B-D:

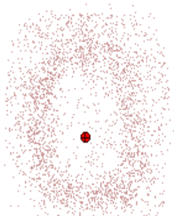
https://secure-media.collegeboard.org/secure/ap/pdf/physics-c-electricity-magnetism/ap15_physics_cem_sg.pdf?__gda__=1460817927_535c43317c9bd1f2ed779e000c2186d6

Chapter 30 Current and Resistance (Liza Addai)

The goal of Chapter 30 is to learn how charge moves through a conductor as current.

30.1 The Electron Current

- Current, by definition, is the motion of charges.
- Charges that move in a conductor are charge carriers.
- Electrons are the charge carriers in metals.
- The electric field E causes the sea of electrons to move in one direction. Add sea of elec. pic



- **Drift speed v_d,** the net motion of the electron speed, is usually small.
- The electron current ie is the number of electrons per second that pass through a cross section of a wire or other conductor
- Increased drift speed v= increased electron current $N_e = i_e \Delta t$
- Figure 30.3, Chapter 30.1
- Electron current is related to drift speed by the equation $i_e = n_e A v_d$

30.2 Creating a Current

- An electron current is sustained by pushing on the sea of electrons with an electric field.
- An electron current is a non equilibrium motion of charges sustained by an internal electric field. How is an electric field created in a wire?
- In Figure 30.8a, there is no current in the wire. There is also a uniform surface charge density which means no electric field. Figure30.8ab. Once the wires are connected the excess electron on the negative wire move to the positive one. This rearranges the surface charge into a nonuniform distribution which causes the internal electric field inside the wire.
- As always, the electric field goes from the positive end of the wire to the negative end.
- An electron travelling through a metal with no electric field has frequent collisions with the ions of the metal but no net displacement. With an electric field the electron slowly travels in the direction opposite the electric field. The electron speeds up in between collisions, but each collision slows it down, transferring most of its kinetic energy to the ion. The energy transfer acts as the friction that raises the temperature of the wire. **The magnitude of the electron's average velocity is the drift speed of the electron.**
- The average speed of an electron pushed by an electric field is $v_d = (et/m)E$

30.3 Current and Current Density

- Current I in a wire is the rate of charge flow: $I = dQ/dt$ which can be rearranged to find the amount of charge delivered by the current during a time interval $Q = I\Delta t$
- Current in a wire can be defined as $I = ei_e$ or $I = en_e v_d A$
- Current density J=I/A (units A/m^2)
- **Law of Conservation of Current:** The current is the same at all points in a current-carrying wire. The rate of electrons leaving a light bulb is the same as the rate of electrons entering the light bulb.
- **Kirchhoff's junction law:** The sum of currents into a junction is the same as the sum entering a junction. $\sum I_{in} = \sum I_{out}$ fig. 30.16

30.4 Conductivity and Resistivity

- **Conductivity** can be thought of as the absence of resistivity
- Conductivity characterizes a material as a whole. Different materials have different conductivities. Table 30.2
- The **resistivity** of a material tells us how reluctantly the electrons move in response to the electric field. p(resistivity)=$1/\sigma=m/n_e e^2 t$

30.5 Resistance and Ohm's Law

- The current is proportional to the potential difference between the ends of a conductor.
- The resistance of a conductor depends on the length, diameter, and the resistivity of the material the conductor is made from.$R = pL/A$ Unit Ω(ohm).
- Establishing a potential difference between the ends of a conductor with a certain resistance indirectly creates a current through the conductor by creating an electric field.
- **Ohm's Law:**$I = \Delta V/R$
- Batteries are a source of potential difference. Figure 30.19

Problems to work out

- #2- Finding drift speed. It's pretty simple, but there are a few calculations and mental leaps.
- #10- this is purely equation plugging.
- #22- This problem has you finding the material of a wire. Hint: it involves resistivity.
- #23- the properties of silver are a key element in solving this problem.
- #34- Many variables are given in the problem, but this is really just a long-winded way to find current.

Others

- #49- This problem seems complicated on the first read, but the given variables are you everything you need to solve it. It can be solved in less than four steps.

Ch. 31: (Circuits) by Olivia Boezio and Tommy Kolibash

Key Ideas

- Current in series resistors is the same through each, whereas the voltage across series resistors adds to the total voltage.
- The voltage across parallel resistors is the same across each, whereas the current through parallel resistors adds to the totally current.
- The brightness of a light bulb depends on the power dissipated by the bulb.
- A capacitor blocks current once it has been connected for a while.
- Need to know that the time constant of an RC circuit is RC.

Formulas

Formulas

Ohm's Law: $I = \frac{\Delta V}{R}$

Current: $I = \frac{dQ}{dt}$

Resistance of wire in terms of its properties: $R = p\frac{L}{A}$

Power in a circuit: $P = IV$

Time constant for RC circuit: $\tau = RC$

Kirchhoff's Junction Law: $\Sigma I_{in} = \Sigma I_{out}$

Kirchhoff's Loop Law: $\Delta V_{loop} = \Sigma(\Delta V)_i = 0$

Key:
V=Voltage
R=Resistance
Q=Charge
t=Time
p=Resistivity of material
L=Length
A= Cross-

Current: The flow of electric charge. In a circuit, the current is the amount of charge passing a given point per unit time.

$$I = \frac{\Delta V}{R}$$

Current, *I,* is the amount of charge flowing past a certain point divided by the time interval during which you're measuring. Current is measured in coulombs/second. i.e. 1 C/s = 1 Ampere or 1 A.

Resistance: A property of a circuit that resists the flow of current.

Three physical properties of the wire affects its resistance

- The material the wire is made out of: The **resistivity**,p, of a material is an intrinsic property of that material. Good conducting materials, like gold, have low resistivities.
- The length of the wire, L: the longer the wire, the more resistance it has.
- The cross-sectional area A of the wire: the wider the wire, the less resistance it has.

These three properties come together to form the equation: $R = p\frac{L}{A}$

This equation is useful for when you need to calculate the resistance of a wire from scratch; however, you can also find resistance by rearranging Ohm's Law.

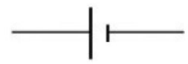
Resistor: Something you put in a circuit to change the circuit's resistance.

The way that a resistor(s) affects the current in a circuit is described by Ohm's law:

Ohm's law: $V = IR$

Resistors in Series and in Parallel

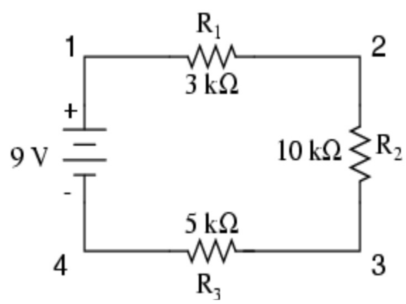
Common symbols of circuits

Component	Circuit Diagram Symbol
Wire	
Resistor	
Light bulb	
Cell	
Battery	
Switch	

Series Resistors

To find the equivalent resistance of series resistors, you just add up all the individual resistor values.

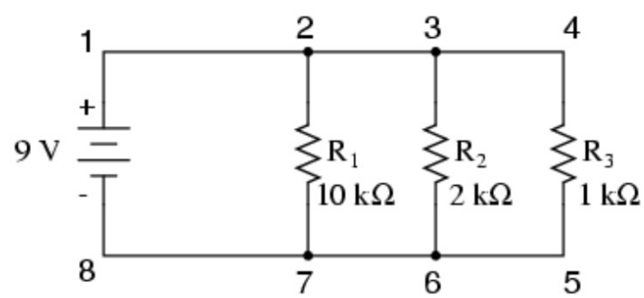
$R_{eq} = R_1 + R_2 + R_3\ldots$



Parallel Resistors

Parallel resistors are connected in such a way that you create several paths through which current can flow. In Parallel, the current must split, then immediately come back together.

$$\frac{1}{Req} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}\cdots$$



*Note that any equivalent resistance of parallel resistors is *less than* any individual resistor in the parallel combination.

Important Rules:

1. When two resistors are connected in SERIES, the amount of current that flows through one resistor equals the amount of current that flows through the other resistor.
2. When two resistors are connected in PARALLEL, the voltage across one resistor is the same as the voltage across the other resistor.

*For additional help on solving circuits see pages 200-202 in **5 steps to a 5 AP Physics C** book.

Kirchoff's Laws:

Junction Law: At any junction, the current entering equals the current leaving. Charge in a circuit is conserved: you do not lose any current when the wire bends or branches.

Loop Law: The sum of the potential differences around any loop or closed path is zero.

Steps for using Kirchoff's loop rule:
- Choose a direction of current and draw arrows on your circuit to indicate the direction.
- Follow the loop in the direction you chose. When you cross a resistor, the voltage is $-IR$, where R is the resistance and I is the current. This is an application of Ohm's Law.
- When you cross a battery, if you trace from the - to the + add the voltage of the battery, if + to the - then subtract the battery's voltage.
- Set the sum of your voltages equal to zero. Solve. If the current calculated is negative then the direction you chose was wrong, the current flows in the direction opposite to your arrows.

Ammeters: Measure current and must be hooked up in SERIES with a circuit.
Voltmeters: Measure voltage and must be hooked up in PARALLEL with the circuit.

*For more detail, step by step problems, and MC practice problems, visit Ch. 19 (pg. 195-215)

Chapter 32: The Magnetic Field (Adam Huffman, Wade Stoddard)

Key Points:

- A moving charge creates a magnetic field around it.
- Magnetic field lines INSIDE of a magnet point south pole to the north pole. OUTSIDE the magnet the field lines point from north to south.
- HAND RULES(curvy and flat) they are used to find the direction of force when a magnet moves inside of a magnetic field. **Curvy-** use right hand for positive charges and left hand for negative. Point the tip of pencil in direction of permanent magnetic field and the way in which your fingers are facing will tell you the direction of the temporary magnetic field. **Flat-** use your fingers as the direction of the permanent magnetic field. Then use your thumb as the direction of the charge. (right hand is still for positive charges and left hand for negative). The direction of your palm will tell you the direction of force. **NOTE:** if you cannot physically use the hand rules and it is impossible to "act out" the scenario that means there is no force.
- Tesla is unit of magnetic field strength.
- Magnetic field is perpendicular to the charge's motion and the external magnetic field.

Key Formulas and applications for them:

- **Biot Savart Formula-** $Bwire = \mu o I/2\pi d$

This formula is applied if you know the current of a loop you can also determine the magnetic field of the loop. $\mu_0 = 4\pi * 10^{-7}$

- **Magnetic Force-** $Fb=qVBsin\theta$

This is used to determine the force of the magnetic field, it can also be rearranged algebraically to find many variables in a given problem. This can also be used as a way to find the force on a charge using cross-product $qV \times B$ and the hand rule to determine the direction of the force.

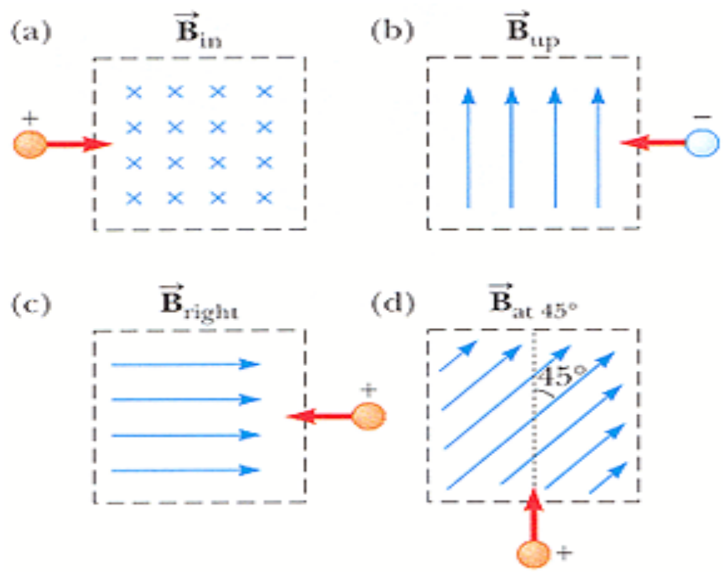
- **Ampere's Law-** $\oint B(dl) = \mu o(I)$

This law has to do with magnetic flux is separate from the distance from current. This is how electric flux worked in a previous chapter. Magnetic flux however is dependent on the charge that is enclosed. This is similar to the formula above because it can determine B based on moving charges or current, however, it is less specific.

- **Solenoid Field Strength-** $Bsolenoid=\mu o(n)I$

Solenoid field strength is dependent on the amount of turns of wire there are which is the variable *n* in relation to the current and length of that wire. The magnetic field in a solenoid is resultant of all the coils in the center.

Hand Rule Examples/Review:



For these examples, you will use the flat hand rule:

a) The charge is positive so right hand will be used. The permanent magnetic field is into the page so your fingers will point away from you, and the charge is moving right so your thumb is to the right. If done right, your palm is facing upwards meaning the force is up.

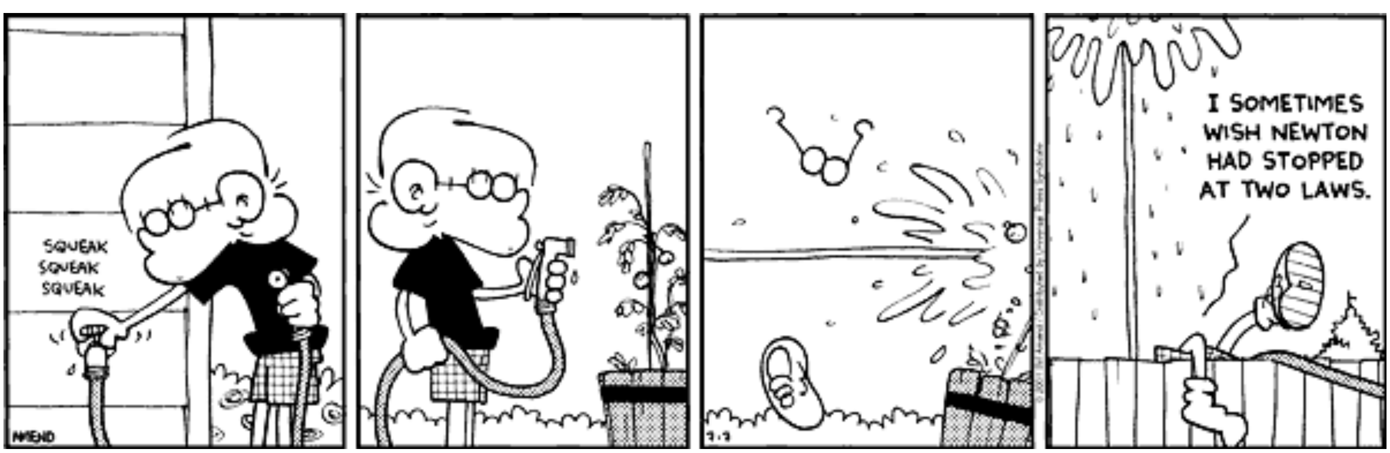
b) Negative charge so left hand. Fingers pointed up with the magnetic field, and thumb to the left with the charge. This makes your palm face you, showing the force is towards you (out of the page).

-Next two can be used as practice.
For the magnetic field in loops and wires, the curvy hand rule is used instead.

Important Problem to Rework:

-Biot Savart example from the book #50
The magnetic field strength at the north pole of a 2 cm diameter, 8 cm long Alnico magnet is .10 Tesla. To produce the same field with a solenoid of the same size carrying a current of 2 Amps, how many turns of wire would you need? Is this feasible?

This problem is important because it uses the Biot Savart Law and mentions solenoids. You use this law to determine the amount of turns the coils needs.
First set it up with this formula; $B_s = \mu_o (n) I / l$
Then plug in the variables it gives you $0.10T = 4\pi * 10^{-7}$ (number of turns) / .08 meters
= 3180 turns which is feasible with a wire with a small diameter and high current.

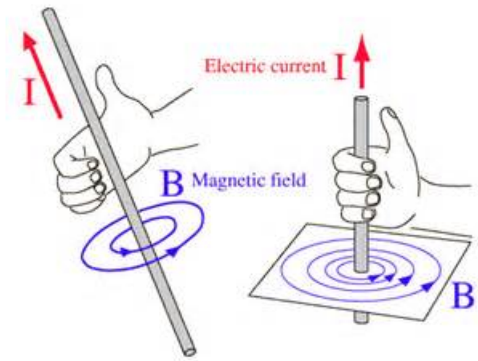


Chapter 33: Electromagnetic Induction by Derrick Reedus (DJ), Cris Fair

Electromagnetic Induction is the process of using magnetic fields to produce voltage, and in complete circuits, a current.

All magnets are dipoles, which means that they have two poles. Magnets go from the North pole to the South pole. When you cut a magnet in two you don't separate poles, but instead you create two magnets.

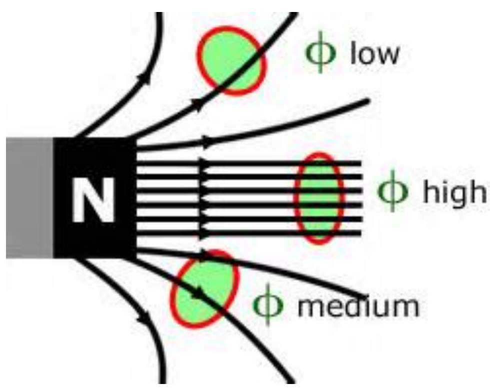
RIght hand rule: To find the direction of the magnetic field. Put a pencil in your right hand. Point your thumb in the direction of the current. Wrap your fingers around the pencil. The tips of your curled fingers indicate the magnetic field going into the page, shown by a X. And the knuckles show the magnetic field going out of the page, shown by a dot.



The flat hand rule has your thumb the direction the particle is moving, the other four fingers is the magnetic field direction, and the palm of your hand indicates the force of the field.

Flux is a term that is generally associated with a field bound by a certain area. Magnetic Flux is any area that has a magnetic field passing through it.

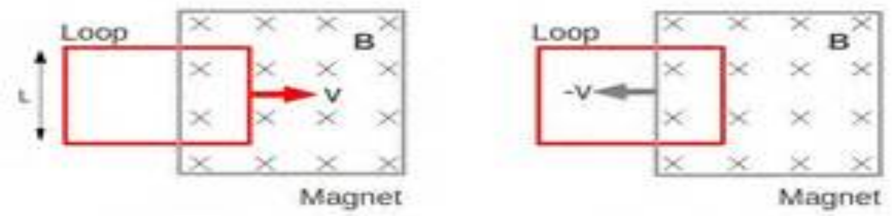
- $\Phi B = B \cdot A$ Unit: Tm2 or Weber(Wb)



How can we change flux?

- Magnetic field through the loop changes
- Increase or decrease the area
- Rotate the wire along an axis perpendicular to the field which will change the angle between the area and magnetic field vectors

An EMF (source of electrical potential) is created by a changing magnetic field is known as an induced EMF. Induced EMF's generate currents. Charge carriers inside the wire experience a magnetic force. This force causes them to move, separating the positive and the negative charges which causes those to create an electric field. They will continue to separate until the electric and magnetic g=force are in equilibrium.



(a) Loop is moving (b) Magnet is moving

- Magnetic Force: F = q(v x B)

Lenz's Law- There is an induced current in a closed, conducting loop if and only if the magnetic flux through the loop is changing. The induced magnetic field opposes the change in the flux.
Faraday's Law - Any change in the magnetic flux of a wire will cause an emf to be induced in the wire. The change could be produced by changing the magnetic field strength, moving the wire into or out of the magnetic field, or rotating the wire relative to the magnetic field.

,

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

- An induced electric field is present whether there's a conducting loop or not

An electric field created by charges, positive or negative, is called a Coulomb electric field. An induced electric field caused by a changing magnetic field and not by charges is called a non-Coulomb electric field.

Maxwell's Theory of Electromagnetic Waves proposed that a changing electric field creates an induced magnetic field, a new kind of magnetic field not tied to the existence of currents. He was able to predict that electric and magnetic fields would be able to sustain themselves, free from charges and currents, if they took the form of an electromagnetic wave.

Three Applications of Induced Currents

Generators- A device that transforms mechanical energy into the electrical energy. A coil of wire rotates in a magnetic field. Both the field and area of the loop are constant, but the magnetic flux through the loop changes continuously as the loop rotates. The induced current is then removed from the rotating loop by brushes that press up against rotating slip rings.

Transformers- Two wrapped coils on an iron core. The left is the primary coil that has the magnetic field to follow the iron core to the right coil. The left is the secondary coil, the alternating current through the primary causes an oscillating magnetic flux through the secondary to make an induced emf.

Metal Detectors- Consists of 2 coils: a transmitter coil and a receiver coil. A high frequency alternating current in the transmitter coil generates an alternating magnetic field along the axis. The magnetic field creates a changing flux through the receiver coil and causes an alternating induced coil.

Inductor- A coil of wire used in a circuit for the purpose of providing inductance. An ideal inductor is one for which the wire forming the coil has no electric resistance. The SI unit for inductance is henry.

LC Circuits- radios, televisions, and cell phones all are based on electromagnetic signals that oscillate at a well defined frequency. These oscillations are generated and detected by a simple circuit consisting of an inductor and a capacitor in parallel known as a LC Circuit.

LR Circuit- A circuit consisting of an inductor, a resistor, and perhaps a battery is called an LR Circuit.

Other Important Formulas

-Force on a current-carrying wire: F = I x B x L

-Induced emf for rectangular wire: $\mathcal{E}$ = BLv

-Magnetic field due to straight current wire: $B = \frac{\mu_0 I}{2\pi r}$

Problems to re-work:

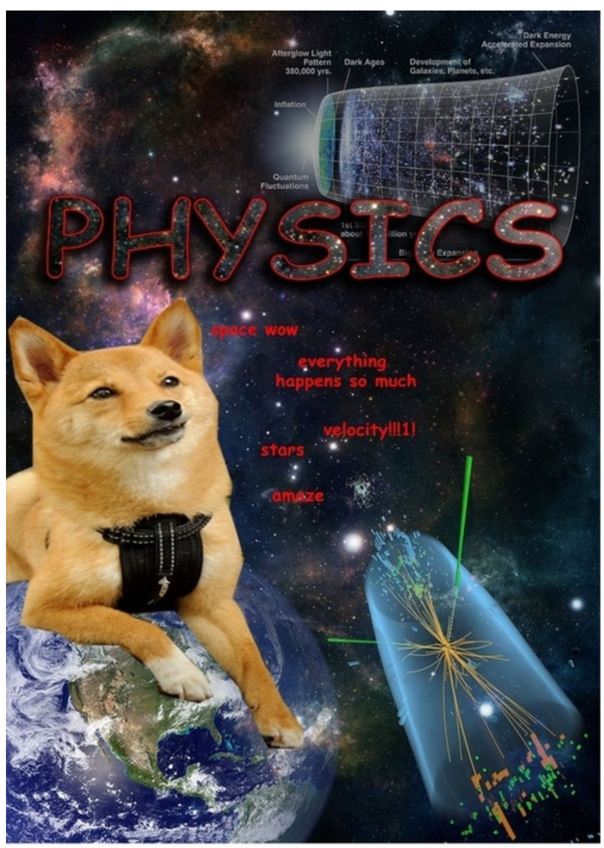
Conceptual (Packet):

Question 1: Because it'll help with the right hand rule so people can get it if they're not comfortable with it, and to help with the different ways the current can flow.

Question 24 and 25: For LR circuits to see what it's like with the graph and how the inductor can cause to the circuits current at the beginning.

Book:

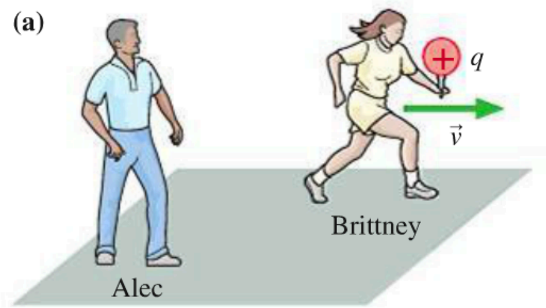
Example 33.4 (page 970) and question 4 (page 996): For magnetic field help one with an angle just in case it pops up and just a refresher to get people to have a better understanding.



Ch. 34 Review by Alan Waterhouse (Sections 1-4)

34.1 Reference Frames

FIGURE 34.1 Brittney carries a charge past Alec.



Charge q moves with velocity $\vec{v}$ relative to Alec.

-Think like Inertial reference frames.

-Brittney only sees an electric field.

-Alec sees an electric and magnetic field.

-Magnetic fields depend on the point of view.
If there is no velocity relative to the viewer, there is no magnetic field.

34.2-34.4 Background and study of Maxwell's equations

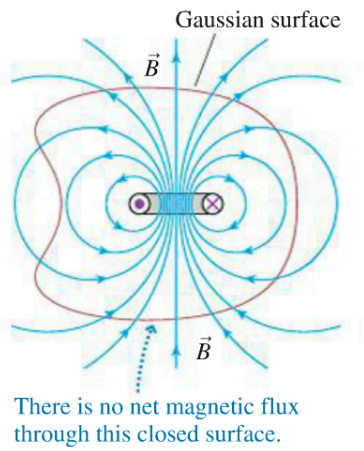
Maxwell's equations are a compilation of 4 different equations:

$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{in}}{\epsilon_0}$	Gauss's law
$\oint \vec{B} \cdot d\vec{A} = 0$	Gauss's law for magnetism
$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_m}{dt}$	Faraday's law
$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{through} + \epsilon_0 \mu_0 \frac{d\Phi_e}{dt}$	Ampère-Maxwell law

1) Gauss's law is used to measure the electric flux of a charge. Some rules for Gauss's law:
- -Qin, is the charge enclosed. Charge outside of the Gaussian surface gives 0 flux.
- -The Gaussian surface can be any shape, it is only dependent on the charge.
- -Negative charges just cause a negative flux. Qin is not an absolute value (||)

2) Gauss's law for magnetism is used to measure the magnetic flux of an enclosed magnetic dipole.

FIGURE 34.13 There is no net flux through a Gaussian surface around a magnetic dipole.



-This is a unique situation because no matter what, the magnetic flux is always 0.

-The positive and negative ends of the dipole cancel each other out.

-This is also independent of the shape of the Gaussian surface.

3) Faraday's law is used to measure the voltage created by emf by the change of magnetic flux.

-This can help us to find the induced current by a change in flux.

4) Ampère-Maxwell's law helps us find the summation of forces on a charged particle caused by both an electric and a magnetic field.

-You can write it three ways:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0(I_{\text{through}} + I_{\text{disp}}) = \mu_0\left(I_{\text{through}} + \epsilon_0 \frac{d\Phi_e}{dt}\right)$$

1) The first uses a line integral that we really don't have to deal with.
2) The second uses two forms of current with the vacuum permeability constant distributed throughout.
3) The third puts the second into more complicated, but useful terms by describing what I_{disp} is.

Review Problems:

For Gauss's law: Ch. 27 Conceptual problem #6

Because it helps show what's truly affecting magnetic flux.

For Faraday's law: Ch. 33 Problems #13, 31

Because it uses Faraday's law and shows more practical applications like finding current or finding the measured emf in a solenoid.

For Ampère-Maxwell's law: Ch. 32 #21

I couldn't really find any problems from Ch. 34, but there are some covering Ampère's law in a previous chapter.