1-a

Constant Speed Vs. Average Speed

Similarities: $v_{avg} = \frac{\Delta x}{\Delta t}$ when speed is constant then the $v_{avg} = v_{constant}$

Difference: "v" does not need to be constant for v_{avg} to be calculated. (Even "a" doesn't need to be known.) Any change in distance divided by the time it took to travel gives v_{avg}.

1-b

Newton's 1st Law (the law of inertia)

Objects traveling with constant velocity (speed and direction) (or 0 velocity) have no net force on them.

No net force also means a = 0.

No net force does **not** mean no force. Only that the vertical forces add to zero and the horizontal forces also cancel out.

So, if v is constant and there is a 5N push, there must be a 5N pull, too.

1-c

Newton's 2nd Law (the law of force and motion)

This law says that acceleration is caused by force and nothing else. (Note: There is no relationship between velocity on force.)

F_{net}=ma requires that you add up the forces acting on an object. Do **not** add the forces the object creates.

$F_{AonB} + F_{ConB} + F_{DonB} + \ldots = ma$

1-d

Newton's 3rd Law (the law of action-reaction pairs)

When two objects pull on each other, their forces are equal and opposite. Ie. Earth's gravity pulls down on you just as much as your gravity pulls up on the Earth.

$F_{A\ on\ B} = -F_{B\ on\ A}$ is always true, but if object A is much less massive than B, it will move a lot more because of the force. Also, other large forces pushing on A may overpower $F_{B\ on\ A}$.

1-e

Gravity

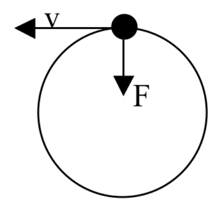
$F_G = -G\frac{m_1 m_2}{r_{12}^2}$ is always true. If you use Earth's mass and radius for m_1 and r_{12}, you get F_G = -mg.

Gravity is a very weak force, so you only notice it when you are close to an extremely massive object like a planet.

Don't forget r is squared, so halving the radius quadruples the F_G.

1-f,g

Circular Motion



Both force and acceleration point towards the center.

Velocity points tangent and is changing though speed is constant.

A perpendicular force will only change direction, not speed, and will create circular motion.

When the force stops, the object takes off tangent to the circle, not away from the center.

2-a,b

Kinetic Energy And Gravitational Potential Energy

KE=½mv^2 is the energy of motion for single objects. KE's always add together (never subtract). Do not confuse with p=mv, which is not energy and is a vector.

PE_G=mgh is energy that could be transferred from Earth's gravity field into an object's KE, because of a change in height. Only vertical height changes matter.

2-c

Conservation of Mechanical Energy

If there is no air friction (an object is in free fall), then $(KE+PE)_{initial}=(KE+PE)_{final}$.

If, an object starts at rest and falls to the ground, $KE_{initial}$ and PE_{final} both equal zero leaving $PE_{initial}=KE_{final}$. This special case is NOT always true, though.

2-d,g Momentum And Collisions	$p=mv$ is a vector, so opposite directions subtract (unlike energy) $p_{initial}=p_{final}$ for all CST Physics collisions. So, add(/subtract) the initial mv's and set that equal to the final mv's. Do <u>not</u> use $(m_1+m_2)v$ for p_{final} unless objects have the same v. If 2 objects starting together break apart, $p_{initial}=0$ & the separating mv's must be equal but opposite.
2-e,f Conservation of Momentum vs. Conservation of Energy Elastic and Inelastic Collisions	Elastic collisions are perfectly bouncy with no energy loss (i.e. atom collisions or very good bouncy balls). Both KE and p are conserved. Inelastic collisions are sticky. Energy is lost to heat, sound, light, smashing of the object, etc. p and total energy are conserved, **<u>not</u>** KE. p only changes if there is an F_{net} pushing the object.
3-a Heat Flow Vs Work	Heat & work are energy forms. Work may add KE to an object and friction may remove KE from the object, so work is converted to heat. Heat is the energy in the random velocities of billions of atoms. Work is energy from an organized motion. If you can measure a change in size or position, work was done. Heat energy involves temperature change.
3-b Heat Engines	Energy conservation requires that the energy input to an engine is equal to the energy output from an engine. (This is not true as the engine heats up or cools done, but is true while the engine temperature is constant.) Input comes from a high temperature source. Output is waste heat & work done (& work to reset the engine to the starting position).

3-c Thermal Energy Gas in a Container Total Energy	Thermal energy is the energy from random motion of atoms in an object. It changes with temperature. Inside a container, higher temp means higher pressure, harder collisions between atoms, & faster speeds, <u>but no</u> density or spacing changes. Chemical PE, gravitational PE, KE, etc. (and thermal energy) add into the total energy of an object.
3-d,e Entropy	Entropy measures disorder and always increases with time. A local decrease in entropy must be balanced by a larger increase elsewhere (i.e. cooling a refrigerator requires burning fuel at a power plant). Entropy increases when objects heat up, break apart, or mix with other things. (i.e. ice melting, plate breaking, opening a window to mix air)
4-a Wave Definition	Waves are a traveling oscillation/wiggle of something that carries energy (not mass) from one place to another. Wave frequency is controlled by the source and does not generally change after the wave is created. Wave velocity is controlled by the medium the wave moves through and is not effected by the frequency.
4-b,d Wave: Transverse (guitar string) vs. Longitudinal (sound)	Transverse wave can only happen in solids (ie. rocks, springs, strings). The wiggle is perpendicular to the velocity. Longitudinal waves can go through any medium (solid, liquid, gas, plasma). The wiggle is parallel to the velocity. Sound is longitudinal with a speed determined by the kind of air it is in.

4-c

Wave Equation

Frequency vs. Period

$v = f\lambda$ just check the units and plug in the values.

Frequency (f) is the number of waves per second. Period (T) is the number of seconds per wave. So, a wave that takes 2 seconds to pass has a period of 2 seconds and frequency of ½ a wave per second. $f = 1/T$

Frequency has units of 1/s or Hz, which mean exactly the same thing.

4-f (properties of all waves)

Refraction

Refraction is when a wave gets bent by a change in medium (i.e. light entering water from the air) (i.e. mirages in the desert from unevenly heated air)

Medium changes affect a waves speed and refraction is the result of the speed change.

4-e

Light Waves

A light waves travel at the speed of light, period.

Large f Small λ

Gamma
<u>x-ray</u>
ultra violet
<u>visible</u>
infrared
<u>radio waves</u>

Small f Large λ

4-f (properties of all waves)

Doppler Effect

When a sound emitting object moves towards a listener, the wavelength gets squished smaller for that listener (a higher pitch is heard). As the object moves away the the wave gets spread (a lower pitch is heard).

The Doppler effect doesn't care if the sound source or listener is the one moving. The effect is the same.

4-f (properties of all waves)

Interference (Beats)

When two waves "collided" they pass through each other unharmed. Instead of being destroy, they create an inference pattern in which wave parts that are wiggling in the same direction add together and parts wiggling in opposite directions subtract.

Beats occur when two sound sources with almost equal frequencies interfere to make a slow rise and fall in volume.

4-f (properties of all waves)

Polarization

Polarization can only happen to transverse waves. It occurs when there is more wiggle in one direction than another. (i.e. shaking a rope up and down is vertical polarization, but shaking in rope randomly in all directions is no polarization)

A polarizing lens/surface only allows one kind of wiggle through. So, two polarizers perpendicular to each other will block all waves.

4-f (properties of all waves)

Diffraction

Diffraction happens when a wave spreads out around a corner (i.e. hearing sound through an open window even when you can't see the source.).

There is no change in medium for diffraction.

States of Matter

What makes gas, liquid, and solid different is their atomic bonds, <u>NOT</u> density. Solids have strong, rigid atomic bonds, gasses have no bonds and liquids are in between. A side effect of strong bonds is solids are usually more dense, but this is not a rule (think: ice v. water).

Only rigid bonds can pull sideways on atoms (transverse). Loose bonds require direct collisions to move neighbors (longitudinal).

5-a,b

Ohm's Law

"Conservation" of Voltage

For this course, V = IR is always true. V, I & R must all refer to a single resistor. (Do not use a battery's voltage with a resistor's resistance.)

(Voltage measures the kinetic energy a particle will gain crossing a space per unit of charge. So, it is similar to potential energy.) For any closed circuit, $V_{gain}=V_{loss}$ or $V_{battery}= \Sigma V_{drops} = IR_{eff}$. (<u>ONLY</u> for a one resistor circuit will battery voltage = one resistor's voltage.)

5-i

Plasma

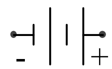
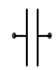
Plasma is a state of matter similar to a gas except electrons and protons of atoms are separated. So, it is ionized and a great conductor.

High temperature (i.e. the sun) can cause atom collision speeds that knock off electrons. Also, high voltage (i.e. fluorescent lights) can pull electrons off atoms – since electrons and protons get tugged in opposite directions by voltage.

5-a,b,d

Circuit Symbols

Transistors

Name	"Purpose"	Symbol
Battery	supply electrical energy over a long period of time	
Resistor	slow down current (makes heat)	
Capacitor	store energy for quick release	
Transistor	amplifies a weak signal (i.e. loud speakers)	

5-e, f

Electric Field (E)
(positive points to negative)
Vs.
Magnetic Field (B)
(North points to South)

Charged particles create electric fields that push on other charged particles at a distance.

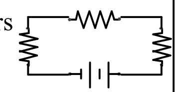
In magnetic materials, electron movement around atoms is organized in the same "direction" creating a magnetic field.

For both E and B, opposites attract (+/-, N/S), likes repel, and neutral is often attracted to both.

5-a,b

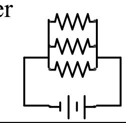
Parallel vs Series Circuits

Series – Only one path with the resistors lined up end to end. (1 path = 1 current everywhere) (more resistors slows current/greater R_{eff})



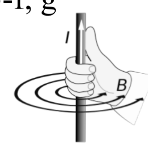
$$R_{eff} = R_1+R_2+R_3$$

Parallel – current splits into two or more paths (branch currents sum to main current) (more branches = faster current flow/less less R_{eff})

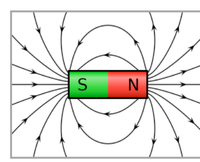


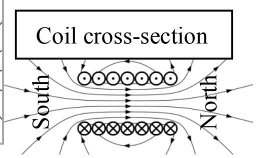
$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

5-f, g



Magnetic Field Direction





A straight wire will make circular magnetic field lines that curve around the wire the same direction as the closed fingers of a fist if your thumb points the direction of the current.

A coil of wire (a.k.a. solenoid) with a current will make oval shaped field lines that go around the walls of the coil. (making the coil behave like a bar magnet)

5-c

Electric Power
(battery production and resistor dissipation)

Power is energy per unit of time or the speed energy is being created/used. Conservation of energy requires that Power production at a battery = Power loss at resistors. ($P_{battery} = \Sigma P_{resistors}$)

While the following equations can be used on any circuit element, typically P=IV is used to find power produced by a battery and $P=I^2R$ is used to find power lost/dissipated by a resistor.

5-h

Magnetic Induction

When a magnetic field changes the change creates an electric field that can push on stationary charged particles.

When the number of field lines going through a circuit loop changes (a.k.a. the magnetic field gets stronger/weaker), then a current is created in the loop. This is induction.

The direction of the current will always create field lines that cancel the change in the external magnetic field.