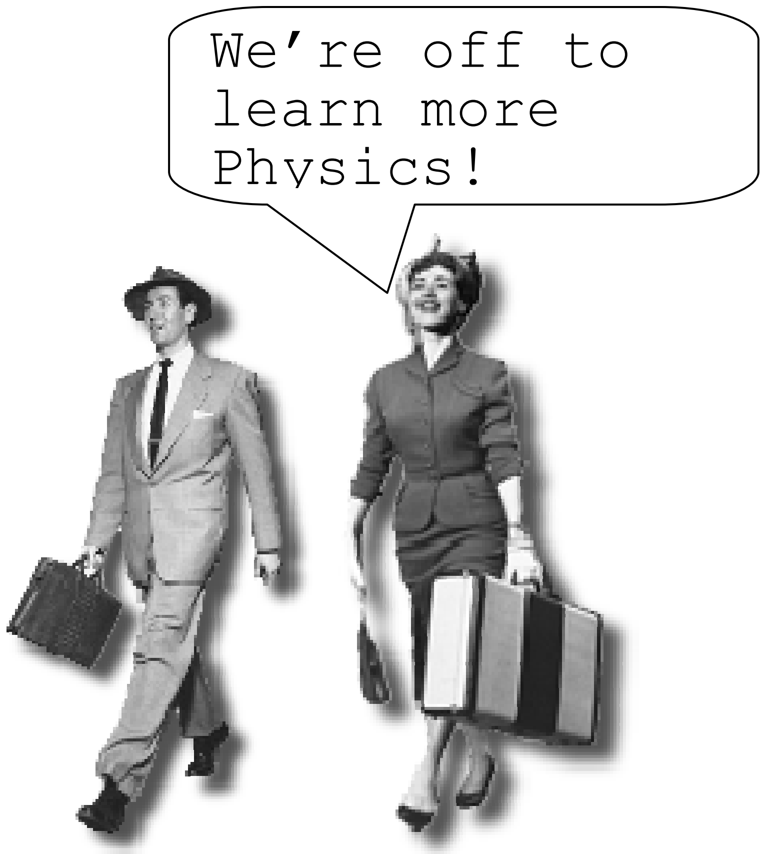
PHYSICS II LABS

PHY 202/222



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Lab Report Guidelines

A good lab report should convey information quickly, accurately and neatly. People who read your reports (including me) will want to know first what you were trying to do and what you found. If they want to know more they will read the rest of your report. For that reason, all lab reports for this class should be written in sections and follow the same basic outline.

- **Objective – 2 points** – a brief statement that describes the purpose of the lab.
- **Conclusion – 4 points** – a statement of the findings of the lab, answering the objective, with a discussion comparing your results with the expected results (were there errors or equipment faults or what could have been done differently or better.) **The conclusion should prove or disprove the objective.** The conclusion does not describe the steps you took, but what you discovered.
- **Questions – 2 points** – answer any questions in complete, grammatically correct sentences.
- **Procedures – 2 points** - a quick overview of the experimental equipment and steps taken. Someone should be able to replicate your work from your explanation. Should include a diagram of test equipment setup.
- **Data – 2 points** – recorded measurements including datasheets, tables and graphs where necessary.
- **Calculations – 2 points** – show your calculations neatly, with enough explanation to be able to follow what happened.
- **Presentation – 2 points** – Is the report neat and attractive? Are sections in the right order? Is the grammar and spelling acceptable? Is the report typed with computer generated graphs and diagrams? All these make it look nice, but much more importantly, are very valuable job skills. As with all things in life, neatness and presentation count, but are secondary to discovery and learning and substance.

I have a rubber stamp that looks something like this:

Obj 2	Data 2
Conc 4	Calc 2
? 2	Pres 2
Proc 2	/16 Total

When I grade your lab, I will stamp your paper, and will either check each item or take off credit for deficiencies in each area. The number on the bottom right will be the grade out of a possible 16 points.

Lab is an important part of a Physics class. It lets you get your "hands on the material" and see it really work. These are things I hope you get from participating in lab:

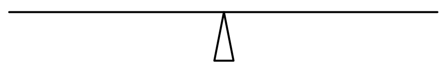
- An understanding of the principles we discuss in class
- An understanding of how scientists approach and solve problems, and how you can solve problems by careful study, measurement and problem solving skills
- A curiosity about the world and how it works
- Computer skills – a valuable job skill
- Writing skills – a valuable job skill
- Problem solving skills – a valuable job skill
- Some fun

Lab 1: Torque and Equilibrium of A Rigid Body

Materials	**Ideas**
• Meter stick	• Torque
• Balance stand	• Equilibrium
• Mass hangers	• Statics
• Spring scales	
• Triple-beam balance	
• Protractor	

<u>Procedure 1</u> - Center of Gravity of a Meter Stick

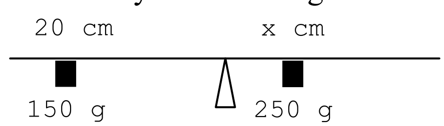
- Find a straight meter stick and place a mass hanger near the center of the stick
- Place the mass hanger on the balance stand to support the meter stick
- Find the point where the meter stick balances – this is called the center of mass



Balance point of meter stick ____________ (This is center of mass of the meter stick.)

<u>Procedure 2</u> – Balancing two Masses with the Balance at the Center of Mass

- Suspend a 150-gram mass from the meter stick at the 20-cm mark.
- Pivot the meter stick at the balance point found in step 1.
- Mathematically calculate the position required for a 250-gram mass so that the system will be in equilibrium.
- Determine the equilibrium position for the 250-gram mass experimentally.
- Compare the experimental result with the predicted result.
- If the results do not agree within 2 mm, suggest what might be the cause of the error. Repeat the experiment to confirm your reasoning.



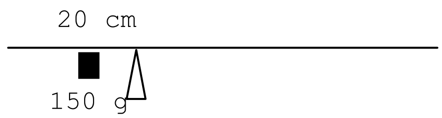
Show Calculations to Determine Equilibrium Position of 250-gram Mass

Predicted Position of 250-gram Mass for Equilibrium ____________

Actual Position of 250-gram Mass for Equilibrium ____________ % Error ____________

Experiment 3 - Find the Mass of the Meter Stick

- Suspend a 150-gram mass suspended at the 20-cm mark
- With no other masses on the meter stick, move the mass hanger at the center of mass of the meter stick to find the point at which the meter stick will balance.
- Using the distance from the center of mass to the new balance point, mathematically determine the mass of the meter stick.
- Use the triple-beam balance to determine the actual mass of the meter stick.
- Compare the two experimental results.
- If the results do not agree within 2 grams, suggest what might be the cause of the error. Repeat the experiment to confirm your reasoning.

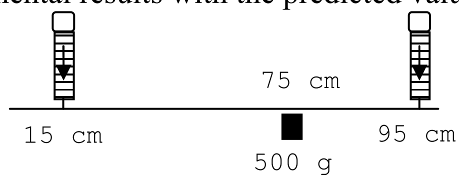


Balance point of the meter stick with 150-gram mass _____________
Show Calculations to Determine the Mass of the Meter Stick

Predicted mass of the meter stick, __________________ Actual mass of the meter stick, from balance ________________ % Error ___________

Experiment 4. Forces on a System

- Suspend the meter stick from two spring scales at the 15-cm mark and the 95-cm mark, and suspend a 500 g mass from the 75-cm mark, as shown below.
- Calculate what the scale readings will be for both spring scales. Include the actual mass of the meter stick.
- Set up the meter stick as shown and determine the actual scale readings.
- Compare the experimental results with the predicted values.



Show Calculations to Determine Scale Readings

Predicted reading of spring scale at 15 cm mark ________________

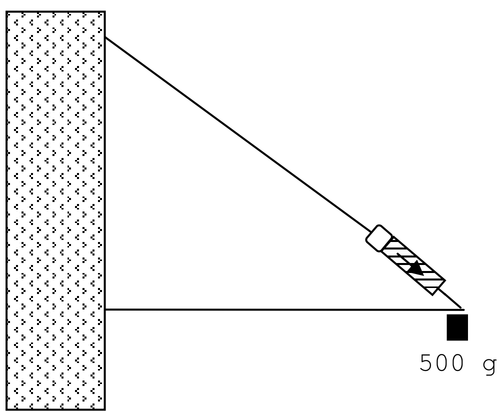
Actual reading of spring scale at 15 cm mark ________________ % Error ___________

Predicted reading of spring scale at 95 cm mark ________________

Reading of spring scale at 95 cm mark _________________ % Error ____________

<u>Experiment 5</u> - Load Suspended from a Boom

- Support a meter stick at one end using a string and spring scale.
- Place a 500 gram load will be placed at the end of the meter stick. (Don't let the load fall on you or others.)
- Measure the angle between the string and meter stick
- Observe the actual scale reading.
- Calculate what the scale should read. Include the actual mass of the meter stick as well as the load and hangers in your calculations.
- Compare the experimental result with the predicted result.
- If the results do not agree within 20 grams, suggest what might be the cause of the error. Repeat the experiment to confirm your reasoning.



Calculation to Determine Reading of Spring Scale

Predicted reading of spring scale _________________

Actual reading of spring scale __________________ % Error ____________

Lab 2: Density, Specific Gravity, Pressure and Hydrostatic Pressure

Objective: To measure the density, specific gravity, pressure and hydrostatic pressure of various objects and liquids

Materials: Single-pan balance

- Weights
- Graduated cylinders and beakers
- Wood dowel
- Aluminum cylinder
- Unknown fluid

Procedure 1: Density and Specific Gravity – Find the mass and volume of the following objects in order to calculate the density and specific gravity of each.

	Mass	Volume	Density g/cm^3	Density kg/m^3	Density lb/ft^3	Reference Density	% Error	Specific Gravity
Water								
"mystery" liquid								
Brass cylinder								
Brass rect. solid								
Aluminum cylinder								
Stopper with holes								
Odd shaped object								

Procedure 2: Pressure – Using the values of mass above find the pressure the objects exert on a tabletop.

	Mass	Area of contact	Pressure Pa	Pressure kPa	Pressure Atm	Pressure psi
Brass cylinder, end						
Aluminum cylinder, end						
Rectangular solid – big side						
Rectangular solid – little side						

<u>Procedure 3</u>: Hydrostatic Pressure – Using the values of density for the liquids find the hydrostatic pressure at the following depths.

Depth	Gauge pressure under Water (Pa)	Absolute pressure under Water (Pa)	Gauge pressure under "mystery" liquid (Pa)	Absolute pressure under "mystery" liquid (Pa)
1m				
5 m				
10 m				
100 m				
1000 m				

Lab 3: Archimedes' Principle/ Buoyancy

Objective: Use several methods to find the specific gravity of fluids.

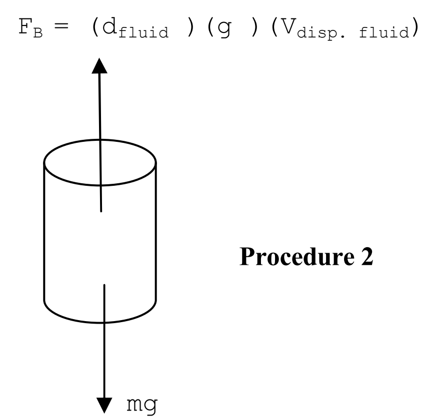
Background – Imagine you are currently employed by Sunshine Corporation. Sunshine Corporation supplies a food product to retail chains. Materials are received in bulk as concentrate and then mixed and diluted. The resulting product is then bottled for shipment. In order to remain competitive, Sunshine Corporation must meet minimum quality standards set by the retail firms who are its customers. If the product is too dilute, (indicated by low specific gravity) the entire shipment will be rejected by the customer. On the other hand, if the product is too concentrated, (indicated by high specific gravity) money will be lost because too much concentrate is being given away.

In situations like that of Sunshine Corporation the uncertainty in the value of specific gravity becomes very important. For example, if a retail chain rejects the shipment because they allege specific gravity is too low, you as the responsible employee of Sunshine Corp. will be challenged to show that the lowest possible value you obtained was still more than the minimum allowable value. Thus, even though the accuracy and nominal value are important, it is the minimum possible value that will determine whether the product meets specification or will be rejected.

Since specific gravity is critical to the final quality of the products being shipped, you have been asked to devise a test for the production department to measure specific gravity. In order to recommend the best method, you decide to evaluate a number of possibilities.

Procedure 1:

- Measure the mass and volume of the liquid in a graduated cylinder.
- Calculate density and specific gravity.

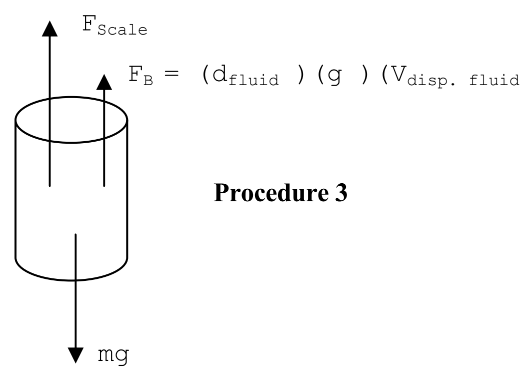


Procedure 2

Procedure 2:

- Measure the volume of the liquid in a graduated cylinder.
- Measure the mass of a wooden dowel.
- Place the dowel in the graduated cylinder so that it floats in the fluid.
- Measure the change in volume in fluid.
- Sum the forces and solve for d_{fluid} and Sp. Gr.

This is referred to as a "Hydrometer".



Procedure 3

Procedure 3:

- Record the mass of a metal object.
- Record the volume of the liquid in a graduated cylinder.
- Suspend the mass from a hand scale and completely submerge the mass into the fluid.
- Record the new volume of the liquid and calculate

the volume of the mass.

- Record the apparent mass of the brass mass from the hand scale.
- Calculate the density of the fluid.
- Calculate the specific gravity of the fluid.

Procedure 4:

- Use a glass hydrometer to determine specific gravity.

Analysis - Answer questions on a separate sheet of paper in complete, grammatically correct sentences.

1. Which method results in the least uncertainty?

2. Which method provides the most significant figures?

3. Concerning accuracy, did each method include the correct value of specific gravity? (Answer this question only if specific gravity is known.)

Conclusion

Prepare an *internal memorandum* to the production department, to include:
Summary of specific gravity for each method in a table,
Recommend the best method and state your reason for making the selection.

	Procedure 1		Water	Fluid 1	Fluid 2
1	Mass empty cyl.	(g)			
2	Vol. Liquid	(cm^3)			
3	Mass cyl. + liq.	(g)			
4	Calc. mass liq.	(g)			
5	Calc. Density	(g/cm^3)			
6	Calc. sp. gr.				

	Procedure 2		Water	Fluid 1	Fluid 2
1	Mass of wood	(g)			
2	Init. Vol. Liquid	(cm^3)			
3	Final Vol. Liquid	(cm^3)			
4	Calc. Displaced Vol.	(cm^3)			
5	Calc. Density	(g/cm^3)			
6	Calc. sp. gr.				

	Procedure 3		Water	Fluid 1	Fluid 2
1	Mass of metal object, m_m	(g)			
2	Initial volume of fluid	(cm^3)			
3	Volume, metal submerged in fluid	(cm^3)			
4	Calc. vol. of metal, V_m (3.- 2.)	(cm^3)			
5	Apparent mass m_m' (from scale)	(g)			
6	CALC. density d_f	(g/cm^3)			
7	CALC. sp. gr.				

	Procedure 4		Water	Fluid 1	Fluid 2
1	Density of Fluid	(g/cm^3)			

Lab 4: Linear Thermal Expansion

Objective: Determine the coefficient of thermal expansion for aluminum, copper or iron.

Equipment Required:

- Linear expansion apparatus with metal rod
- Thermocouple and digital read out
- Boiler
- Bunsen burner and ring stand

Introduction: The coefficient of thermal expansion is defined by the equation:

$$\Delta L = aL_o(T_f - T_i)$$

so

$$\frac{\Delta L}{L_o(T_f - T_i)} = a$$

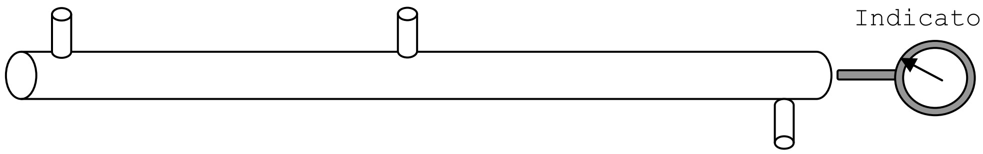
SAFETY PRECAUTIONS:

- **This lab involves boiling water and steam.**
- **Do not sit near the Bunsen burner or boiler.**
- **Do not lean over the Bunsen burner.**
- **Make sure your clothing and hair are away from the flame.**
- **Alert everyone on the team if it becomes necessary to move hoses or any equipment.**
- **Turn off the gas when the Bunsen burner is not being used.**
- **Keep the flame low and away from the rubber tubing on the boiler or else the rubber tubing may catch fire!**

Procedure

- Fill the steam generator half full of water, replace the cap and run a rubber tube to the steam inlet of the heating jacket.
- The hose from the boiler to the linear expansion apparatus should slope continuously downward from the boiler to the expansion apparatus. There should be no points along the hose that would allow steam and water to pocket.
- Fit the temperature inlet with a short piece of rubber tubing and tie or clamp the tubing tightly around the thermometer probe. No steam should leak out through the temperature inlet.
- Place the drain over the sink or run a piece of rubber tubing to the sink. All steam should exit the system through the drain.
- Measure and record the length of the sample metal rod and place it inside the heating jacket. Place the rod/heating jacket in the base so that the rod is firmly held between the screw of the base and the dial indicator.
- Record the room temperature.
- Zero the dial indicator by turning the face of the dial until the needle points to zero.
- Place the steam generator on a ring stand over a Bunsen burner and bring the water to boil. Keep the flame fairly low and away from the rubber tubing on the steam generator.

- When the dial indicator stops increasing (approximately after 10 minutes) record the change in length in thousandths of an inch. Convert to centimeters.
- Calculate a, the coefficient of Linear Expansion and compare with a reference value.
- Repeat as needed with other sample rods.



Conclusion - Make a table comparing the values of thermal expansion that you obtained with the tabulated value in your text. Do the results agree within your reported limits of experimental uncertainty?

	Aluminum	Brass	Copper	Iron
L_o , Initial Length (cm)				
T_i , Initial Temp (^oC)				
T_f, Final Temp (^oC)				
ΔT (^oC)				
ΔL , change in length (0.001 inch)				
ΔL , change in length (cm)				
a, Coefficient of linear expansion				
a_{Ref}	24×10^{-6} / ^oC	19×10^{-6} / ^oC	17×10^{-6} / ^oC	12×10^{-6} / ^oC
% Error				

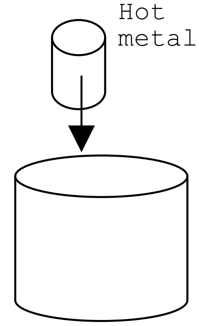
Lab 5: Calorimetry

Equipment

- Thermometer
- Beakers
- Insulated container
- Balance
- Bunsen burner, tripod and wire gauze
- Metal sample
- Ice

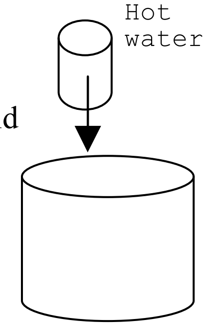
SAFETY PRECAUTIONS: In this experiment you will be using an open flame and boiling water. Do not sit near the Bunsen burner. Do not sit near the beaker of boiling water. Do not lean over the Bunsen burner. Make sure your clothing and hair are away from the flame. Alert everyone when hot material is being transferred. Use tongs to handle hot material. Turn the gas off whenever the Bunsen burner is not being used to heat water.

Procedure 1 - Specific Heat of the Metal



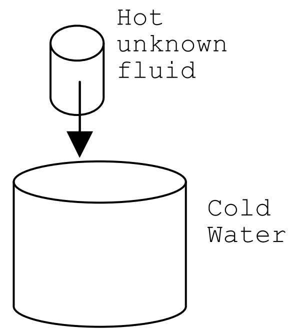
- Find the mass of the metal sample.
- Place the metal into a beaker of water and heat until the water reaches the boiling point.
- While the water is heating, pour a measured amount of water into an insulated container. There should be just enough water to completely cover the metal sample.
- After the water begins to boil, wait at least five minutes. This will permit the metal to come to the temperature of the hot water.
- Place a thermometer in the insulated container and record the temperature of the water.
- Record the temperature of the hot water and then use tongs to place the hot metal into the insulated container.
- Record the equilibrium temperature, which will be the maximum temperature that is observed.
- Calculate the specific heat of the metal.
- Compare to reference value of the specific heat of the metal.

Procedure 2 - Specific Heat of an unknown fluid



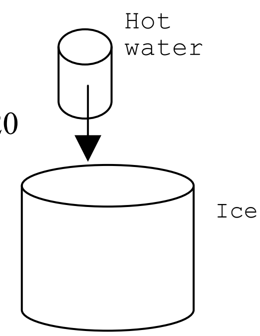
- Heat a measured amount of water until it reaches the boiling point.
- While the water is heating, place a measured amount of unknown fluid into an insulated container.
- Place a thermometer in the container of unknown fluid and record the fluid temperature.
- Pour the boiling water into the container of unknown fluid and record the equilibrium temperature, which will be the maximum temperature that is observed as the two solutions mix.
- Calculate the specific heat of the unknown fluid.

Procedure 3 - Specific Heat of an unknown fluid



- Heat a measured amount of the unknown fluid until it reaches approximately 75 to 85 C. **DO NOT LET IT BOIL.**
- While the fluid is heating, place a measured amount of water into an insulated container.
- Place a thermometer in the container of water and record the fluid temperature.
- Record the temperature of the hot unknown fluid and then pour the hot fluid into the container of water.
- Record the equilibrium temperature, which will be the maximum temperature that is observed as the two solutions mix.
- Calculate the specific heat of the liquid.
- Compare to the value obtained in procedure 2.

Procedure 4 - Specific Heat and Latent Heat



- Heat a measured amount of water (50 to 80 ml) until it reaches approximately 75 to 85 C.
- When the water has heated, find the mass of a small amount of ice (10 to 20 g).
- Place the ice in the insulated container and record the temperature.
- Pour the hot water into the insulated container and record the equilibrium temperature, which will be the maximum temperature that is observed as the ice and heated water mix.
- Calculate the latent heat of the ice.
- Compare to the reference value for L_f.

	Mass metal (g)	**Temp metal (^{O}C)**	**Mass Water (g)**	**Temp Water (^{O}C)**	**Final T (^{O}C)**	**C_{metal} (kJ/kg ^{O}C)**	**Ref. C_{metal}**	**% error**
Procedure 1 metal								
	Mass water (g)	**Temp water (^{O}C)**	**Mass fluid (g)**	**Temp fluid (^{O}C)**	**Final T (^{O}C)**	**C_{fluid} (kJ/kg ^{O}C)**	**% Diff**	-
Procedure 2 fluid								-
Procedure 3 fluid								-
	Mass 1 (g)	**Temp 1 (^{O}C)**	**Mass 2 (g)**	**Temp 2 (^{O}C)**	**Final T (^{O}C)**	**L (cal/g)**	**Ref. L**	**% error**
Procedure 4 ice								

Lab 6: Boyle's Law

Objective - To observe the relation between absolute pressure and volume for a gas.

Equipment

- Meter stick
- Glass funnel
- Graduated glass cylinder (buret) with stopper
- Buret clamp and ring stand
- Rubber tubing

Background - An ideal gas is any gas that is far from its boiling point. Dry air is an ideal gas because normally air is hundreds of degrees celsius above its boiling point. However, water vapor is not an ideal gas because the boiling point of water is relatively high. For water vapor to become an ideal gas, it would have to be heated to at least 400 C.

Boyle's Law states that for any ideal gas the product of absolute pressure and volume will remain constant:

$$p\,V = \text{constant}$$

This means that $p_1 V_1 = p_2 V_2 = p_3 V_3 = ...$ So the product of pressure and volume is always the same.

Finally, since mercury vapor is toxic, mercury will not be used in this experiment. Instead, water will be used to measure pressure. It will be necessary to convert pressure in units of mm H_2O to mm Hg (read: millimeters of water to millimeters of mercury).

The conversion is 1 mm Hg = 13.6 mm H_2O

Procedure

- Determine P, the barometric pressure. If the pressure is expressed in inches of Hg, convert to millimeters of Hg. (25.4 mm = 1.00 in)
- Assemble the apparatus, connecting a glass funnel and a 50-ml buret with a long length of tubing. Use a ring stand to support the buret with a buret clamp. Obtain a rubber stopper to fit the top of the buret and a meter stick.
- Fill the funnel with water. Remove the stopper on the buret so the water level will rise in the buret. Eliminate all bubbles or air pockets in the tubing. The bubbles can be removed by elevating the rubber tubing several times. Take your time with this step, because in order to obtain good data, it is important that no bubbles remain in the tubing.
- Carefully position the funnel adjacent to the buret so that the level in the buret is very close to the 30.0 ml mark AND the funnel is approximately 1/3 full of water. (Both conditions must be observed!) When you have done this, carefully adjust the level in the funnel to exactly coincide with the level in the buret. Holding the levels equal, place the stopper in the buret top, and read the volume in the buret (keeping the levels equal) to the nearest 0.1

ml mark.

Check to see that
a) the level in the funnel and buret coincide
b) the stopper is in the top of the buret
c) the reading in the buret is 30.0 ml plus or minus 2.0 ml
d) the funnel is about a third or half full
e) there aren't any bubbles in the tubing

- Then, record the volume exactly.
- Using the meter stick, RAISE the funnel until the bottom of the meter stick is positioned on the meniscus of the level in the buret and water in the funnel is positioned at the 500 mm (50 cm) mark on the meter stick. Note: There must be a 500 mm difference between the water levels in the buret and the funnel.
- Record the volume in the buret.
- Raise the funnel higher until the levels are 1000 mm apart. This means that the funnel will be at the 1000 mm (100 centimeter) mark and the bottom of the meter stick will be at the meniscus level in the buret. Record the volume in the buret.
- Lower the funnel until the level of water in the funnel is exactly 500 mm below the level of water in the buret. Record the volume in the buret.
- Lower the funnel until the level of water in the funnel is exactly 1000 mm below the level of water in the buret. Record the volume in the buret.
- It will be necessary to measure the volume of air in the buret that is between the rubber stopper and 0.0 mark. First, mark the location of the bottom of the stopper in the buret using masking tape or a marking pen. Then, disassemble the apparatus. Fill the buret all the way up to the point that has been marked. Then, pour water slowly from the buret into a 10-ml graduate until the water level in the buret is at the zero mark. Read and record the amount of water that has been poured into the 10-ml graduate. The volume of water in the 10-ml graduate is equal to the volume of air between the stopper and the 0.00 ml mark and is called the volume correction factor. The volume correction factor must be added to all volume readings that were taken. The resulting volume is the true volume of air in the buret.

Questions

1. Prepare a graph showing nominal pressure in mm Hg (ordinate) versus nominal volume in ml (abscissa). Use "+" symbols to indicate the points on the graph. Extend the horizontal and vertical lines of the "+" symbols to indicate the minimum and maximum limits of the measured values.

2. How many molecules of air were in the sample that was observed in the buret? Take the average value of the "p V" constant that you have determined and use this value in the numerator of the following ideal gas relation:

$N = (p\,V)/(kT)$ where $k = 1.38 \times 10^{-23}$ J/K (Boltzmann constant) K

You will need to measure room temperature and convert room temperature to absolute temperature.

3. How many moles of air were in the sample that was observed in the buret?

$n = (p\,V)/(RT)$ where $R = 8.3145$ J/mole K (universal gas constant)

4. How many grams of air were in the sample that was observed in the buret? Consider that there are 29 grams per mole of air.

5. Air in a tire has a volume of 0.725 m^3 and a pressure of 35 psig. The tire is placed on a vehicle, and the volume becomes 0.695 m^3. What will be the pressure in the tire, in psig and in kilopascals?

Data

Barometric pressure (from step 1.) P = ___________________ mm Hg

This will be the value of "P" in the calculation for column C below.

A	B	C	D	E	F	G
Height	Height (A/13.6)	Pressure (P+B)	Volume in Buret	Volume Correction	Corrected Volume (D+E)	Pressure xVolume (CxF)
mm H_2O	mm Hg	mm Hg	ml	ml	ml	Mm Hg mL
0						
+500						
+1000						
-500						
-1000						

Lab 7: Heat Engines

Today we will study four systems where we put heat in and get work out.

- **Procedure 1: Thermoelectric Converter Fan**
- Boil water in a 200 ml beaker and fill another 200ml beaker with cold water, or even better, ice water.
- Place the thermoelectric converter with one leg in each beaker.
- After a couple of minutes, the fan will begin to turn.
- Every couple of minutes, record the T_H (hot temperature), T_C (cold temperature) and calculate ideal efficiency until the fan stops.

Time	T_H	T_C	Rpm	ΔT	Ideal Efficiency

Questions
In terms of thermodynamics, what makes the fan turn?

Why does the fan slow down and then stop?

What happens to the efficiency/rpm of the fan? Include a graph of RPM vs. ΔT.

Why does T_C increase?

How does this illustrate entropy?

Procedure 2: Thermoelectric Converter "coil"

- Re-heat T_H to boiling. Refill T_C with cold or ice water.
- Place the thermoelectric converter coil with one side in the hot water and one side in the cold water.
- Every couple of minutes, check the voltage between the two terminal screws.

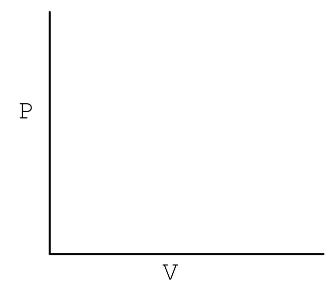
Time	T_H	T_C	ΔT	V

Questions
What happens to the voltage? Include a graph of Voltage vs. ΔT.

Procedure 3: Popcorn

- Estimate the volume of a kernel of popcorn. Heat the popcorn with a little oil until it "pops".

Questions
Draw a P-V diagram of the system.
What thermodynamic process occurs while the popcorn is heating? Why?



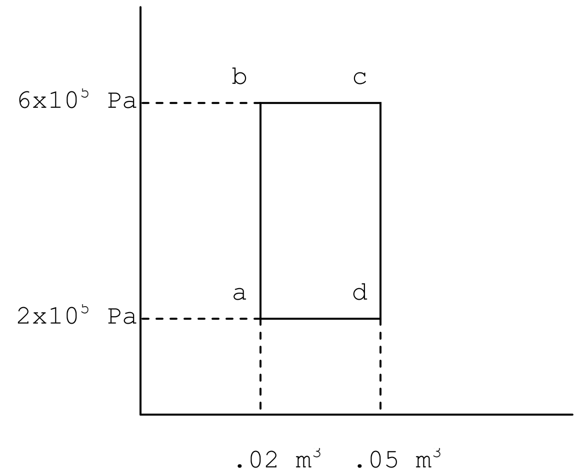
What thermodynamic process occurs when the popcorn pops? Why?

Procedure 4: Marble in a Test Tube
CAUTION – Point the test-tube away from all people in the room, do not overheat. The marble could shoot out of the end or the test-tube could shatter from excessive pressure. Wear protective goggles.

- Find a marble that will just barely roll in a test tube and record the mass of the marble.
- Place an inch of water in a test tube.
- Drop in the marble.
- Wave the test-tube over the flame to **slowly** heat the water until the marble is lifted by the steam beneath.

Questions
Calculate the work done by the steam to lift the marble.

Consider a system that is taken along the paths shown on the P-V diagram. Assume $U_a = 30{,}000$ J.



Find the work done by the system in going from a to b.

Find the work done by the system in going from b to c.

If 20 kJ of heat enters the system along the path from a to b, what is the internal energy at point b?

If the internal energy at point c is 95 kJ, how much heat enters or leaves the system along the path from b to c?

Run it backwards: If 21 kJ of heat enters the system in going from **a to d,** what is internal energy at point d?

Run it backwards: Find the heat that enters the system along the path from d to c.

If the system is taken along the closed loop a→b→c→d→a, how much work is done?

Find the area of the rectangular path.

What is the net heat that enters the system?

Lab 8: Voltage, Current & Resistance

Objective
To measure the current in a lamp.
To measure voltage across a lamp.
To determine the resistance of a lamp.
To determine the resistance of a resistor.

Equipment
0-10 volt power supply
Globe EDM-16 0-10 volt voltmeter
Cenco galvanometer with 5.0 volt range, and 100 ohm shunt resistor
110-115 volt 32 c.p. lamp
"unknown" resistor

Procedure - The meters used in this experiment can be damaged if improperly connected or current or voltage exceeds values on each range and scale. Teams will be responsible for repair or replacement cost of damaged equipment. Your instructor will check the circuit for each part of this experiment.

Part 1. Using the Voltmeter to Measure Potential Difference at a Power Supply
1.1. Connect the voltmeter to the output terminals of the power supply. Observe that positive polarity is red and that negative polarity is black. Turn on the power supply and adjust the output so that the voltmeter reads 9.0 volts. (If the voltmeter reads less than zero, it is connected backwards. Check polarity of your connections!)

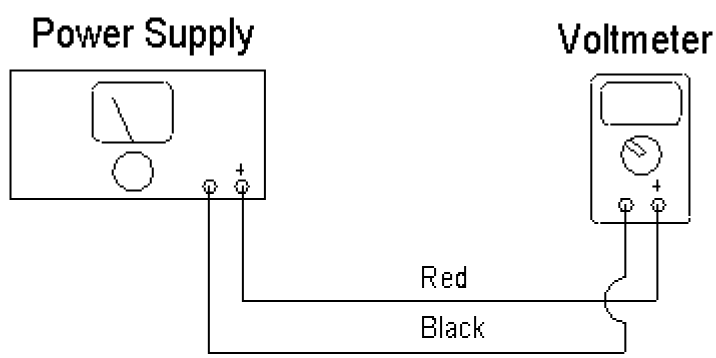


Figure 1: Procedure 1.1

Part 2. Using the Voltmeter to Measure Potential Difference at the Lamp

2.1 Turn off the power supply. Leave the voltmeter connected to the terminals of the power supply. Use additional wires to connect the power supply terminals to the test lamp.

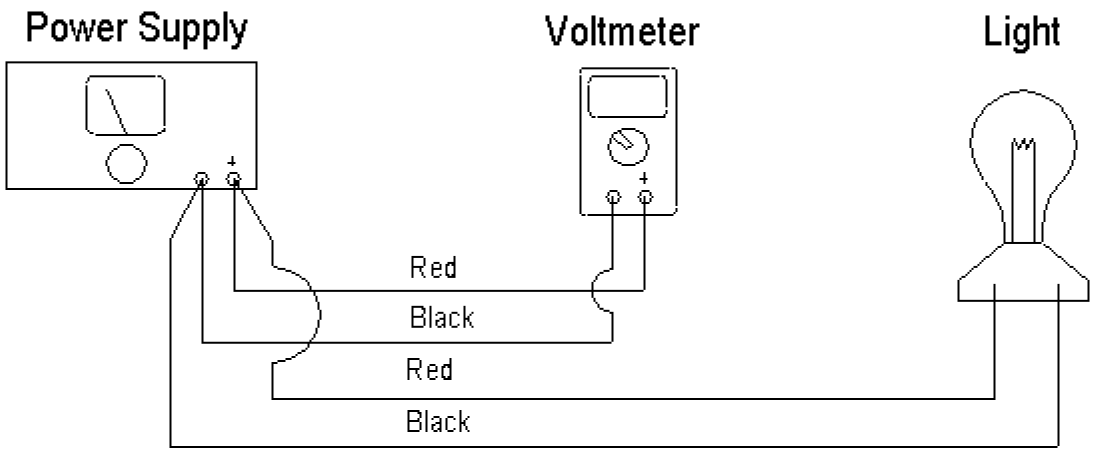


Figure 2: Procedure 2.1

2.2. Turn on the power supply. Adjust the output so that the voltmeter reads 9.0 volts.

2.3. This step must be performed with the power supply left on. Leave the output setting like it was in step 3. First, carefully remove the voltmeter wires from the power supply terminals. Connect the voltmeter wires across the lamp, being careful to observe polarity of the connections. Then, record the voltage that is observed.

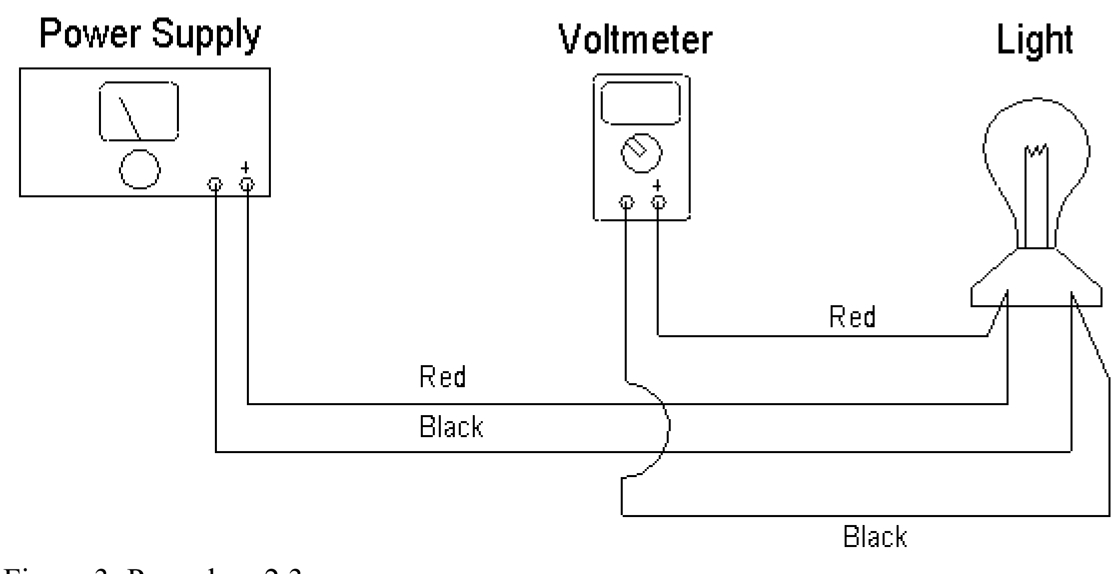


Figure 3: Procedure 2.3

Part 3. Using the Ammeter to Measure Rate of Charge Flowing to the Lamp
3.1. Turn off the power supply. Leave the voltmeter connected to the lamp. Connect the ammeter so that you can measure charge flowing into the lamp.

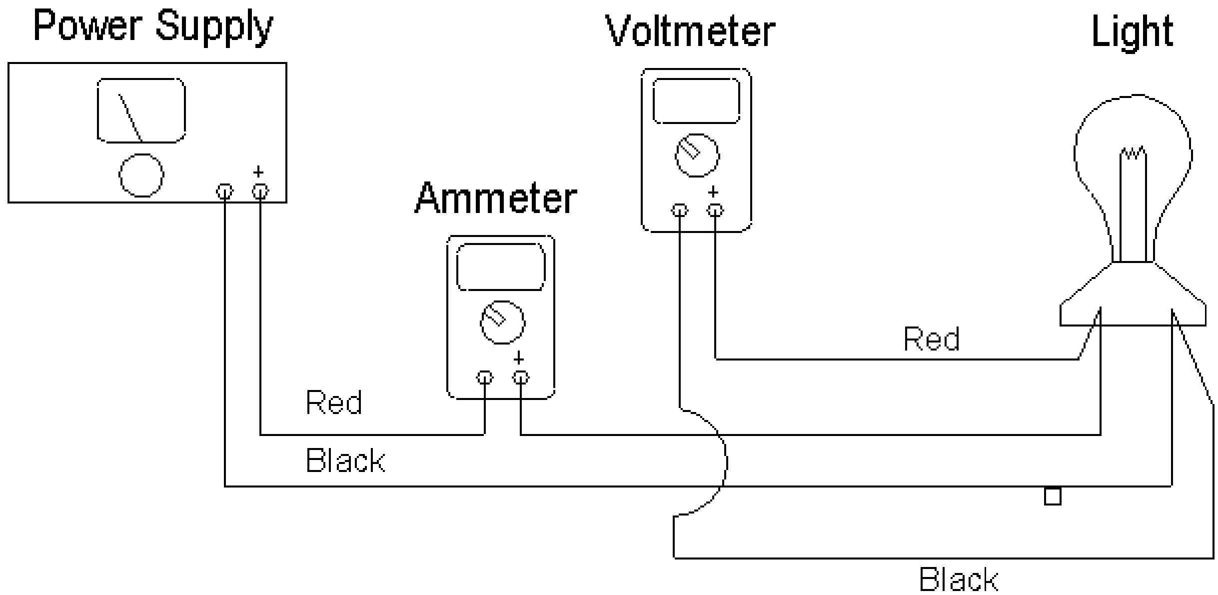


Figure 4: Procedure 3.1

3.2. Turn on the power supply and adjust the output, if necessary, so that the voltmeter reads 9.0 volts. Record the charge flowing to the lamp.

Part 4. Using the Ammeter to Measure Rate of Charge Flowing from the Lamp
4.1. Turn off the power supply. Leave the voltmeter connected to the lamp. Connect the ammeter so that you can measure charge flowing out of the lamp.

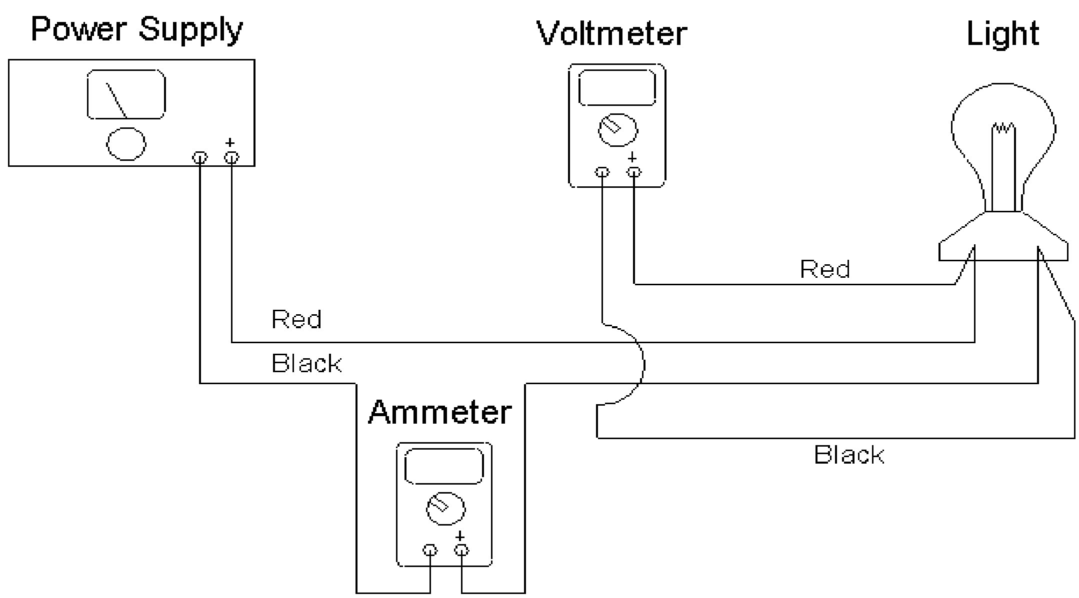


Figure 5: Procedure 4.1

4.2. Turn on the power supply and adjust the output, if necessary, so that the voltmeter reads 9.0 volts. Record the current in the circuit.

Part 5. Ohm's Law

5.1. Without changing the circuit, adjust the voltage of the power supply so that the voltmeter reads 1.0 volt.

5.2. Record the current in the lamp.

5.3. Repeat steps 5.1. and 5.2. for potential differences across that lamp form 1.5 to 6.0 volts in 0.5 volt increments.

5.4. Prepare a graph of voltage across the lamp (y-axis) versus current in the lamp (x-axis).

5.5. Determine the slope of the best-fit line through the data. The slope of the line is the resistance of the lamp.

Part 6. Unknown Resistance

6.1. Replace the lamp with the resistor that has been provided. Measure voltage across the resistor and the current through the resistor. Calculate resistance of the resistor using Ohm's Law.

6.2. Determine the resistance of the unknown resistor by observing its color code.

There will be three colored bars or rings on the resistor. There is also a gold or silver ring on the resistor. When reading resistance, orient the resistor so the gold or silver band is toward the right. Then read the three color-coded bands starting from left and going toward the right.

The first two colors indicate the first two digits. The third color indicates the power of ten. Thus, orange, blue, red denotes 36×10^2 ohms = 3600 ohms.

black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
violet	7
gray	8
white	9

Gold denotes that the resistance is within 5% of the indicated value. Silver denotes that the resistance is within 10% of the indicated value.

Data

Part 1.1	Voltage at power supply	
Part 2.3	Voltage at lamp	
Part 3.2	Charge flowing to lamp	
Part 4.2	Charge flowing from lamp	

Part 5. Ohm's Law

Graph Ohm's Law data & find slope

Voltage across lamp	Current in Lamp

Part 6. Unknown resistor

6.1 ___________ volts ___________ amperes ___________ Calculated Resistance

6.2 colors __________ ____________ __________ ____________

___________ Labeled Resistance

___________ Labeled Tolerance

___________ Measured Resistance with multimeter

___________ Is resistor in tolerance?

Lab 9: Capacitance

Objectives

- Determine the charge stored in a capacitor.
- Determine the capacitance of a capacitor.
- Observe the meaning of time constant.
- To verify the formulas for capacitors connected in parallel and series.

Equipment

- Digital multimeter (DMM)
- Analog voltmeter with 0-25 volt scale
- Electrolytic capacitors
- Decade Resistor Counter
- Power Supply
- knife switch

Background - A capacitor is a device that stores electrical energy. Capacitors are made up of two conducting plates separated by air or other insulating material. The material used for separating the conducting plates is called the dielectric. The capacity for storing charge depends on the area of the plates, the separation distance between the plates, and the dielectric material used. For electrolytic capacitors, such as used in this experiment, the dielectric is polarity-dependent. Electrolytic capacitors have large capacitance and can therefore store considerable energy in a relatively small volume. However, they can be damaged if polarity of the voltage is incorrect or if voltage across the plates exceeds rated voltage.

The circuit on the next page shows a capacitor, battery, resistor, and switch, as well as a voltmeter and an ammeter. When the switch is open, no charge flows from the battery. When the switch is closed, the battery supplies energy to move electrons from one plate of the capacitor to the other plate of the capacitor. The plate with a deficit of electrons becomes positively charged. The plate with a surplus of electrons becomes negatively charged. Thus, charge accumulates in the capacitor, but no current flows through the capacitor because the plates are separated by the dielectric insulator.

As charge accumulates on the plates of the capacitor, the potential difference increases between the plates until it reaches the same potential difference as that of the battery. At this point, the system is in equilibrium and no more charge flows from the battery.

Capacitance is measured by placing a specific amount of charge on the capacitor and then measuring the resulting potential difference. The capacitance, C, is found by the following relationship: $C = q / V$ where C is the capacitance in farads, q is the charge in coulombs, and V is the potential difference in volts.

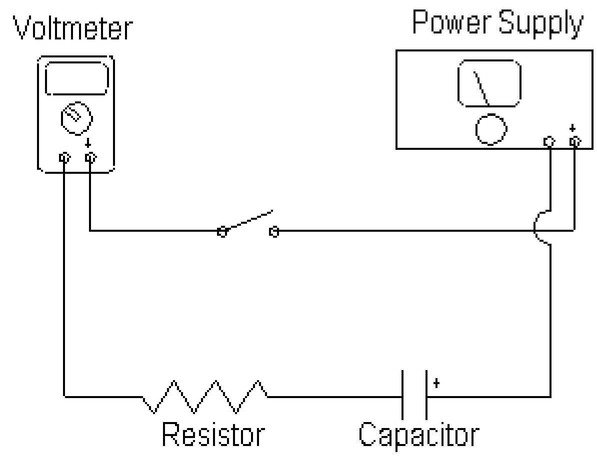
The equivalent capacitance for capacitors connected in parallel and in series has been shown in your text to be:

$$C_{Total} = C_1 + C_2 + C_3 + \ldots \quad \text{and} \quad \frac{1}{C_{Total}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

In Parallel — In Series

Procedure 1

- Set up the circuit shown below. Be careful to observe polarity of the meters, the battery and the capacitor. The wire at the black end of the capacitor is connected internally to the positive plate. The wire at the silver end is connected internally to the negative plate.
- The "common" connection to the DMM is negative. The positive connection will be labeled mA. Note that the connections labeled for voltage and resistance and for 10 amperes are not used. The rotating knob on the DMM should be one step from the most sensitive current position.
- Select a 27,000 ohm resistor for the circuit. The purpose of the resistor is to limit the flow of charge to the capacitor.
- The knife switch should remain in the OPEN position.
- Your instructor will check the setup before the knife switch is closed. The DMM can be damaged if it is connected improperly and the team will be responsible for repair or replacement cost.
- With one lab partner timing and others reading and recording values of current, close the knife switch, wait five seconds, and take readings every five seconds. It may be necessary to switch to the most sensitive current setting for best accuracy. Estimate the readings from the ammeter as closely as possible. When the change in current becomes relatively small, readings can be taken every ten seconds. As the current changes less and less, readings can be taken every 20 seconds until the current becomes too small to read or change in current is negligible. Voltage supplied by the battery can be recorded when the interval between ammeter readings is 10 seconds.



- Open the knife switch. Connect a piece of wire across both wires from the capacitor to discharge the capacitor. NOTE: The DMM will be damaged if this step is performed with the knife switch closed.

Procedure 2

- Replace the capacitor with the second capacitor. Repeat the above steps for capacitor C_2.

Procedure 3

- Discharge both capacitors. Repeat the above steps for capacitor C_1 and C_2 in parallel.

Procedure 4

- Discharge both capacitors. Repeat the above steps for capacitor C_1 and C_2 in series.

Procedure 5

- Graph each of the capacitor charging data. Find the time that it took to fill 63% of the capacitor and record this as the measured Time Constant.

Procedure 6

- Find the area (charge) under each of the curves using the triangular approximation, trapezoidal rule and Simpson's rule (see last page) and calculate Capacitance = Q/V. Show your work.

Data Sheet for Lab 9

Rated capacitance of capacitor C_1 : __________ microfarads

Rated capacitance of capacitor C_2 : __________ microfarads

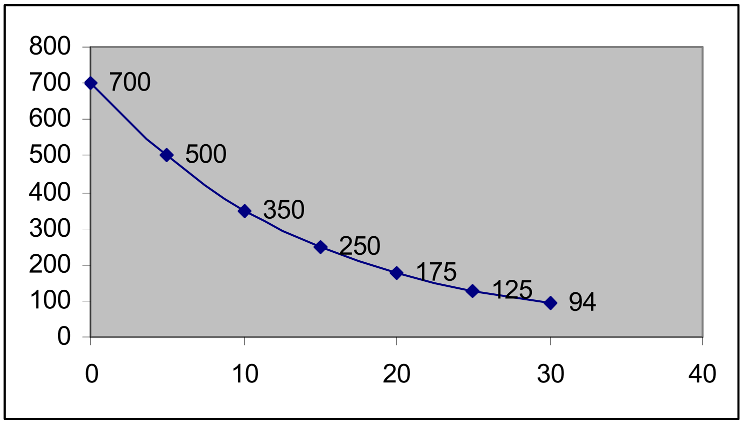
Rated resistance of resistor: __________ Ohms

Voltage of battery (while supplying charge in circuit): ________ volts

	C_1	C_2	C_1 & C_2 In Series	C_1 & C_2 In Parallel
Calc/Rated Capacitance				
Calculated Time Constant				
Time (s)	Current (μA)	Current (μA)	Current (μA)	Current (μA)
0 s				
5 s				
10 s				
15 s				
20 s				
25 s				
30 s				
35 s				
40 s				
45 s				
50 s				
55 s				
60 s				
Measured Time Constant				
Triang. Charge				
Triang. Capac.				
Trap. Charge				
Trap. Capac.				
Simps. Charge				
Simps. Capac.				

Methods of Estimating Area under a Curve

Here are some ways to estimate the area under a curve. (A is the area under the curve, b is an incremental length along the x-axis and y is the height of the curve at each incremental point along the x –axis)

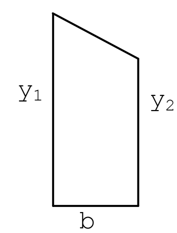


Triangular Approximation – Imagines the curve as a triangle and finds the area of the triangle.

$A \approx 1/2\ b\ h$

Example: $A \approx 1/2\ (30)\ (700)$
$A \approx 10{,}500$

Trapezoidal Rule – Cuts the area under the curve into trapezoids. Recall: $A = 1/2\ b(y_1 + y_2)$.



$A \approx 1/2\ b\ (y_o + y_1) + 1/2\ b\ (y_1 + y_2) + 1/2\ b\ (y_2 + y_3) + ...$
$= 1/2\ b\ (y_o + y_1 + y_1 + y_2 + y_2 + y_3 + ... + y_n)$
$= 1/2\ b\ (y_o + 2\ y_1 + 2\ y_2 + 2\ y_3 + ... + y_n)$
$A \approx b\ (1/2\ y_o + y_1 + y_2 + y_3 + 1/2\ y_n)$

Example: $A \approx 5\ (700/2 + 500 + 350 + 250 + 175 + 125 + 94/2)$
$A \approx 5\ (1797) = 8985$

Simpson's Rule – Assumes a parabolic curve on top. See your Calculus book. Area must be divided into an even number of increments.

$A \approx 1/3\ b\ [y_o + 4\ y_1 + 2\ y_2 + 4\ y_3 + 2\ y_4 + ...\ 4\ y_{n-1} + y_n]$
$A \approx b/3\ (y_o + 4\ y_1 + 2\ y_2 + 4\ y_3 + ... + y_n)$

Example: $A \approx (1/3)\ 5\ [700 + (4 \times 500) + (2 \times 350) + (4 \times 250) + (2 \times 175) + (4 \times 125) + 94]$
$A \approx 5/3\ [5344] = 8907$

Note that in your calculation of area the units will be microampere seconds, or microcoulombs.

Lab 10: Magnetism & Induction

Objectives

- To determine the polarity of Earth's north pole.
- To observe magnetic lines of force (magnetic field).
- To verify the right-hand rule for the direction of charge and the resulting polarity of the magnetic field.
- To verify Faraday's Law.
- To determine the pole strength of a magnet.

Equipment

- compass
- 2 bar magnets
- horseshoe magnet
- power supply
- knife switch
- PVC coupling
- galvanometer
- meter stick
- 55-turn or 110-turn air-core coil
- 440-turn or 880-turn air-core coil
- red and black lead wires with allgator clips
- red and black lead wires with banana jacks
- iron filings
- manilla folder or other heavy paper
- typing paper

Procedure 1 – Magnetic Poles – using magnets and a compass answer the following questions.	
Does the south pole of a bar magnet attract or repel the north-pointing needle of the compass?	
Does the north pole of a bar magnet attract or repel the north-pointing needle of the compass?	
What is the polarity of the north pole of the Earth?	

Procedure 2 – Magnetic Field Lines

- Place a magnet on the bench.
- Cover the magnet with a piece of thick paper, and then place a sheet of white paper on top of the thick paper.
- Gently and uniformly sprinkle iron filings over the white paper.
- Tap the paper very gently once or twice so that the filings can align themselves with the magnetic field.
- Sketch the paths of the iron filings on the white paper. Label the magnetic poles on the sketch and attach the sketch to your lab report.
- Carefully pick up the sheet of paper and return the iron filings to the container.

Do the above procedures for the following: Horseshoe magnet, 2 bar magnets N to S, 2 bar magnets N to N. Include the sketches with your report.

Procedure 3 – Electromagnetic Poles

- Construct the circuit for the one-turn, air-core coil as shown below. The knife switch in the circuit should be OPEN.

- Have your instructor check the circuit before proceding to the next step.
- With the knife switch in the OPEN position, adjust the power supply for 5.0 volts D.C.
- Place a compass near the coil. Then position the coil so that the axis of the coil makes about a 45 degree angle with the compass needle. Predict whether the north pole of the compass needle will be attracted or repelled when the knife switch is closed.
- MOMENTARILY close the knife switch to observe the deflection of the compass needle.

Procedure 3 – Electromagnetic Poles	
Use the right-hand rule to predict whether the north pole of the compass needle will be attracted or repelled when the knife switch is closed.	
Based on the deflection of the compass needle, what is the polarity of the electromagnet?	
Describe how the right-hand rule confirms the polarity observed with the compass needle.	

Procedure 4 – Electromagnetic Induction – describe the effects of inserting a magnet into a coil of wire on a galvanometer.

Insert a bar magnet into a	55 turn coil	800 turn coil
North pole quickly		
South pole quickly		
North pole slowly		
South pole slowly		

Explain what effect the following factors have:

- magnetic polarity (north or south pole of magnet)
- number of turns of wire in coil
- speed of the magnet

Describe how the results confirm the formula $EMF = V = -N\frac{\Delta\Phi}{\Delta t} = \frac{-N(BA - B_0A_0)}{t}$

Would it make any difference if the magnet remained stationary and the coil moved into the magnet? Why?

Procedure 5 – Magnetic Pole Strength

- Tape a sheet of paper to the counter. Using a compass to indicate north, draw a line on the sheet of paper which runs in the direction from the north pole to the south pole of the earth.

- Place a meter stick along the line on the paper so that the meter stick extends from north to south.
- Place a magnet at the south end of the meter stick, in line with the meter stick. Orient the magnet so that the south pole of the magnet touches the meter stick and the north pole of the magnet points away from the meter stick.
- Position a compass at the north end of the meter stick (at the opposite end fo the bar magnet).
- There will be a point along the meter stick where the Earth's magnetic field will balance the field of the bar magnet; this point is called the neutral point. To locate the neutral point, slowly move a compass along the meter stick toward the bar magnet, rotating the compass to determine when the needle will be perpendicular to the meter stick. The location where compass needle deflection becomes perpendicular is the neutral point. At this point the magnetic field of the Earth balances the magnetic field of the bar magnet.
- Measure the distance d_1 in meters from the neutral point to the edge of the south pole of the magnet.
- Measure the distance d_2 in meters from the neutral point to the edge of the north pole of the magnet. (Add the length of the magnet to D_1.)
- Calculate the magnetic pole strength, M, from the relationship:

$$B_E = 10^{-7}\ \text{Wb/Am}\ (d_1^{-1} - d_2^{-1})\ M$$

where B_E is the magnetic field intensity of the Earth, and is approximately 5×10^{-5} T. What are the units of magnetic pole strength?

Procedure 6 Magnetic Induction

- Suspend two bar magnets from a ringstand and arrange two air-core coils so that each is near one of the bar magnets. The polarity of the bar magnets should be the same when they are near the coils.
- Allow one of the bar magnets to swing into one of the coils. Observe the deflection of the other magnet.
- Use the right-hand rule to determine the direction of current in each coil. Label or note the positive wires from the coils. Connect the positive wires together and then connect the negative wires to each other.
- Allow the bar magnet to again swing into the first coil. Observe the deflection of the other magnet.
- Disconnect the positive wires from each other. Reconnect the positive wires so that a galvanometer is in series with the two coils.
- Allow the bar magnet to again swing into the first coil. Observe the deflection of the galvanometer.
- Explain the behavior of the second magnet when the first magnet was moved into a coil. Which coil acts as a generator and which coil acts as a motor?

Lab 11: Optics

Optics is the study of light and how light interacts with matter and itself. In this experiment we will observe three main topics of optics; reflection, refraction and color mixing.

Equipment

- Light box and optics set
- Power supply
- Protractor
- Ruler
- Paper
- Sharp Pencil

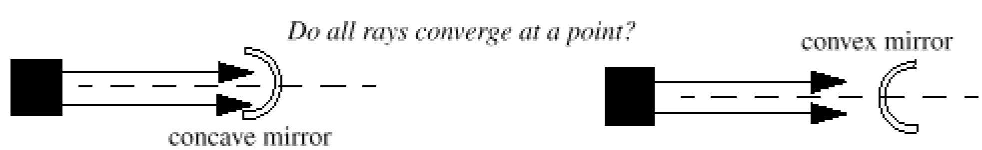
Vocabulary

- Reflection – “bouncing” a ray of light
- Refraction – the bending of a ray of light
- Plane - flat
- Concave – curved inward
- Convex – curved outward
- Normal – a line drawn at a right angle
- Converge – come together
- Diverge – move apart

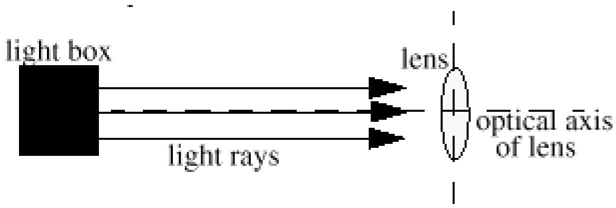
Setup - Connect the electrical plugs for the light box into the DC outputs of the power supply. Plug the power supply in and adjust the voltage with the knob on the front of the power supply to **NO MORE THAN 10 VOLTS DC**. Supplying more than 10 V will cause the (very expensive) light bulb to burn out.

Place the light box on a blank sheet of paper. Insert the "four slit mask” in the end of the light box farthest from the light source. Adjust the lens with the black knob on the top of the light box, until the four light rays viewed on the sheet of paper are parallel.

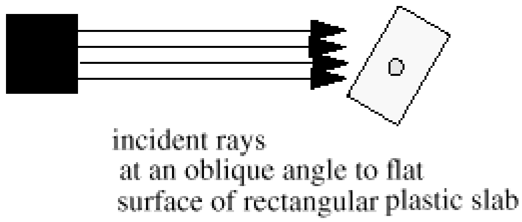
Reflection - With the lights dimmed, observe the light paths for both sides of all of the different kinds of mirrors in the light box kit. Sketch the position of the mirror. Then, sketch the rays of light before and after they strike the mirror. Answer the questions on the datasheet.



Refraction - With the lights dimmed, observe the light paths for both sides of all of the different kinds of lenses in the light box kit. Sketch the position of the lens. Then, sketch the rays of light before and after they strike the lens. Answer the questions on the datasheet.



Include the rectangular prism with the prism rotated as shown below.



Color Mixing - Use the colored slides in the optics set to observe color mixing. Drop a red color slide into the end of the light box nearest to the bulb. Open the side mirrors of the light box and drop a blue slide into one side of the light box and the yellow slide into the other side. Allow the light to fall on a white piece of paper (vertical or horizontal). By opening and closing the side mirrors, observe what new colors are created. Fill in the table on the datasheet.

Optics Report

Reflection

1) What type of mirrors cause all rays to converge at a point?

2) Pick one ray in your diagram of reflection with a plane mirror. Draw a normal to the line representing the mirror at the point where the ray strikes the mirror. Measure the angle between the "mirror" and incoming ray. This is called the angle of incidence. Now measure the angle between the mirror and the outgoing ray. This is the angle of reflection. What happened?

3) What is true about the angle of incidence and angle of reflection for the curved mirrors?

4) In your diagram of the semicircular concave mirror, measure the distance from the mirror to the point where the rays converge. This is called the focal length. The point where the rays converge is called the focal point.

5) In your diagram of the semicircular convex mirror, continue the lines representing the reflected rays back through the "mirror". Do they cross at a point? What is the focal length?

Refraction

1) What type of lenses or prisms cause all rays to converge at a point?

2) Pick one ray in your diagram of refraction with the rectangular prism. Measure the small angle between the "prism" and incoming ray. This is called the angle of incidence. Now measure the small angle between the "prism" and the outgoing ray. This is the angle of refraction. What happened?

3) What is true about the angle of incidence and angle of refraction for the curved lenses?

4) In your diagram of the convex lens, measure the distance from the lens to the point where the rays converge. This is called the focal length. The point where the rays converge is called the focal point.

5) In your diagram of the concave lens, continue the lines representing the refracted rays back through the "lens". Do they cross at a point? What is the focal length?

Color Mixing

Fill in the table below from your color mixing experiments. Report your findings from the three given combinations and three other combinations you created.

Mix Color	Mix Color	Resulting Color
Red	Blue	
Red	Yellow	
Blue	Yellow	

Lab 12: Spectroscopy

Incandescent light:
Draw the spectrograph.

1 2 3 4 5

What color is "bent" the most?

What color seems most intense?

1 2 3 4 5

Mystery Gas 1 light:
Draw the spectrograph.

What is it?

1 2 3 4 5

Mystery Gas 2 light:
Draw the spectrograph.

What is it?

1 2 3 4 5

Mystery Gas 3 light:
Draw the spectrograph.

What is it?

Lights on ceiling:
Draw the spectrograph.

1 2 3 4 5

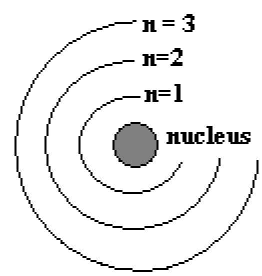
What is it?

1) Why is the spectrum of white (incandescent) light a continuous "rainbow"?

2) Why do different gasses have different "fingerprints" and what do the fingerprints tell us?

3) How can we tell what distant stars or planets are composed of?

4) Balmer developed the formula $\lambda = 3645.6 \times 10^{-8}\,\text{cm}\left(\frac{n^2}{n^2 - 4}\right)$ to predict the wavelengths of the emitted lines for Hydrogen when an electron falls from the nth shell to the 2^{nd} shell. Find the wavelengths of the first three bands by substituting 3, 4 and 5 for n.



5) Quantum Mechanics is a branch of Physics that deals with energy at the level of the atom. It states that energy cannot be released in any amount but only in discrete amounts, similar to how a water droplet has to get to a certain size before it drips. Since the bands of color represent energy releases, how do the discrete bands of color in the spectra support this idea?

Lab 13: Power Supplies

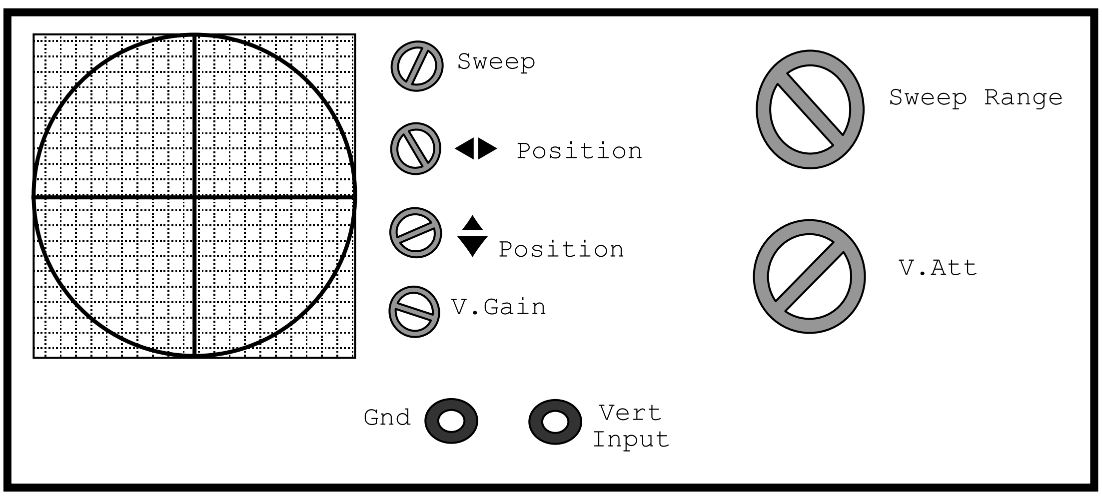
Objectives

- Learn about transformers, diodes, power supplies and how to use an oscilloscope

Equipment

- Power Supply
- Oscilloscope
- Digital multimeter (DMM)
- Demountable transformer
- Electrolytic capacitors
- Diodes
- Inductor

Procedure 1 – Oscilloscopes



- Make the following settings on the oscilloscope: the big "Sweep Range" knob to 10-100 Hz, the big V.Att to 1/100.
- Attach leads from the two terminals of a battery to the Vert Input and Gnd jacks on the oscilloscope. Draw the screen. Why is this kind of electricity called direct current?
- Attach leads from the two AC outputs on the lab power supply to the Vert Input and Gnd jacks on the oscilloscope.
- Adjust the Voltage Knob on the power supply; what changes on the screen? Why is this kind of electricity called alternating current?
- Turn the power supply on til the voltage reads 10 V.
- Adjust the small knobs to figure out what they all do.

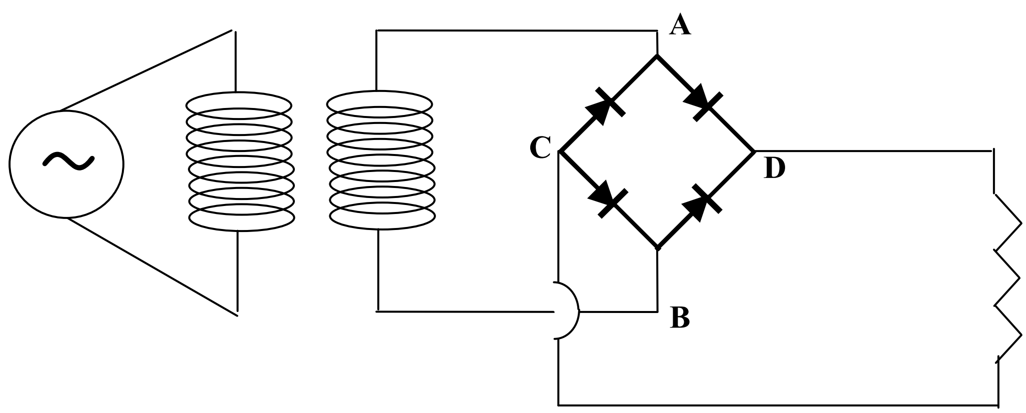
Procedure 2 - Transformers

- **Turn the power off at the power supply.**
- Attach leads from the AC outputs on the power supply to the terminals on one of the coils of the demountable transformer and place the coil on the transformer core.
- Place a second coil on the other side of the core and complete the core.

- Turn on the power supply to 12 VAC and measure the voltage at the primary and secondary coils and record these in the table.
- Calculate the voltage which should appear across the secondary with the formula $\frac{N_1}{N_2} = \frac{V_1}{V_2}$ and record this in the table
- **Turn off the power supply** and swap the primary and secondary coils by replacing the leads on the second coil and measure the voltage at the primary and secondary coils.
- **Turn off the power supply** and make other combinations of coils to complete the table.

Procedure 3 – Full Wave Rectification and Filtering

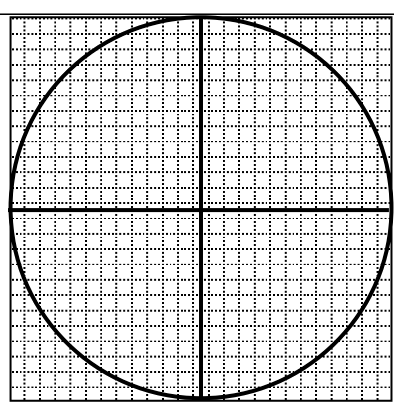
- A diode is a semiconductor device that allows current to pass in only one direction.
- Build a rectifier (bridge circuit) out of diodes as shown below and place a resistor across the outputs as shown

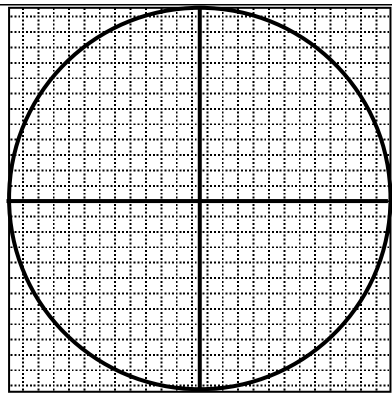


- Observe and draw the oscilloscope when you touch the leads to AB, AC, BC and CD.
- Unplug the transformer and place a capacitor in parallel with the resistor.
- Observe and draw the oscilloscope when you touch the leads to CD. Measure the DC voltage across CD. What has the circuit done?

Data Sheet for Lab 9

Procedure 1 – Oscilloscopes

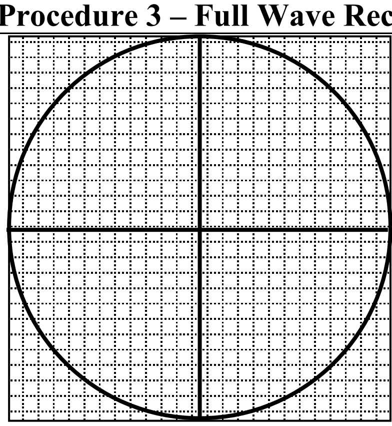
	Draw the graph of the battery output voltage. Why is this kind of electricity called direct current?

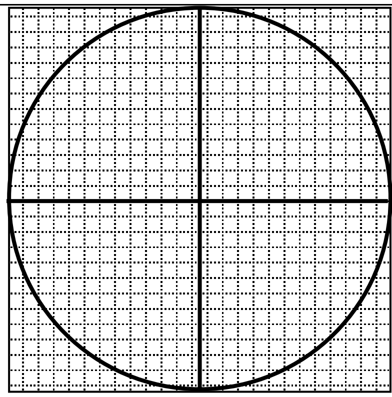
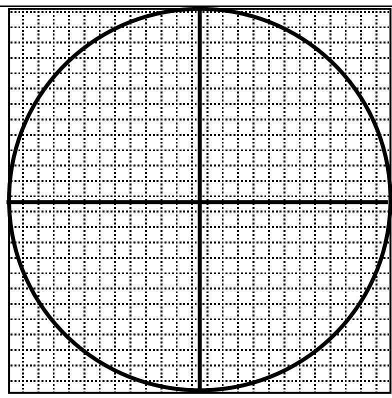
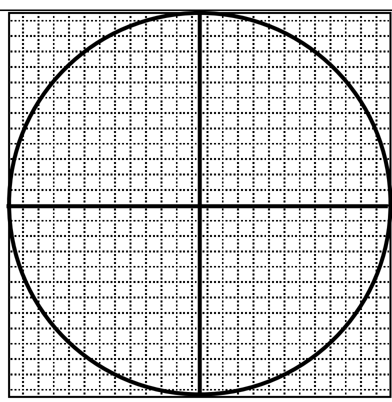
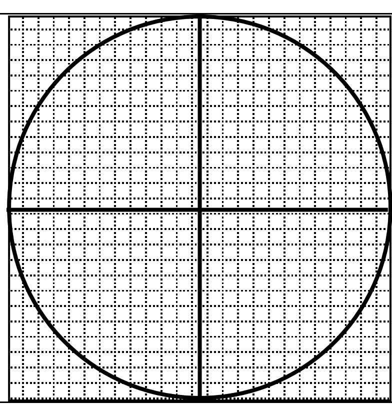
	Draw the graph of the power supply AC output voltage. Adjust the Voltage Knob on the power supply; what changes on the screen? Why is this kind of electricity called alternating current?
Describe the function of the four small knobs	
Sweep	
◀▶ Position	
▲▼ Position	
V.Gain	

Procedure 2 - Transformers

N_1	N_2	V_1	V_2	$V_{2 \text{ from formula}}$

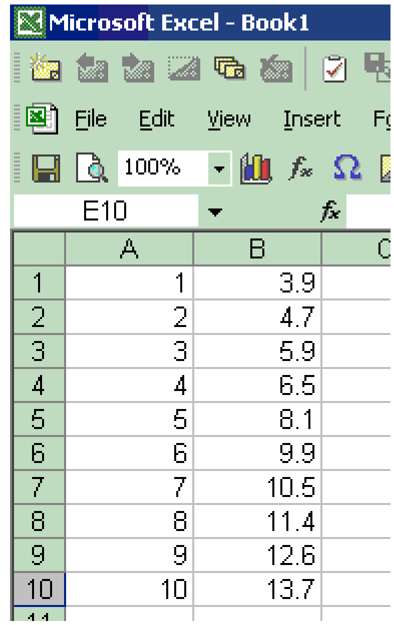
Procedure 3 – Full Wave Rectification and Filtering

	Draw the oscilloscope output points A and B. What kind of electricity is this?

	Draw the oscilloscope output points A and C. What happened to half of the oscillation?
	Draw the oscilloscope output points B and C. What happened to the other half of the oscillation?
	Draw the oscilloscope output points C and D. What happened?
	Procedure 4: Add a capacitor in parallel with the resistor. Draw the oscilloscope output points B and C. What happened?
VDC with multimeter	

Appendices

Excel Graphing

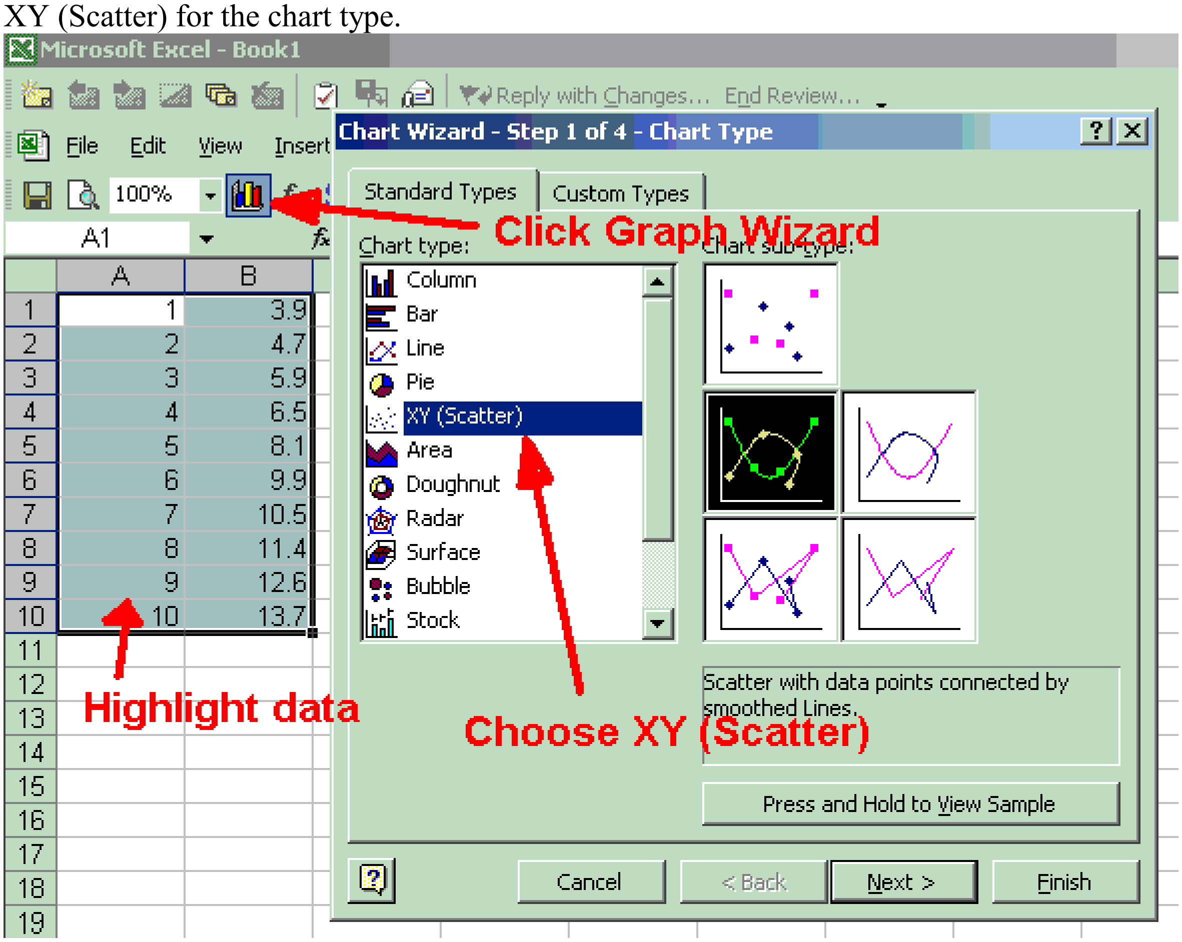


We will draw lots of graphs of the data we collect in lab this semester. Excel (or any other spreadsheet program) makes it very easy to graph and use that data. Some of the advantages to graphing in Excel rather than on paper by hand are the following:

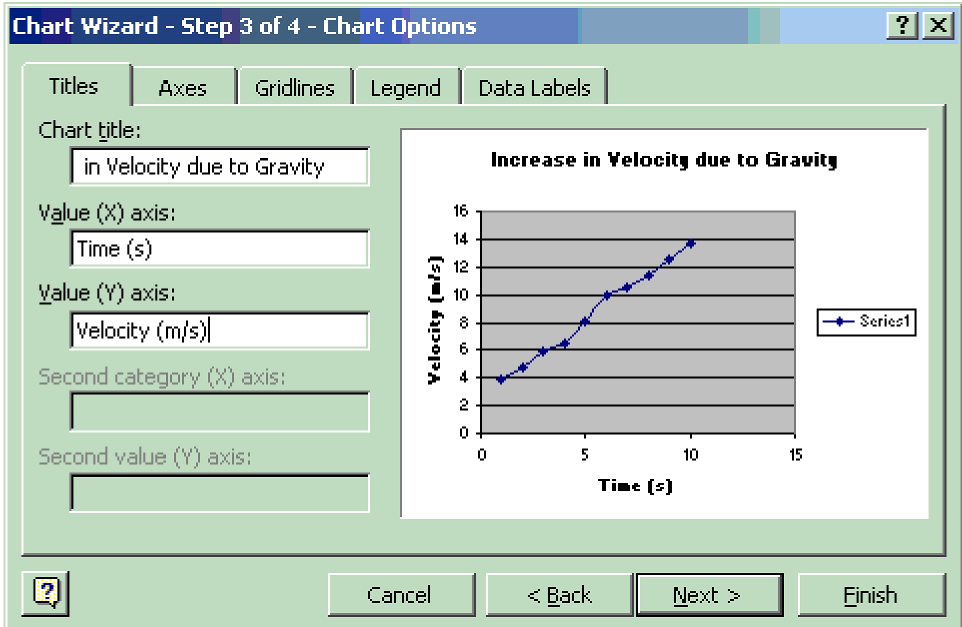
- easy and quick to do
- can print a nice looking graph with titles, units, labels
- can do linear regressions without knowing a ton of statistics
- can save, back-up, copy and email data to lab-partners or to me
- learn computer skills/valuable job skills

Step 1: Put the data into Excel: Place the data for the x-axis in column A (1,2,3...) and the data for the y-axis in column B (3.9, 4.7, ...)

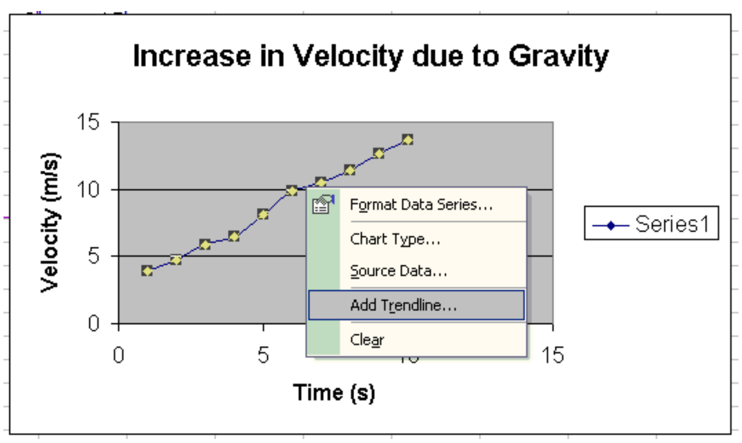
Step 2: Using the mouse, highlight the entire data block, click the Graph Wizard button, choose XY (Scatter) for the chart type.



Step 3: Click next. Click next again. Enter Chart title, X axis label, Y axis label. Click Finish

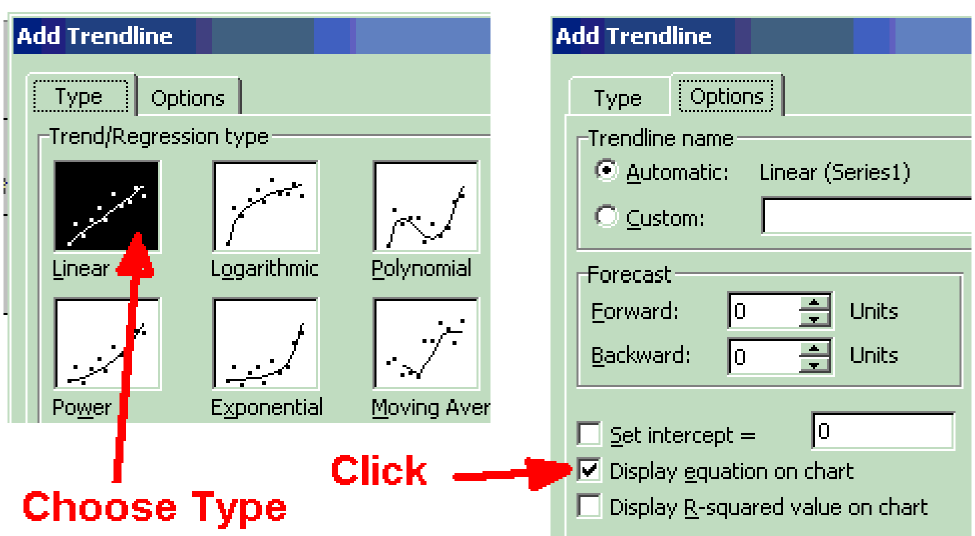


Step 4: To add a trendline, click the line connecting the data points, right click to get the window options, select Add Trendline



Step 5: Select the type of Trendline - generally linear in these labs. On the options tab, select the "Display equation on chart" option.

Step 6: To print, click on graph and click Print.



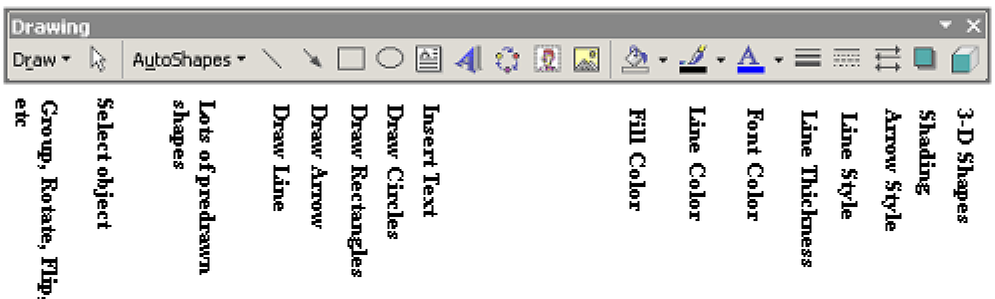
Producing Scientific/Graphical Documents with Word

There are many features included in Word (and all the other word-processing programs) to make it very easy to produce professional looking documents that include diagrams, mathematical equations, subscipts and superscripts. Hopefully this will get you started. If you have questions, come by.

Including diagrams – If you already have a diagram you would like to put in your document, click Insert:Picture:From File and go find your file.

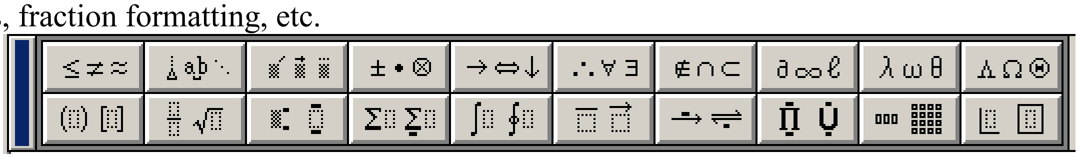
If you find a graphic on the web you want to use (assuming it's copyright free) then right-click the graphic, select copy, go to your Word document, put the cursor where you want it and right-click, select paste.

Producing diagrams – First activate the "Drawing" toolbar by clicking View:Toolbars:Drawing

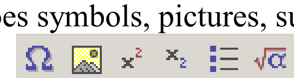


To use any of the functions shown, simply click the icon, move the mouse to where you want the object to be, and click and drag. For example, all of the diagrams in this labbook were made with this toolbar.

Including Equations – To write formatted mathematical equations, use equation editor. It is included free with MS Word (but may not have been installed on your computer). Simply click Insert:Object, select Microsoft Equation. A new window/tool bar comes up with hundreds of math symbols, fraction formatting, etc.



Subscripts and superscripts – x^3 and $v_2'^2$ are easy to do with subscript and superscript functionality in Word. Select the text you want to put up or down and click Format:Font, choose subscript or superscript.

Setting up shortcuts – If you are going to do a lot of this kind of editing it's easier to set up buttons to get there quicker. Click Tools:Customize. Any of the buttons and functions you see can be added to any toolbar, or you can build your own custom toolbar and throw all the old ones away. Here's a little toolbar I built that does symbols, pictures, superscripts, subscripts, bulleted lists and equations with the click of a button. 

TI Calculator Graphing

If a thug walked up to you in a dark alley and said "Quick, plot a quadratic regression of these data points or you're toast, buddy." would you make it out alive? The following functionality is available on the TI-83, but sometimes it's hard to recall the way to get there. This is designed to serve as a ready reference. Print, cut and fold to wallet size. The life you save may be your own.

Lists/Regress:
Clear lists: [STAT] 4 L1[,] etc.
Edit lists: [STAT] 1
Plot lists: [2nd][Y=] (set options) [GRAPH]
Regress: [STAT][▸] (choose 4 - C)
Plot Reg: [VARS] 5 [▸][▸] 1 [GRAPH]

Tables:
Setup Fcns: [Y=]
Setup: [2nd][WINDOW]
Edit: [2nd][GRAPH]
Clear: ClrTable from Catalog
Evaluate Functions:
[VARS][▸] 1 (pick fcn) [(][#][)]
Change Plot Props:
[WINDOW] or [ZOOM] or [2nd][ZOOM]

Competencies for Physics II

202 - Algebra Physics II

Fluid Mechanics
Temperature, Heat, Gas Laws,Thermodynamics
Electricity and Magnetism
Optics

Module1: Fluid Mechanics

222 - Calculus Physics II
Static Equilibrium
Fluids
Temperature, Heat, Gas Laws, and Thermodynamics
Electricity and Magnetism
Optics

Module1: Static Equilibrium

- Demonstrate an understanding of the requirements for equilibrium.
- Define center of gravity, indeterminate structure.
- Prepare force diagrams and determine forces on a body using concepts of static equilibrium.
- Obtain data in the laboratory manually and with transducers and a graphing calculator interface to verify concepts introduced in this module, and properly report results of laboratory work.

Module 2: Fluids

- Define the following: hydrostatic pressure, gauge pressure, absolute pressure, density, specific gravity, buoyant force.	- Define fluid, density, pressure, specific gravity.
- Convert SI units of pressure to other commonly used units of pressure.	- State commonly used units of pressure.
- Solve word problems involving pressure and density.	
- Demonstrate an understanding of Pascal's Principle and its applications in hydraulics.	- Apply Pascal's Principle to problems in hydraulics.
- Demonstrate an understanding of Archimede's Principle and apply this concept to situations where objects are floating and submerged.	- Apply Archimedes' Principle to problems involving floating and submerged objects.
- Demonstrate an understanding of the equation of continuity and apply this concept in solving problems in HVAC and hydraulics.	- Demonstrate an understanding of the Equation of Continuity and apply this concept to fluids in conduits.
- Use Bernoulli's equation to predict pressure in closed tubes.	- Utilize Bernoulli's Equation to estimate pressures in closed conduits.
- Demonstrate an understanding of the meaning of accuracy, precision and least count, and apply these concepts to estimate uncertainty of measurements in the laboratory.	
- Safely and properly use equipment in the laboratory in order to verify concepts introduced in this module. - Properly report results of laboratory work.	- Obtain data in the laboratory manually and with transducers and a graphing calculator interface to verify concepts introduced in this module, and properly report results of laboratory work.
	- Apply the hydrostatic equation to determine pressures in liquid columns.
	- Define buoyant force, apparent weight.
Module 2: Temperature, Heat, Gas Laws and Thermodynamics	**Module 3: Temperature, Heat, Gas Laws and Thermodynamics**
- Know four scales used to indicate temperature and be able to convert temperatures from one scale to another.	- Know four scales used to indicate temperature and be able to convert temperatures from one scale to another.
- Determine changes in length, area and volume given a change in temperature.	- Determine changes in length, area and volume given a change in temperature.
- Explain the unique behavior of water as it approaches its freezing point.	- Explain the unique behavior of water as it approaches its freezing point.
- Apply the equivalence of heat and mechanical energy in the solution of problems involving heat and work.	- Apply the equivalence of heat and mechanical energy in the solution of problems involving heat and work.
- Define specific heat, latent heat of fusion and latent heat of vaporization, and apply these concepts to problems in calorimetry.	- Define specific heat, latent heat of fusion and latent heat of vaporization, and apply these concepts to problems in calorimetry.
- State three method of heat transfer, and be aware of variables involved with each method.	- State three method of heat transfer, and be aware of variables involved with each method.
- Define ideal gas, atomic mass, atomic number, molecule, moles, kinetic theory, RMS average.	- Define ideal gas, atomic mass, atomic number, molecule, moles, kinetic theory, RMS average.
- Demonstrate an understanding of and apply the ideal gas law to determine volume, pressure, temperature, mass and number of molecules.	- Demonstrate an understanding of and apply the ideal gas law to determine volume, pressure, temperature, mass and number of molecules.
- Give examples of macroscopic and	- Give examples of macroscopic and microscopic

microscopic properties, define thermodynamic system, internal energy, isobaric process, isochoric process, isothermal process, adiabatic process, Carnot engine, thermal efficiency, cycle, ideal work, coefficient of performance, entropy.	properties, define thermodynamic system, internal energy, isobaric process, isochoric process, isothermal process, adiabatic process, Carnot engine, thermal efficiency, cycle, ideal work, entropy.
- Demonstrate an understanding of and apply the first and second laws of thermodynamics.	- Apply the first and second laws of thermodynamics to processes.
- Calculate temperature, heat flow and efficiency of Carnot engines.	- Calculate temperature, heat flow and efficiency of Carnot engines.
- Graph pressure, temperature and volume relationships for heat engines and determine work in or out of a cycle.	- Graph pressure, temperature and volume relationships for heat engines and determine work in or out of a cycle.
- Relate basic thermodynamic processes to practical applications involving steam and the compression of gases.	- Relate basic thermodynamic processes to practical applications involving steam and the compression of gases.
- Calculate coefficients of performance for refrigerators and heat pumps.	
- Determine changes in entropy for processes.	- Determine changes in entropy for processes.
- Relate entropy to probability and statistics, and its implications to philosophical concepts such as the “arrow of time”, and heat death of the universe.	- Relate entropy to probability and statistics, and its implications to philosophical concepts such as the “arrow of time,” and heat death of the universe.
- Use reference standards to evaluate and optimize procedures in the laboratory.	
- Safely and properly use equipment in the laboratory in order to verify concepts introduced in this module.	- Safely and properly use equipment in the laboratory in order to verify concepts introduced in this module.
- Properly report results of laboratory work in the following formats: scientific report, letter, memo.	- Properly report results of laboratory work.
	- State to zeroth, first, and second laws of thermodynamics.
	- Explain pressure and temperature in terms of the ideal gas theory.
	- Explain triple point of water as a reference temperature.
Module 3: Electricity and Magnetism	**Module 4: Electricity and Magnetism**
- Give practical applications involving static electricity.	- Give practical applications involving static electricity.
- Define electric charge, insulator, conductor, charging by induction, electric field, neutron, electric dipole, dipole moment, electric potential, electron volt, capacitance, electric current, resistance, internal resistance, saturation, magnetic domain.	-Define electric charge, insulator, conductor, charging by induction, electric field, neutron, electric dipole, dipole moment, electric potential, electron volt, capacitance, permittivity constant, quanta of charge, dielectric, time constant, electric current, resistance, internal resistance, saturation, magnetic domain.
- Apply Coulomb’s law to problems involving electric charges.	- Apply Coulomb’s law to problems involving electric charges.
- Compare properties of electric fields, gravitational fields and strong fields.	- Compare properties of electric fields, gravitational fields and strong fields.
- Be aware of classic and modern concepts of fields.	- Be aware of classic and modern concepts of fields.

- Determine electric field for point charges and charged plates.	- Determine electric field for point charges and charged plates.
- Determine electric potential and work in situations involving point charges and charged surfaces.	- Determine electric potential and work in situations involving point charges and charged surfaces.
- Demonstrate an understanding of relationships between charge, potential difference and capacitance.	- Demonstrate an understanding of relationships between charge, potential difference and capacitance.
- Determine capacitance of capacitors in combination.	- Determine capacitance of capacitors in combination.
- Apply Ohm's law in direct current circuits.	- Apply Ohm's law in direct current circuits.
- Determine resistance of resistors in combination.	- Determine resistance of resistors in combination.
- Determine power and energy in series and parallel electric circuits.	- Determine power and energy in series and parallel electric circuits.
- Explain the nature of magnetism in terms of atomic theory and domains.	- Explain the nature of magnetism in terms of atomic theory and domains.
- Demonstrate an understanding of relationship between electric current and magnetic field.	- Demonstrate an understanding of relationship between electric current and magnetic field.
- Use "right-hand rules" to determine direction of field, current, and force.	- Use "right-hand rules" to determine direction of field, current, and force.
- Determine magnetic forces on moving charges.	- Determine magnetic forces on moving charges.
- Determine torque on a current loop.	- Determine torque on a current loop.
- Apply Faraday's Law of Induction to problems involving conductors and magnetic fields.	- Apply Faraday's Law of Induction to problems involving conductors and magnetic fields.
- Apply Lenz's Law to determine electric and magnetic polarity.	- Apply Lenz's Law to determine electric and magnetic polarity.
- Define electromotive force and magnetic flux and apply these concepts to generators and motors.	- Define electromotive force and magnetic flux and apply these concepts to generators and motors.
- Calculate electromotive force and magnetic flux for rotating conductors, and graph these relationships versus angle and time.	- Calculate electromotive force and magnetic flux for rotating conductors, and graph these relationships versus angle and time.
- Describe a typical transformer and determine input and output relationships between voltage and current.	- Describe a typical transformer and determine input and output relationships between voltage and current.
- Safely and properly use equipment in the laboratory in order to verify concepts in electricity and magnetism.	- Safely and properly use equipment in the laboratory in order to verify concepts in electricity and magnetism.
- Properly report results of laboratory work.	- Properly report results of laboratory work.
	- Determine electric field for an electric dipole.
	- Apply Gauss' Law to determine electric field.
	- Explain the atomic view of the nature of a dielectric
	- Use Ampere's Law to find magnetic field.
Module 4: Optics	**Module 5: Optics**

- Demonstrate an understanding of models of light.	- Demonstrate an understanding of models of light.
- Define angle of incidence, angle of reflection, specular reflection, diffuse reflection, index of refraction, total internal reflection, thin lens, focal length, focal point, virtual image, real image, inverted image, dispersion, constructive and destructive interference, primary colors, chromatic aberration.	- Define angle of incidence, angle of reflection, specular reflection, diffuse reflection, index of refraction, total internal reflection, thin lens, focal length, focal point, virtual image, real image, inverted image, dispersion, constructive and destructive interference, primary colors, chromatic aberration.
- Apply the law of reflection in ray diagrams.	- Apply the law of reflection in ray diagrams.
- Apply Snell's law to problems involving refraction.	- Apply Snell's law to problems involving refraction.
- Determine object and image relations for convex and concave lens by ray tracing and using the thin lens equation.	- Determine object and image relations for convex and concave lens by ray tracing and by using the thin lens equation.
- Determine ray paths for convex, concave and parabolic mirrors.	- Determine ray paths for convex, concave and parabolic mirrors.
- Apply the lens maker's equation to determine index of refraction and focal length.	- Apply the lens maker's equation to determine index of refraction and focal length.
- Demonstrate an understanding of how lenses are used to correct nearsighted and farsighted vision.	- Demonstrate an understanding of how lenses are used to correct nearsighted and farsighted vision.
- Demonstrate an understanding of Huygen's Principle and applications in wave optics involving reflection and refraction.	- Demonstrate an understanding of Huygen's Principle and applications in wave optics involving reflection and refraction.
- Safely and properly use equipment in the laboratory in order to verify concepts in optics.	- Safely and properly use equipment in the laboratory in order to verify concepts in optics.
- Properly report results of laboratory work.	- Properly report results of laboratory work.

Tables of Physical Data

Frequently used constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
speed of light in vacuum	c, c_0	299 792 458	$\mathrm{m\ s^{-1}}$	(exact)
magnetic constant	μ_0	$4\pi \times 10^{-7}$	$\mathrm{N\ A^{-2}}$	
		$= 12.566\,370\,614... \times 10^{-7}$	$\mathrm{N\ A^{-2}}$	(exact)
electric constant $1/\mu_0 c^2$	ϵ_0	$8.854\,187\,817... \times 10^{-12}$	$\mathrm{F\ m^{-1}}$	(exact)
Newtonian constant of gravitation	G	$6.6742(10) \times 10^{-11}$	$\mathrm{m^3\ kg^{-1}\ s^{-2}}$	1.5×10^{-4}
Planck constant	h	$6.626\,0693(11) \times 10^{-34}$	J s	1.7×10^{-7}
$h/2\pi$	$\hbar$	$1.054\,571\,68(18) \times 10^{-34}$	J s	1.7×10^{-7}
elementary charge	e	$1.602\,176\,53(14) \times 10^{-19}$	C	8.5×10^{-8}
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,72(18) \times 10^{-15}$	Wb	8.5×10^{-8}
conductance quantum $2e^2/h$	G_0	$7.748\,091\,733(26) \times 10^{-5}$	S	3.3×10^{-9}
electron mass	m_e	$9.109\,3826(16) \times 10^{-31}$	kg	1.7×10^{-7}
proton mass	m_p	$1.672\,621\,71(29) \times 10^{-27}$	kg	1.7×10^{-7}
proton-electron mass ratio	m_p/m_e	$1836.152\,672\,61(85)$		4.6×10^{-10}
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,568(24) \times 10^{-3}$		3.3×10^{-9}
inverse fine-structure constant	α^{-1}	$137.035\,999\,11(46)$		3.3×10^{-9}
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	$10\,973\,731.568\,525(73)$	$\mathrm{m^{-1}}$	6.6×10^{-12}
Avogadro constant	N_A, L	$6.022\,1415(10) \times 10^{23}$	$\mathrm{mol^{-1}}$	1.7×10^{-7}
Faraday constant $N_A e$	F	$96\,485.3383(83)$	$\mathrm{C\ mol^{-1}}$	8.6×10^{-8}
molar gas constant	R	$8.314\,472(15)$	$\mathrm{J\ mol^{-1}\ K^{-1}}$	1.7×10^{-6}
Boltzmann constant R/N_A	k	$1.380\,6505(24) \times 10^{-23}$	$\mathrm{J\ K^{-1}}$	1.8×10^{-6}
Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3 c^2$	σ	$5.670\,400(40) \times 10^{-8}$	$\mathrm{W\ m^{-2}\ K^{-4}}$	7.0×10^{-6}
Non-SI units accepted for use with the SI				
electron volt: (e/C) J	eV	$1.602\,176\,53(14) \times 10^{-19}$	J	8.5×10^{-8}
(unified) atomic mass unit $1\ \mathrm{u} = m_u = \frac{1}{12}m(^{12}\mathrm{C}) = 10^{-3}\ \mathrm{kg\ mol^{-1}}/N_A$	u	$1.660\,538\,86(28) \times 10^{-27}$	kg	1.7×10^{-7}

Greek Alphabet

Α α	alpha	
Β β	beta	
Γ γ	gamma	
Δ δ	delta	
Ε ε	epsilon	
Ζ ξ ζ	zeta	
Η η	eta	
Θ θ	theta	
Ι ι	iota	
Κ κ ϰ	kappa	
Λ λ	lambda	
Μ μ	mu	
Ν ν	nu	
Ξ ξ	xi	
Ο ο	omicron	
Π π	pi	
Ρ ρ	rho	
Σ σ	sigma	
Τ τ	tau	
Υ υ	upsilon	
Φ φ ϕ	phi	
Χ χ	chi	
Ψ ψ	psi	
Ω ω	omega	

Planetary Data

Object	Radius	Mass	Orbital Radius	Orbital Period	Gravity
Sun	6.96 E8 m	1.99 E30 kg	-	-	
Mercury	2450 km	3.28 E23 kg	0.387 AU	0.241 Years	.38g
Venus	6050 km	4.90 E24 kg	0.723 AU	0.615 Years	.90g
Earth	6380 km	5.98 E24 kg	1 AU (1.5E11 m)	1 Year	g
Moon (to Earth)	1740 km	7.35 E22 kg	3.84 E8 m	29 days	.167g
Mars	3400 km	6.58 E23 kg	1.524 AU	1.881 Years	.38g
Jupiter	71500 km	1.90 E25 kg	5.203 AU	11.862 Years	2.6g
Saturn	60000 km	5.68 E26 kg	9.516 AU	29.458 Years	1.2g
Uranus	25500 km	8.97 E25 kg	19.166 AU	84.013 Years	1.1g
Neptune	25000 km	1.02 E26 kg	30.012 AU	164.793 Years	1.2g
Pluto	1200 km	1.79 E23 kg	39.557 AU	248.530 Years	.43g

Elastic Properties of Selected Engineering Materials

Material	Density (kg/m^3)	Young's Modulus 10^9 N/m^2	Ultimate Strength S_u 10^6 N/m^2	Yield Strength S_y 10^6 N/m^2
Steel	7860	200	400	250
Aluminum	2710	70	110	95
Glass	2190	65	50 (compress)	...
Concrete	2320	30	40 (compress)	...
Wood	525	13	50 (compress)	...
Bone	1900	9	170 (compress)	...
Polystyrene	1050	3	48	...

Coefficients of Friction

Material 1	Material 2	Conditions	μ
Glass	Glass	Clean	0.9 - 1.0
Wood	Wood	Clean & dry	0.25 - 0.5
Wood	Wood	Wet	0.2
Steel	Steel	Clean	0.58
Steel	Steel	Oiled	0.2
Rubber	Solids	Dry	1-4
Teflon	Steel	Clean	0.04
Waxed Hickory	Dry Snow		0.03 - 0.06
Brass	Ice		0.02 - 0.08

Speed of Sound in Various Bulk Media

Gases		Liquids at 25°C		Solids	
Material	v (m/s)	Material	v (m/s)	Material	v (m/s)
Hydrogen (0°C)	1286	Glycerol	1904	Diamond	12000
Helium (0°C)	972	Sea water	1533	Pyrex glass	5640
Air (20°C)	343	Water	1493	Iron	5130
Air (0°C)	331	Mercury	1450	Aluminum	5100
		Kerosene	1324	Brass	4700
		Methyl alcohol	1143	Copper	3560
				Gold	3240
				Lucite	2680
				Lead	1322
				Rubber	1600

Material Density (g/cm^3)

Liquids		Solids		Gasses	
Water at 4 C	1.0000	Aluminum	2.7	Air	0.001293
Water at 20 C	0.998	Copper	8.3-9.0	Carbon dioxide	.001977
Gasoline	0.70	Gold	19.3	Carbon monoxide	0.00125
Mercury	13.6	Iron	7.8	Hydrogen	0.00009
Milk	1.03	Platinum	21.4	Helium	0.000178
		Uranium	18.7		
		Ice at 0 C	0.92		

Datasheets for Lab

Data Sheet for Lab 1: Torque

Procedure 1 - Center of Gravity of a Meter Stick

Balance point of meter stick ____________ (This is center of mass of the meter stick.)

Procedure 2 – Balancing two Masses with the Balance at the Center of Mass
Draw a diagram and show calculations to determine equilibrium position of 250-gram Mass

Predicted Position of 250-gram Mass for Equilibrium ____________

Actual Position of 250-gram Mass for Equilibrium ____________ % Error ____________

Experiment 3 - Find the Mass of the Meter Stick

Balance point of the meter stick with 150-gram mass _____________
Draw a diagram and show calculations to determine the mass of the meter stick

Predicted mass of the meter stick, __________________

Actual mass of the meter stick, from balance __________________ % Error ____________

Experiment 4. Forces on a System
Draw a diagram and show calculations to determine scale readings

Predicted reading of spring scale at 15 cm mark _________________

Actual reading of spring scale at 15 cm mark _________________ % Error ____________

Predicted reading of spring scale at 95 cm mark _________________

Reading of spring scale at 95 cm mark _________________ % Error ____________

Experiment 5 - Load Suspended from a Boom
Draw a diagram and show calculations to determine reading of spring scale

Predicted reading of spring scale _________________

Actual reading of spring scale __________________ % Error ____________

Datasheet for Lab 2: Density, Specific Gravity, Pressure and Hydrostatic Pressure

Procedure 1: Density and Specific Gravity – Find the mass and volume of the following objects in order to calculate the density and specific gravity of each.

	Mass	Volume	Density g/cm^3	Density kg/m^3	Density lb/ft^3	Reference Density	% Error	Specific Gravity
Water								
"mystery" liquid								
Brass cylinder								
Brass rect. solid								
Aluminum cylinder								
Stopper with holes								
Odd shaped object								

Procedure 2: Pressure – Using the values of mass above find the pressure the objects exert on a tabletop.

	Mass	Area of contact	Pressure Pa	Pressure kPa	Pressure Atm	Pressure psi
Brass cylinder, end						
Aluminum cylinder, end						
Rectangular solid – big side						
Rectangular solid – little side						

Procedure 3: Hydrostatic Pressure – Using the values of density for the liquids find the hydrostatic pressure at the following depths.

Depth	Gauge pressure under Water (Pa)	Absolute pressure under Water (Pa)	Gauge pressure under "mystery" liquid (Pa)	Absolute pressure under "mystery" liquid (Pa)
1m				
5 m				
10 m				
100 m				
1000 m				

Datasheet for Lab 3: Archimedes' Principle/ Buoyancy

Objective: Use several methods to find the specific gravity of fluids.

	Procedure 1		Water	Fluid 1	Fluid 2
1	Mass empty cyl.	(g)			
2	Vol. Liquid	(cm^3)			
3	Mass cyl. + liq.	(g)			
4	Calc. mass liq.	(g)			
5	Calc. Density	(g/cm^3)			
6	Calc. sp. gr.				

	Procedure 2		Water	Fluid 1	Fluid 2
1	Mass of wood	(g)			
2	Init. Vol. Liquid	(cm^3)			
3	Final Vol. Liquid	(cm^3)			
4	Calc. Displaced Vol.	(cm^3)			
5	Calc. Density	(g/cm^3)			
6	Calc. sp. gr.				

	Procedure 3		Water	Fluid 1	Fluid 2
1	Mass of metal object, m_m	(g)			
2	Initial volume of fluid	(cm^3)			
3	Volume, metal submerged in fluid	(cm^3)			
4	Calc. vol. of metal, V_m (3.- 2.)	(cm^3)			
5	Apparent mass m_m' (from scale)	(g)			
6	CALC. density d_f	(g/cm^3)			
7	CALC. sp. gr.				

	Procedure 4		Water	Fluid 1	Fluid 2
1	Density of Fluid	(g/cm^3)			

Datasheet for Lab 4: Linear Thermal Expansion

Objective: Determine the coefficient of thermal expansion for aluminum, copper or iron.

	Aluminum	Brass	Copper	Iron
L_o , Initial Length (cm)				
T_i , Initial Temp (^oC)				
T_f , Final Temp (^oC)				
ΔT (^oC)				
ΔL , change in length (0.001 inch)				
ΔL , change in length (cm)				
a, Coefficient of linear expansion				
a_{Ref}	$24 \times 10^{-6} / {}^oC$	$19 \times 10^{-6} / {}^oC$	$17 \times 10^{-6} / {}^oC$	$12 \times 10^{-6} / {}^oC$
% Error				

Datasheet for Lab 5: Calorimetry

	Mass metal (g)	**Temp metal (^{O}C)**	**Mass Water (g)**	**Temp Water (^{O}C)**	**Final T (^{O}C)**	**C_{metal} (kJ/kg ^{O}C)**	**Ref. C_{metal}**	**% error**
Procedure 1 metal								
	Mass water (g)	**Temp water (^{O}C)**	**Mass fluid (g)**	**Temp fluid (^{O}C)**	**Final T (^{O}C)**	**C_{fluid} (kJ/kg ^{O}C)**	**% Diff**	-
Procedure 2 fluid								-
Procedure 3 fluid								-
	Mass 1 (g)	**Temp 1 (^{O}C)**	**Mass 2 (g)**	**Temp 2 (^{O}C)**	**Final T (^{O}C)**	**L (cal/g)**	**Ref. L**	**% error**
Procedure 4 ice								

Datasheet for Lab 6: Boyle's Law

Objective - To observe the relation between absolute pressure and volume for a gas.

Barometric pressure (from step 1.) P = ___________________ mm Hg

This will be the value of "P" in the calculation for column C below.

A	B	C	D	E	F	G
Height	Height (A/13.6)	Pressure (P+B)	Volume (step 4 to 8)	Volume Correction (step 9)	Corrected Volume	Pressure xVolume (PxF)
mm H_2O	mm Hg	mm Hg	ml	ml	ml	mm Hg mL
0						
+500						
+1000						
-500						
-1000						

Datasheet for Lab 7: Heat Engines

Procedure 1: Thermoelectric Converter Fan

Time	T_H	T_C	Rpm	ΔT	Ideal Efficiency

Questions

In terms of thermodynamics, what makes the fan turn?

Why does the fan slow down and then stop?

What happens to the efficiency/rpm of the fan? Include a graph of RPM vs. ΔT.

Why does T_C increase?

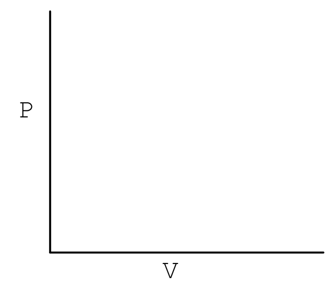
How does this illustrate entropy?

Procedure 2: Thermoelectric Converter "coil"

Time	T_H	T_C	ΔT	V

Questions
What happens to the voltage? Include a graph of Voltage vs. ΔT.

Procedure 3: Popcorn
Questions
Draw a P-V diagram of the system.

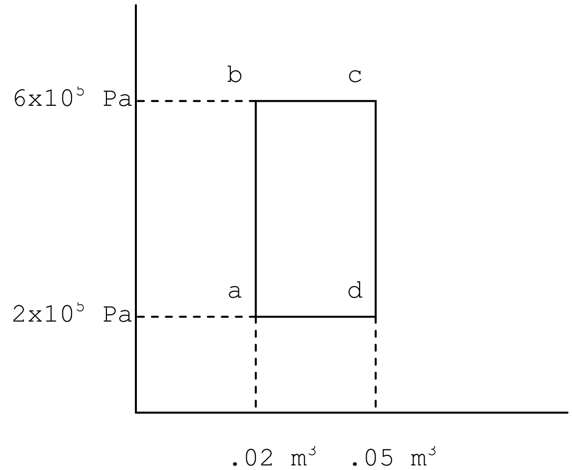


What thermodynamic process occurs while the popcorn is heating? Why?

What thermodynamic process occurs when the popcorn pops? Why?

Procedure 4: Marble in a Test Tube
Questions
Calculate the work done by the steam to lift the marble.

Consider a system that is taken along the paths shown on the P-V diagram. Assume U_a = 30,000 J.



Find the work done by the system in going from a to b.

Find the work done by the system in going from b to c.

If 20 kJ of heat enters the system along the path from a to b, what is the internal energy at point b?

If the internal energy at point c is 95 kJ, how much heat enters or leaves the system along the path from b to c?

Run it backwards: If 21 kJ of heat enters the system in going from **a to d,** what is internal energy at point d?

Run it backwards: Find the heat that enters the system along the path from d to c.

If the system is taken along the closed loop a→b→c→d→a, how much work is done?

Find the area of the rectangular path.

What is the net heat that enters the system?

Datasheet for Lab 8: Voltage, Current & Resistance

Part 1.1	Voltage at power supply	
Part 2.3	Voltage at lamp	
Part 3.2	Charge flowing to lamp	
Part 4.2	Charge flowing from lamp	

Part 5. Ohm's Law

Graph Ohm's Law data & find slope

Voltage across lamp	Current in Lamp

Part 6. Unknown resistor

6.1 ___________ volts ___________ amperes ___________ Calculated Resistance

6.2 colors __________ ____________ __________ ____________

___________ Labeled Resistance

___________ Labeled Tolerance

___________ Measured Resistance with multimeter

___________ Is resistor in tolerance?

Data Sheet for Lab 9: Capacitance

Rated capacitance of capacitor C_1 : __________ microfarads

Rated capacitance of capacitor C_2 : __________ microfarads

Rated resistance of resistor: __________ Ohms

Voltage of battery (while supplying charge in circuit): ________ volts

	C_1	C_2	C_1 & C_2 In Series	C_1 & C_2 In Parallel
Calc/Rated Capacitance				
Calculated Time Constant				
Time (s)	Current (μA)	Current (μA)	Current (μA)	Current (μA)
5 s				
10 s				
15 s				
20 s				
25 s				
30 s				
35 s				
40 s				
45 s				
50 s				
55 s				
60 s				
Measured Time Constant				
Triang. Charge				
Triang. Capac.				
Trap. Charge				
Trap. Capac.				
Simps. Charge				
Simps. Capac.				

Datasheet for Lab 10: Magnetism & Induction

Procedure 1 – Magnetic Poles – using magnets and a compass answer the following questions.	
Does the south pole of a bar magnet attract or repel the north-pointing needle of the compass?	
Does the north pole of a bar magnet attract or repel the north-pointing needle of the compass?	
What is the polarity of the north pole of the Earth?	

Procedure 2 – Magnetic Field Lines
Include the sketches with your report.

Procedure 3 – Electromagnetic Poles	
Use the right-hand rule to predict whether the north pole of the compass needle will be attracted or repelled when the knife switch is closed.	
Based on the deflection of the compass needle, what is the polarity of the electromagnet?	
Describe how the right-hand rule confirms the polarity observed with the compass needle.	

Procedure 4 – Electromagnetic Induction – describe the effects of inserting a magnet into a coil of wire on a galvanometer.

Insert a bar magnet into a	**55 turn coil**	**800 turn coil**
North pole quickly		
South pole quickly		
North pole slowly		
South pole slowly		

Explain what effect the following factors have:

- magnetic polarity (north or south pole of magnet)
- number of turns of wire in coil
- speed of the magnet

Describe how the results confirm the formula $\mathrm{EMF} = \mathrm{V} = -\mathrm{N}\dfrac{\Delta\Phi}{\Delta t} = \dfrac{-\mathrm{N}(\mathrm{BA} - \mathrm{B_0A_0})}{t}$

Would it make any difference if the magnet remained stationary and the coil moved into the magnet? Why?

Procedure 5 – Magnetic Pole Strength

Show your calculations to determine the magnetic pole strength, M, from the relationship:

$$B_E = 10^{-7}\ \text{Wb/Am}\ (d_1^{-1} - d_2^{-1})\ M$$

Procedure 6 Magnetic Induction

Briefly describe what happened.

Datasheet for Lab 11: Optics

Optics Report

Reflection
1) What type of mirrors cause all rays to converge at a point?

2) Pick one ray in your diagram of reflection with a plane mirror. Draw a normal to the line representing the mirror at the point where the ray strikes the mirror. Measure the angle between the “mirror” and incoming ray. This is called the angle of incidence. Now measure the angle between the mirror and the outgoing ray. This is the angle of reflection. What happened?

3) What is true about the angle of incidence and angle of reflection for the curved mirrors?

4) In your diagram of the semicircular concave mirror, measure the distance from the mirror to the point where the rays converge. This is called the focal length. The point where the rays converge is called the focal point.

5) In your diagram of the semicircular convex mirror, continue the lines representing the reflected rays back through the “mirror”. Do they cross at a point? What is the focal length?

Refraction
1) What type of lenses or prisms cause all rays to converge at a point?

2) Pick one ray in your diagram of refraction with the rectangular prism. Measure the small angle between the "prism" and incoming ray. This is called the angle of incidence. Now measure the small angle between the "prism" and the outgoing ray. This is the angle of refraction. What happened?

3) What is true about the angle of incidence and angle of refraction for the curved lenses?

4) In your diagram of the convex lens, measure the distance from the lens to the point where the rays converge. This is called the focal length. The point where the rays converge is called the focal point.

5) In your diagram of the concave lens, continue the lines representing the refracted rays back through the "lens". Do they cross at a point? What is the focal length?

Color Mixing

Fill in the table below from your color mixing experiments. Report your findings from the three given combinations and three other combinations you created.

Mix Color	**Mix Color**	**Resulting Color**
Red	Blue	
Red	Yellow	
Blue	Yellow	

Datasheet for Lab 12: Spectroscopy

Incandescent light:
Draw the spectrograph.

1 2 3 4 5

What color is “bent” the most?

What color seems most intense?

1 2 3 4 5

Mystery Gas 1 light:
Draw the spectrograph.

What is it?

1 2 3 4 5

Mystery Gas 2 light:
Draw the spectrograph.

What is it?

1 2 3 4 5

Mystery Gas 3 light:
Draw the spectrograph.

What is it?

Lights on ceiling:
Draw the spectrograph.

1 2 3 4 5

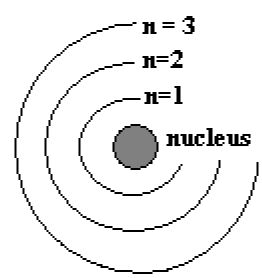
What is it?

1) Why is the spectrum of white (incandescent) light a continuous “rainbow”?

2) Why do different gasses have different “fingerprints” and what do the fingerprints tell us?

3) How can we tell what distant stars or planets are composed of?

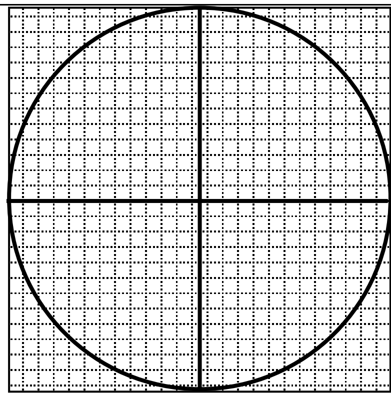
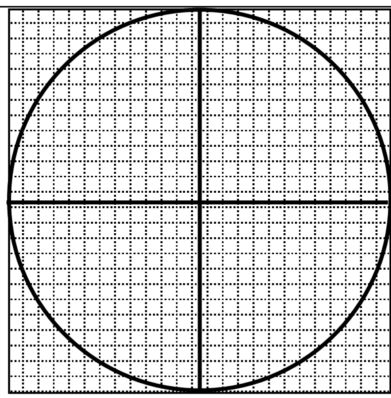
4) Balmer developed the formula $\boxed{\lambda = 3645.6 \times 10^{-8}\,\text{cm}\left(\frac{n^2}{n^2 - 4}\right)}$ to predict the wavelengths of the emitted lines for Hydrogen when an electron falls from the nth shell to the 2nd shell. Find the wavelengths of the first three bands by substituting 3, 4 and 5 for n.



5) Quantum Mechanics is a branch of Physics that deals with energy at the level of the atom. It states that energy cannot be released in any amount but only in discrete amounts, similar to how a water droplet has to get to a certain size before it drips. Since the bands of color represent energy releases, how do the discrete bands of color in the spectra support this idea?

Datasheet for Lab 13: Power Supplies

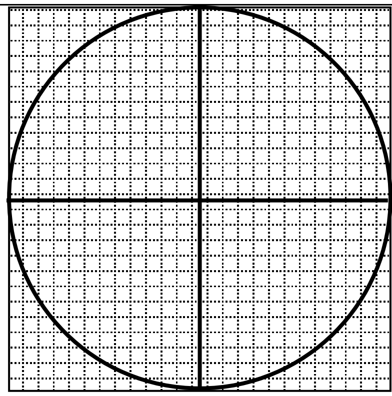
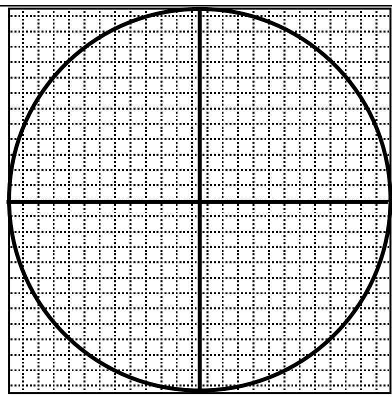
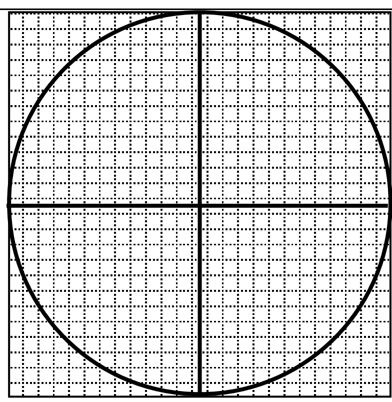
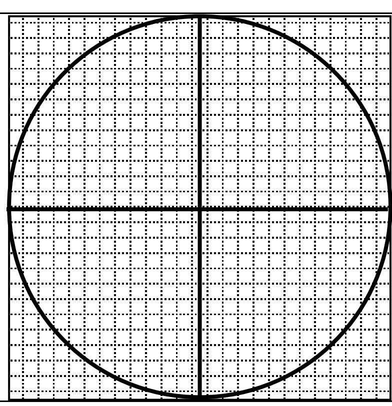
Procedure 1 – Oscilloscopes

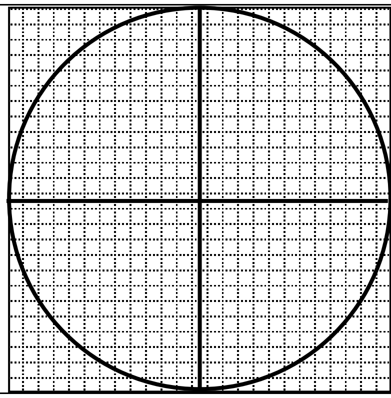
	Draw the graph of the battery output voltage. Why is this kind of electricity called direct current?
	Draw the graph of the power supply AC output voltage. Adjust the Voltage Knob on the power supply; what changes on the screen? Why is this kind of electricity called alternating current?
Describe the function of the four small knobs	
Sweep	
◀▶ Position	
▲▼ Position	
V.Gain	

Procedure 2 - Transformers

N_1	N_2	V_1	V_2	$V_{2\text{ from formula}}$

Procedure 3 – Full Wave Rectification and Filtering

	Draw the oscilloscope output points A and B. What kind of electricity is this?
	Draw the oscilloscope output points A and C. What happened to half of the oscillation?
	Draw the oscilloscope output points B and C. What happened to the other half of the oscillation?
	Draw the oscilloscope output points C and D. What happened?

	Procedure 4: Add a capacitor in parallel with the resistor. Draw the oscilloscope output points B and C. What happened?
VDC with multimeter	