Semester II lab quiz Study Guide (E&M, Optics)
Physics 136/164

In this guide, lab titles/topics are listed alphabetically, with a page break in between each one.

You are allowed to refer to your handwritten lab notebook during quizzes, and to the pre-lab and post-lab exercises, but not to the printed lab manual.

Students work alone on lab quizzes.

Questions and tasks on the lab quizzes are based directly on what you have learned and done in lab activities. Therefore you should expect to turn in a perfect quiz if your lab notebook is complete, detailed, well-written and explains completely how you carried out activities and interpreted them. Patience and extreme care will be rewarded, but careless mistakes will be costly.

TIPS:
Read the descriptions and sample questions, discuss them with your lab partners, and please come in with any questions.

Be familiar with the experiments, calculations and concepts.

Check your work and pay attention to details; verify and include units, label graph axes, read and use your calculator carefully.

Keep a neat lab notebook with diagrams and details, and answer all questions with full sentences in your lab notebook.

Atomic Spectra

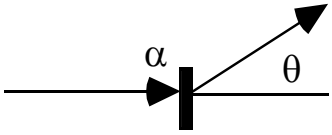
Given a gas discharge tube apparatus containing an unknown gas, measure some wavelengths with a spectrometer and identify the gas in the tube (you would be provided with some tables of characteristic wavelengths for various gases). You may also be given the angles.

Given a lamp filled with a known gas and a table of wavelengths, determine at which angles the spectral lines would appear for the n=1 "bright band" (the first set of lines).

Be able to convert between inverse angstroms, inverse centimeters, inverse millimeters, inverse meters.

Given the number of lines per mm/cm/m, calculate the slit spacing (or vice versa).

Calculate one of the following quantities, given the others: slit spacing, either angle in the picture, wavelength of the light.



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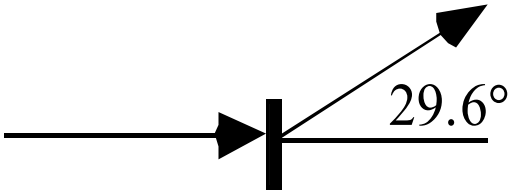
SAMPLE

Light from an excited, gas-filled discharge tube enters a diffraction grating, and a narrow colored line is seen at the angle indicated. This diffraction grating has 700 slits per millimeter. Note that this may be **different** than the grating that some of you used in lab.

a. What is the distance between adjacent slits? Report the answer in m.
b. What is the wavelength of that spectral line? Use the customary units of angstroms when reporting spectral wavelengths.



DC Circuits I and II

Given a table of current and voltage data for an arbitrary resistor, plot V vs. I and determine the resistance from analyzing the graph.

Be able to physically set up a circuit with specified resistor(s) in series or parallel with other resistor(s), or with combinations of resistors. Be able to place voltmeters and ammeters to measure the voltage or current across/through any circuit element or combination of elements.

Be able to measure the resistance of resistors using a multimeter.

SAMPLE
The current vs. voltage characteristics for an unknown resistor are indicated in the table below.

V (volts)	I (mA)
1	0.35
2	0.68
3	1.02
4	1.35
5	1.60

a. On graph paper, make a large graph of voltage vs. current.
b. What is the resistance of the resistor? Include units. Use the graph to determine your answer, and explain your reasoning.

SAMPLE
Please go to a test bench where you will find two multimeters, a power supply, and a resistor board.
Set everything up so that:
a. The power supply is outputting **seven** (7.0) volts through the load. Remember, don't trust the needle pointer display. Use one of the meters just to check the initial value; it won't drift much after that.
b. The load has resistors 1 and 3 in series with each other, and the combination is in parallel with resistor 2.
c. One of the meters measures the voltage across the series combination.
d. The other meter measures the current through resistor 2.

SAMPLE
a. Draw a circuit diagram, involving a power supply, a voltmeter, an ammeter, and two 500 ohm resistors connected in parallel, set up so that the ammeter measures the current through only one of the resistors and the voltmeter measures the voltage across it.
b. If the power supply is set at 8.0 V, what will be the reading of the voltmeter? What will be the reading of the ammeter?

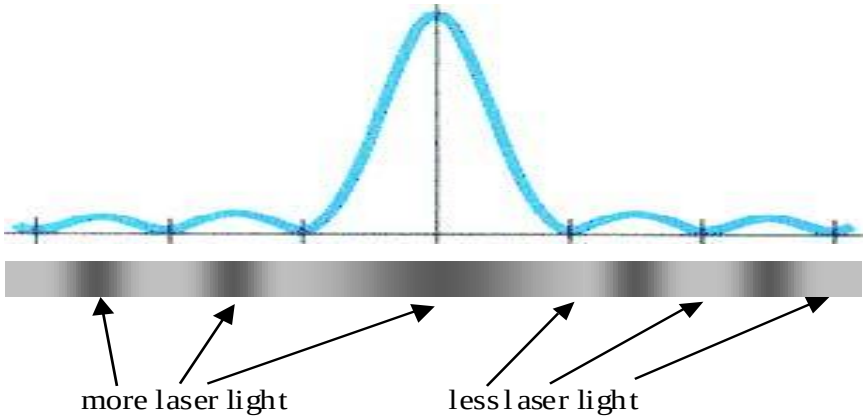
Diffraction and Interference of Light

Given an actual-size pattern observed on a screen when a laser of a certain wavelength shines through one or two narrow slits…

- determine whether there is 1 slit or 2.
- Calculate one of the following quantities, given the others: distance from the slit(s) to the screen, wavelength of the laser, width of the single slit, or distance between the centers of the 2 narrow slits.

SAMPLE

1. Here is the *actual–size* pattern projected on a screen when a laser (NOT NECESSARILY the same color that you used in lab) shines through a single narrow slit.



The shaded regions represent bands of light, seen against the white screen. For example, the central shaded band is a bright region, with more laser light. (In other words, the graph represents light intensity vs. position.) The screen is a distance 3.18 m beyond the slit plate.

The width of this slit is 80.4 μm. Calculate the wavelength of the light in nanometers.

2. If a double slit is turned into a triple slit by adding a third narrow opening halfway between the original two openings in the double slit, what happens to the distance between bright fringes on the screen?

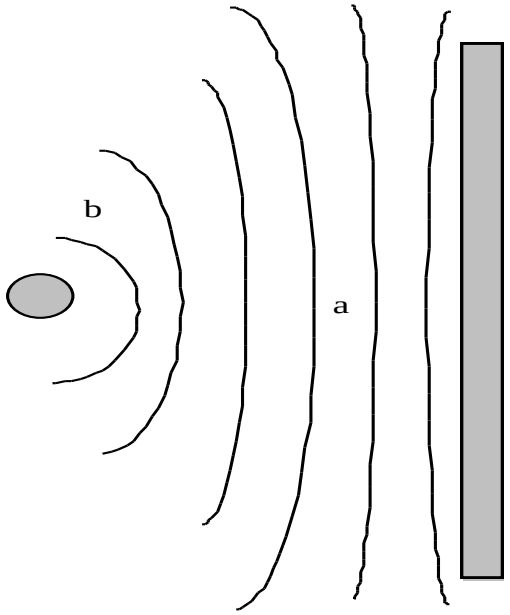
Electric Field and Electric Potential

Given a map of equipotential lines, draw E field lines (or vice versa).
Estimate (quantitatively) the E field strength and direction at any point.

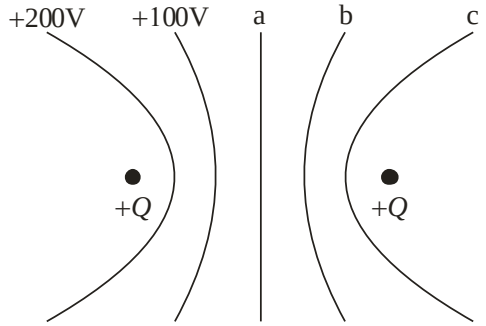
SAMPLE

A seven volt battery is connected across two electrodes, positive terminal to the oval electrode and negative terminal to the flat electrode. The figure shows portions of the equipotential lines between two electrodes, with each line indicating an electric potential that differs by one volt from that of adjacent lines.

Draw the electric field lines for this electrode configuration. Indicate the direction of the electric field by using arrowheads.
What is the magnitude of the electric field at point a? Point b? Include units.



Two equal positive charges are placed one meter apart (see figure below). The equipotential lines are at 100 V intervals. What is the potential for line c? Include units.



Electromagnetic Induction

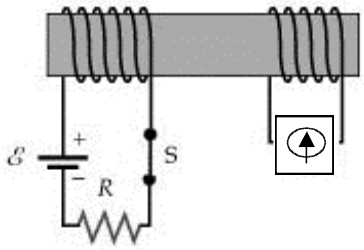
Given a circuit similar to the one below, determine* which way the galvanometer needle deflects when…

- the switch is closing, or opening
- the coils are moved toward or away from each other
- the resistance of R is suddenly decreased or increased (this could be done by cooling it down or heating it up, for example)
- magnets are moved near the secondary coil. (e.g., "A south pole is suddenly brought in from the right side. Which way does the needle deflect?")

*To receive any credit, you must get far more than 50% of them correct, and be prepared to show all reasoning, such as information on the direction and magnitude of the primary and secondary fields (e.g., "it points left") and the direction of current flows (e.g, "clockwise as seen from the right").

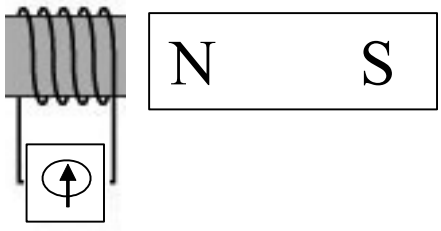
SAMPLES 1 and 2

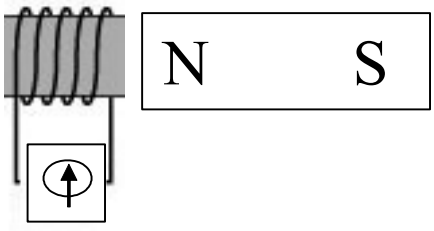
1. The primary coil slides to the right, closer to the secondary coil.
2. The resistance of R is suddenly increased.



SAMPLES 3 and 4

The magnet below moves to the right, so it is moving away from the secondary coil. (Do it for each of the diagrams. Note how the two diagrams differ.)





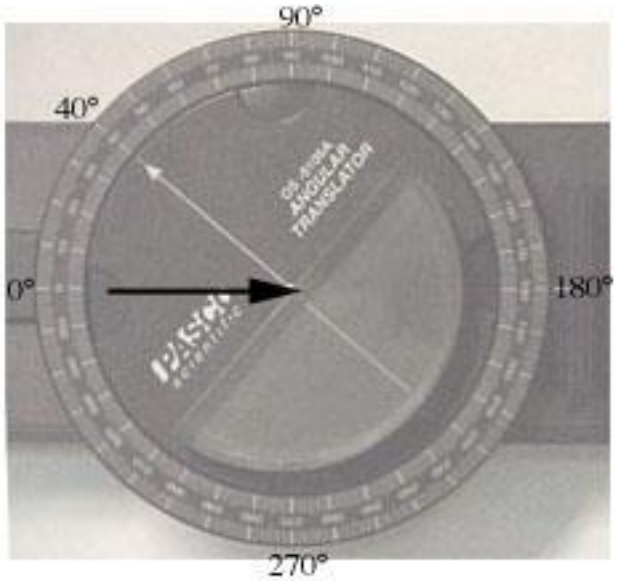
Geometrical Optics

Given a semicircular prism like you had in the Snell's Law lab, calculate one of the following quantities, given the others: index of refraction, angle of an incoming light beam or its complement, angle of refracted light beam or its complement, speed of light in the material. Be able to draw a scale diagram of the incoming and refracted rays, using a protractor.

Given a diagram of a plane mirror and an incoming or outgoing light ray, determine the direction of the other ray.

Given a ray trace diagram, determine the focal length of a converging lens or of a diverging lens.

Example: A narrow beam of light comes in from the left and shines on a semicircular piece of plastic, and the arrow points to the 40° mark as shown. The index of refraction of this material is 1.8. Determine the *angular position at which the viewing screen should be placed* so that the REFRACTED beam of light will hit the center of the screen. Besides giving the angle, place an "X" at that location on the picture to confirm that it makes sense.



Kirchhoff's Laws

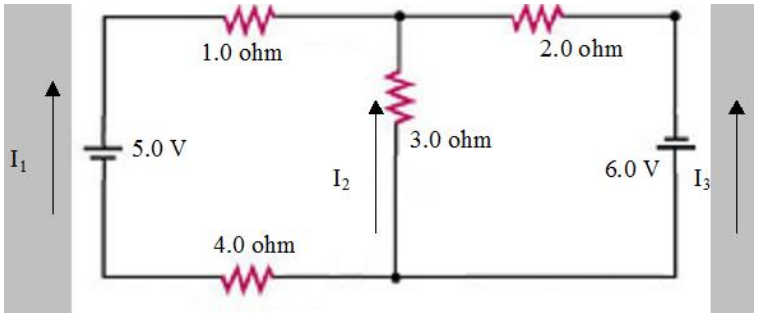
Given a multiloop circuit with any number of batteries and any number of resistors (such as the example shown), apply Kirchhoff's 2 laws and write down equations that could be solved to find all of the unknown currents. Note that the circuit and/or its labels will **not** be the same ones you analyzed in lab.

Given a set of simultaneous equations for up to 3 unknown variables (e.g., currents, resistances, or battery voltages), solve the system of equations for the 3 unknowns. Be able to interpret the sign of an unknown current to determine which way the current flows "in real life."

Given some resistors with an unknown current flowing through each one, and a multimeter, determine the amount (and flow direction) of each of the unknown currents.

SAMPLE 1

In this sample, you are asked to write down the unknown equations, AND to solve them, so this is more than will be required on a quiz (though you could be asked either of the 2 parts). If more batteries or more resistors were added to the diagram, you should know how to include them in your equations.



(You may check your final answers with these:)

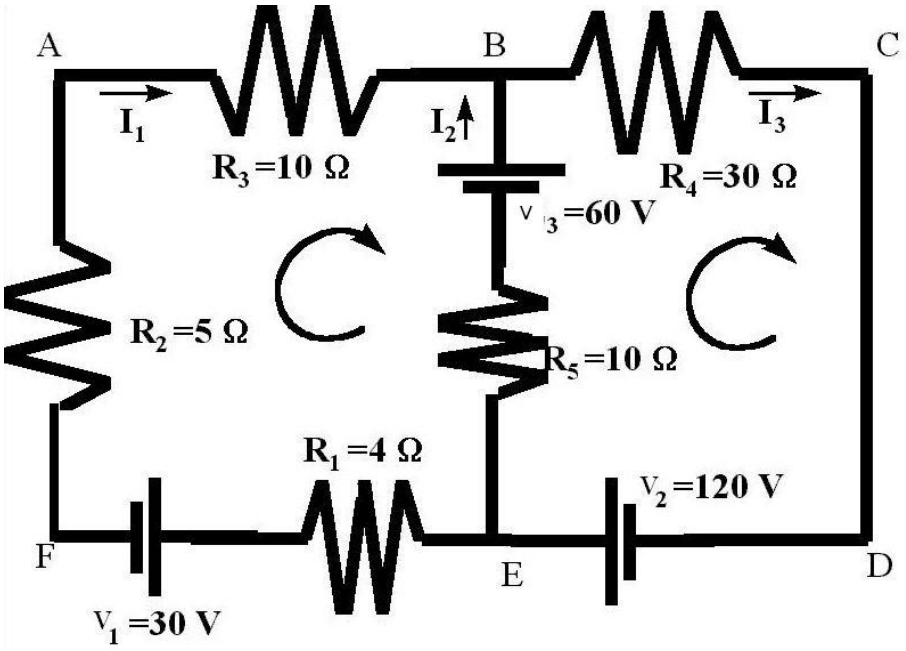
I1 = +43/31 amps, so it's passing through 1.0 Ω from left to right

I2 = +20/31 amps, coming up the middle

I3 = - 63/31 amps, so in real life it's passing through 2.0 Ω from left to right

SAMPLE 2

In this sample, you are asked to write down the unknown equations, AND to solve them, so this is more than will be required on a quiz (though you could be asked either of the 2 parts). If more batteries or more resistors were added to the diagram, you should know how to include them in your equations.



If you want to check your equations, the solutions, in amperes, are:

$$I_1 = -1\frac{37}{53}\text{ A} \approx -1.698\text{ A}$$

$$I_2 = 5\frac{41}{53}\text{ A} \approx 5.774\text{ A}$$

$$I_3 = 4\frac{4}{53}\text{ A} \approx 4.075\text{ A}$$

The negative sign on the first current means that the real-life current actually flows opposite to direction of the initial guess.

That is, you initially guessed that I_1 flowed upward, from location F toward location A. The negative sign for that variable in the solution simply means that when you set up the circuit, in real life a current of 1.698 amperes flows from location A to location F, *downward* through resistor R_2.

Polarized Light

With 2-3 polarizers, and appropriate given information, solve for unknowns: orientations (angle of polarizers), intensity after passing through all polarizers (using Law of Malus), intensity between any two polarizers, initial intensity, initial state of polarization

SAMPLE

A beam of initially unpolarized light travels through 3 closely-spaced, ideal polarizers. WHEN THE POLARIZERS ARE ALL ALIGNED, the intensity of light after it has passed through all three polarizers is 10 lux. Now they are arranged as follows: the "pass axis" of the first polarizer is oriented vertically, the pass axis of the second is oriented at 35° from the vertical, and the third polarizer has its pass axis exactly horizontal.

What is the intensity of the light between the second and third polarizers? (6.71 lux)

What is the intensity of light after it's passed through the third polarizer? (2.21 lux)

What is the intensity of the initially unpolarized light? (20 lux)

Thin Lenses

Given a ray diagram, determine the focal length of a converging lens.

Given a diagram like the following, with an object at A and the final image at C, know how to use the thin lens equation and the sign conventions that go with it, for any two-lens problem.

For example, you may be asked to determine the location of the intermediate image given x1, x2 and f1. You should realize that this is the object for lens 2. Or, given x3, x4 and f2, determine where the object for lens 2 is, and hence the location of the intermediate image.

As another example, you can deduce the focal length of either lens, given sufficient information such as all of the x positions and either the location of the intermediate image or the focal length of the other lens.

SAMPLE

The experimental set-up pictured below has 2 lenses, located as indicated. The first lens is a lens with focal length of +120 mm. The object to be imaged is located at point A, at x=10 cm. The final image is seen on a white screen located 8.25 cm to the right of the second lens, at point C.

a. Where is the intermediate image located, i.e., the image formed by the first lens?
b. What is the focal length of the second lens, in mm?