PHY 1120

Final Exam
Summer 2020

Name Alex Yeoh Table #_____

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Answer 3 of 4 PSP questions

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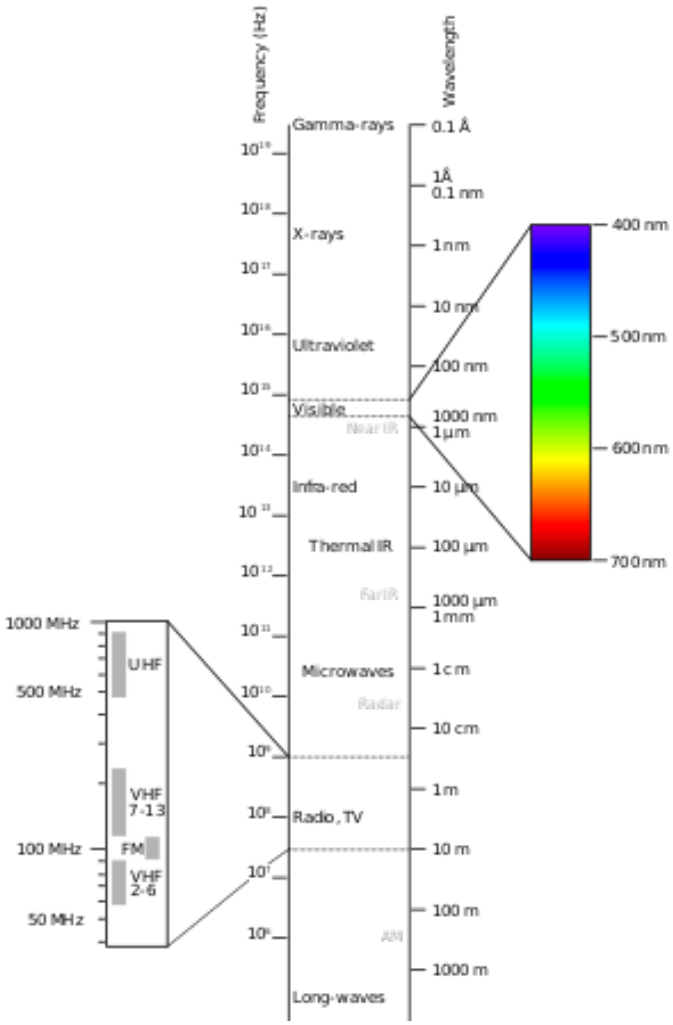
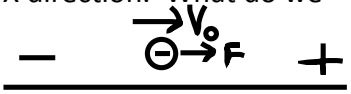
Total _____ / 150 pts



Clearly check or fill in the box in front of the answer(s) you are selecting. Each question will have at only one correct answer. (2 pts. each)

1) An electron is traveling at an increasing velocity in the +X direction. What do we know about the E-field in this situation?

- ☐ E-field is in the +X direction
- ☐ E-field is Zero
- ☒ E-field is in the -X direction
- ☐ Depends on the size of the base charge



Increasing velocity implies a force pulling/ pushing in the x+ direction, since the charge is negative, the E-field would be anti-parallel

2) If a capacitor has the area of it's plates doubled, how does the capacitance change?

- ☐ The capacitance is halved
- ☒ The capacitance doubled
- ☐ The capacitance is quadrupled
- ☐ The answer depends on the voltage

$C=\varepsilon^*A/d$
doubling A doubles C

3) For a simple circuit, if I double the voltage and keep the resistance fixed, what happens to the Power used by that circuit?

- ☒ The power is quadrupled
- ☐ The power is doubled
- ☐ The power is unchanged
- ☐ The power is halved

$P=V^2/R$
if V gets doubled, the doubling gets squared making power 4x

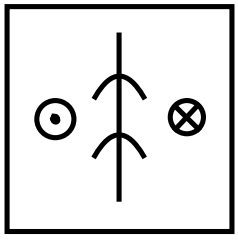
4) Three resistors, 37 Ω, 97 Ω, 57 Ω, are connected in parallel. What is the total resistance of the circuit?

- ☐ 0.055 Ω
- ☒ 18 Ω
- ☐ 191 Ω
- ☐ Answer not provided

Rtotal = 1/(1/r1+1/r2+1/r3)=1/(1/37+1/97+1/57)=18.22

5) A wire is laying on the table in front of you and extends from the near edge of the table to the far edge. If the current goes away from you, which way does the magnetic field, on the left side of the wire, point?

- ☐ Away from you, parallel to the table
- ☐ Into, and perpendicular, to the table
- ☒ Out of, and perpendicular, to the table
- ☐ Toward you, parallel to the table



Because of RHR #1, the mag field on the left of a wire with a current flowing away would be out of the table

6) A coil of wire with an area of 0.3 m^2 consisting of 7 loops experiences a perpendicular magnetic filed that is 0.5 Teslas. What is the total magnetic flux through the loops?

- ☐ 0.00 Wb
- ☐ 0.15 Wb
- ☐ 0.32 Wb
- ☒ 1.05 Wb

Flux=BA=0.5*0.3=0.15
because there are 7 loops
7*15=1.05

7) Orange light has a wavelength of 600 nm. If I halve the frequency, what is true about the new light?

- ☐ It is now ultraviolet light
- ☐ It's still orange but the lightwave travels slower
- ☐ It's still orange but the lightwave travels faster
- ☒ It's now infrared light

c=f*λ
λ=c/f
halving frequency
λ=c/(0.5f)
2λ=c/f
new wavelength = 1200nm
because light always moves at a constant speed

8) A mirror produces an image with a magnification of +5. Describe the location, size, and orientation of the image produced. Circle one from each pair of answers

Same side as object / opposite side as object
Upright / Inverted
Real / Virtual
Enlarged / Reduced

m=hi/ho=-di/do
5=hi/ho=-di/do
hi must be larger than ho
di must be negative and larger than do
because this is a mirror and di is negative, it must be virtual
because magnification is >1 it must be enlarged

9) In the Young's Double-Slit experiment, if we double the distance between the slits, what happens to the distance between the first and second maxima?

- ☐ The distance is doubled
- ☐ The distance increases, but is not doubled
- ☐ The distance increases, but is not halved
- ☒ The distance is halved

x=mλl/d
if d doubles, x is halved

10) Two, 5-Ohm resisters, in series, are attached to a 12V battery. If you increase the resistance of the first resistor (R1), what happens to the current through the second (R2)?

- ☐ The current through R2 increases and is now greater than the current through R1
- ☐ The current through R2 decreases and is now less than the current through R1
- ☐ The current through R2 increases and is the same as the current through R1
- ☒ The current through R2 decreases and is the same as the current through R1

Because they are in series
Iseries=I1=I2

an electron is ejected because
the work-function < the photon

because the electron is ejected
it can't have 0 kinetic energy,
and kinetic energy can't be 0

11) A 3.2 eV photon hits a metal electrode with a work-function of 2.3 eV. What can be said about this situation?

- [x] an electron is ejected from the surface with a positive Kinetic Energy
- [ ] an electron is ejected from the surface but has no Kinetic Energy
- [ ] an electron is ejected from the surface with a negative Kinetic Energy
- [ ] an electron is not ejected from the surface

12) Which color of light has a greater amount of energy?

- [ ] Red
- [ ] Orange
- [ ] Green
- [x] Blue

Wavelength is inversely proportional to energy

13) Two 10 µC charges, one positive and one negative, are spaced 10 cm apart, what is the electric potential in the middle between the two ?

- [ ] 3,600,000 V
- [ ] 1,800,000 V
- [x] 0 V
- [ ] More information needed

V=kq/r=9e9*10e-6/0.1=900000
V=kq/r=9e9*-10e-6/0.1=-900000
Net potential =0V

14) The primary side of a transformer takes in 120 Volts and has 75 coils. The secondary side of the transformer has an output voltage of 24 Volts, how many coils are on the secondary side?

- [x] 15 Coils
- [ ] 75 Coils
- [ ] 300 Coils
- [ ] More information needed

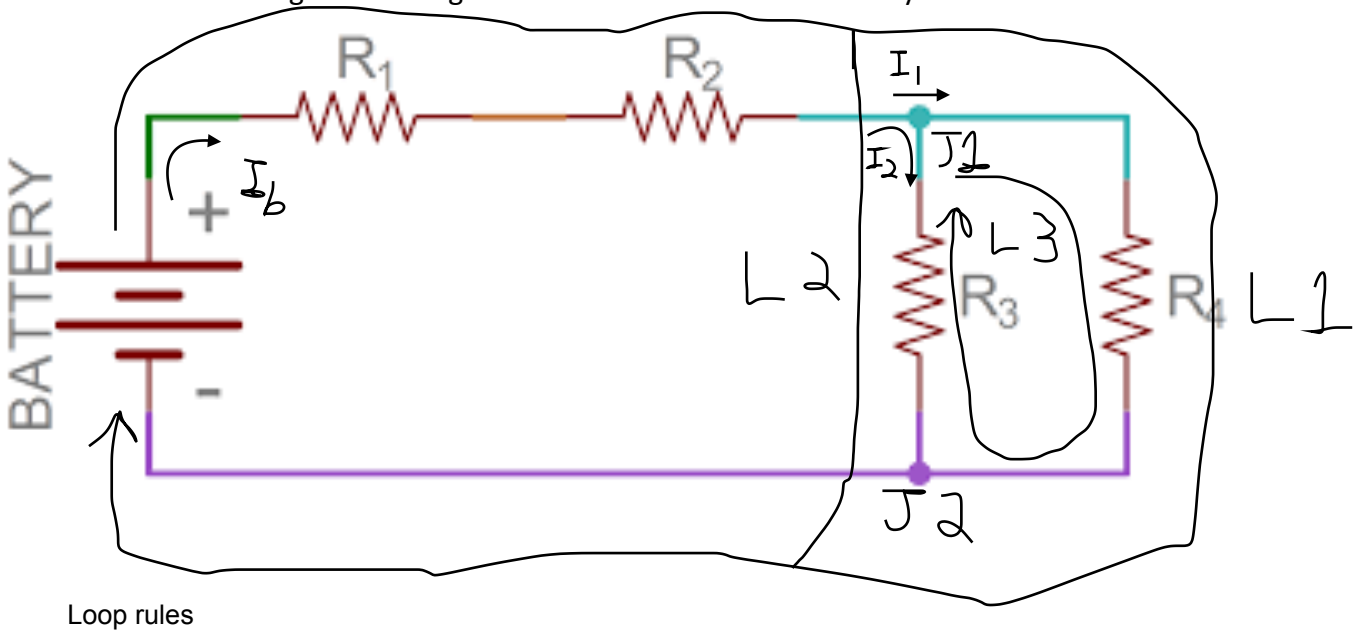
Vs/Vp=Ns/Np
Ns=Vs*Np/Vp=24*75/120=15

15) When using a lens to magnify the text for reading, what is true about the focal length, object distance, and image distance?

- [x] f is positive.
- [ ] f is negative.
- [x] d_o is positive.
- [ ] d_o is negative.
- [x] d_i is positive.
- [ ] d_i is negative.

PSP Style: Solve the problem. Make sure to show your work in **detail**. Answer any THREE of the PSP problems. (25 pts each)

16) Given the circuit below, write ALL of Kirchhoff's Equations. Write the equations in terms of variables. $R_1 = 12\ \Omega$, $R_2 = 47\ \Omega$, $R_3 = 24\ \Omega$, and $R_4 = 37.5\ \Omega$, determine the current through and voltage across each resistor if the battery in the circuit is 48 V.



Loop rules
L1: Vb-IbR1-IbR2-I1R4=Vb-Ib*12-Ib*47-I1*37.5=0
L2: Vb-IbR1-IbR2-I2R3=Vb-Ib*1b-I2*47-I2*24=0
L3: -I1R4+I2R3=-I1*37.5+I2*24=0
Junction Rules
J1: Ib=I1+I2
J2: I1+I2=Ib

Currents

Solving for Ib (current in R1 and R2)
Step 1: combine all resistors
R3+4=1/(1/24+1/37.5)=14.63
Rtotal=12+47+14.63=73.6
Step 2: solve for I
V=IR, I=V/R=48/73.6=0.652A

Solving I1 (current in R4)
Step 1: plug into L1 and solve
48-0.652*12-0.652*47-I1*37.5=0
I1=0.254A

Solving I2 (current in R3)
Step 1: plug into L2 and solve
48-0.652*12-0.652*47-I2*24=0
I2=0.397A

Voltage

Solving for V1
Step 1: plug into V=IR and solve
V=0.652*12=7.822V

Solving for V2
Step 1: plug into V=IR and solve
V=0.652*47=30.638V

Solving for V3
Step 1: plug into V=IR and solve
V=0.397*24=9.540V

Solving for V4
Step 1: plug into V=IR and solve
V=0.254*37.5=9.540V

Summary

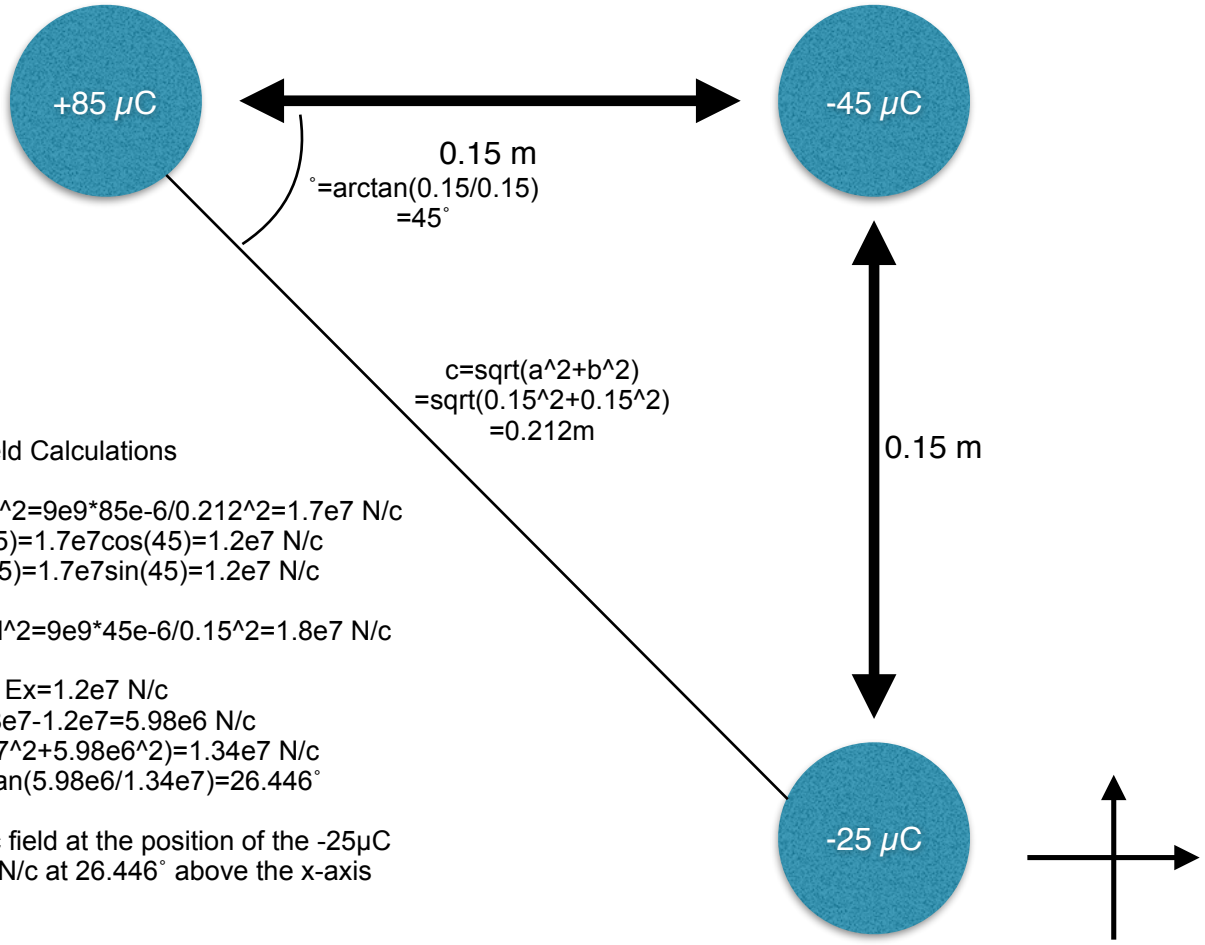
R1: V=7.822V, I=0.652A

R2: V=30.638V, I=0.652A

R3: V=9.540V, I=0.0.397A

R4: V=950V, I=0.254A

18) Find the electric field (magnitude and direction) at the position of the -25 µC charge THEN determine the net force (magnitude and direction) on -25 µC charge. To receive full credit you must answer the questions above in order.



E-field Calculations

E(of +85 on -25)=K*q/d^2=9e9*85e-6/0.212^2=1.7e7 N/c
Ex (of +85 on -25)=1.7e7cos(45)=1.2e7 N/c
Ey (of +85 on -25)=1.7e7sin(45)=1.2e7 N/c

E(of -45 on -25)=K*q/d^2=9e9*45e-6/0.15^2=1.8e7 N/c

Net Ex=1.2e7 N/c
Net Ey=1.8e7-1.2e7=5.98e6 N/c
Net E=sqrt(1.2e7^2+5.98e6^2)=1.34e7 N/c
Direction: °=arctan(5.98e6/1.34e7)=26.446°

Statement: the electric field at the position of the -25µC charge is 1.34*10^7 N/c at 26.446° above the x-axis

Force Calculations

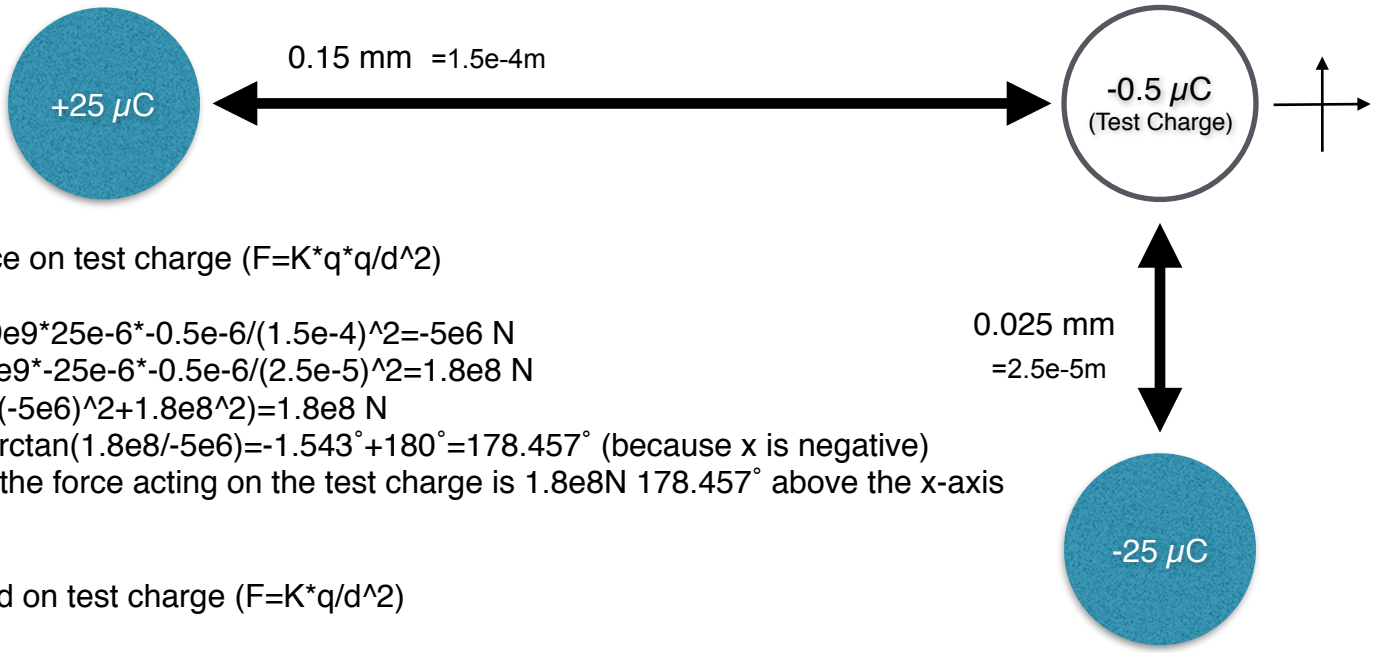
F(of +85 on -25)=K*q*q/d^2=9e9*85e-6*25e-6/0.212^2=425 N
Fx (of +85 on -25)=425cos(45)=300.52 N
Fy (of +85 on -25)=425sin(45)=300.52 N

F(of -45 on -25)=K*q*q/d^2=9e9*45e-6/0.15^2=450 N

Net Fx=300.52 N
Net Fy=300.52-450=-149.48 N
Net F=sqrt((-149.38)^2+300.52^2)=335.64 N
Direction: °=arctan(-149.48/300.52)=-26.446°

Statement: the force at the position of the -25µC charge is 335.64N at 26.446° below the x-axis

19) This semester we learned how to calculate (1) Electric Forces, (2) Electric Fields, and (3) Electric Potential. Some were easier to calculate than others. Use the example below to show which one(s) is/are easier to determine and why. Calculate enough of the values to prove your case.



Electric force on test charge (F=K*q*q/d^2)

F(of +25)=9e9*25e-6*-0.5e-6/(1.5e-4)^2=-5e6 N
F(of -25)=9e9*-25e-6*-0.5e-6/(2.5e-5)^2=1.8e8 N
Net F=sqrt((-5e6)^2+1.8e8^2)=1.8e8 N
Direction=arctan(1.8e8/-5e6)=-1.543˚+180˚=178.457˚ (because x is negative)
Statement: the force acting on the test charge is 1.8e8N 178.457˚ above the x-axis

Electric field on test charge (F=K*q/d^2)

F(of +25)=9e9*25e-6/(1.5e-4)^2=1e13 N/c
F(of -25)=9e9*-25e-6/(2.5e-5)^2=-3.6e14 N/c
Net F=sqrt(-3.6e14^2+1e13^2)=3.601e14 N/c
Direction=arctan(-3.6e14/1e13)=-1.543˚
Statement: the electric field acting on the test charge is 3.601N/c 1.543˚ below the x-axis

Electric potential on test charge (F=K*q/d)

V(of +25)=9e9*25e-6/(1.5e-4)=1.5e9 V
V(of -25)=9e9*-25e-6/(2.5e-5)=-9e9 V
Net V=1.5e9-9e9=-7.5e9 V
Statement: the total electric potential at the test charge is -7.5e9V

Electric potential is the easiest to calculate because there are the fewest variable and position only needs to be considered as far as distance is concerned

Complete the short-answer question below. Be aware the question may have multiple parts. You must answer all parts to receive full credit. Show all work. Partial credit may be given for partially correct or complete answers. (5-10 pts. each)

20) A concave mirror has a radius of 0.35m. If the d_o is 75 cm, where is the image located? Is the image real or virtual? Upright or inverted? Bigger or smaller (10 pts)

R=2f, so the focus is at 17.5cm

1/f=1/di+1/do
di=1/(1/f-1/do)=1/(1/17.5-1/75)=22.8cm

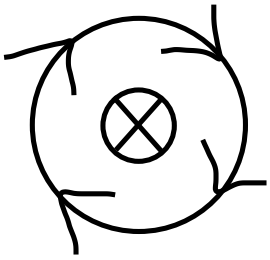
m=-di/do=-22.8/75=-0.3

m=hi/ho
since m is negative and <1, the image must be inverted and smaller

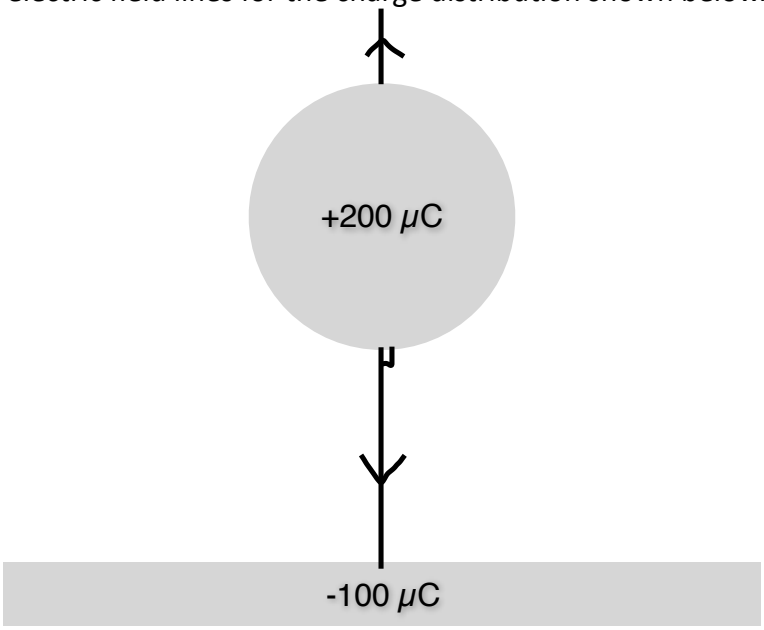
21) A coil of 15 loops of wire is laying on the table. It experiences an increasing magnetic field going into the table. If the magnetic field goes from 0.15 T to 0.85 T in one-third of a second and the coil has a diameter of 6 centimeters, determine the magnitude of the induced EMF and the direction of the induced current (10 pts)

V=-n*Δflux/t=-15*(BA-BA)/(1/3)=3*-15*A(B-B)=-45*(π*(d/2)^2)*(0.85-0.15)=-45*0.7*π*(0.06/2)^2=-31.5*π*0.03^2=-0.089V

because the magnetic field it experiences goes into the table (mag field goes in at the center of the loop) due to RHR #1, the induced current must be clockwise



22) Draw the electric field lines for the charge distribution shown below. (5 pts)



23) A Red Supergiant star has a measured temperature of 4,500K. Light from this star, which has a frequency of 4.3×10^{14} Hz. That light is incident on a pair of thin slits spaced 0.3 mm apart. If the screen is 1.50 m from the double-slit, what is the spacing between the 2nd Minima and the 3rd Maxima? (10 pts)

0.3mm=0.0003m
c=fλ, λ=c/f=3e8/4.3e14=6.977e-7m

3rd maxima
x=mλl/d=2*6.977e-7*1.5/0.0003=0.007m

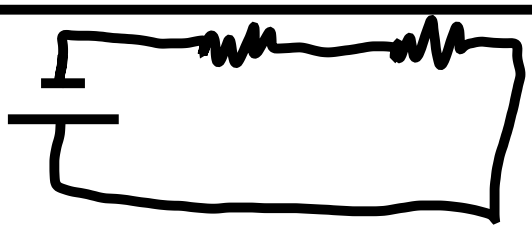
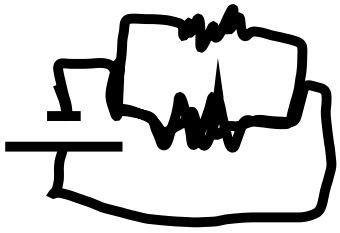
2nd minima
x=(m+1/2)λl/d=(1+0.5)*6.977e-7*1.5/0.0003=0.005m

distance between the maxima and minima
0.007-0.005=0.001744m

24) Pick one topic not covered in this exam that you learned this semester **or** one topic you're proud of mastering. Explain that topic and show me you know the physics behind that topic. (10pts)

Circuits

Two types

	Series	Parallel
diagram		
Resistance	Rtotal=R1+R2	1/Rtotal=1/R1+1/R2
Current	Ibattery=I1=I2	Ibattery=I1+I2
Voltage	Vbattery=V1+V2	Vbattery=V1=V2

Electromotive force (EMF): electric potential from a non-electrical source, like a battery (generates the force from electric potential difference between the cathode and anode) and is measured in V

Series

total resistance is the sum of resistors because there is only one path

current is all equal because there is only one path so the limiting resistor sets the current for the entire circuit

voltage is the sum of voltages at each resistor because there is only one path so each resistor has to share the electrons, so to speak

Parallel

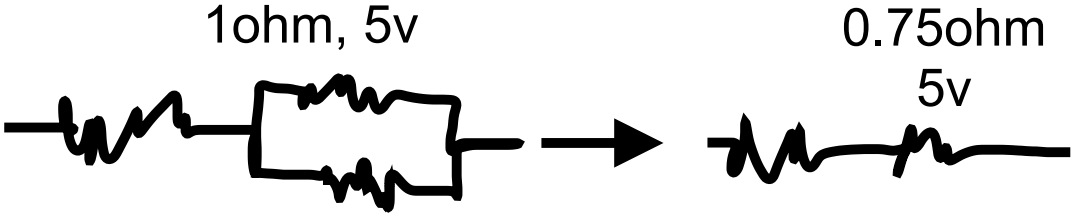
current is the sum of currents because the electrons can choose which path they want to go through

Voltage is all equal because the electrons can take the path of least resistance so each resistor doesn't have to share electrons

total resistance is 1/Rtotal=1/R1+1/R2 because I=V/R so Ibattery=V1/R1+V2/R2 but since Vbattery=V1=V2, Ibattery=V(1/R1+1/R2) which can be written as Ibattery/V=1/R1+1/R2 but since V=IR, Ibattery/(IR)=1/R1+1/R2 which can be simplified to 1/Rtotal=1/R1+1/R2

The rules in the table above can be mixed and matched to solve for different situations

Example: this can be simplified into a series



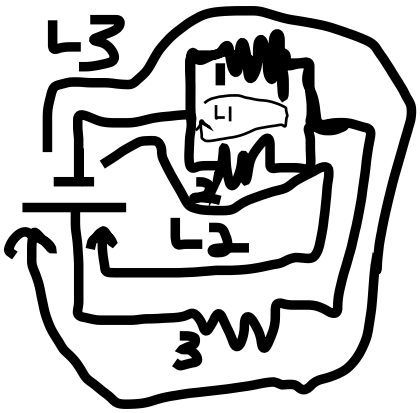
Because 1/Rtotal=1/R1+1/R2, you can plug the values given to solve for Rtotal (0.75ohm) and because Vbattery=V1=V2, you know that Voltage would stay the same

Loop and Junction rules

Loop rule In any complete circuit, there is no change in potential (conservation of energy, energy can't be created or destroyed)

$V_{battery}-I_1R_1-I_2R_2-\ldots=0$

Example



In the example there are 3 loops

L1: $-I_1R_1+I_2R_2=0$

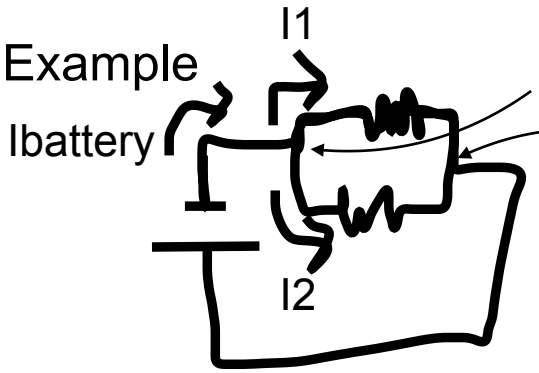
L2: $V_{battery}-I_2R_2-I_3R_3=0$

L3: $V_{battery}-I_1R_1-I_3R_3=0$

Junction rule The current going in equals the current coming out (conservation of mass, electrons can't be created or destroyed)

$I_{battery}=I_1+I_2$

Example



In the example there are 2 junctions

Junction 1: $I_{battery}=I_1+I_2$

Junction 2: $I_1+I_2=I_{battery}$

Combine these rules with the equations from the table above and V=IR to solve any simple problem involving voltage, current or resistance