Physics 221

Exam 3

Name: ______________________________

1. A hollow metal sphere is electrically neutral (no excess charge). A small amount of negative charge is suddenly placed at one point P on this metal sphere. If we check on this excess negative charge a few seconds later we will find one of the following possibilities:

The excess charge has distributed itself evenly over the outside surface of the sphere. Conductors have some electrons which are free to move anywhere within the sphere. When there's some excess charge, each like charge repels each other so spread as far apart as possible. The furthest distance apart would be evenly distributed over the outside surface.

2. A hollow sphere made out of electrically insulating material is electrically neutral (no excess charge). A small amount of negative charge is suddenly placed at one point P on the outside of this sphere. If we check on this excess negative charge a few seconds later we will find one of the following possibilities:

All of the excess charge remains right around P. An insulating material does not allow electrons to move around.

3. The electric field

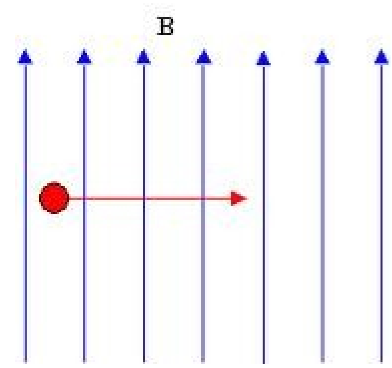
Is always perpendicular to an equipotential surface.

4. Is the change in potential energy, ΔU, of a *positive* particle increasing, decreasing, or staying the same when it is moved from point i to f?

stay the same because is both cases, the charge is equal distances from the charge.

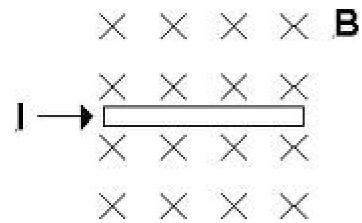
5. A *negative* particle is shown entering a magnetic field (directed up or in the + y direction). Initially the particle has a speed in the positive x direction as shown. What is the direction of force on the particle?

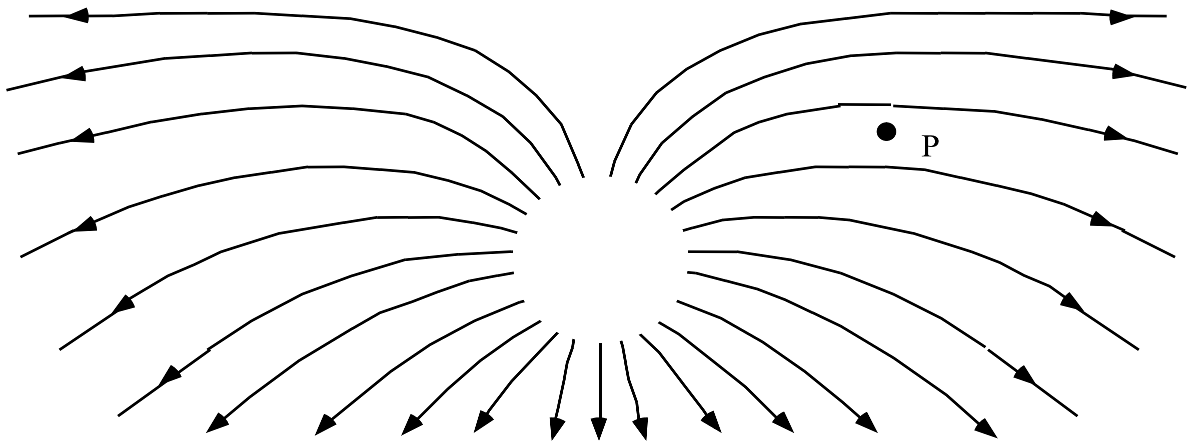
Into the paper. Use the right hand rule which shows a force out of the paper BUT this is a negative particle so the force is in the opposite direction.



6. A current carrying wire is place in an *external* magnetic field. What is the direction of the force felt by the wire?

Up (y direction) Use the right hand rule. The x's indicate that the magnetic field is going into the paper.





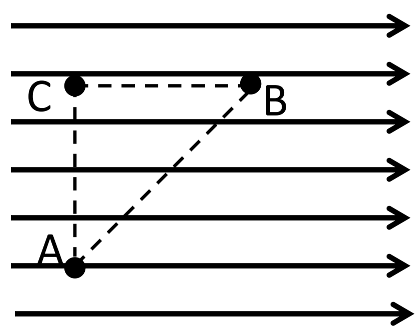
7. What is the direction of the electric force on a *negative* charge at point P in the diagram above?

← The Electric field indicates the direction of force that would be felt by a positive charge. Here you have a negative charge so it'll feel a force in the opposite direction that the field lines indicate.

A uniform electric field points to the right as shown. If the change in electric potential in moving from point A to point B is - 4 V, what is the difference in potential between points

8. A to C

0 V because this would be along A and C lie on the same equipotential line.

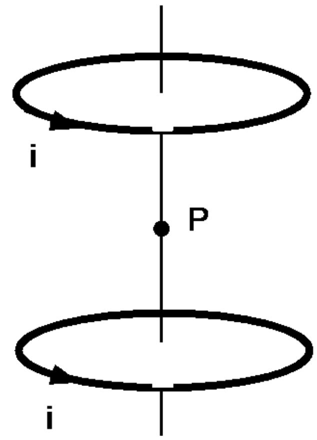


9. C to B

-4 V because A to B is -4 V and the potential only changes when you move along the electric field lines.

10. Two identical loops of wire carry identical currents i. The loops are located as shown in the diagram. Which arrow best represents the direction of the magnetic field at the point P midway between the loops?

↑ use the right hand rule to find the magnetic field create by each loop. In both cases it puts up in the middle of the loop. So these two fields add giving a bigger field up.



The back of a laptop has a tag that says all sorts of things and the only lines with numbers read: “Part no. PLL3AU-00G00C”, “Serial No. Z9258104K”, “DC19V - - - 1.58A”.

11. What is the power used by this laptop?

$P = I\,\Delta V$ = 1.58 A * 19 V = **30 W**

12. How much current does this laptop draw?

1.58 A

13. What is the potential difference across the laptop?

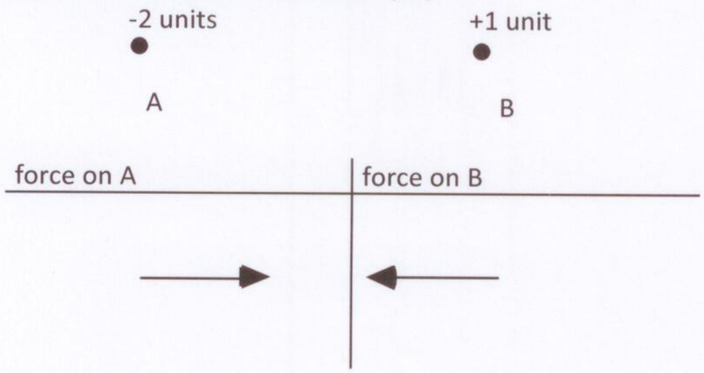
19 V

14. If electricity is $0.12/ kWh, how much will it cost to run the laptop for 2 hours?

30W (1kW/1000W) * 2 hours = 0.06 kWh

0.06 kWh * $0.12 / kWh **= $0.007**

The picture below shows a particle (labeled B) which has a net electric charge of +1 unit. Several centimeters to the left is another particle (labeled A) which has a net charge of -2 units. Choose the pair of force vectors (the arrows) that correctly compare the electric force on A (caused by B) with the electric force on B (caused by A).

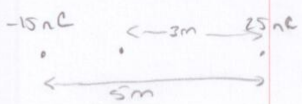


The forces are equal and opposite. In this case they attract each other.

Two point charges are placed 5 meters apart. The charge on the left is -15 nC and the charge on the right is +25nC.

16. Find the electric field at a point between the charges, 3.0 meters from the +25nC charge.

Electric field points away from + charges & towards - charges



$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \frac{Nm^2}{C^2} \cdot 15\times10^{-9}C}{(2m)^2} = -33.75\ N/C$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \frac{Nm^2}{C^2}\ 25\times10^{-9}C}{(3m)^2} = -25\ N/C$$

$$E_{TOT} = E_1 + E_2 = -33.75\ N/C + -25\ N/C = \boxed{-58.75\ N/C}$$

17. Find the electrostatic force on an electron that is placed between the charges at a point 3.0 meters from the +25nC charge.

$$F = qE = -1.6\times10^{-19}C \cdot -58.75\ N/C$$
$$= \boxed{9.4\times10^{-18}N}$$

18. Find the potential energy of the electron if it's between the charges at a point 3.0 meters from the +25nC charge.

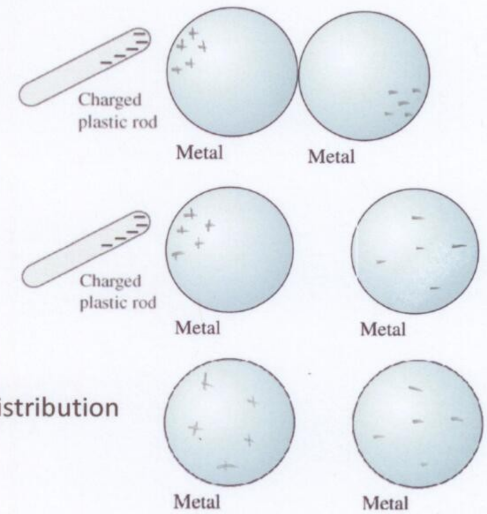
$$U_1 = \frac{kq_1q_e}{r} = \frac{9\times10^9 Nm^2/C^2 \cdot -15\times10^{-9}C \cdot -1.6\times10^{-19}C}{2.0m} = 1.08\times10^{-17}J$$

$$U_2 = \frac{kq_2q_e}{r} = \frac{9\times10^9 Nm^2/C^2 \cdot 25\times10^{-9}C \cdot -1.6\times10^{-19}C}{3.0m} = -1.2\times10^{-17}J$$

$$U_{TOT} = U_1 + U_2 = 1.08\times10^{-17}J + -1.2\times10^{-17}J$$
$$\boxed{= -1.2\times10^{-18}J}$$

7 pts

18. Two neutral metal spheres are touching. A negatively charged plastic rod is brought near, *but does not touch*, the left sphere. While the plastic rod remains near the left sphere, the right sphere is moved away. Then the rod is moved away.



   a. In the third diagram, what, if any, is the charge on the left sphere?

   Positive

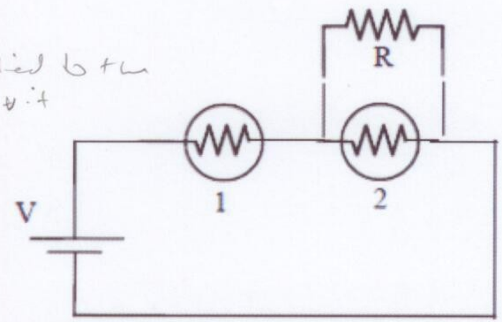
   b. In the third diagram, what, if any, is the charge on the right sphere?

   Negative

   c. On all three diagrams given show the charge distribution on the spheres for that situation.

15

19. The circuit to the right has two bulbs, 1 and 2, both with a resistance of 24 Ω. The extra resistor has a resistance of 12 Ω and the potential difference supplied to the circuit is ΔV = 48 V.



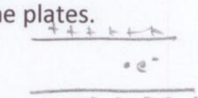
   a. Consider the circuit with just the 2 bulbs while the extra resistor R is not attached. Determine the current through and potential difference across each bulb.

   b. Consider the circuit with the extra resistor attached across bulb 2 as shown. What is the current through and the potential difference across each bulb in that case.

   c. Compare the brightness of each bulb (1 before vs 1 after and 2 before vs. 2 after) with and without the extra resistor in place – mathematically justify your answer.

15

20. A capacitor has a charge of 5.0 μC on each plate when a potential difference of 120 V is across the plates. The plates are separated by 12×10^{-4} meters.



   a. Find the electric field between the plates.

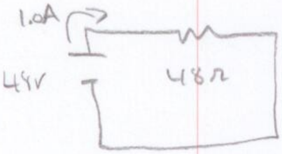
   b. Find the electrostatic force on an electron which is between the plates, 4.0×10^{-4} meters from the positive plate.

   c. How much energy is stored in this capacitor?

   d. How much work does it take to move the electron horizontally between the plates?

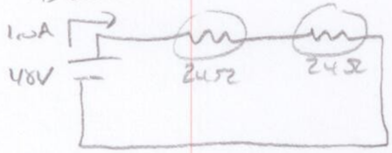
19a.

$24\,\Omega + 24\,\Omega = 48\,\Omega$



$I = V/R = 48\text{V}/48\,\Omega = 1.0\text{A}$

back out

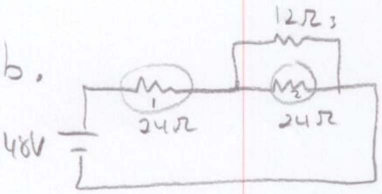


$\Delta V_1 = I_1 R_1$
$= 1.0\text{A}\ 24\,\Omega = 24\text{V}$

$\Delta V_2 = I_2 R_2$
$= 1.0\text{A}\ 24\,\Omega = 24\text{V}$

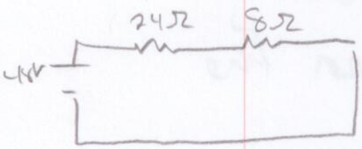
$$\boxed{\begin{aligned} I_1 &= 1.0\text{A} \\ \Delta V_1 &= 24\text{V} \\ I_2 &= 1.0\text{A} \\ \Delta V_2 &= 24\text{V} \end{aligned}}$$

b.

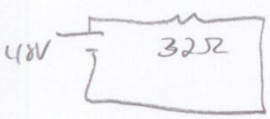


$\frac{1}{12} + \frac{1}{24} = \frac{1}{R_{23}}$

$R_{23} = 8\,\Omega$

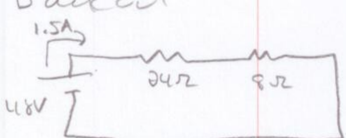


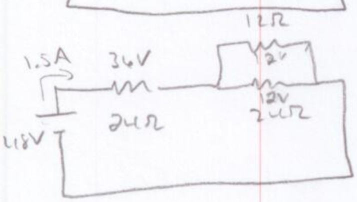
$24\,\Omega + 8\,\Omega = 32\,\Omega$



$I = V/R = \frac{48\text{V}}{32\,\Omega} = 1.5\text{A}$

back out





$\Delta V_1 = I_1 R_1 = 1.5\text{A}\ 24\,\Omega = 36\text{V}$

$\Delta V_{23} = I_{23} R_{23} = 1.5\text{A}\ 8\,\Omega = 12\text{V}$

$\Delta V_2 = \Delta V_3 = \Delta V_{23} = 12\text{V}$

$I_2 = \frac{\Delta V_2}{R_2} = \frac{12\text{V}}{24\,\Omega} = 0.5\text{A}$

$I_3 = \Delta V_3 / R_3 = 12\text{V}/12\,\Omega = 1.0\text{A}$

$$\boxed{\begin{aligned} I_1 &= 1.5\text{A} \\ \Delta V_1 &= 36\text{V} \\ I_2 &= 0.5\text{A} \\ \Delta V_2 &= 12\text{V} \\ I_3 &= 1.0\text{A} \\ \Delta V_3 &= 12\text{V} \end{aligned}}$$

c. $P_{1a} = I_{1a} \Delta V_{1a} = 1.0\text{A}\ 24\text{V} = 24\text{W}$

$P_{1b} = I_{1b} \Delta V_{1b} = 1.5\text{A}\ 36\text{V} = 54\text{W}$

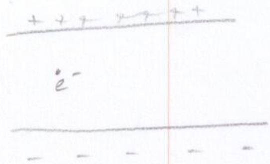
Bulb 1 is much brighter when the extra resistor is in place!

$P_{2a} = 1.0\text{A}\ 24\text{V} = 24\text{W}$

$P_{2b} = 0.5\text{A}\ 12\text{V} = 6\text{W}$

Bulb 2 is much dimmer when the extra resistor is in place.

20.



$Q = 5\mu C = 5.0\times10^{-6}\,C$

$\Delta V = 120V$

$d = 12\times10^{-4}\,m$

a. $E = \Delta V/\Delta x = \frac{120V}{12\times10^{-4}m} = \boxed{100{,}000\,V/m}$

b. $F = qE = 1.6\times10^{-19}C \;\; 100{,}000\,V/m$

$\boxed{= -1.6\times10^{-14}\,N}$

c. $U = \frac{1}{2} Q\Delta V = \frac{1}{2}\; 5.0\times10^{-6}C \;\; 120V$

$\boxed{= 3\times10^{-4}\,J}$

d. <u>Zero</u> The potential is the same along any horizontal line between the plates.