

4. Two charges, each of charge +3 microCoulombs, are located at $x = -1$ meter and $x = +1$ meter as shown.

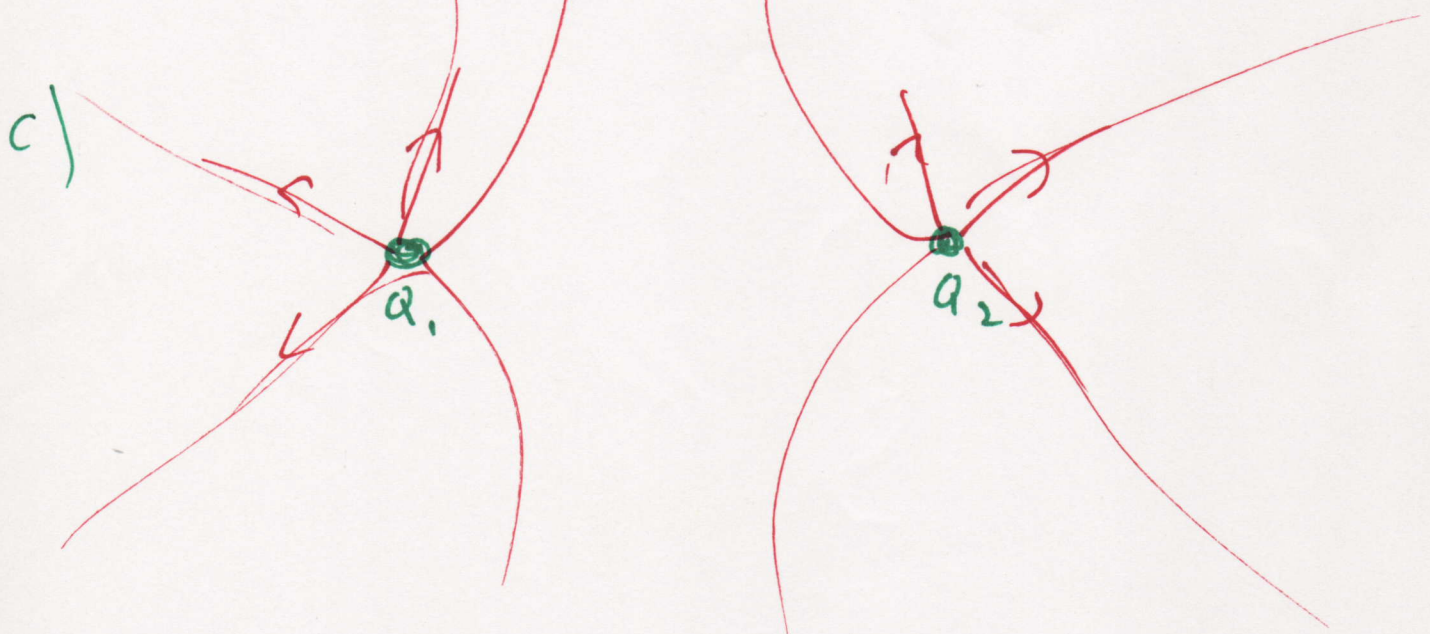
- (a)(12) At the point, P, $x=0, y = +1$ meter, find the electric field (magnitude and direction)
- (b)(8) If an electron is placed at point P, what is the force on it?
- (c)(5) Draw at least six electric field lines.

a) $E_{\text{from } Q_1} = \frac{kQ_1}{r^2} = \frac{(9 \times 10^9)(3 \times 10^{-6})}{(\sqrt{2})^2} = 1.35 \times 10^4 \text{ N/C}$ $\nearrow 45^\circ$

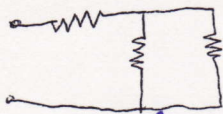
$E_{\text{from } Q_2} = \frac{kQ_2}{r^2} = 1.35 \times 10^4 \text{ N/C}$ $\nwarrow 45^\circ$

add vectors $E_x = 0$ $E_y = (1.35 \times 10^4) \sin 45^\circ \times 2$
 $= 1.96 \times 10^4 \text{ N/C}$

b) $F = qE = (1.6 \times 10^{-19})(1.96 \times 10^4)$ direction is \uparrow
 $= 3.2 \times 10^{-15} \text{ N}$ \downarrow



1. (a)(10) A 9Ω resistor and a 6Ω resistor are connected in series to a battery. The voltage drop across the 6Ω resistor is 12 Volts. What is the voltage of the battery? What is the power given off by each resistor? (Ignore any internal resistance in the battery)
- (b)(10) The same two resistors are now connected in parallel to a new battery. The current through the 9Ω resistor is 0.25 amps. What is the voltage of the battery? What is the power given off by each resistor?
- (c)(5) For each circuit below, are the three resistors in series, in parallel, or neither?



neither

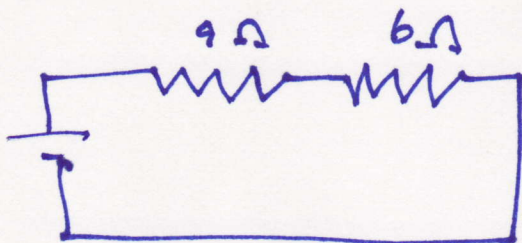


series



parallel

a)



$$R_{eq} = 15\Omega$$

$$I = \frac{V_{battery}}{15\Omega}$$

$$V_{6\Omega} = 12 = \left(\frac{V_{batt}}{15\Omega} \right) (6\Omega)$$

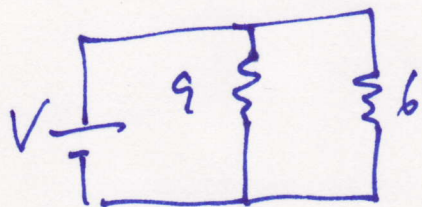
$$\boxed{V_{batt} = 30V}$$

$$I = 2 \quad P = I^2 R$$

$$P_9 = 2^2 \cdot 9 = 36 \text{ W}$$

$$P_6 = 2^2 \cdot 6 = 24 \text{ W}$$

b)



$$I_9 = 0.25$$

$$V_9 = (0.25)(9) = 2.25V$$

$$P_9 = I^2 R = \frac{1}{16} \cdot 9 = \frac{9}{16} \text{ W}$$

$$V_{battery} = 2.25V$$

$$P_6 = \frac{V^2}{R} = \frac{2.25^2}{6} = \frac{5}{6} \text{ W}$$

2. A screwdriver is made of a metal with a resistivity of $2 \times 10^{-8} \Omega\text{-m}$ and a diameter of 4 millimeters. It is put across the terminals of a 3 millifarad capacitor – the terminals are 5 centimeters apart.

(a)(5) What is the resistance of the 5 centimeter section of the screwdriver?

(b)(10) The capacitor is charged to 500 Volts. How much energy is stored in the capacitor? What is the charge on each plate?

(c)(5) When a screwdriver is put across the terminals, how long does it take before the voltage across the capacitor is $1/e \sim 37\%$ of its initial value?

(d)(5) An electron is placed near the negative terminal. It flies across to the positive terminal. What is its kinetic energy when it arrives?

$$a) R = \frac{\rho L}{A} = \frac{(2 \times 10^{-8})(.05)}{\pi (2 \times 10^{-3})^2} = \boxed{8 \times 10^{-5} \Omega}$$

$$b) Q = CV = (3 \times 10^{-3})(500) = \boxed{1.5 \text{ Coul}}$$

$$U = \frac{1}{2} CV^2 = \frac{1}{2} (3 \times 10^{-3})(500)^2 = \boxed{375 \text{ J}}$$

$$c) t = RC = (8 \times 10^{-5})(3 \times 10^{-3}) = \boxed{2.4 \times 10^{-7} \text{ sec}}$$

$$d) \text{Energy} = q_e V = (1.6 \times 10^{-19})(500 \text{ V}) = \boxed{8 \times 10^{-17} \text{ J}}$$

3. A nervous physicist worries that the two metal shelves of his wood frame bookcase might obtain a high voltage if charged by static electricity (produced by friction). The empty shelves are each 50 cm. by 20 cm. and are 20 cm. apart.

(a)(8) What is the capacitance of the bookshelves?

(b)(7) If opposite charges of 2 nanoCoulombs are put on them, what is the voltage between them?

(c)(5) To determine if this voltage is dangerous, calculate the total energy stored in the capacitor.

(d)(5) The physicist then puts some papers between the shelves. The dielectric constant of paper is 4.0. Now, what is the voltage between the shelves?

$$a) C = \frac{A\epsilon_0}{d} = \frac{(0.5)(0.2)(8.85 \times 10^{-12})}{0.2} = 4.4 \times 10^{-12} \text{ F}$$

$$b) Q = CV \Rightarrow V = \frac{Q}{C} = \frac{2 \times 10^{-9}}{4.4 \times 10^{-12}} = \boxed{455 \text{ V}}$$

$$c) \frac{1}{2} CV^2 = \frac{1}{2} (4.4 \times 10^{-12}) (455)^2 = \boxed{4.5 \times 10^{-7} \text{ J}}$$

d) Q_{same} , C ~~increases~~ ^{increases} by 4, V decreases by 4

$$\therefore \boxed{V = 112 \text{ V}}$$

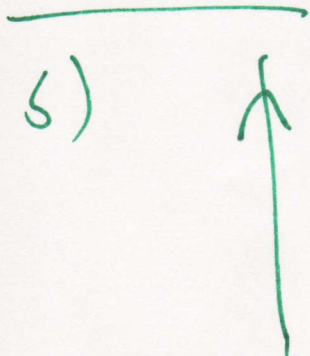
4. (a)(10) A lightning bolt is vertical and has a current of 20000 Amps. The earth's magnetic field points north and is 6×10^{-5} Tesla. What is the force per meter on the lightning bolt? The force is to the west. Does the current flow up from the earth or down towards the earth?

(b)(15) A compass is 4 meters directly below a high voltage power line which runs north-south. The current is 2000 amps and runs north. What is the magnitude and the direction of the magnetic field **due to** the power line? Including the earth's field, what direction does the compass needle point? (Note: answer in degrees W or E of north).

$$F = ILB, \quad \frac{F}{L} = IB = (20000)(6 \times 10^{-5}) = \boxed{1.2 \text{ N}}$$

current is up

5)



$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7})(2000)}{2\pi(4)} = \boxed{10^{-4} \text{ T}}$$

west

