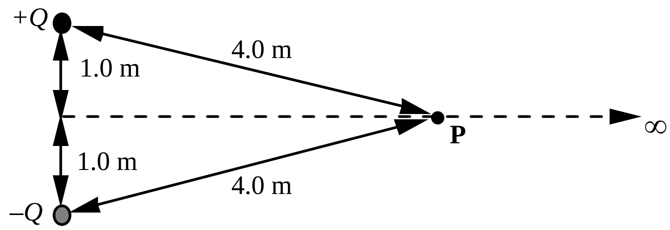
Name:____KEY__________________

Phys.116 Exam I
12 July 2004

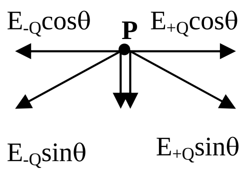
Please do not turn the page until you are told to do so. When you do so, make sure that you have all three problems on your copy of the test.

In order to get credit on a problem, you must show your work. If you only write down an answer without the work leading up to it, you will get no credit for it, even if it is the right answer.

1. Two charges of opposite sign and equal magnitude Q = 2.0 C are held 2.0 m apart as shown in the figure.



a.(5 points) Determine the magnitude of the electric field at the point **P**.



The x-direction components of the electric fields from the two charges cancel each other out. The only components left are the vertical components, which have the same magnitude.

$$E_{+Q} = k\frac{Q}{r^2};$$

$$E_{total} = 2E_{+Q}\sin\theta = 2k\frac{Q}{r^2}\left(\frac{y}{r}\right) = 2(9\times10^9)\left(\frac{2}{4^2}\right)\left(\frac{1}{4}\right) = 5.6\times10^8\ V/m$$

b.(5 points) Determine the electric potential at the point **P**.

$$V_{at\,P} = k\frac{+Q}{r} + k\frac{-Q}{r} = 0\ V$$

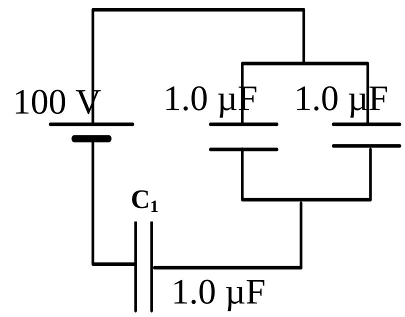
c.(5 points) How much work is required to move a 1.0 C charge from infinity to the point **P**?

$$W = -(EPE_f - EPE_i) = -q(V_f - V_i) = 0\ J$$

d.(5 points) What force would the 1.0 C charge experience (magnitude and direction) at point **P**?

$F = qE_{total} = 1(5.6\times10^8) = 5.6\times10^8\ N$ in the negative y-direction.

2. a. (7 points) What is the equivalent capacitance of the combination of capacitors shown in the circuit?



Parallel combination => $C_{23} = C_2 + C_3 = 1.0 + 1.0 = 2.0\mu F$

Series combination => $\frac{1}{C_{123}} = \frac{1}{C_{23}} + \frac{1}{C_1} = \frac{1}{2.0} + \frac{1}{1.0} = \frac{3.0}{2.0} = 1.5\mu F^{-1}$

=> $C_{123} = 0.67\mu F$

b.(6 points) How much charge is stored on capacitor C_1?

The charge stored on capacitor C_1 is the same as the charge stored on the equivalent capacitor C_{123}, because the charge stored on capacitors connected in series is the same as the charge on the equivalent capacitor.

$$Q_{123} = Q_1 = Q_{23} = C_{123}V = 0.67(100) = 67\ \mu C$$

c.(7 points) How much charge is stored on the other two capacitors?

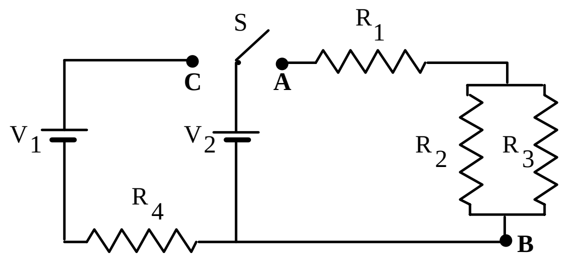
The potential drop across capacitor C_1 is $V_1 = \frac{Q_1}{C_1} = \frac{67\times10^{-6}}{1.0\times10^{-6}} = 67\,V$. Then, the potential drop across the two capacitors connected in series is $V_{23} = V - V_1 = 100 - 67 = 33\,V$. The charge across each of the two parallel capacitors will be $Q_2 = C_2V_{23} = 33\mu C$ and $Q_3 = C_3V_{23} = 33\mu C$.

3. The figure shows a circuit. The switch S can be closed on either point **A** or **C**, but not both at the same time. Use the following quantities:

$V_1 = V_2 = 12$ V

$R_1 = R_4 = 1.0\ \Omega$

$R_2 = R_3 = 2.0\ \Omega$



a.(5 points) What is the equivalent resistance between the points **A** and **B**?

R_2 and R_3 are connected in parallel. $R_{23} = \left(R_2^{-1} + R_3^{-1}\right)^{-1} = \left(\frac{1}{2.0} + \frac{1}{2.0}\right)^{-1} = 1.0\ \Omega.$

R_1 and R_{23} are connected in series. $R_{123} = R_1 + R_{23} = 1.0 + 1.0 = 2.0\ \Omega.$

b.(5 points) Determine the current through R_1 when the switch **S** is closed on **A**.

The current through R_1 is the current through the equivalent resistor R_{123},

$$I_1 = I_{123} = \frac{V_2}{R_{123}} = \frac{12}{2.0} = 6.0\ A$$

c.(5 points) At what rate is energy dissipated by R_1 when the switch **S** is closed on **A**?

$$P_1 = I_1{}^2 R_1 = (6.0)^2 (1.0) = 36\, W$$

d.(5 points) Determine the current through R_4 when the switch **S** is closed on **C**.

By Kirchhoff's Loop Rule, the sum of the potential drops equals the sum of the potential rises. Assume that the current I travels CCW through the (left) loop. Then KLR will read:

$V_1 + IR_4 = V_2$ or

$12 + I(1.0) = 12.$

Solving for I gives $I = 0\ A$.