PHY232 Spring 2002 Practice Exam 1

2/5/02: **Note**: In Question 1, the equation for E had too many q's in it. It's now fixed.

1. What is the value of the electric field at the origin of a coordinate system if a 7μC charge is placed at the point (x,y) = (– 0.18 m, – 0.24 m)?

 a) <u>7.0´ 10^5 N/C</u>
 b) 2.1×10^6 N / C
 c) 70 N/C
 d). 2.1×10^5 N / C
 e) zero

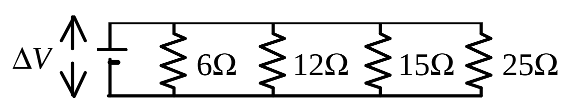
Distance to origin = $r = \sqrt{0.18^2 + 0.24^2} = 0.30$ m
$E = k_e q / r^2 = 7.0\times 10^5$ N/C

2. Consider the following statements.
 I. Resistance of parallel connected resistors is smaller than the value for each resistor.
 II. Capacitance of parallel connected capacitors is smaller than the value for each capacitor.
 III. Charged by a battery, a capacitor has the same magnitude of charge on each plate.

Are the statements true or false?

 a) I, II and III are true.
 b) <u>I and III are true, but II is false</u>.
 c) I and II are true, but III is false.
 d) II is true, but I and III are false.
 e) I, II, and III are false.

3. Four resistors are connected in parallel to a voltage source as shown in the diagram to the right. The 25 Ω resistor carries a current of 5 A. What is the total current supplied by the battery to the resistors?



 a) <u>45A</u>
 b) 35A
 c) 25A
 d) 15A
 e) 5A

$\Delta V = (5A)\cdot(25\Omega) = 125$ V
$1/R_{eq} = 1/6 + 1/12 + 1/15 + 1/25 \rightarrow R_{eq} = 2.8\ \Omega$
$\therefore I = \Delta V / R_{eq} = 45$ A

4. A parallel plate capacitor with square plates 25cm on a side, separated by 1mm, is charged to 16×10^{-12} C. What voltage difference exists between the plates?

 Note: capacitance of a parallel plate capacitor, $C = \dfrac{\varepsilon_0 A}{d}$.

 a) 1.5 V
 b) 9.0 V
 c) <u>29 mV</u>
 d) 0.18 V
 e) 50 V

$C = \varepsilon_0(0.25\text{m})^2/(0.001\text{m}) = 5.5\times 10^{-10}$ F
$\Delta V = Q/C = (1.6\times 10^{-11}\text{ C})/(5.5\times 10^{-10}\text{ F}) = 2.9\times 10^{-2}$ V

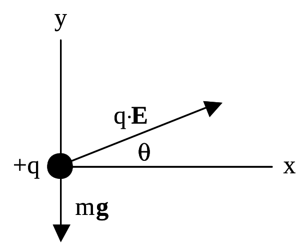
5. An electric water heater (R = 8 Ω) draws 15 A of current when connected to the voltage supply. If the electric company charges $0.10/kW·hour (energy dissipated by a power source of 1kW, in 1hr.), what is the cost of operating the water heater for 4 hours?
   a) $1.20
   b) $0.05
   c) <u>$0.72</u>
   d) $4.80
   e) $0.12

> $P = I^2 \cdot R = (15\text{A})^2 \cdot (8\Omega) = 1.8$ kW
> $P \cdot \Delta t = (1.8\text{kW}) \cdot (4\text{hr}) = 7.2$ kW-hr
> $ = (7.2 kW-hr)·($0.10/kW-hr) = $0.72

6. What work is done by an electric field moving a –3 μC charge from a point where the electric potential is 40V to another point where the potential is 25V <u>higher</u>?
   a) <u>75 mJ</u>
   b) 120 μJ
   c) 45 μJ
   d) 15 μJ
   e) 195 μJ

> For (-) charge, electric force points in direction of motion between the two points. ∴ $W > 0$.
> $W = q \cdot \Delta V = (3\times10^{-6}\text{C}) \cdot (25\text{V}) = 7.5\times10^{-5}$ J

7. Near the earth's surface, for a particle with charge, +q, and mass, m, to accelerate **horizontally**, an electric field of magnitude, E, must act at what angle, θ, from horizontal? (Hint: a gravitational force, **F** = mg, acts downward on the particle)
   a) $\theta = \sin^{-1}\left[\frac{mg}{qE}\right]$
   b) $\theta = \cos^{-1}\left[\frac{mg}{qE}\right]$
   c) $\theta = \tan^{-1}\left[\frac{mg}{qE}\right]$
   d) $\theta = \sin^{-1}\left[\frac{qE}{mg}\right]$
   e) $\theta = \cos^{-1}\left[\frac{qE}{mg}\right]$



> To balance gravitational force,
> $q \cdot E_y = mg = q \cdot E \cdot \sin(\theta)$
> ∴ $\theta = \sin^{-1}[mg/(qE)]$

8. Consider the spot mid-way between two positive point charges of equal magnitude. Which statement below is true?
   a) Both the electric field and the electric potential are zero.
   b) The electric potential is zero but the electric field is not.
   c) <u>The electric field is zero but the electric potential is not</u>.
   d) The sum of electric field and the electric potential is zero.
   e) Both the electric field and the electric potential are non-zero.

9. For 18 grams of water (1 mole, 6.02×10^{23} atoms) to obtain a charge of 1μC, what **fraction** of the molecules must lose one electron?

- a) 1 part in 10^{23}
- b) 1 part in 6×10^{23}
- c) 1 part in 6×10^{18}
- **d) <u>1 part in 10^{11}</u>**
- e) 1 part in 10^{5}

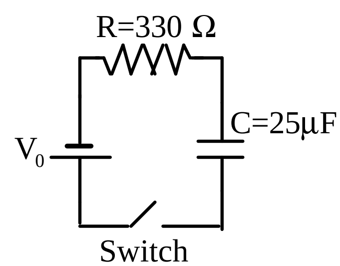
> \# of electrons in 1μC = 1×10^{-6}C/1.6×10^{-19}C = 6.2×10^{12}
> fraction = $6.2\times10^{12}/6.0\times10^{23} = 1.0\times10^{-11}$

10. From a great distance, a positive point charge of 2.0μC is fired with a kinetic energy of 25J, directly at a <u>fixed</u> positive point charge of 5.0μC. When the moving charge slows to a stop, what is the distance between the charges.

- a) 4.0×10^{-13} m
- b) 2.0×10^{-13} m
- c) 9.0×10^{-3} m
- d) 1.8×10^{-3} m
- **e) <u>3.6 mm</u>**

> $KE_i = PE_f = k_e q_1 q_2 / r$; Note: KE_f and $PE_i = 0$
> $r = k_e q_1 q_2 / KE_i$
> $= 9\times10^{9} \cdot 2.0\times10^{-6} \cdot 5.0\times10^{-6} / 25 = 3.6\times10^{-3}$ m

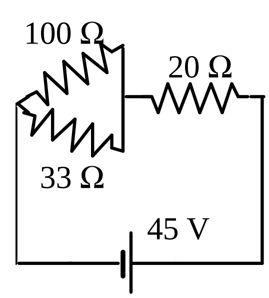
11. When the switch in the circuit at the right is closed, how long does it take for the capacitor to reach 98% of the battery voltage?



- a) 8 msec
- **<u>b) 32 msec</u>**
- c) 330 msec
- d) 825 msec
- e) 4.12 sec

> $\Delta V(t) = V_0(1-e^{-t/RC})$
> $\Delta V(t)/V_0 = 0.98 = (1-e^{-t/RC})$
> $\therefore 0.02 = e^{-t/RC}$
> take *ln* of both sides of equation
> -3.91 = -*t*/*RC*
> $t = 3.91\cdot(330\Omega)\cdot(25\times10^{-6}\text{F})$
> $= 3.2\times10^{-2}$ s

12. In the circuit at the right, what is the voltage drop across the 20 Ω resistor?



- **a) <u>20 V</u>**
- b) 25 V
- c) 33 V
- d) 2.25 V
- e) 1 V

> 100Ω and 33Ω resistors are in parallel
> $1/R_{eq} = 1/100 + 1/33$; $R_{eq} = 24.8\Omega$
> Total circuit resistance:
> $R_{total} = 24.8\Omega + 20\Omega = 45\Omega$
> $I = 45\text{V}/R_{total} = 1.0$ A
> $\Delta V = (1.0\text{A})\cdot(20\Omega) = 20$ V