Physics 121 Midterm Exam 2 Special Code 1111

Name________________________ Student No.________________

2010 March 26

Multiple choice questions have one correct answer. Mark the correct answer on the bubble sheet with a soft pencil. Make sure you fill in the bubbles for your name and student number on the bubble sheet, as well as the "Special Code." Complete the problems on this paper clearly showing your work and reasoning.

Do not tear this sheet off!

Useful Constants

elementary charge	$e = 1.602 \times 10^{-19}$ C
electron mass	$m_e = 9.11 \times 10^{-31}$ kg
proton mass	$m_p = 1.67 \times 10^{-27}$ kg
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/Nm^2}$
electrostatic constant	$K = 9.0 \times 10^9 \mathrm{Nm^2/C^2}$
speed of light in vacuum	$c = 2.998 \times 10^8$ m/s

Useful P120 Formulae

$$\begin{aligned} f &= ma \\ d &= vt \\ v &= v_0 + at \\ d &= v_0 t + \frac{1}{2}at^2 \end{aligned}$$

Electricity

Coulomb's Law: $\vec{\mathbf{F}} = \frac{kq_1q_2}{r_{12}^2}\hat{\mathbf{r}} = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}^2}\hat{\mathbf{r}} = \vec{\mathbf{E}}q$

Electric Flux: $\phi = \vec{\mathbf{E}} \cdot \vec{\mathbf{A}}$

Gauss's Law: $\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{Q}{\epsilon_0}$

Electric Potential: $V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$

Capacitors

$Q = CV;\ \ C = \epsilon_0 A/d$

Problem	11	12	13	14a	14b	15	
Score							
Maximum	6	5	5	4	4	6	

Problems Total:________________/30

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1. **Three identical charged particles are placed at the corners of an equilateral triangle. The net electrical force on any one of the particles is**

   a) parallel to one of the triangle sides that meet at the particle

   b) perpendicular to one of the triangle sides that meet at the particle.

   c) parallel to the triangle side opposite the particle

   d) perpendicular to the triangle side opposite the particle

   e) zero

2. **Two charged particles are a distance d apart. The force of either one on the other has magnitude F. If the distance between them is doubled the magnitude of the force becomes**

   a) $2F$

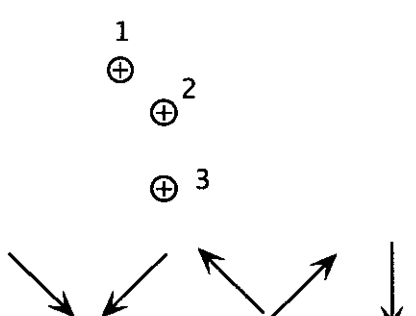
   b) $F/2$

   c) $4F$

   d) $F/4$

   e) None of the above

3. **A positively charged particle moves on a curved path in an electric field. Its position is shown at three consecutive times, 1,2 and 3. Which arrow best represents the direction of the net electric field at the position of point 2. (The only forces are electrostatic and the time intervals are equal.)**



a) b) c) d) e)

4. **The length of a side of a certain cube is L. The cube has no charge inside of it. A uniform electric field has a magnitude E and is normal to two of the sides and tangent to the other four. The net electric flux at the surface of the cube is**

   a) EL^2

   b) $2EL^2$

   c) $4EL^2$

   d) $6EL^2$

   e) zero

5. **Equipotential surfaces**

   a) intersect conducting surfaces

   b) are always spheres

   c) are always planes

   d) are perpendicular to electric field lines

   e) are tangent to electric field lines

6. **Gauss's law can be written as**

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0},$$

   where Q refers to

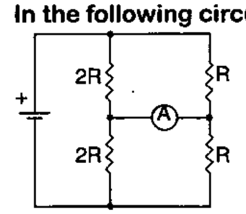
   a) the net charge inside the closed surface

   b) the charge residing on insulators inside the closed surface

   c) all the charge in the physical system

   d) any charge inside the closed surface that is arranged symmetrically

7. **In the following circuit the current through A**



   e) flows to the right

   f) flows to the left

   g) is zero

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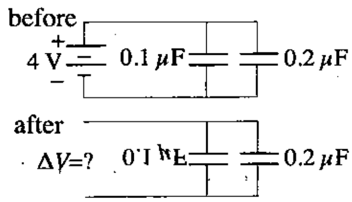
8. A 0.1 μF capacitor of and a 0.2 μF capacitor are in parallel and charged to 4 V. The 4-volt battery is disconnected and one capacitor is turned around so that + end of the 0.2 μF capacitor is connected to the negative terminal of the 0.1 μF capacitor and vice-versa. The voltage across the pair is now



a) zero

b) 1 .3V

c) 2 V

d) 3.3 V

e) None of the above

9. The electric potential inside a hollow conducting sphere with a net positive charge (choose the best answer)

a) must be zero

b) is constant

c) increases linearly with distance from the centre

d) is proportional to $1/r$ where r is the distance from the centre

e) none of the above is true

10. A parallel plate capacitor with air between the plates has capacitance of 100 pF. If the air is replaced with a material which has a dielectric constant of 2 the capacitance is

a) 100 pF

b) 200 pF

c) 400 pF

d) 50 pF

e) 25 pF

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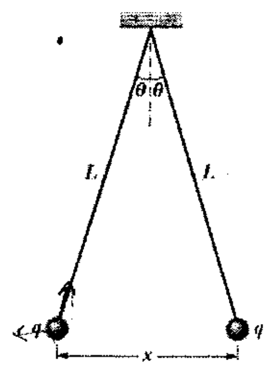
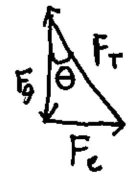
11. Two tiny conducting balls of identical mass m and identical charge q hang from non-conducting threads of length L. If L = 1 m, m = 9 g, and x = 6 cm, what is the magnitude of q? (Assume all values are exact.) [6]

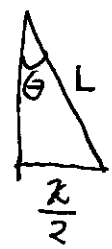


$$F_T = F_g + F_e$$



$$\Rightarrow \quad \tan\theta = \frac{F_e}{F_g}$$

also, from diagram:



$$\sin\theta = \frac{x/2}{L}$$

or: $$\tan\theta = \frac{x/2}{\sqrt{L^2 - x^2/4}}$$

$$\Rightarrow F_e = F_g \frac{x}{2\sqrt{L^2 - x^2/4}}$$

$$k q^2/r^2 = k q^2/x^2 = \frac{mgx}{2\sqrt{L^2 - x^2/4}}$$

$$\Rightarrow q = \sqrt{\frac{x^2 mg}{2k\sqrt{L^2 - x^2/4}}} = 3.25 \times 10^{-8}\,C$$

12. Imagine that the charge on the right-hand ball is changed from q to $2q$, while the left-hand charge remains the same. Describe clearly what happens to both of the two angles labelled θ. Explain. [5]

The force on each charge is doubled, but both masses still have the same mass, so they both still make the same angle, but θ will be larger due to the stronger F_e

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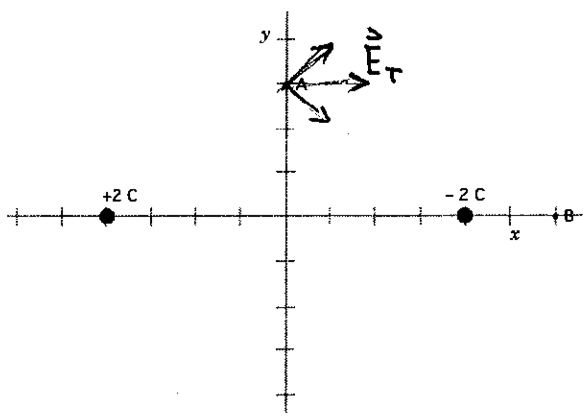
13. An electric dipole is made from a –2 C charge at (4,0) m and a +2 C charge at (–4, 0) m.

Calculate the electric field vector at point A (0, 3). Express the result using unit vector notation and draw the vector on the diagram. [5]



$$\vec{E} = \frac{Kq}{r^2}\hat{r}, \quad \hat{r} = \frac{\vec{r}}{|r|} \Rightarrow \vec{E} = \frac{Kq}{|r|^3}\vec{r}$$

$$\vec{r}_1^{\,(+2)} = (0-(-4))\hat{i}, (3-0)\hat{j}) = 4\hat{i} + 3\hat{j}$$

similairly $\vec{r}_2^{\,(-2)} = -4\hat{i} + 3\hat{j}$

$$\vec{E}_T = \vec{E}_1 + \vec{E}_2 = \frac{Kq_1}{|r_1|^3}\vec{r}_1 + \frac{Kq_2}{|r_2|^3}\vec{r}_2 = \frac{K(+2C)}{|5|^3}(\vec{r}_1 - \vec{r}_2) = \frac{18\times10^9}{125}(8\hat{i} + 0\hat{j})$$

$$= 1.15\times10^9\,\hat{i}\,\frac{N}{C}$$

14. Consider again the dipole of the previous problem.

a) What is the electric potential at point A? [4]

$|r|$ is the same for both charges

$$\Rightarrow V_T = V_1 + V_2 = \frac{Kq_1}{|r|} + \frac{Kq_2}{|r|} = \frac{K}{|r|}(\underset{+2}{q_1} + \underset{-2}{q_2}) = 0$$

b) What is the electric potential at point B, (6,0)? [4]

$$V = K\left(\frac{q_1}{|r_1|} + \frac{q_2}{|r_2|}\right) = K\left(\frac{2}{10} + \frac{-2}{2}\right) = K\left(\frac{-4}{5}\right) = -7.2\times10^9\,V$$

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15. Two flat, square conducting plates of area A are separated by distance d. ($A^{½} >> d$) A potential difference of V is applied across the plates. What is the surface charge density, η, on each plate? (Express your answer as a formula in terms of A, d, V and ϵ_0. **[6]**

$$Q = CV, \quad Q = \eta A$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$\Rightarrow \quad \eta \cancel{A} = \left(\frac{\varepsilon_0 \cancel{A}}{d}\right) V$$

$$\eta = \frac{\varepsilon_0 V}{d}$$