

Sample Exam 1

Phy122 Electricity and Magnetism
July 8 2010

Name: _____

You have until 11:45 to complete this exam. You are allowed one index card for formulas and notes. You may have a calculator (but it probably won't help you) but no cell phones or other electronic devices are allowed. Please ask me if any questions come up during the test. I hope you do well!

1. Multiple Choice. [20 Points]

Circle the correct answers.

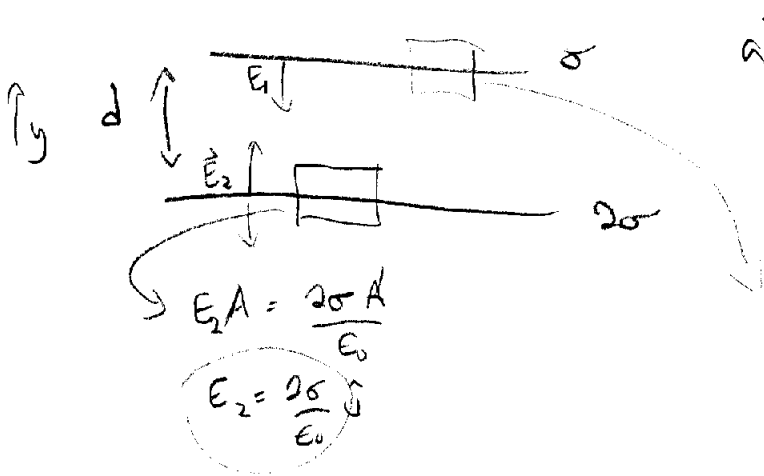
- (a) A charge is inside a spherical balloon. As the balloon expands, what happens to the total flux going through the balloon?
- i. The flux decreases
 - ii. The flux increases
 - iii. The flux remains the same
 - iv. It is impossible to tell from the information given.
- (b) A point charge q is placed at the center of the cavity of a conducting shell of radius R . What is the field outside the shell, at a distance r ?
- i. 0
 - ii. kq/R^2
 - iii. kq/r^2
 - iv. $kq/(4\pi R^2)$
- (c) Two negative point charges are separated by a distance d . The electric field is strongest:
- i. directly between the two charges
 - ii. everywhere along the line that separates the two charges (perpendicular to the line that connects them)
 - iii. along the line that connects the charges, but not in the region between them.
 - iv. just below either of the charges.
- (d) Two charged bugs exert a force of 2 N on each other. What will be the force if they walk toward each other so that they are only one-quarter as far apart?
- i. 1/8 N
 - ii. 1/2 N
 - iii. 8 N
 - iv. 32 N

$$F = \frac{kq_1q_2}{r^2} = 2 \text{ N}$$

$$F' = \frac{kq_1q_2}{(r/4)^2} = 16F = 32 \text{ N}$$

2. Infinite Pancakes [30 points]

- (a) Two infinite planes are placed on top of one another with a layer of air between them so that they are separated by a distance d . The bottom plane has charge per unit area of 2σ , while the top plane has charge per unit area of σ . Find the Electric field in the space between the two plates
- (b) What is the potential difference between the plates?
- (c) A charge Q is embedded in the bottom plate. What is the electric field above the two plates and directly above that charge?



a) Use Gauss' law to find E
(or look up previous result)

$$\int \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\epsilon_0}$$

$$E_1 A = \frac{\sigma A}{\epsilon_0}$$

$$E_1 = \frac{\sigma}{\epsilon_0} (-\hat{y})$$

$$E_2 A = \frac{2\sigma A}{\epsilon_0}$$

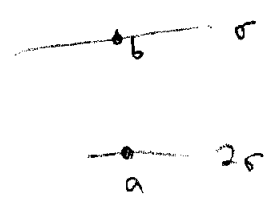
$$E_2 = \frac{2\sigma}{\epsilon_0} \hat{y}$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = \frac{\sigma}{\epsilon_0} (-\hat{y}) + \frac{2\sigma}{\epsilon_0} \hat{y}$$

$$\vec{E} = \frac{\sigma}{\epsilon_0} \hat{y}$$

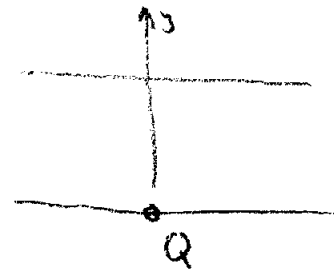
b) $V_b - V_a = - \int_a^b \vec{E} \cdot d\vec{\ell}$
 $= \int E d\ell$
 $= Ed$

$$V = \frac{\sigma d}{\epsilon_0}$$



next

c) above:
use superposition:



$$\vec{E} = E_{\text{from the plates}} + E_{\text{from top plate}} + E_Q$$

$$= \frac{2\sigma}{\epsilon_0} \hat{y} + \frac{\sigma}{\epsilon_0} \hat{y} + \frac{kQ}{y^2} \hat{y}$$

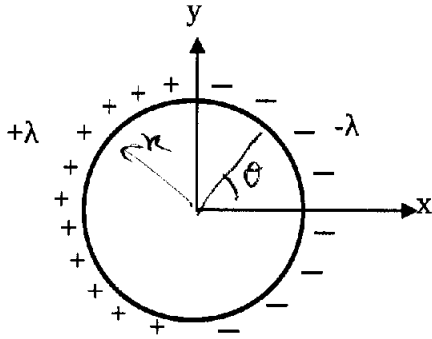
$r^2 = y^2$ directly above

$$\vec{E} = \left(\frac{3\sigma}{\epsilon_0} + \frac{kQ}{y^2} \right) \hat{y}$$

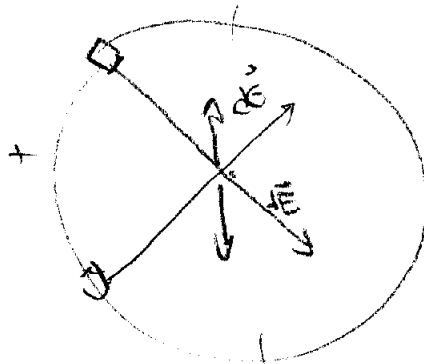
3. A Fancy Ring [30 of points]

A thin ring of charge of radius R sits in the x - y plane. One half of the ring is negatively charged with uniform density $-\lambda$, and the other half is positively charged with a uniform density $+\lambda$, as shown.

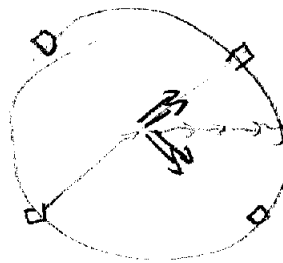
- (a) Find the electric field in the center. [Hint: remember that a small arc length $ds=r d\theta$]
 (b) Find the electric potential at the center.



a) Consider symmetry!



- y-components cancel



x-components from each quadrant add

$$d\vec{E} = d\vec{E}_x + d\vec{E}_y$$

$$E = \int dE_x + \int dE_y$$

$$= 4 \int_0^{\pi/2} \frac{k dq}{R^2} \cos\theta \uparrow$$

$$= 4 \int_0^{\pi/2} \frac{k \lambda R d\theta}{R^2} \cos\theta \uparrow$$

$$= \frac{4k\lambda}{R} \int_0^{\pi/2} \cos\theta d\theta \uparrow$$

$$= \frac{4k\lambda}{R} \left[\sin\theta \right]_0^{\pi/2} \uparrow$$

$$\vec{E} = \frac{4k\lambda}{R} \hat{i}$$

4. There will be an additional question on the exam [20 points]