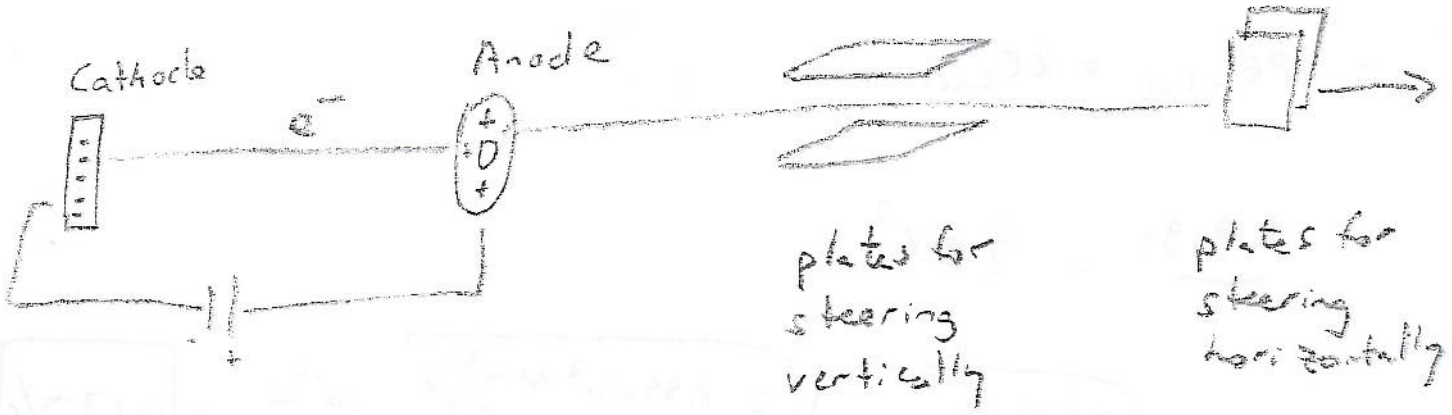
Physics 212 Test 1 Fall 2008

1 (10 points) Draw a conceptual sketch of a cathode ray tube. Label the key parts, and explain w it works in two or three sentences.



Electrons are accelerated from cathode to anode. They are steered horizontally and vertically in a series of plates.

2.(10 points) Two $1kg$ objects are each charged to $+1\mu C$ and are arranged so they are one meter apart. One charge is fixed (*i.e.* nailed down) so that it can't move, and the other is let go. It flies away without friction. What is its speed when it is very far away?

$$PE_{initial} = KE_{final}$$

$$\frac{kq_1q_2}{r} = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2kq_1q_2}{mr}} = \sqrt{\frac{2\ 8.99\times10^9\ N\,m^2/C^2}{1kg}}\ \frac{10^{-6}C}{\sqrt{1m}} = \boxed{0.13\ m/s}$$

3.(10 points) A proton is released from rest in a uniform electric field of magnitude $8 \times 10^4 V/m$. The proton undergoes a displacement of $0.5m$ in the direction of the field. Find the change in the electric potential of the proton as a result of this displacement.

$$\Delta V = -Ed$$

$$= -8 \times 10^4 \, V/m \times 0.5m = \boxed{-4 \times 10^4 \text{ Volts}}$$

4.(10 points) Consider an electric potential given by:

$$V = ax^2 + b(y-1)^2 + cz$$

where a, b, and c are constants. What is the direction of the corresponding electric field at the origin $(x, y, z = 0)$?

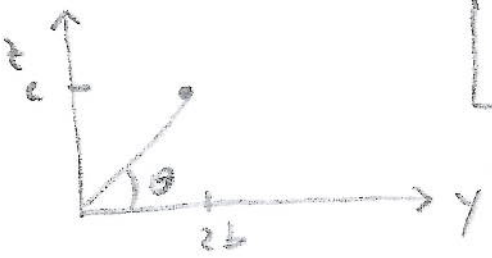
$$E_x = -\frac{\partial V}{\partial x} = 2ax$$

$$E_y = -\frac{\partial V}{\partial y} = -2b(y-1)$$

$$E_z = -\frac{\partial V}{\partial z} = c$$

at $(x, y, z) = (0, 0, 0)$, $\vec{E} = (0, 2b, c)$

$\theta = \tan^{-1}\frac{c}{2b}$ in y-z plane

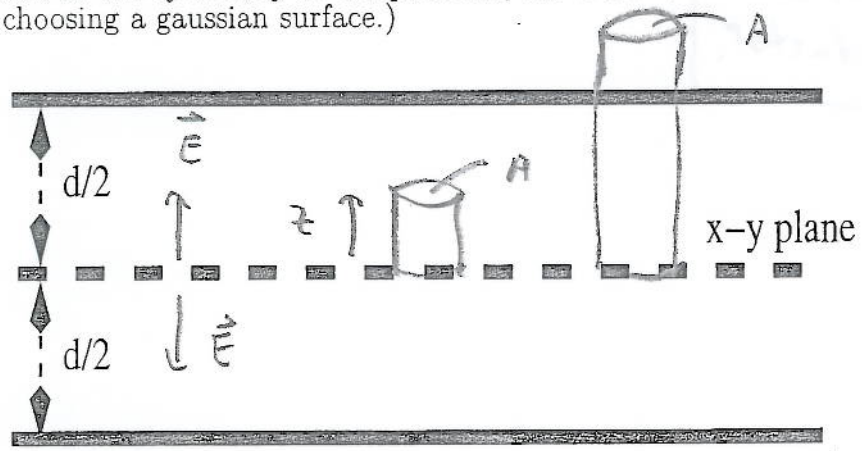


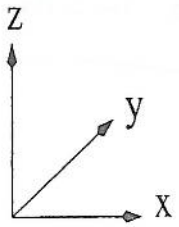
5.(10 points) A spherical conductor of radius R is charged to $-100nC$. Determine the electric field for $r < R$.

$E = 0$ inside a conductor.

6. (25 points total.) Show the details of your calculations. Put a box around each final answer.

A slab of charge, infinite in both the x and y directions, lies centered on the $x-y$ plane. Its thickness (in the z direction) is d, and its volume charge density is given by $\rho(z) = a|z|$. (Note that due to the symmetry of the problem, the electric field is zero in the $x-y$ plane. This may help in choosing a gaussian surface.)





(a)Calculate the electric field in the region *inside* of the charge as a function of z.

$$\oint \vec{E}\cdot d\vec{A} = \frac{1}{\epsilon_0} q_{enclosed}$$

$$EA = \frac{1}{\epsilon_0} q_{enclosed} \qquad q_{enclosed} = \int \rho\, dV = \int_0^z a z' A\, dz' = aA\frac{z^2}{2}$$

$$EA = \frac{1}{\epsilon_0} aA\frac{z^2}{2}$$

$$\boxed{\vec{E} = \frac{a z^2}{2\epsilon_0}\hat{z}}$$

(a)Calculate the electric field in the region *outside* of the charge as a function of z.

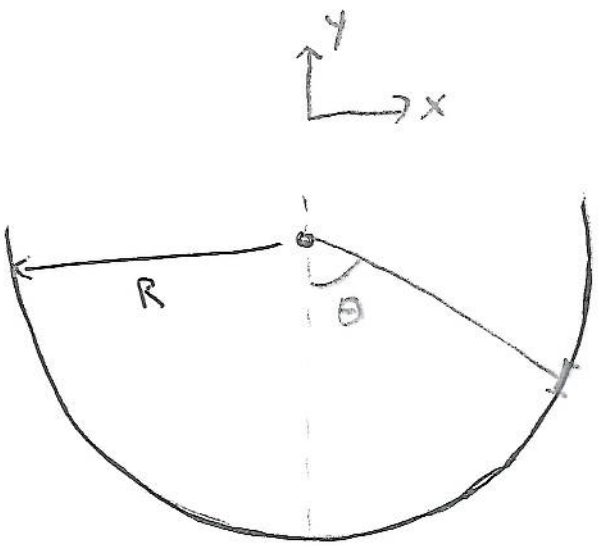
$$q_{enclosed} = aA\frac{(d/2)^2}{2} = aA\frac{d^2}{8}$$

$$EA = \frac{1}{\epsilon_0} aA\frac{d^2}{8}$$

$$\boxed{\vec{E} = \frac{a d^2}{8\epsilon_0}\hat{z}}$$

7. (25 points total.) **Show the details of your calculations. Put a box around each final answer.**

A thin rod with charge Q has been bent into a semicircle of radius R. Find an expression for the electric field at the center.



$$\lambda = \frac{Q}{\pi R}$$

length: $R\,d\theta$

$dq = \lambda R\,d\theta$

$E_x = 0$ by symmetry

$$E_y = \int \frac{k\,dq}{R^2}\cos\theta = \frac{k}{R^2}\lambda R \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos\theta\,d\theta$$

$$= \frac{k\lambda}{R}\sin\theta\Big]_{-\frac{\pi}{2}}^{\frac{\pi}{2}} = \frac{2k\lambda}{R} = \boxed{\frac{2kQ}{\pi R^2}}$$

$$= \frac{Q}{2\pi^2\epsilon_0 R^2}$$