Exam 1
Physics 3, Mar 1, 2019

Some direction:

No phones or other device that connects to the internet.

You may use a calculator, and I would prefer you to plug in numerical answers and keep three sig figs regardless of the correct number of sig figs in the problem.

Present clear and complete answers:

Explain your answers clearly but briefly. You want to aim for a level of solution that someone taking this class would be able to understand. A diagram and a few words may help.

Start calculations with first principles: things like definitions ($\vec{E} \equiv \frac{\vec{F}}{Q}$) or empirical laws (like Coulomb's Law or Newton's Laws) or conservation laws.

Check time:

The point values for each problem are shown next to the question number. Time yourself accordingly. The total value of the exam is 100 points. **Good luck!**

Some constants:

$$K = k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \, Nm^2/C^2 \approx 9 \times 10^9 \, Nm^2/C^2$$

$$\epsilon_0 = 8.85 \times 10^{-12} C/N/m^2$$

$$e = 1.6 \times 10^{-19} C$$

Helpful Equations:

$$F = |\vec{F}| = k\frac{|qQ|}{r^2} \qquad \vec{F} = k\frac{qQ}{r^2}\hat{r}$$

$$\vec{E} \equiv \frac{\vec{F}}{Q}$$

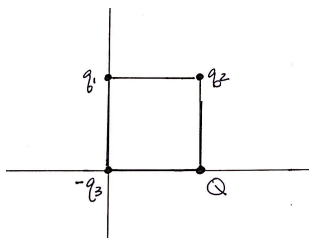$$E = |\vec{E}| = k\frac{|q|}{r^2} \qquad \vec{E} = k\frac{q}{r^2}\hat{r}$$
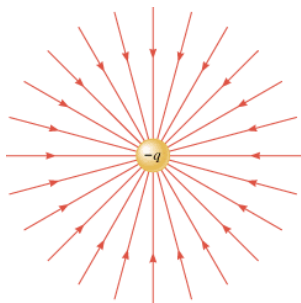
$$dq = \lambda d\ell$$

$$dq = \sigma da = \eta da$$

$$dq = \rho dV$$

NAME:_____

1. (10 points) Four charges are on the corners of a square as shown. Draw the free-body diagram (force diagram) for Q.


2. (5 points) Here's a diagram of the electric field for a negative point charge. Where is the field the strongest?

3. (15 points) Two charges are on the x-axis. $q = 3C$ and is located at $x = -4$m. $Q = 2C$ and is located at $x = +2$m. What is the force on q?

4. (15 points) A point charge of $q = 2\mu C$ is at the center of a circle of radius $R = 3\text{cm}$. For each of the points marked on the circle, find the electric field. You may leave your answer in components or magnitude and direction, whichever you prefer.
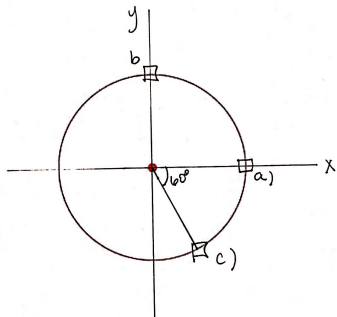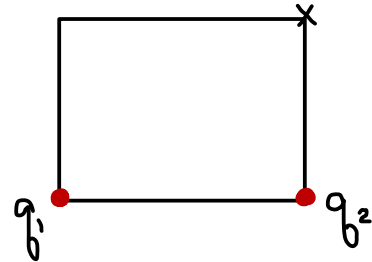

(a) What is $\vec{E}$ at a)

(b) What is $\vec{E}$ at b)

(c) What is $\vec{E}$ at c)

5. (20 points) Two point charges are located on the bottom two corners of a 6cm × 8cm rectangle. $q_1 = 2\mu$C and $q_2 = -1\mu$C.

(a) Find the electric field at the point marked with an "x".

(b) If you put a charge $Q = 4\mu$C at the "x", what would the force on it be?

6. (20 points) A circular ring of radius R has a charge $+q$ uniformly distributed along its left half, and $-q$ distributed over the right half. Find the electric field at the center.

7. (15 points) A thin rod of length L has a *non-uniform* linear charge distribution, $\lambda = cx$ where c is a positive constant and x is the distance along the rod from one end to the other. Find the total charge q on the rod (in terms of λ, c, and L).