Print your full name:  

Sign your name:  

Please fill in your Student ID number:  

IMPORTANT  

Read these directions carefully:

• There are 5 problems totalling 100 points. Check your exam to make sure you have all the pages. Work each problem on the page the problem is on. You may use the back. If you need extra pages, I have plenty up front.

• **Indicate what you are doing!** We cannot give full credit for merely writing down the answer. **Neatness counts!** I will give generous partial credit if I can tell that you are on the right track. This means you must be neat and organized.

• Each problem with its associated figure is self explanatory. If you *must* ask a question, then come to the front, being as discrete as possible so as not to disturb others.

• Put your name on each page it is asked for. You will lose credit if you fail to print your name on each page it is asked for.
Problem 1. 20 points.

Three charges are arranged on the corners of a square of side $L$. The charges have magnitude $+Q$, $-2Q$, and $+Q$ respectively, as shown in the Figure:

Calculate the electric field at the point $P$ shown in the Figure. $P$ is the corner of the square where there is no charge. Remember that electric field is a vector, so calculate both the $x$ and $y$ components.
A long straight thin wire is positively charged with charge per unit length $\lambda$. Surrounding and concentric with this wire is a hollow cylinder of inner radius $R_1$ and outer radius $R_2$. The cylinder carries a uniform negative charge, such that the entire system is electrically neutral.

(a) Calculate the charge per unit volume $\rho$ inside the cylinder. Express your answer in terms of $\lambda$, $R_1$, and $R_2$.

(b) Calculate the electric field in the region inside the inner part of the cylinder. That is, for $r \leq R_1$ where $r$ is the distance from the axis. Assume that $r$ is greater than the (very small) radius of the wire.

(c) Calculate the electric field in the solid part of the cylinder, that is, for $R_1 \leq r \leq R_2$.

(d) Calculate the electric field outside the cylinder, that is, for $r \geq R_2$.

Note: You may continue this problem on the next page.
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Problem 2. Continued...
Problem 3. 20 points.

Consider the same three charges shown in Problem 1. The Figure is reproduced here for your convenience.

Calculate the total electrostatic potential energy stored in this collection of three charges. DO NOT just write down the answer. Explain what you are writing down.
Problem 4. 25 points.

(a) Consider a uniformly charged rod of length $L$ and total charge $Q$. Calculate the electric potential $V$ at a point $P$ a distance $a$ from the end of the rod.

Hint: There is more than one way to set this up. I would choose the left end of the rod to be $x = 0$, and the right end to be $x = L$. Then I would calculate the potential due to a small (differential) piece of the rod at position $x$, and add them up.

Useful Integral: $\int \frac{du}{u} = \ln u$

(b) Calculate the electric field at the same point $P$. Hint: Use the answer from part (a) and you don’t need to do any integral.

Note: You may continue this problem on the next page.
Print your name: ________________________________

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Problem 4. *Continued*...
Problem 5. 5 points.

Note: **Work this problem last.** It is only 5 points.

Consider the same three charges shown in Problem 1. The Figure is reproduced here for your convenience.

Show approximately where on this Figure the electric field is zero. Indicate your answer by drawing an X about where you think the field is zero.

*Hint:* First look at the answer you got in Problem 1. Which way is it pointing? Now, then think about what is the field at the center of the square. Which way is the field there? Now, you should be able to answer the problem.