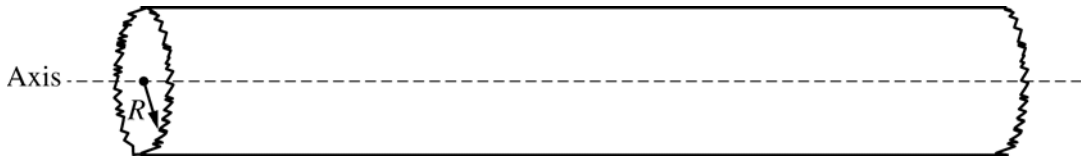
**PHYSICS C: ELECTRICITY AND MAGNETISM**

**SECTION II**

**Time—45 minutes**

**3 Questions**

**Directions:** Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.




E&M 1.

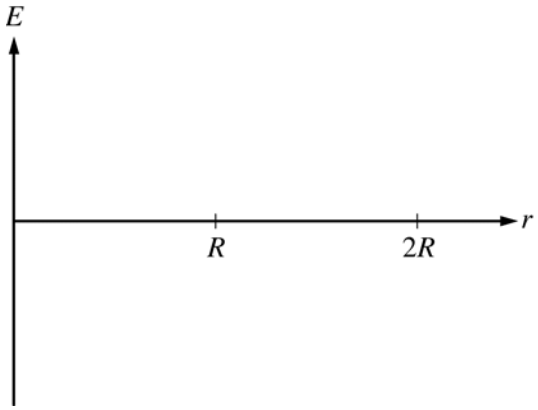
A very long, solid, nonconducting cylinder of radius $R$ has a positive charge of uniform volume density $\rho$.

A section of the cylinder far from its ends is shown in the diagram above. Let $r$ represent the radial distance from the axis of the cylinder. Express all answers in terms of $r$, $R$, $\rho$, and fundamental constants, as appropriate.

(a) Using Gauss's law, derive an expression for the magnitude of the electric field at a radius $r < R$. Draw an appropriate Gaussian surface on the diagram.

(b) Using Gauss's law, derive an expression for the magnitude of the electric field at a radius $r > R$.

(c) On the axes below, sketch the graph of electric field $E$ as a function of radial distance $r$ for $r = 0$ to $r = 2R$. Explicitly label any intercepts, asymptotes, maxima, or minima with numerical values or algebraic expressions, as appropriate.



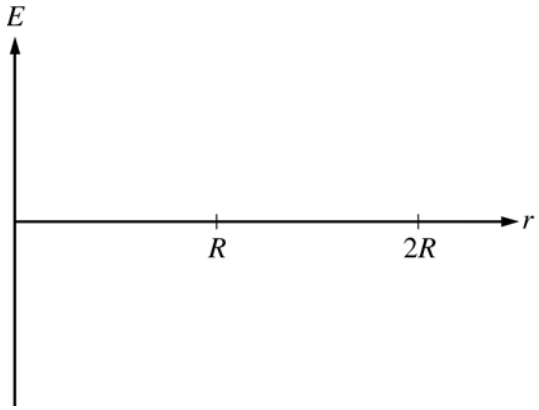

(d)

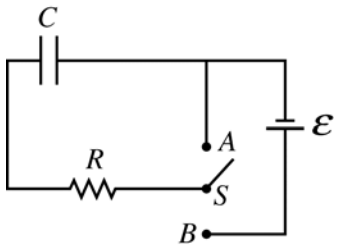
i. Derive an expression for the magnitude of the potential difference between $r = 0$ and $r = R$.

ii. Is the potential higher at $r = 0$ or $r = R$ ?

____ $r = 0$ ____ $r = R$

(e) The nonconducting cylinder is replaced with a conducting cylinder of the same shape and same linear charge density. On the axes below, sketch the electric field $E$ as a function of $r$ for $r = 0$ to $r = 2R$. Explicitly label any intercepts, asymptotes, maxima, or minima with numerical values or algebraic expressions, as appropriate.






E&M 2.

In a lab, you set up a circuit that contains a capacitor *C,* a resistor *R*, a switch *S*, and a power supply, as shown in the diagram above. The capacitor is initially uncharged. The switch, which is initially open, can be moved to positions *A* or *B*.

(a)

i. Indicate the position to which the switch should be moved to charge the capacitor.

__ *A* __ *B*

ii. On the diagram, draw a voltmeter that is properly connected to the circuit in a manner that will allow the voltage to be measured across the capacitor.

After a long time you move the switch to discharge the capacitor, and your lab partner starts a stopwatch. You collect the following measurements of the voltage across the capacitor at various times.

| t (s) | 6 | 18 | 30 | 42 | 54 |
|---|---|---|---|---|---|
| $V(V)$ | 252 | 74 | 33 | 10 | 6 |
| | | | | | |
| | | | | | |

You wish to determine the time constant $\tau$ of the circuit from the slope of a linear graph.

(b)

i. Indicate two quantities you would plot to obtain a linear graph.

ii. Use the remaining rows in the table above, as needed, to record any quantities that you indicated that are not given. Label each row you use and include units.