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 the pink booklet in the spaces provided after each part, NOT in this green insert.

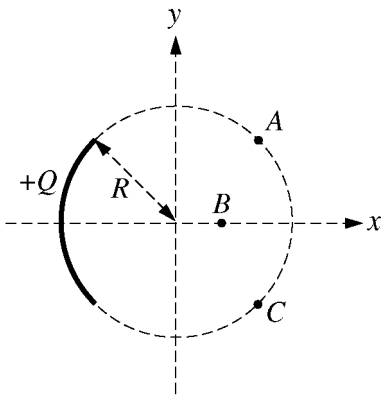


Figure I

E&M. 1.

A charge $+Q$ is uniformly distributed over a quarter circle of radius R, as shown above. Points A, B, and C are located as shown, with A and C located symmetrically relative to the x-axis. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) Rank the magnitude of the electric potential at points A, B, and C from greatest to least, with number 1 being greatest. If two points have the same potential, give them the same ranking.

____ V_A ____ V_B ____ V_C

Justify your rankings.

Point P is at the origin, as shown below, and is the center of curvature of the charge distribution.

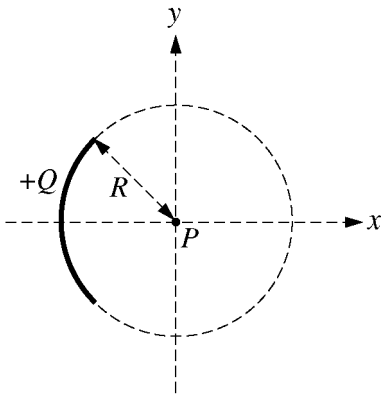
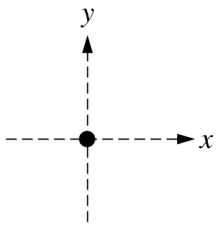


Figure II

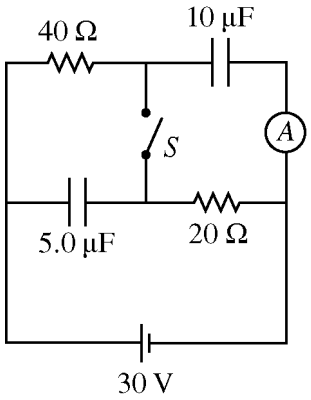
(b) Determine an expression for the electric potential at point P due to the charge Q.

(c) A positive point charge q with mass m is placed at point P and released from rest. Derive an expression for the speed of the point charge when it is very far from the origin.

(d) On the dot representing point P below, indicate the direction of the electric field at point P due to the charge Q.



(e) Derive an expression for the magnitude of the electric field at point P.



E&M. 2.

In the circuit illustrated above, switch S is initially open and the battery has been connected for a long time.

(a) What is the steady-state current through the ammeter?

(b) Calculate the charge on the $10\ \mu F$ capacitor.

(c) Calculate the energy stored in the $5.0\ \mu F$ capacitor.

The switch is now closed, and the circuit comes to a new steady state.

(d) Calculate the steady-state current through the battery.

(e) Calculate the final charge on the $5.0\ \mu F$ capacitor.

(f) Calculate the energy dissipated as heat in the $40\ \Omega$ resistor in one minute once the circuit has reached steady state.