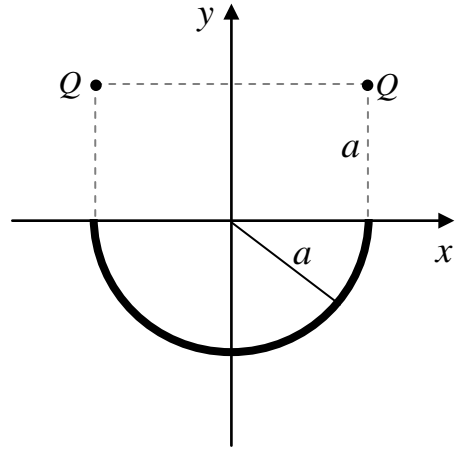


6. (40 points total) Consider the charge distribution shown. A semicircle of radius a centered at the origin carries a uniform positive charge per unit length λ . Two positive point charges Q lie at the points $(-a,a)$ and (a,a) . You may use symmetry arguments when appropriate.

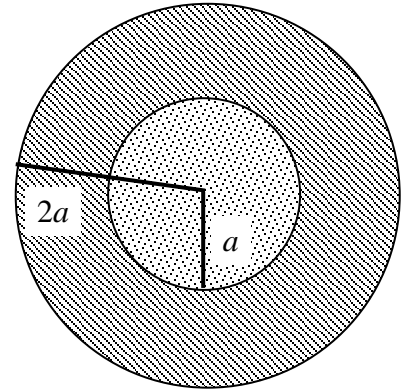


(a) (20 points) Find an expression for the electric field at the origin **due to the charged semicircle only**. Express your answer in unit vector notation.

(b) (15 points) Find an expression for the electric field at the origin **due to the point charges only**. Express your answer in unit vector notation.

(c) (5 points) Find the value of Q for which the electric field at the origin is zero.

7. (40 points total) A solid insulating plastic sphere of radius a carries a total net positive charge $3Q$ uniformly distributed throughout its interior. The insulating sphere is coated with a metallic layer of inner radius a and outer radius $2a$. The conducting metallic layer carries a net charge of $-2Q$.



(a) (10 points) Compute the volume charge density ρ associated with the charge uniformly distributed in the plastic sphere in terms of variables introduced above.

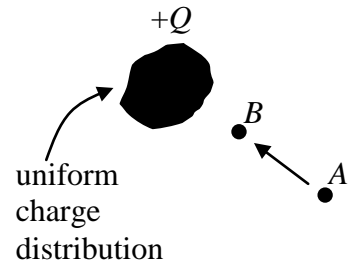
(b) (10 points) Apply Gauss's law to find the magnitude of the electric field in the region $r < a$. In the figure, draw the Gaussian surface you are using, and indicate on that surface the direction of any vectors which appear in the mathematical expression of Gauss's law. Express your answer in terms of a , Q , r , and ϵ_0 . (If you get an expression involving ρ , substitute it from above to re-express your answer in terms of the stated variables.)

(c) (10 points) Find the electric field in the region $a < r < 2a$. Justify your answer.

(d) (10 points) Find the net charge q_i residing on the inner surface of the metallic layer, and the net charge q_o residing on the outer surface of the metallic layer.

8. (40 points total) An irregularly shaped uniform charge distribution with total charge $+Q$ is shown below. An electron (with charge $-e$) starts from rest at point A and moves to point B. The electrostatic potential at A is V_A , and the electrostatic potential at B is V_B .

(a) (10 points) Using only the parameters given above and beginning with an official starting equation, find the work done by the electric field as the electron moves from point A to point B.



(b) (10 points) Is the work done by the electric field as the electron moves from A to B positive, negative, or zero?

(circle one)

POSITIVE

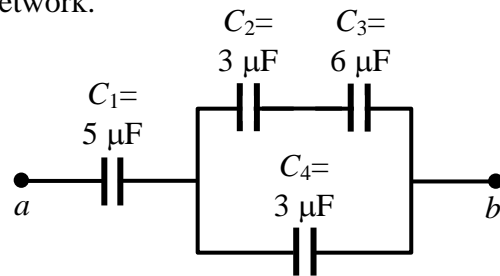
NEGATIVE

ZERO

(c) (20 points) Find the magnitude of the potential difference between the points A and B if the speed of the electron at B is 4.2×10^5 m/s. Begin with an OSE and derive the final expression used to calculate the potential difference.

9. (40 points total) Four capacitors are connected as shown. $C_1 = 5 \mu\text{F}$, $C_2 = 3 \mu\text{F}$, $C_3 = 6 \mu\text{F}$, and $C_4 = 3 \mu\text{F}$. The voltage difference across the capacitor network is $V_{ab} = 60 \text{ V}$.

(a) (20 points) Determine the equivalent capacitance of the capacitor network.



(b) (10 points) Determine the charge Q_1 on capacitor C_1 .

(c) (10 points) Determine the charge Q_4 on capacitor C_4 .