Exercise 21.53

✓ Complete

An electric dipole with dipole moment $\vec{p}$ is in a uniform external electric field $\vec{E}$.

Review | Constants

Part A

Find the orientations of the dipole for which the torque on the dipole is zero measured counterclockwise from the electric field direction.

Enter your answers in degrees separated by a comma.

$\theta =$ 180,0 °

Submit Previous Answers

✓ **Correct**

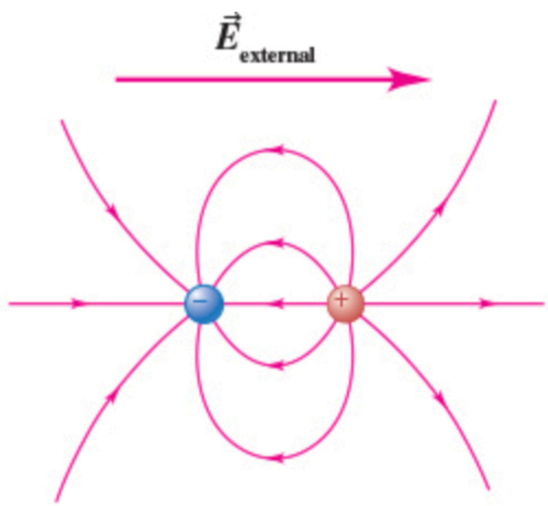
Part B

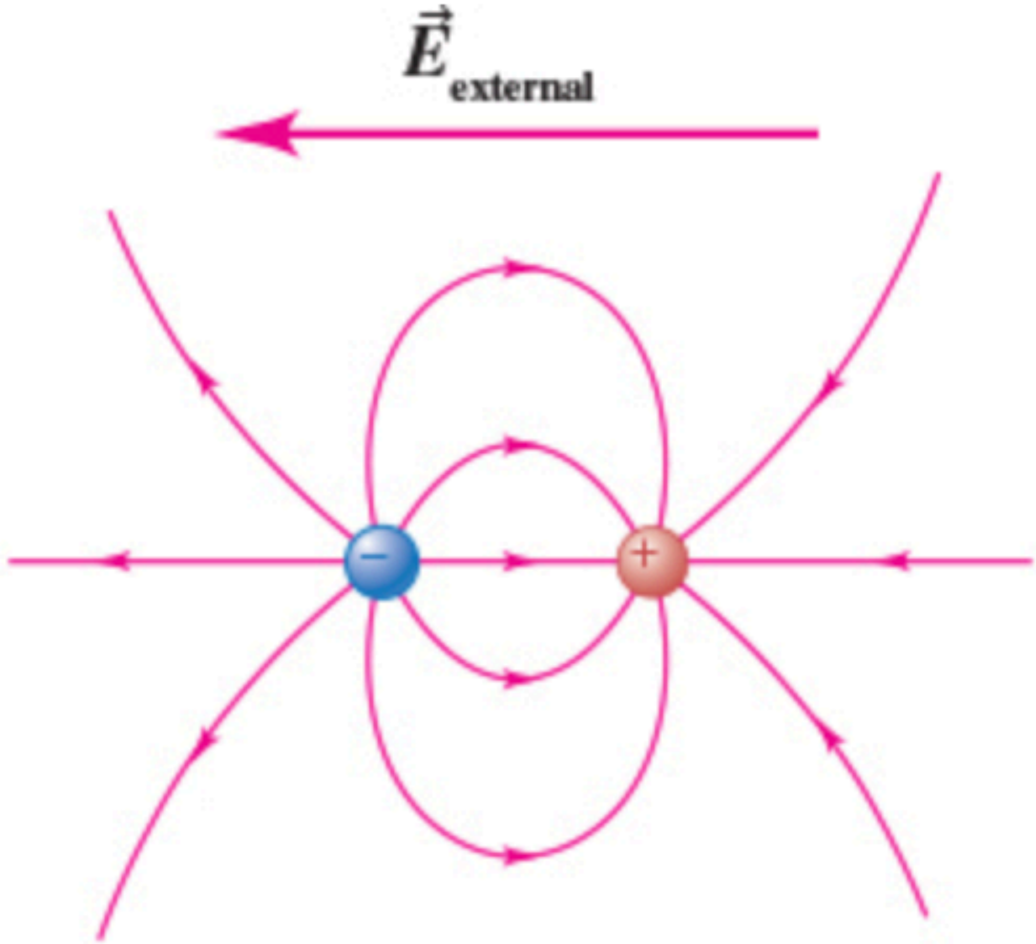
Which of the orientations in part A is stable, and which is unstable? (*Hint:* Consider a small rotation away from the equilibrium position and see what happens.)

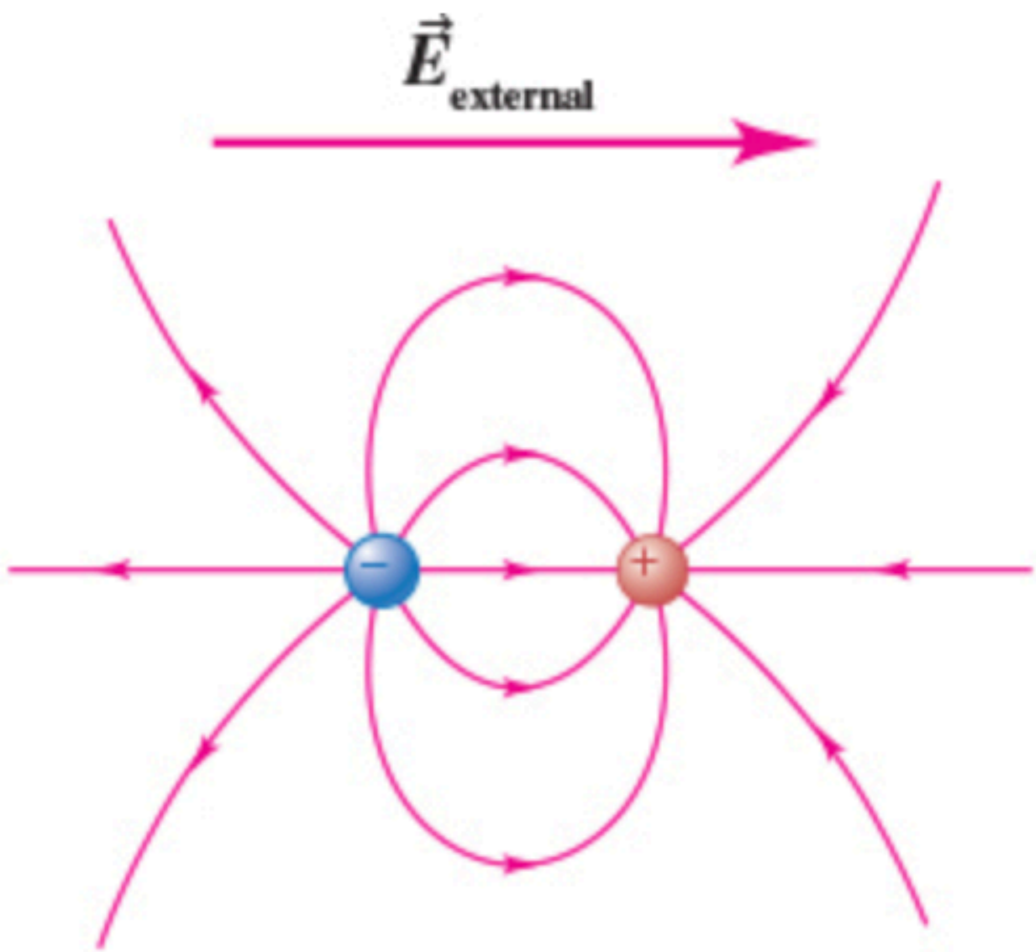
- ○ The orientation is stable only when $\vec{p}$ and $\vec{E}$ point in opposite directions.
- ◉ The orientation is stable only when $\vec{p}$ and $\vec{E}$ point in the same direction.
- ○ Both orientations in part A are stable.
- ○ Both orientations in part A are unstable.

Part C

Choose a figure that correctly shows the dipole's own electric field and the external electric field for the stable orientation i
part B.




$\vec{E}_{external}$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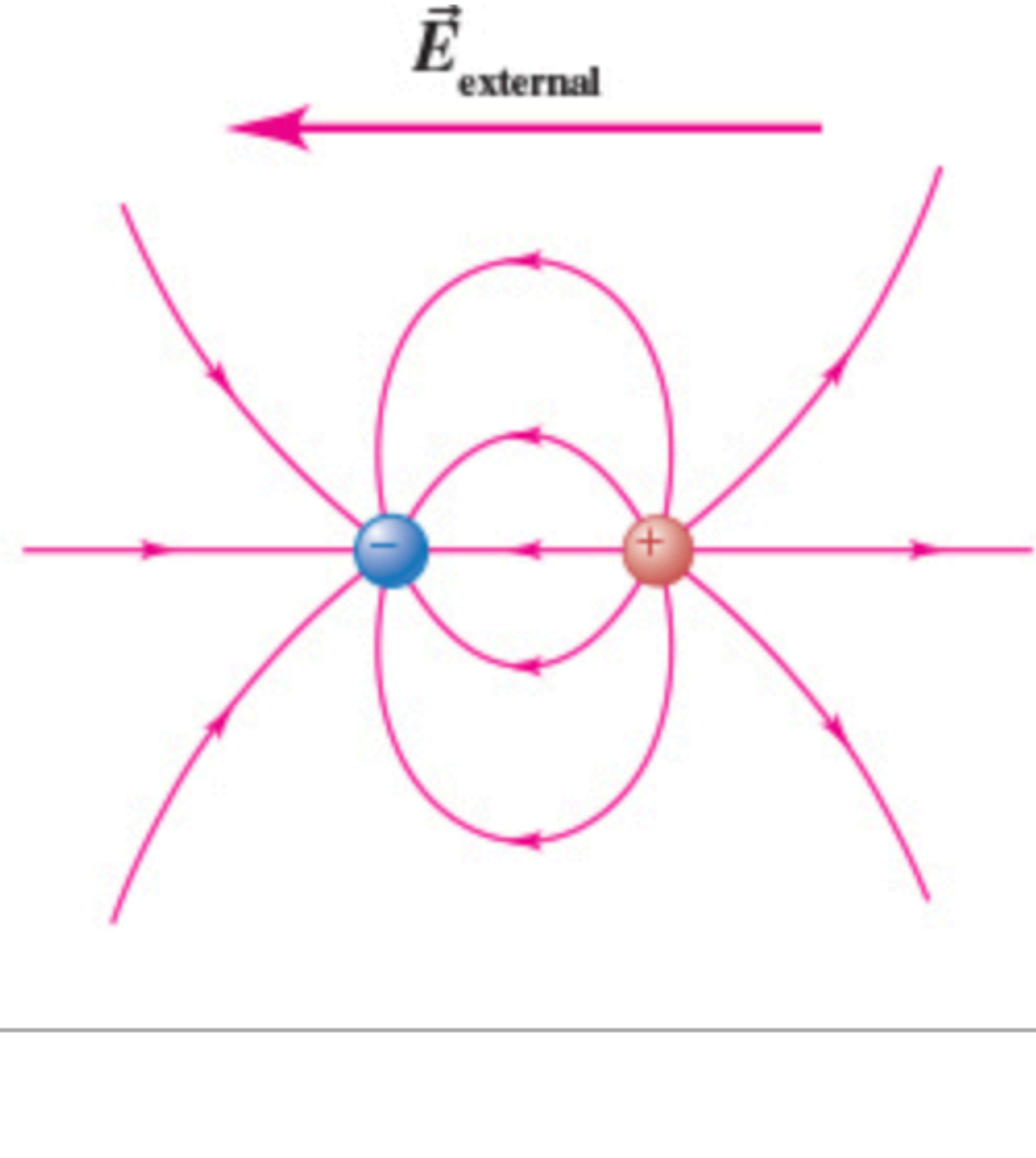


$\vec{E}_{\text{external}}$

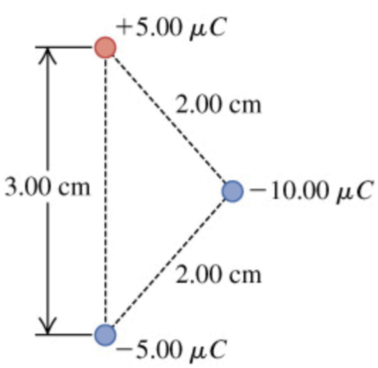
Review | Constants

Three charges are at the corners of an isosceles triangle as shown in (Figure 1). The $\pm 5.00\ \mu C$ charges form a dipole. Suppose that the $+y$-axis is directed upward and the $+x$-axis is directed rightward.

For related problem-solving tips and strategies, you may want to view a Video Tutor Solution of Force and torque on an electric dipole.

Figure

1 of 1



Part A

Find the magnitude of the force the -10.00 μC charge exerts on the dipole.

Express your answer with the appropriate units.

F = Value Units

Submit Request Answer

Part B

Find the direction angle of the force the -10.00 μC charge exerts on the dipole. The angle is measured from the $+x$-axis toward the $+y$-axis.

Express your answer in degrees to three significant figures.

θ = °

Part C

For an axis perpendicular to the plane of the figure at the midpoint of the line connecting the $\pm 5.00\ \mu\text{C}$ charges, find the magnitude of the torque exerted on the dipole by the -10.00 μC charge.

Express your answer with the appropriate units.

τ = Value Units

Submit Request Answer

Part D

What is the direction of the torque in part C?

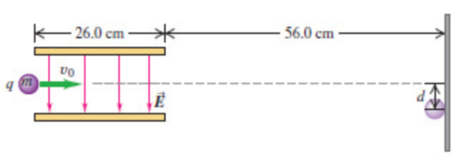
- Clockwise
- Counterclockwise

Review I Constants

A small object with mass m, charge q, and initial speed v_0 = 4.00×10^3 $\mathrm{m/s}$ is projected into a uniform electric field between two parallel metal plates of length 26.0 cm (Figure 1). The electric field between the plates is directed downward and has magnitude E = 600 $\mathrm{N/C}$. Assume that the field is zero outside the region between the plates. The separation between the plates is large enough for the object to pass between the plates without hitting the lower plate. After passing through the field region, the object is deflected downward a vertical distance d = 1.35 cm from its original direction of motion and reaches a collecting plate that is 56.0 cm from the edge of the parallel plates. Ignore gravity and air

Figure

1 of 1



Part A

Calculate the object's charge-to-mass ratio, q/m.

Express your answer in coulombs per kilogram.

q/m = $\mathrm{C/kg}$

Submit Request Answer

Provide Feedback

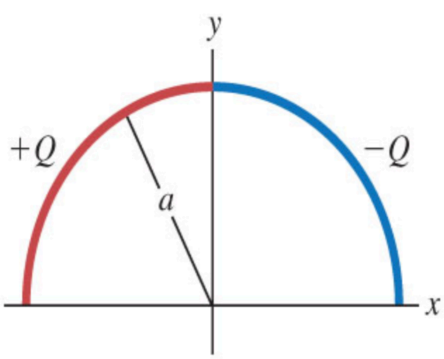
Next

Complete

A semicircle of radius a is in the first and second quadrants, with the center of curvature at the origin. Positive charge $+Q$ is distributed uniformly around the left half of the semicircle, and negative charge $-Q$ is distributed uniformly around the right half of the semicircle in the following figure.(Figure 1)

Figure

1 of 1



Review | Constants

Part A

What is the magnitude of the net electric field at the origin produced by this distribution of charge?

Express your answer in terms of the variables Q, a, and constant k.

$|E| = \frac{4kQ}{\pi a^2}$

Submit Previous Answers

Correct

Part B

What is the direction of the net electric field at the origin produced by this distribution of charge?

- $+x$ direction
- $-x$ direction
- $+y$ direction
- $-y$ direction
- another direction

Exercise 22.9 - Enhanced - with Feedback

Review | Constants

A charged paint is spread in a very thin uniform layer over the surface of a plastic sphere of diameter 18.0 cm, giving it a charge of -59.0 $\mu\mathrm{C}$.

Part A

Find the electric field just inside the paint layer.

Express your answer with the appropriate units. Enter positive value if the field is directed away from the center of the sphere and negative value if the field is directed toward the center of the sphere.

μÅ ?

E = Value Units

Submit Request Answer

Part B

Find the electric field just outside the paint layer.

Express your answer with the appropriate units. Enter positive value if the field is directed away from the center of the sphere and negative value if the field is directed toward the center of the sphere.

μÅ ?

E = Value Units

Part C

Find the electric field 6.00 cm outside the surface of the paint layer.

Express your answer with the appropriate units. Enter positive value if the field is directed away from the center of the sphere and negative value if the field is directed toward the center of the sphere.

$E = -2.36\times10^{7}\ \frac{\mathrm{N}}{\mathrm{C}}$

Submit Previous Answers

Correct

A hollow, conducting sphere with an outer radius of 0.260 m and an inner radius of 0.200 m has a uniform surface charge density of +6.17 $\times$ 10^{-6} $\mathrm{C/m^2}$. A charge of -0.400 $\mu\mathrm{C}$ is now introduced into the cavity inside the sphere.

Review | Constants

Part A

What is the new charge density on the outside of the sphere?

Express your answer with the appropriate units.

σ = Value Units

Submit Request Answer

Part B

Calculate the strength of the electric field just outside the sphere.

Express your answer with the appropriate units.

E = Value Units

Exercise 22.21 - Enhanced - with Solution

The electric field at a distance of 0.147 m from the surface of a solid insulating sphere with radius 0.362 m is 1660 $\mathrm{N/C}$.

You may want to review (Page) .

For related problem-solving tips and strategies, you may want to view a Video Tutor Solution of Field of a uniformly charged sphere.

Review | Constants

Part A

Assuming the sphere's charge is uniformly distributed, what is the charge density inside it?

ρ = $\mathrm{C/m^3}$

Submit Request Answer

Part B

Calculate the electric field inside the sphere at a distance of 0.193 m from the center.

E = $\mathrm{N/C}$

Problem 22.45

Review | Constants

An insulating hollow sphere has inner radius a and outer radius b. Within the insulating material the volume charge density is given by $\rho\left(r\right) = \frac{\alpha}{r}$,where α is a positive constant.

Part A

What is the magnitude of the electric field at a distance r from the center of the shell, where $a < r < b$?

Express your answer in terms of the variables α, a, r, and electric constant ϵ_0.

ΑΣφ ?

E =

Submit Request Answer

Part B

A point charge q is placed at the center of the hollow space, at $r = 0$. What value must q have (sign and magnitude) in order for the electric field to be constant in the region $a < r < b$?

Express your answer in terms of the variables α, a, and appropriate constants.

ΑΣφ ?

q =

Part C

What then is the value of the constant field in this region?

Express your answer in terms of the variable α and electric constant ϵ_0.

ΑΣφ ?

E =

Submit

Request Answer

Problem 22.46

In the early years of the 20th century, a leading model of the structure of the atom was that of the English physicist J. J. Thomson (the discoverer of the electron). In Thomson's model, an atom consisted of a sphere of positively charged material in which were embedded negatively charged electrons, like chocolate chips in a ball of cookie dough. Consider such an atom consisting of one electron with mass m and charge $-e$, which may be regarded as a point charge, and a uniformly charged sphere of charge $+e$ and radius R.

Review | Constants

Part A

Is equilibrium position of the electron at the center of the nucleus.

- (•) Yes
- ( ) No

Submit Previous Answers

✓ Correct

Part B

In Thomson's model, it was assumed that the positive material provided little or no resistance to the motion of the electron. If the electron is displaced from equilibrium by a distance r less than R, find the net force on the electron.

Express your answer in terms of the variables R, e, vector $\mathbf{r}$ and constants π and ϵ_0. Use the 'vec' button to denote vectors in your answers.

ΑΣφ ?

Review | Constants

Part C

Will the resulting motion of the electron be simple harmonic. (*Hint:* Review the definition of simple harmonic motion in Section 13.2 from the textbook. If it can be shown that the net force on the electron is of this form, then it follows that the motion is simple harmonic. Conversely, if the net force on the electron does not follow this form, the motion is not simple harmonic.)

- Yes, it will be.
- No, it will not be.

Submit   Previous Answers

Correct

Part D

Calculate the frequency of oscillation.

Express your answer in terms of the variables m, R, e, and constants π and ϵ_0.

$$f = \frac{1}{2\pi}\sqrt{\frac{e^2}{4\pi m\epsilon_0 R^3}}$$

Submit   Previous Answers

Part E

By Thomson's time, it was known that excited atoms emit light waves of only certain frequencies. In his model, the frequency of emitted light is the same as the oscillation frequency of the electron or electrons in the atom. What would the radius of a Thomson-model atom have to be for it to produce red light of frequency 4.54×10^{14} Hz ? (see Appendix F from the textbook for data about the electron)

Express your answer in meters.

R = 3.14×10^{-10} m

Submit   Previous Answers

Correct

Part F

Compare your answer in the previous part to the radii of real atoms, which are of the order of $10^{-10}\mathrm{m}$.

- ◉ The atom radius in this model is the correct order of magnitude.
- ○ The atom radius in this model is the invalid order of magnitude.

Part G

If the electron were displaced from equilibrium by a distance greater than R, would the electron oscillate? Would its motion be simple harmonic? Explain your reasoning. (*Historical note:* In 1910, the atomic nucleus was discovered, proving the Thomson model to be incorrect. An atom's positive charge is not spread over its volume as Thomson supposed, but is concentrated in the tiny nucleus of radius 10^{-14} to $10^{-15} \mathrm{m}$.)

- The electron would still oscillate. But the motion would not be simple harmonic.
- The electron would not oscillate.
- The electron would still oscillate. The motion would be simple harmonic.

Submit

Previous Answers

Challenge Problem 22.62

Review | Constants

A region in space contains a total positive charge Q that is distributed spherically such that the volume charge density $\rho(r)$ is given by

$$\rho(r) = 3\alpha r/(2R) \quad \text{for } r \leq R/2$$

$$\rho(r) = \alpha[1-(r/R)^2] \quad \text{for } R/2 \leq r \leq R$$

$$\rho(r) = 0 \quad \text{for } r \geq R$$

Here α is a positive constant having units of $\mathrm{C/m^3}$.

Part A

Determine α in terms of Q and R.

Express your answer in terms of variables R, Q and appropriate constants.

ΑΣφ ?

α =

Submit Request Answer

Part B

Using Gauss's law, derive an expression for the magnitude of the electric field as a function of r for $r \leq R/2$. Express your answers in terms of the total charge Q.

Express your answer in terms of variables r, R, Q and appropriate constants.

ΑΣφ ?

E_1 =

Part C

Using Gauss's law, derive an expression for the magnitude of the electric field as a function of r for $R/2 \leq r \leq R$. Express your answers in terms of the total charge Q.

Express your answer in terms of variables r, R, Q and appropriate constants.

$$E_2 = \frac{1}{4\pi r^2 \epsilon_0} \frac{1920Q}{233} \left[\left(\frac{r^3}{3R^3} - \frac{r^5}{5R^5} \right) - \frac{23}{1920} \right]$$

Submit Previous Answers

Correct

Part D

Using Gauss's law, derive an expression for the magnitude of the electric field as a function of r for $r \geq R$. Express your answers in terms of the total charge Q.

Express your answer in terms of variables r, R, Q and appropriate constants.

ΑΣφ ?

$E_3 =$

Part E

What fraction of the total charge is contained within the region $R/2 \le r \le R$?

$\frac{Q_0}{Q}$ =

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Part F

What is the magnitude of $\vec{E}$ at $r = R/2$?

Express your answer in terms of variables R, Q and appropriate constants.

E =

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