

Reading: *Sternheim and Kane*, chapter 5, section 5–6; chapter 16, sections 1–2; and chapter 2, section 1.

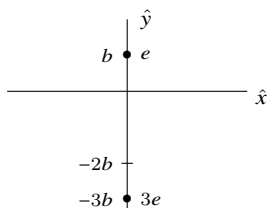
Electromagnetism and Optics, chapter I, sections 1–5.

Please show all of the necessary steps in solving the following problems. Full credit will only be given for complete solutions.

1. A cell membrane 1.00×10^{-8} m thick has positive ions on one side and negative ions on the other. What is the **magnitude** of the force between two ions of charges e and $-e$ at this separation?

2. The distance between the sodium ion and fluorine ion in NaF is about 198 pm. If the sodium ion has a charge of e and the fluoride ion has a charge of $-e$, what is the **magnitude** of the force between them? A *picometer* (pm) is 10^{-12} meters.

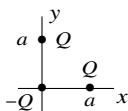
3. A sodium ion Na^+ of charge e and an iron ion Fe^{3+} of charge $3e$ are arranged as shown. What is the **magnitude** and **direction** of the force on the iron ion when $b = 10.0$ nm? Recall that $e = 1.602 \times 10^{-19}$ C.



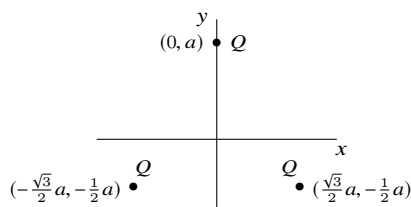
4. What is the electric field at $x = 0$ and $y = -2b$ for the same figure as in problem 3? Is there any place along the \hat{y} -axis where the electric field vanishes?

5. The nucleus of a radium atom has a charge of $88e$. What is the **magnitude** and **direction** (relative to the nucleus, i.e. towards or away) of the electric field at a distance of 1.00×10^{-10} m from the nucleus? What is the magnitude and direction (again, relative to the nucleus) of the force on an electron at this distance? If the mass of an electron is 9.11×10^{-31} kg, what acceleration would it experience?

6. Find the **magnitude** and the **direction** of the force on the charge $-Q$ in the following configuration of charges.



7. Suppose that three equal charges Q are arranged to form an equilateral triangle, as shown. What is the force on the 'top' charge? What is the electric field at the centre of the triangle, $x = 0$ and $y = 0$?



8. Explain why the electric field at the centre of a uniformly charged ring vanishes. A qualitative explanation is sufficient—you do not need to perform any complicated calculations.