

Workbook



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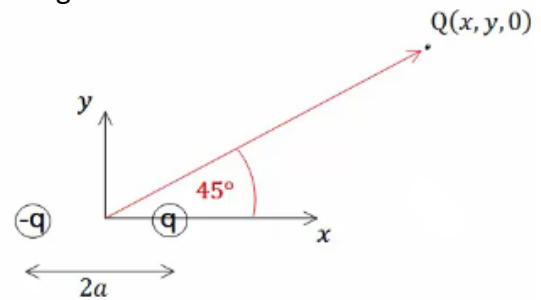
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Electric Dipole

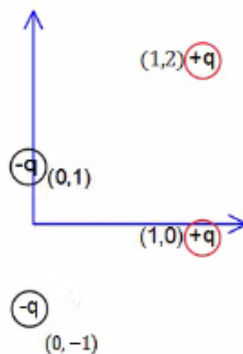
Electric Dipole

Questions

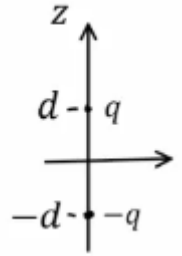
- 1) Two charges q and $-q$ are placed at $x=a$ and at $x=-a$.
- Calculate the force acting on a third charge Q placed at $(x, y, 0)$.
 - Assume that the distance between Q and the origin is much larger than the distance between the other two charges. The angle between Q and the x -axis is 45° (see diagram). Use your answer to 1 to calculate the force on Q .
 - Calculate the dipole moment of charges q and $-q$.
 - Again calculate the force on Q , this time using the equation for a dipole field. How does your answer compare to that of question 2?



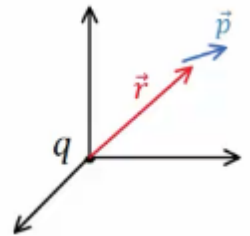
- 2) We are given a dipole of moment $\vec{p} = (p, 0, 0)$, located at the origin.
- Calculate the magnitude p such that if an electron was located at $(a, 0, 0)$ with a velocity of $(v, 0, 0)$, it would eventually come to a stop at $(b, 0, 0)$.
 - Calculate the magnitude p such that if an electron was located at $(a, -\sqrt{2}a, 0)$ with a velocity of $(0, 0, v)$, it would have circular motion.
- 3) Calculate the total dipole moment of the system.



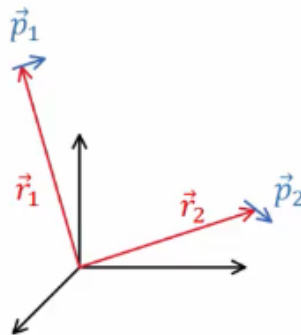
- 4) A charge q is located at $(0,0, d)$ and $-q$ is located at $(0,0, -d)$.
- Calculate the exact potential at a point along the z-axis.
 - What is the minimal value of z such that the approximation of the potential at that point wont deviate more than 1% from the actual value.
 - What is the minimal value of z such that the approximation of the electric field at that point wont deviate more than 1% from the actual value.



- 5) An electric dipole of dipole moment \vec{p} is placed at \vec{r} . A point charge q is at the origin.
- What is the torque acting on the dipole?
 - What is the energy of the dipole?
 - Show that the force acting on the dipole is equal to $\vec{F} = \frac{k(\vec{p} \cdot \vec{r}^2 - 3(\vec{p} \cdot \vec{r}) \cdot \vec{r})}{r^5}$



- 6) Dipole \vec{p}_1 is located at \vec{r}_1 , and dipole \vec{p}_2 is located at \vec{r}_2 .
- Show that the energy of \vec{p}_2 in the field of \vec{p}_1 is:
 - $U = \frac{k}{\tilde{r}^3} [\vec{p}_1 \cdot \vec{p}_2 - 3(\vec{p}_1 \cdot \tilde{\hat{r}})(\vec{p}_2 \cdot \tilde{\hat{r}})]$, where $\tilde{\vec{r}} = \vec{r}_2 - \vec{r}_1$, $\tilde{\hat{r}} = \frac{\tilde{\vec{r}}}{\tilde{r}}$, $\tilde{r} = |\tilde{\vec{r}}|$.
 - This is the energy of a dipole-dipole system. Show that if we were to calculate the energy of \vec{p}_1 in the field of \vec{p}_2 , we would get the same answer.
 - What is the force acting on \vec{p}_2 and \vec{p}_1 ?
 - What is the force on \vec{p}_2 if \vec{p}_2 were parallel to \vec{p}_1 and $\tilde{\vec{r}}$?
And what is the force on \vec{p}_2 if \vec{p}_2 were parallel to \vec{p}_1 but perpendicular to $\tilde{\vec{r}}$?



*For the solutions go see the videos