Department of Physics
Year 1 Tutorials
Module Phys123
Electricity and Magnetism

Tutorial 3

Issued	Thursday 28th October
Hand in to tutors	Wednesday 3rd November 16:00
Tutorials	Friday 5th November

See the Year 1 Notice Board for tutorial groups, tutors, locations and times of tutorials.

Problems

1. A charge of $7\,\text{nC}$ is moved along a vector $\vec{r} = \begin{pmatrix} 3 \\ 2 \\ -1 \end{pmatrix}\text{m}$ in a uniform electric field $\vec{E} = \begin{pmatrix} 1 \\ -2 \\ -1 \end{pmatrix}\text{Vm}^{-1}$. What is the magnitude of the electric field? Over what distance is the charge moved? How much work is done in moving the charge? Explain this result!

2. A particle of charge $9\,\mu\text{C}$ is moved from a position $\vec{r}_1 = \begin{pmatrix} 1 \\ -1 \\ 3 \end{pmatrix}\text{m}$ to a position $\vec{r}_2 = \begin{pmatrix} -1 \\ -1 \\ 0 \end{pmatrix}\text{m}$ in a uniform electric field $\vec{E} = \begin{pmatrix} 2 \\ 2 \\ -1 \end{pmatrix}\text{Vm}^{-1}$. Calculate the vector describing the motion of the particle. Use this vector to calculate the work done in moving the charge. What is the angle between the vector describing the particle's motion and the electric field?

3. An electric dipole $\vec{p} = \begin{pmatrix} -1 \\ 2 \\ 1 \end{pmatrix}\text{Cm}$ is placed in a uniform electric field $\vec{E} = \begin{pmatrix} 3 \\ 1 \\ -1 \end{pmatrix}\text{Vm}^{-1}$. Calculate the torque on the dipole.

4. The potential caused by a complex array of charges in a certain region of space can be described by the equation $V(x,y,z) = x^2 + 2xy + y - xz^2\ \text{V}$, where all distances are measured in metres. If a charge of $3\,\text{mC}$ is moved from position $\vec{r}_1 = \begin{pmatrix} 1 \\ 2 \\ 0 \end{pmatrix}\text{m}$ to $r_2 = \begin{pmatrix} 0 \\ 3 \\ 1 \end{pmatrix}\text{m}$, what is the resulting change in the potential energy of the system?

5. In a large parallel plate capacitor, the potential can be described by the equation $V(x, y, z) = 240y\,V$, where all lengths are measured in metres. Calculate the electric field configuration corresponding to this potential and describe its direction and magnitude.

   A particle of charge of 7 mC is moved from position $\vec{r}_1 = \begin{pmatrix} 0.1 \\ 0.2 \\ 0.3 \end{pmatrix}$ m to $\vec{r}_3 = \begin{pmatrix} 0.3 \\ 0.3 \\ 0.1 \end{pmatrix}$ m inside the capacitor. What is the resulting change in the potential energy of the system?

   Determine the vector describing the displacement of the particle. Use this to calculate the work done in moving the charge and compare the work done with the change in potential energy.

   How would these quantities be affected if the charge were moved from $\vec{r}_1$ to $\vec{r}_2 = \begin{pmatrix} 0.4 \\ 0.1 \\ 0.2 \end{pmatrix}$ m before being moved to $\vec{r}_3$?