ELECTROMAGNETISM

Level 2 Physics problems – Foundations of physics 2

Question 1 Cycle 2 Version 1

Professor D P Hampshire – 2nd Year Physics Lecture Course

These problems are formatively self-assessed. Students who showed the chutzpah to volunteer for the peer-marking pilot scheme will also mark one of their peer's scripts.

Reading Material (Please note that questions may not be exclusively associated with these chapters): Chapter 1 and 2 : Introduction to Electrodynamics, D J Griffiths - work through the questions and answers at the end of the chapter.
Note - The most important issue this week is for you to refine your own procedure for reading and understanding these chapters and making notes that will aid you in revision.

1. Write down Coulomb's law - define all terms you used. [1 mark]

2. If $\underline{\boldsymbol{A}} = 2\hat{\boldsymbol{\imath}} + \hat{\boldsymbol{\jmath}} - 4\hat{\boldsymbol{k}}$, $\underline{\boldsymbol{B}} = \hat{\boldsymbol{\jmath}} - 5\hat{\boldsymbol{k}}$ and $\underline{\boldsymbol{C}} = 5\hat{\boldsymbol{\imath}} + \hat{\boldsymbol{k}}$ show that: [2 marks]

a. $\underline{\boldsymbol{A}} \times (\underline{\boldsymbol{B}} \times \underline{\boldsymbol{C}}) = -105\hat{\boldsymbol{\imath}} + 6\hat{\boldsymbol{\jmath}} - 51\hat{\boldsymbol{k}}$;
b. $\underline{\boldsymbol{B}}(\underline{\boldsymbol{A}}.\underline{\boldsymbol{C}}) - \underline{\boldsymbol{C}}(\underline{\boldsymbol{A}}.\underline{\boldsymbol{B}}) = -105\hat{\boldsymbol{\imath}} + 6\hat{\boldsymbol{\jmath}} - 51\hat{\boldsymbol{k}}$;
c. The angle between $\underline{\boldsymbol{A}}$ and $\underline{\boldsymbol{B}}$ is 26°
d. $\underline{\boldsymbol{A}} \cdot (\underline{\boldsymbol{B}} \times \underline{\boldsymbol{C}}) = -3$

Hint: $\underline{\boldsymbol{A}} \times (\underline{\boldsymbol{B}} \times \underline{\boldsymbol{C}}) = (\underline{\boldsymbol{A}} \cdot \underline{\boldsymbol{C}})\underline{\boldsymbol{B}} - (\underline{\boldsymbol{A}} \cdot \underline{\boldsymbol{B}})\underline{\boldsymbol{C}}$

3. Given: $\underline{\boldsymbol{E}} = e_1\hat{\boldsymbol{\imath}} + e_2\hat{\jmath} + e_3\hat{\boldsymbol{k}}$ and $\underline{\boldsymbol{F}} = f_1\hat{\boldsymbol{\imath}} + f_2\hat{\boldsymbol{\jmath}} + f_3\hat{\boldsymbol{k}}$, write down a general equation for the angle between the vectors $\underline{\boldsymbol{E}}$ and $\underline{\boldsymbol{F}}$. [1 mark]

4. Consider two electrons - one at the origin of a (x, y) coordinate system and the other at the position $(4, 3)$ m. What is the electric field, $\underline{\boldsymbol{E}}$, at the position $(1, 1)$ m? [2 marks]

5. A spherical shell of thickness t, outer radius R, has a uniform volumetic charge density ρ. Using Gauss' law

a. Find an expression for the $\underline{\boldsymbol{E}}$-field outside the sphere, $r > R$. [1 mark]
b. Find an expression for the $\underline{\boldsymbol{E}}$-field within the spherical shell, $R - t < r < R$. [1 mark]
c. Show that the $\underline{\boldsymbol{E}}$-field inside the sphere $(r < R - t)$ is zero. [1 mark]
d. Sketch the variation of the $\underline{\boldsymbol{E}}$-field with distance from the centre of the shell outwards. [1 mark]