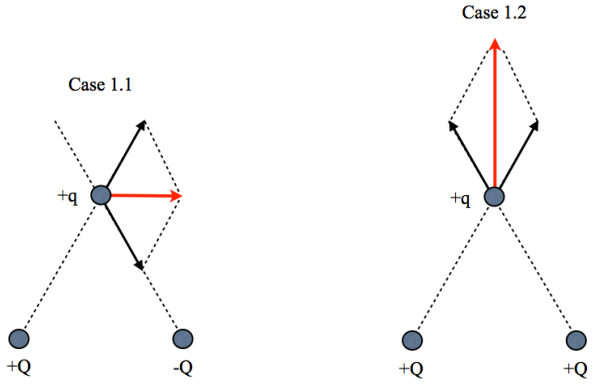
Electromagnetism I – Answers Problem Sheet 1

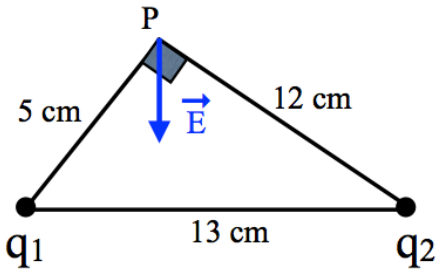


Problem 1. The configurations for the two cases are shown in the figure above. Therefore the answers are:

question (1.1) horizontal to the right, (e); **[2 marks]**

questions (1.2) vertically up, (a) **[2 marks]**

Problem 2. Two charges q_1 and q_2 are placed at the vertices of a right-angled triangle. The value of the charge q_1 is $|q_1| = 15\mu\ C$, but its sign is not know. For the charge q_2, both the sign and the magnitude are not known. The resulting electric field $\vec{E}$ produced by the two charges at P is in the negative y direction (no x component).



1. The two charges q_1 and q_2 must be negative in order for the electric field to be in the negative y direction, with no horizontal component. **[2 marks]**
2. The horizontal component of $\vec{E}$ is zero. Therefore:

$$E_{1x} + E_{2x} = 0$$
$$\frac{1}{4\pi\epsilon_0}\left[\frac{q_1}{r_1^2}\cos\theta_1 - \frac{q_2}{r_2^2}\cos\theta_2\right] = 0$$
$$q_2 = q_1\left(\frac{r_2}{r_1}\right)^2 \frac{\cos\theta_1}{\cos\theta_2}$$

and therefore:

$$\begin{aligned} q_2 &= q_1 \left(\frac{r_2}{r_1}\right)^2 \frac{\cos\theta_1}{\cos\theta_2} \\ &= q_1 \left(\frac{r_2}{r_1}\right) \\ &= -15\mu C \frac{12\,\text{cm}}{5\,\text{cm}} = -36\mu C \end{aligned}$$

[2 marks] (2 marks for correct answer, any method, 1 mark if answer is wrong but method is correct)

3. The electric field has component only in the (negative) y direction, and its value is:

$$\begin{aligned} E_y &= E_{1y} + E_{2y} \\ &= \frac{1}{4\pi\epsilon_0}\left[\frac{q_1}{r_1^2}\sin\theta_1 + \frac{q_2}{r_2^2}\sin\theta_2\right] \\ \text{and}\ \sin\theta_1 &= r_2/13 \ \text{ etc. so:} \\ E_y &= -8.9\times10^9\left[\frac{15\times10^{-6}}{(5\times10^{-2})^2}\left(\frac{12}{13}\right) + \frac{36\times10^{-6}}{(12\times10^{-2})^2}\left(\frac{5}{13}\right)\right]\,\text{N C}^{-1} \\ &= -5.8\times10^7\,\text{N C}^{-1} \end{aligned}$$

[2 marks] (2 marks for correct answer, any method, 1 mark if answer is wrong but method is correct)