Electromagnetic Theory I: Homework 1

Due: 22 August 2025

This assignment will be graded immediately after the due date. If you get all problems correct, then you will receive 100%. If you have made any errors, then I will deduct 10%, point the errors out and you must submit a corrected assignment by 27 August 2025. If there are still errors, then I will deduct another 10% and you must submit the corrected assignment by 4 September 2025. This will continue until you **have solved every problem correctly.**

1 Separation vectors

A charge, labeled A, is located at the point $(3, 3, 0)$. Another charge, labeled B, is located at the point $(0, 2, 2)$. A third charge, labeled C, is at the point $(3, 0, 3)$. Let $\mathbf{r}_A$ denote the position vector for A and $\mathbf{r}_B$ denote the position vector for B, etc, ...

a) Express $\mathbf{r}_A, \mathbf{r}_B$ and $\mathbf{r}_C$ in terms of standard basis vectors.

b) Determine expressions for the separation vectors $\vec{\imath}_{\text{A to B}}, \vec{\imath}_{\text{B to A}}, \vec{\imath}_{\text{A to C}}$ and $\vec{\imath}_{\text{B to C}}$ in terms of standard basis vectors.

c) Using your results to the previous part, verify that

$$\vec{\imath}_{\text{A to C}} = \vec{\imath}_{\text{A to B}} + \vec{\imath}_{\text{B to C}}$$

and that

$$\vec{\imath}_{\text{B to C}} = \vec{\imath}_{\text{B to A}} + \vec{\imath}_{\text{A to C}}.$$

2 Orthogonal vectors

Consider the vectors:

$$\mathbf{A} = 2\hat{\mathbf{z}},$$
$$\mathbf{B} = -2\hat{\mathbf{x}} + 3\hat{\mathbf{y}},$$
$$\mathbf{C} = 2\hat{\mathbf{x}} + 3\hat{\mathbf{y}}, \text{and}$$
$$\mathbf{D} = 3\hat{\mathbf{x}} + 2\hat{\mathbf{y}}.$$

a) Identify all pairs of vectors which are perpendicular to each other.

b) Is there any set of three vectors (from the list above) such they are all perpendicular to each other?

c) Determine all possible vectors (including any not listed above) that are perpendicular to $\mathbf{B}$.

3 Edge length

A solid consists of a rectangular base and four triangular sides as illustrated. The shaded triangle is perpendicular to the shaded rectangle, its rising edges have the same lengths and its height is the same as the length of its base. Determine the length of one of the illustrated dashed edges.
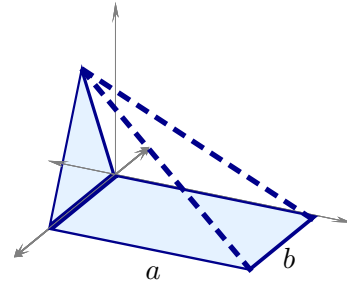
4 Vector algebra and geometry

a) A rectangle has sides of length a and b. A *face diagonal* on this rectangle is a line from one corner through the center to the corner opposite. Using vector algebra determine the angle at which the two face diagonals on the rectangle intersect. You should be able to check that your expression is correct for a square.

b) A *body diagonal* in a cube is a line from one corner through the center of the cube to another corner. There are four body diagonals in any cube. Determine the angles between the four body diagonals at the point where they intersect in the center.