PHYSICS 570 – Master's of Science Teaching

"Electricity"
Lecture 7 – Calculating Electric Field and Force using Coulomb's Law and Vector Components

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Why Bother 2?

Physics is the ultimate "reductionist" science. You take a complex problem and you break it into relatively simple (and perhaps repetitive) steps. Electrostatics is a great example of this. Computers make it all easier … this is what the computers ARE doing anyway.

How to teach it

If you decide problems with four or five charges are too tedious to teach, try teaching two charges … or three.

Component Practice I

$\vec{E}_1$: $|\vec{E}| = 15\,\text{N/C}$ $\theta = 30^\circ$ $\vec{E}_x ?, \vec{E}_y ?$

$\vec{E}_2$: $|\vec{E}| = 30\,\text{N/C}$ $\theta = 135^\circ$ $\vec{E}_x ?, \vec{E}_y ?$

$\vec{E}_1$: $\vec{E}_x = 13\ \text{N/C}, \vec{E}_y = 7.5\ \text{N/C}$

$\vec{E}_2$: $\vec{E}_x = -21.2\ \text{N/C}, \vec{E}_y = 21.2\ \text{N/C}$

$\vec{E}_4$: $\vec{E}_x = 3\ \text{N/C}, \vec{E}_y = 4\ \text{N/C}$

$\vec{E}_5$: $\vec{E}_x = -8\ \text{N/C}, \vec{E}_y = 12\ \text{N/C}$

$\vec{E}_6$: $\vec{E}_x = -6\ \text{N/C}, \vec{E}_y = -2\ \text{N/C}$

Component Practice III

$\vec{E}_4 + \vec{E}_5$?

$\vec{E}_4 + \vec{E}_5 + \vec{E}_6$?

$\vec{E}_1 + \vec{E}_2$?

$\vec{E}_1 + \vec{E}_5$?

What is the result in component form and in angle magnitude form?

Sketch the result.

Component Practice III

$\vec{E}_4 + \vec{E}_5$?

$\vec{E}_4 + \vec{E}_5 + \vec{E}_6$?

$\vec{E}_1 + \vec{E}_2$?

$\vec{E}_1 + \vec{E}_5$?

$\vec{E}_1 = 13\,\hat{i} + 7.5\,\hat{j}$

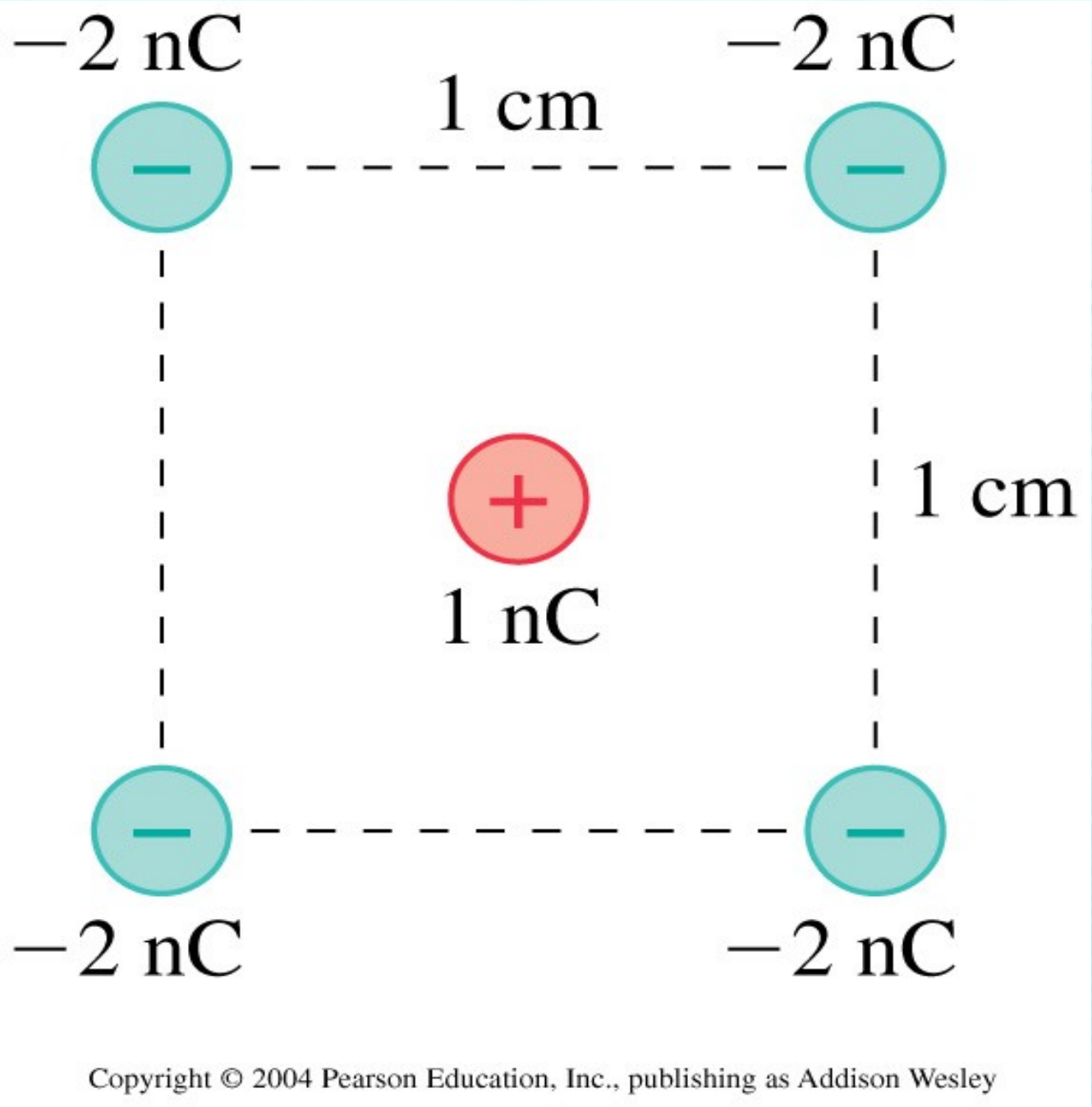
$\vec{E}_2 = -21.2\,\hat{i} + 21.2\,\hat{j}$

$\vec{E}_4 = 3\,\hat{i} + 4\,\hat{j}$

$\vec{E}_5 = -8\,\hat{i} + 12\,\hat{j}$

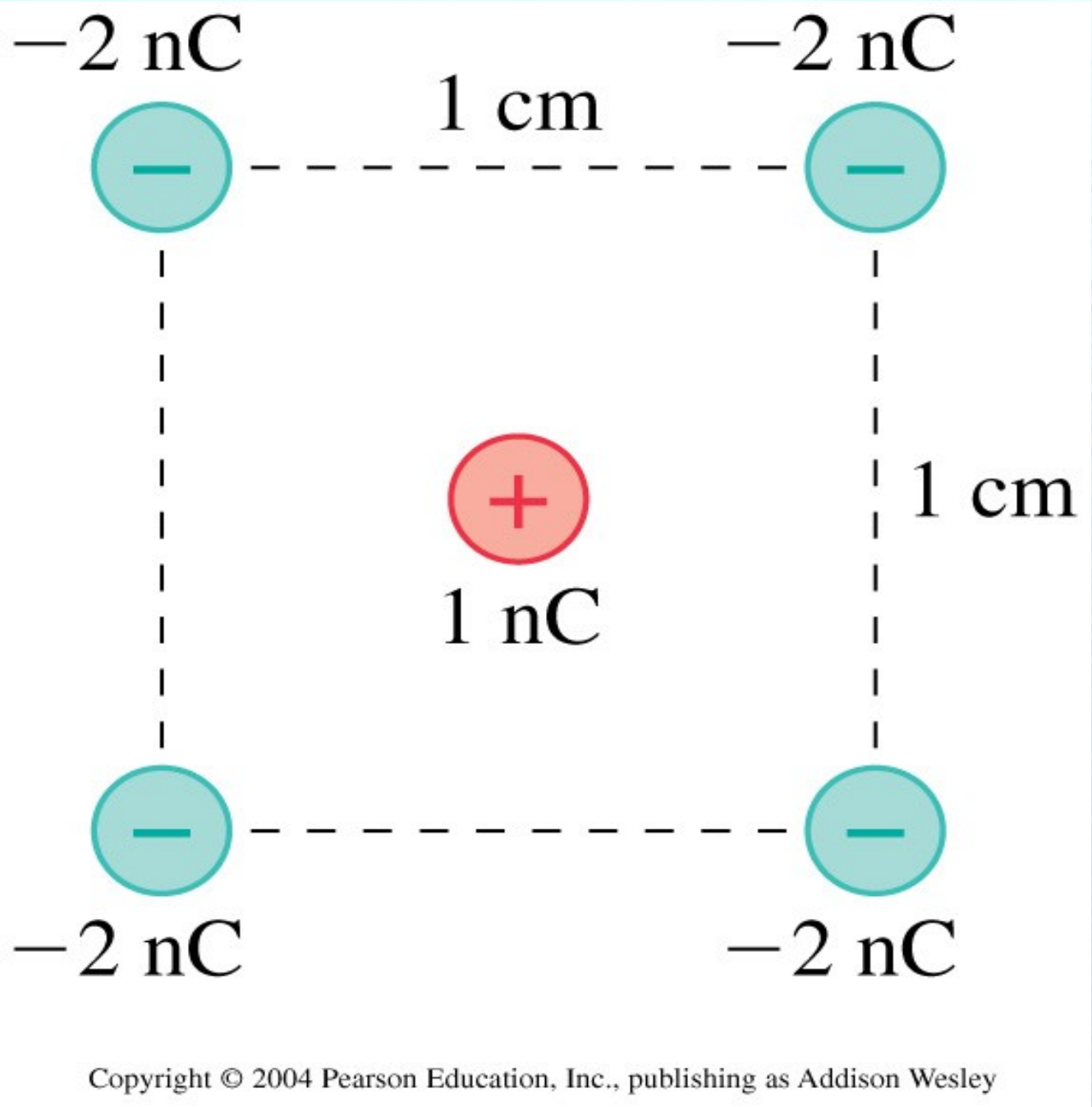
$\vec{E}_5 = -6\,\hat{i} - 2\,\hat{j} + 0\,\hat{k}$

Superposition problem #1



Estimate the direction and magnitude of the force on the central charge due to the other four charges.

Superposition problem #1

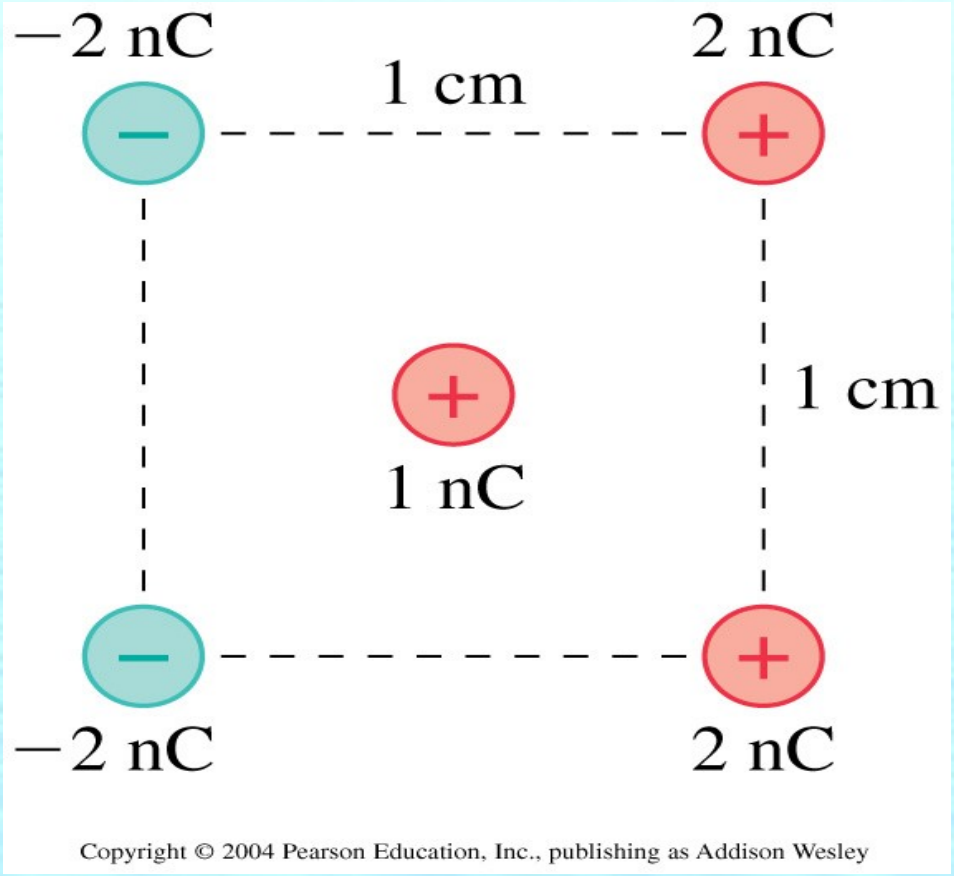


It's zero …

We can just do a sketch to see that.

Or say it is true "by symmetry"

Superposition problem #2

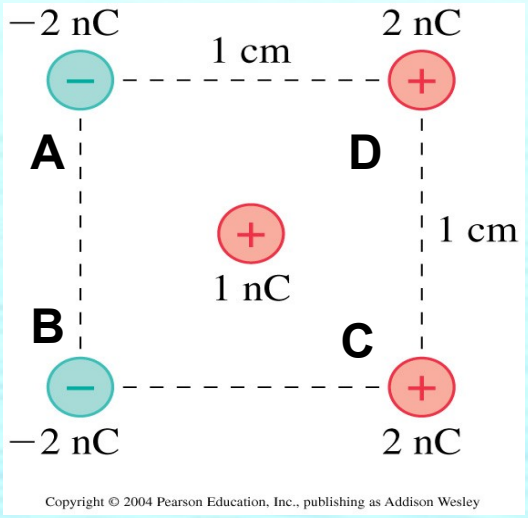


What is the Field and Force on the 1 nC charge in vector component form?

$$\vec{E}_1 = \vec{E}_A + \vec{E}_B + \vec{E}_C + \vec{E}_D$$

$$\vec{F}_1 = q_1 \vec{E}_1$$

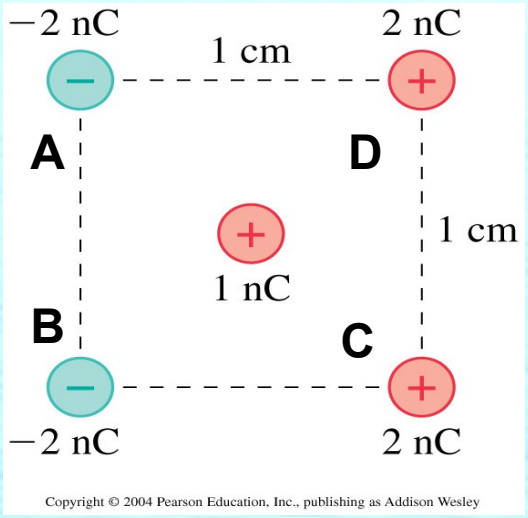
Superposition problem #2



$$\vec{E}_1 = \vec{E}_A + \vec{E}_B + \vec{E}_C + \vec{E}_D$$

$$\vec{F}_1 = q_1 \vec{E}_1$$

Superposition problem #2



$\vec{E}_A$:

$\vec{E}_B$:

$\vec{E}_C$:

$\vec{E}_D$:

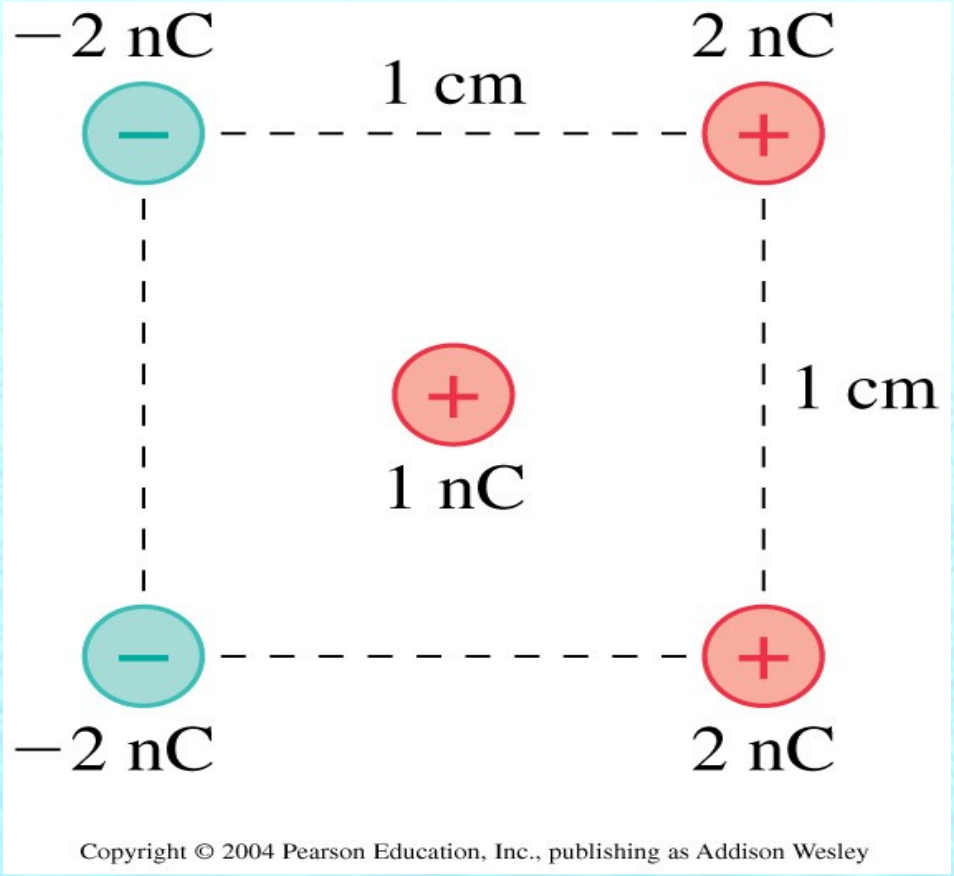
$\vec{E}_1$:

$\vec{F}_1$:

How to teach it

If you decide problems with four or five charges are too tedious to teach, try teaching two charges … or three.

Superposition problem #2a

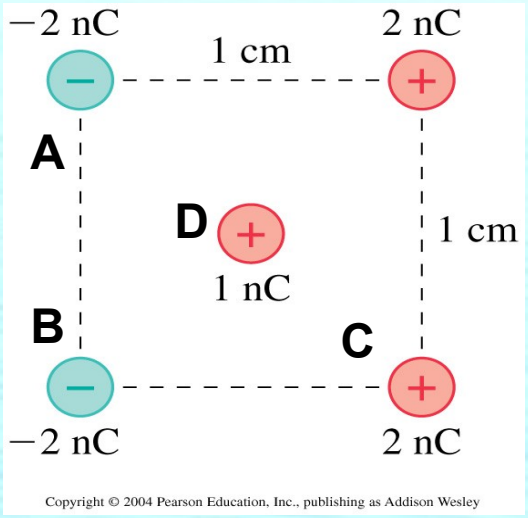


What is the Field and Force on the top right 2 nC charge in vector component form?

$$\vec{E}_2 = \vec{E}_A + \vec{E}_B + \vec{E}_C + \vec{E}_D$$

$$\vec{F}_2 = q_2 \vec{E}_2$$

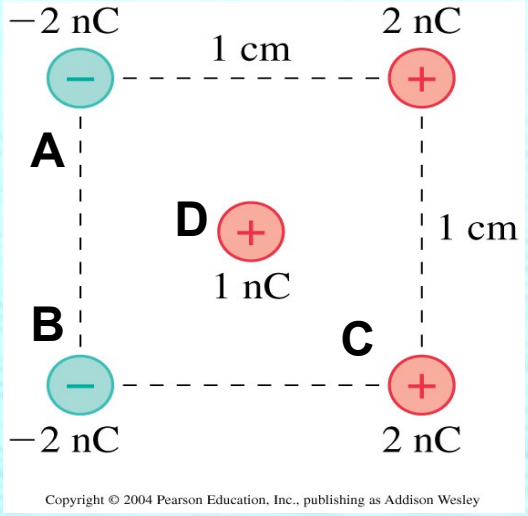
Superposition problem #2a



$$\vec{E}_2 = \vec{E}_A + \vec{E}_B + \vec{E}_C + \vec{E}_D$$

$$\vec{F}_2 = q_2 \vec{E}_2$$

Superposition problem #2a



$\vec{E}_A$:

$\vec{E}_B$:

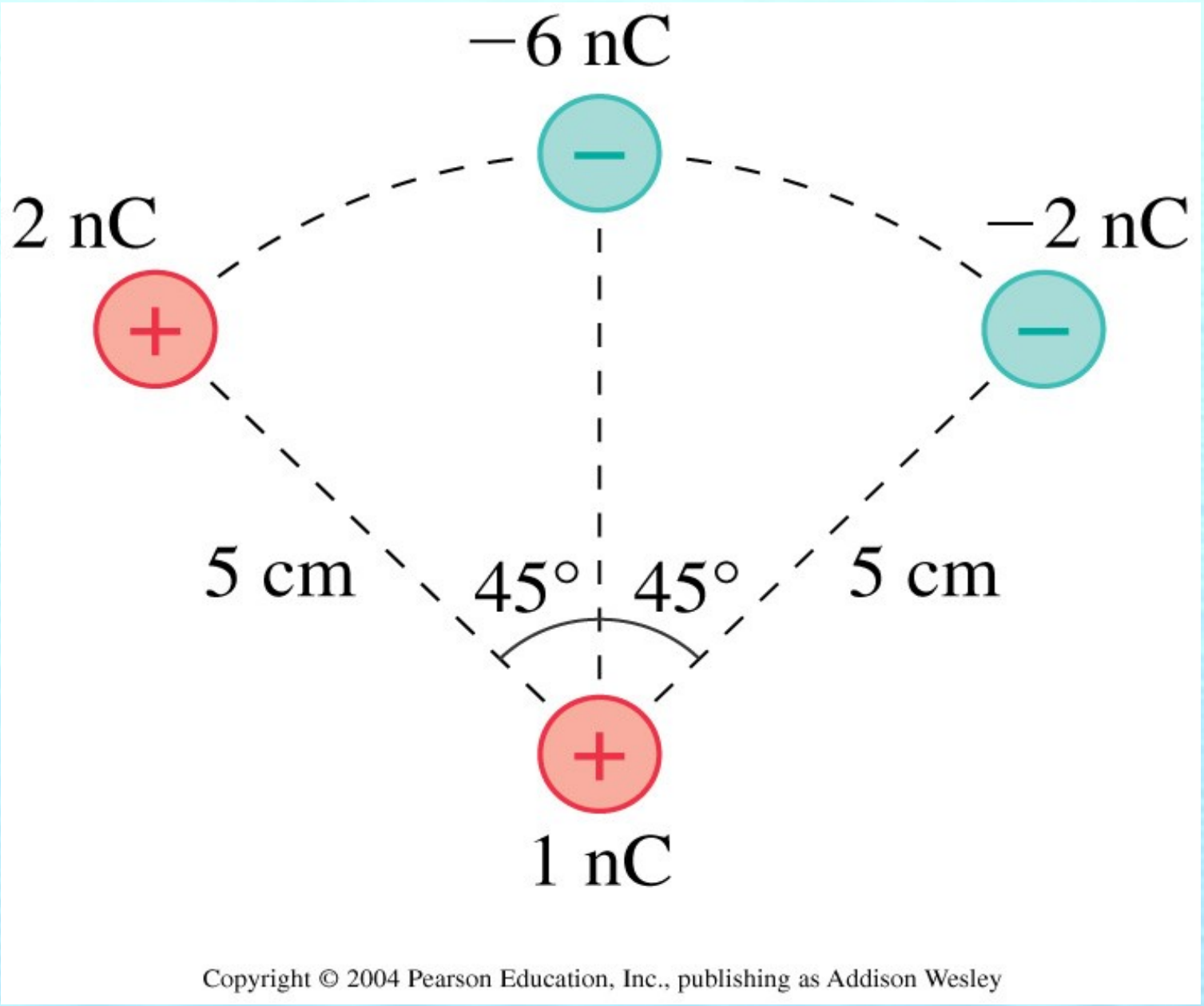
$\vec{E}_C$:

$\vec{E}_D$:

$\vec{E}_2$:

$\vec{F}_2$:

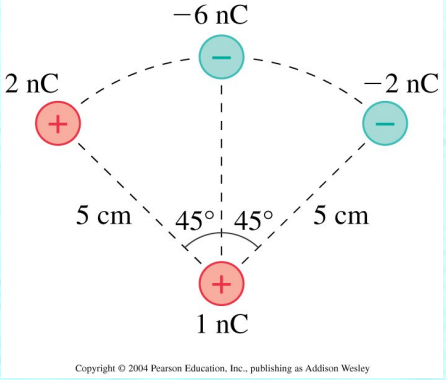
Superposition problem #5



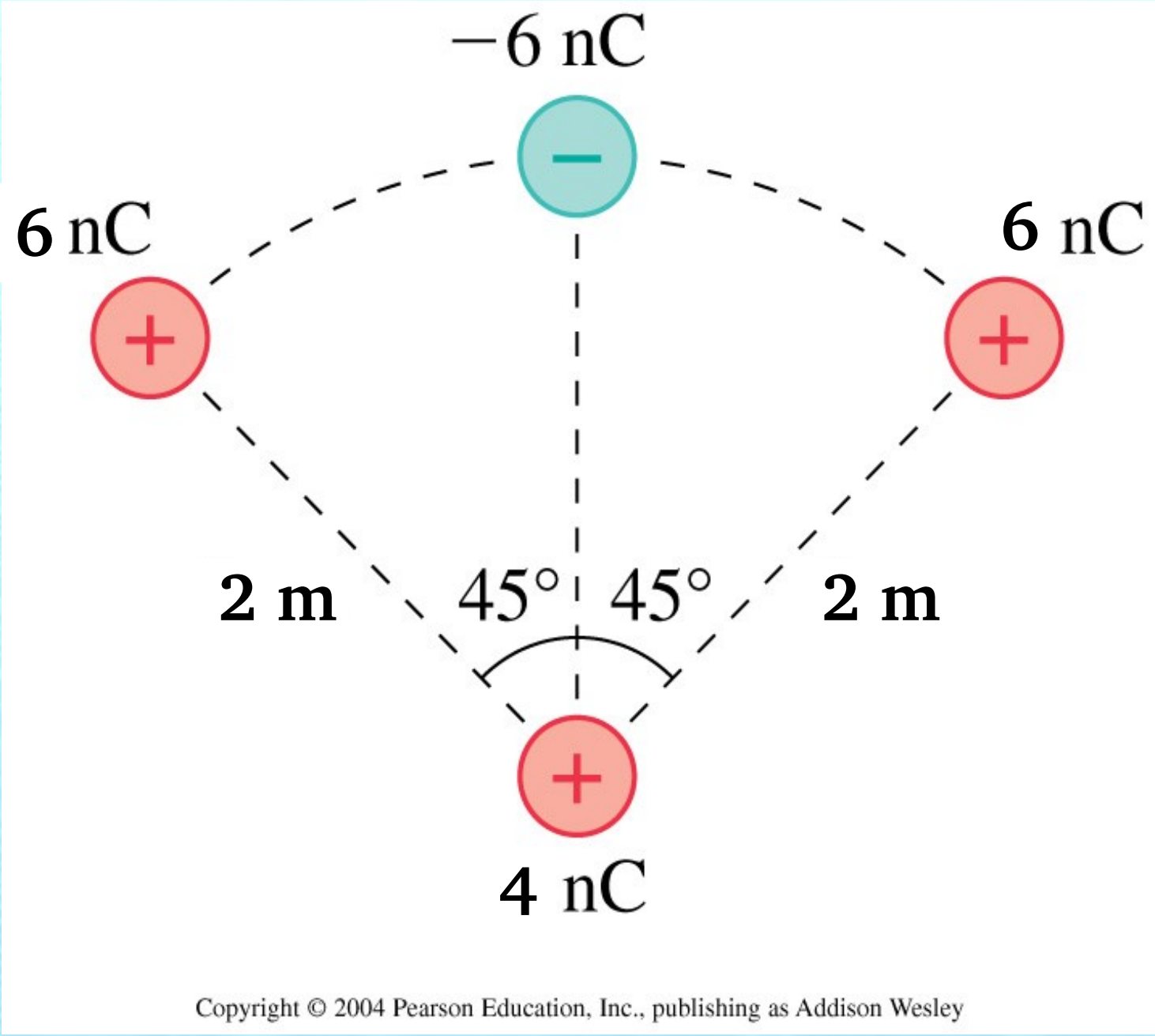
What is the direction of the force on the 1 nC charge?

Too difficult just to do with sketching Need components

Superposition problem #5

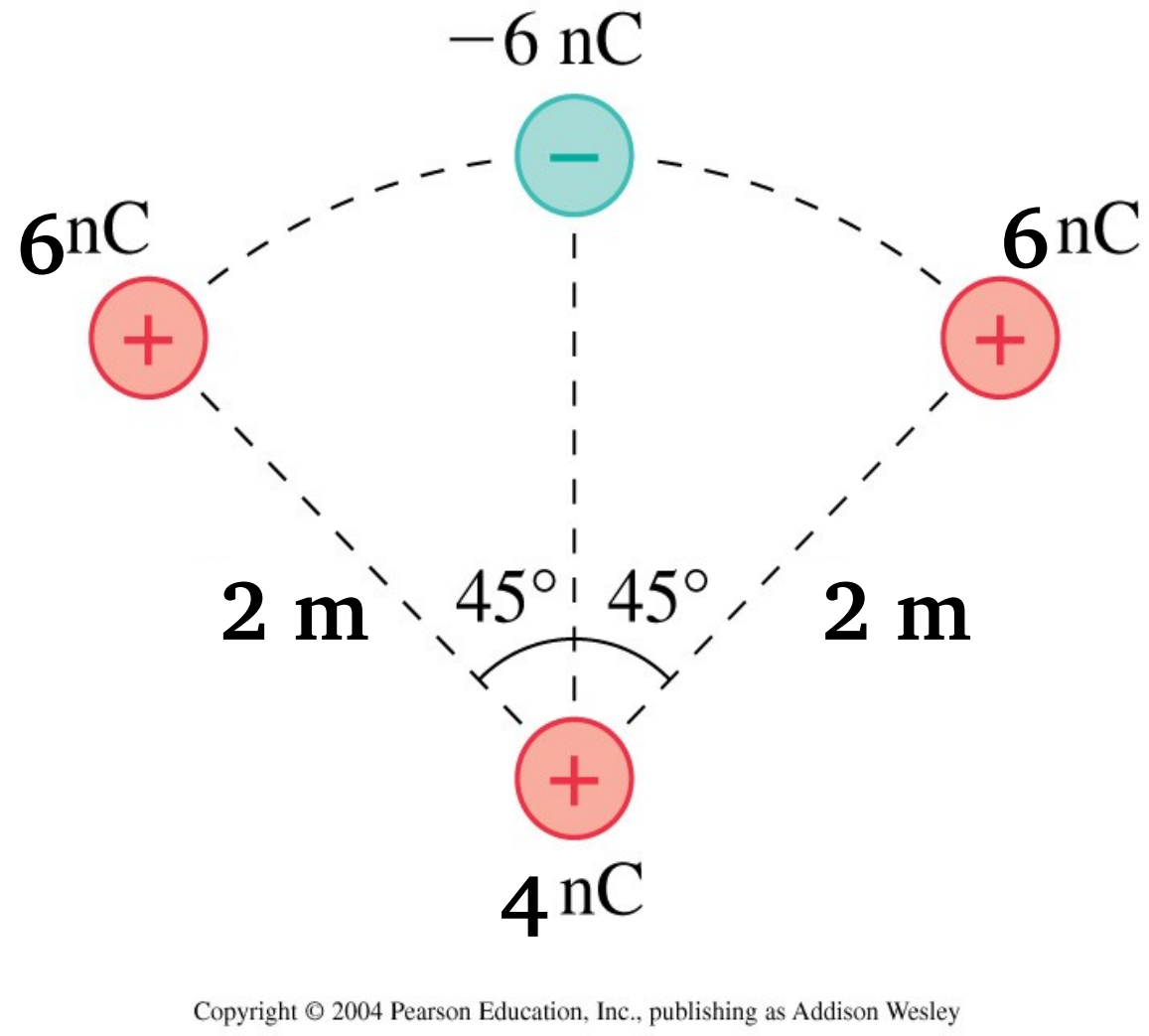


Superposition problem #6

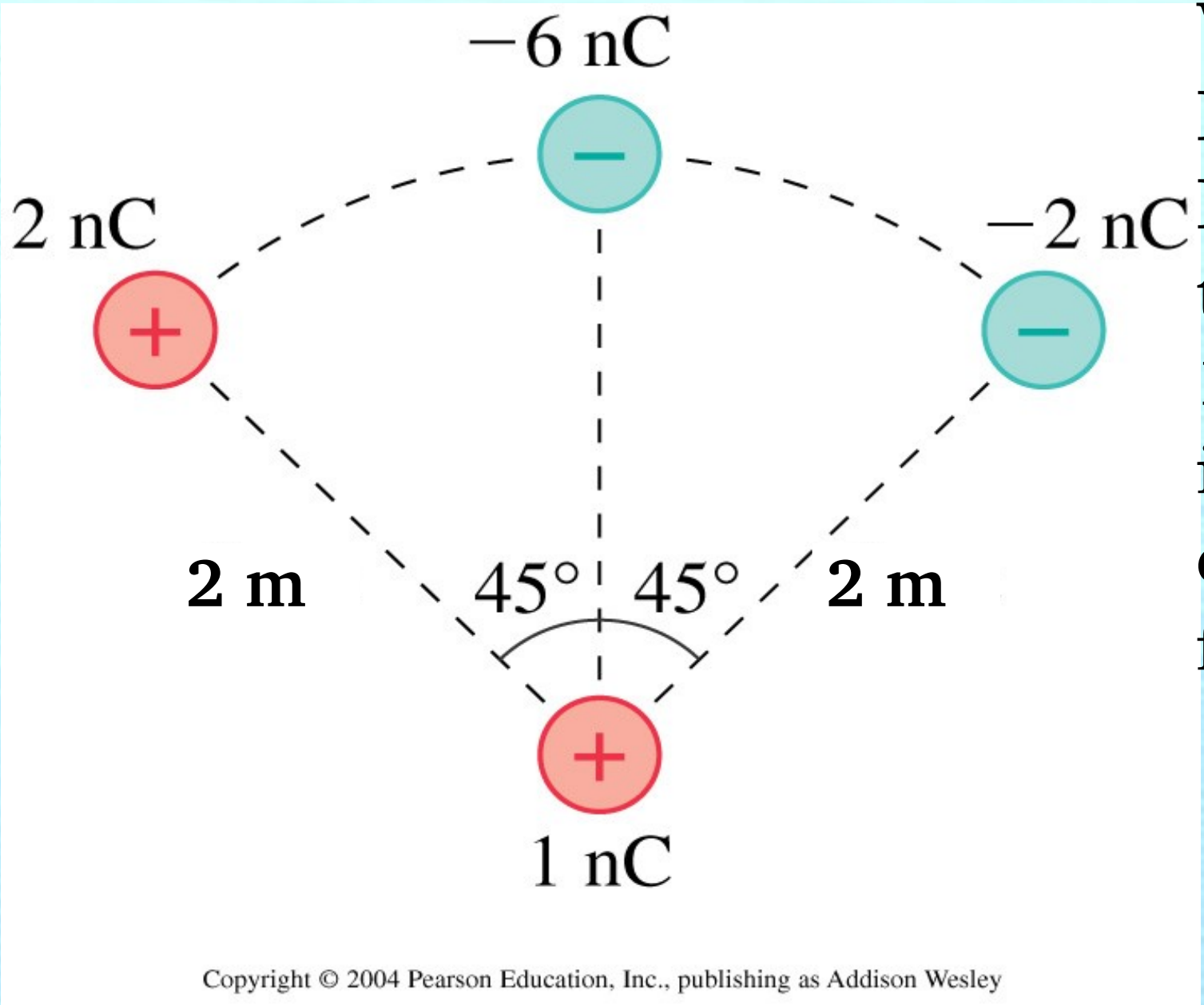


What is the Field and Force on the top right 4 nC charge in vector component form?

Superposition problem #6

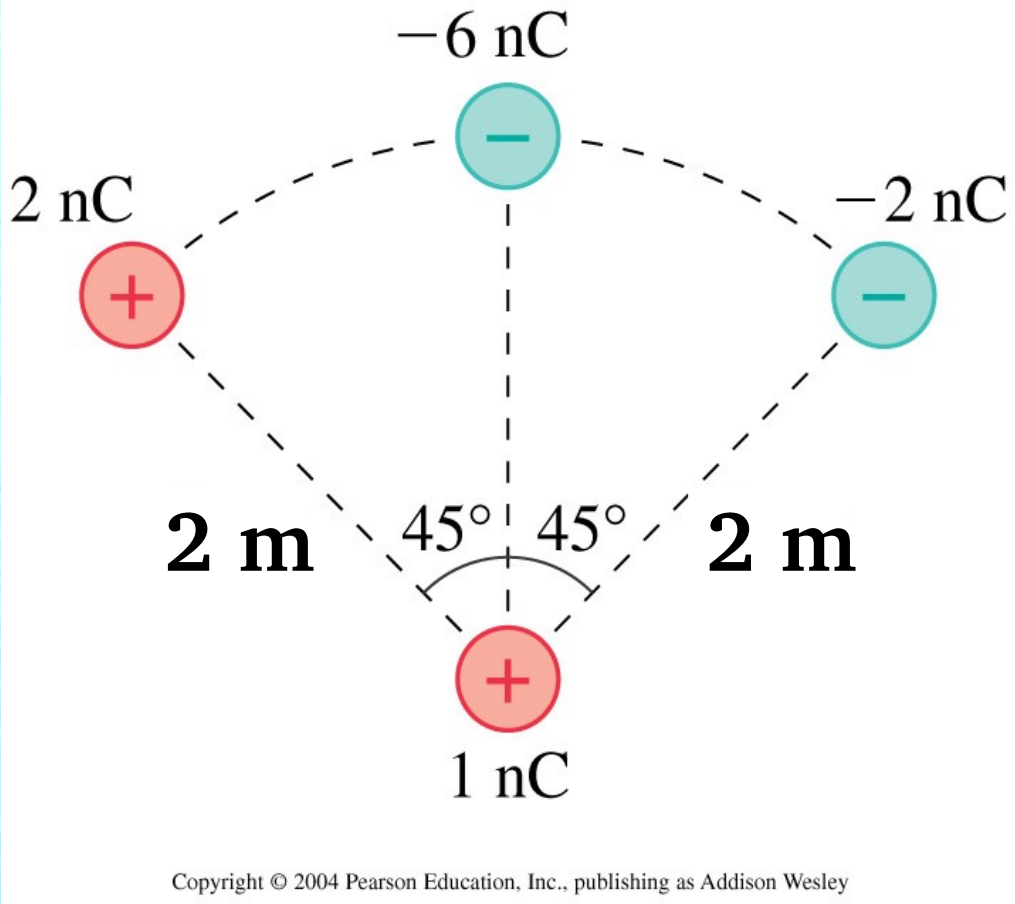


Superposition problem #7

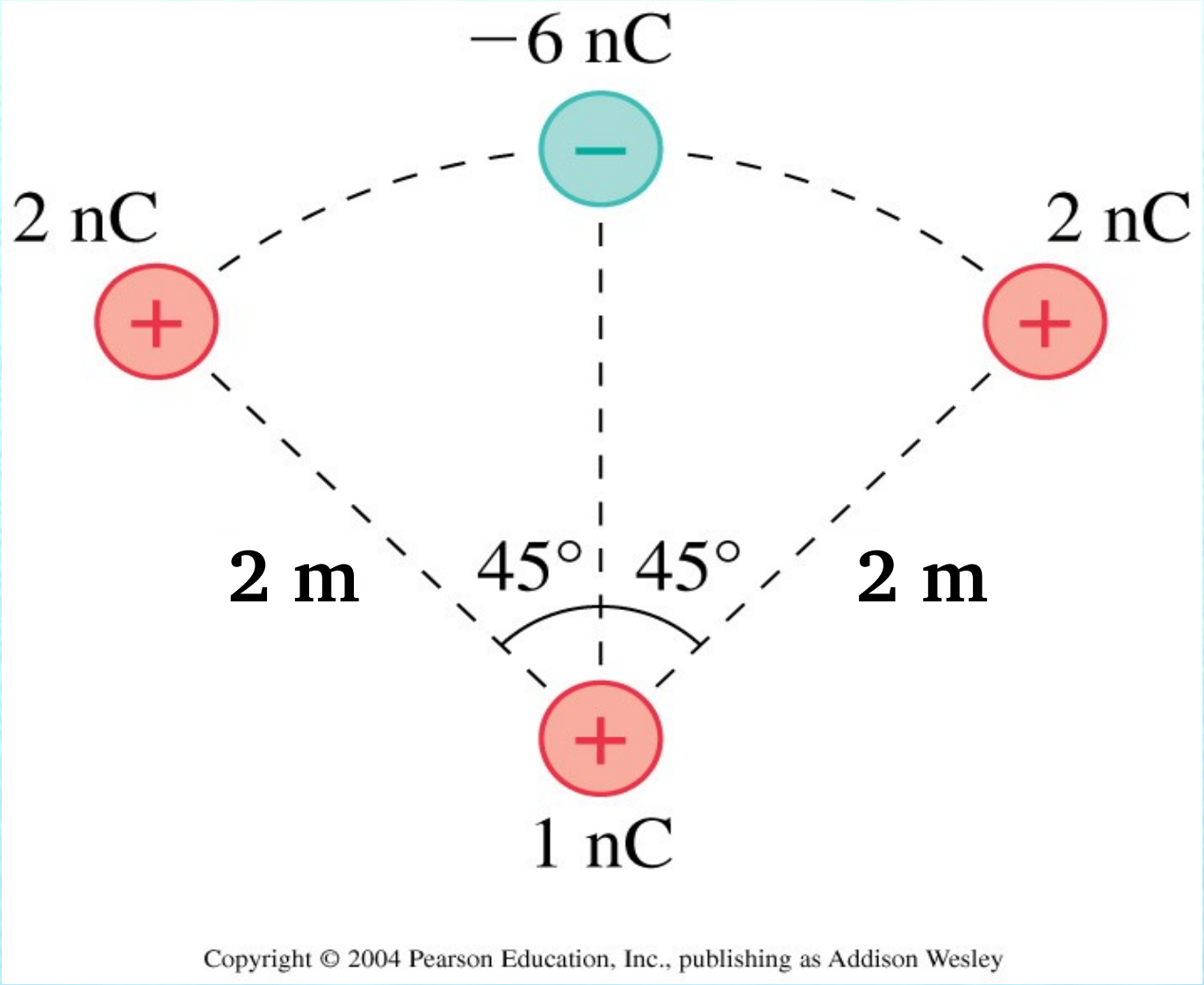


What is the Field and Force on the top right 1 nC charge in vector component form?

Superposition problem #7



Superposition problem #8



HOMEWORK
Use superposition and components to calculate the force and field for problems 6, 7 and 8.
Also send pHeT screenshots (for field only)

Superposition problem #8