# PC212 Tutorial Problem Wilfrid Laurier University

Terry Sturtevant

Wilfrid Laurier University

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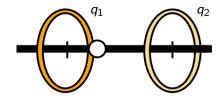
Definition Before Math Calculations Check

# Definition

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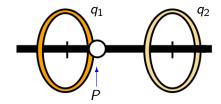
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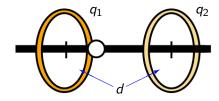
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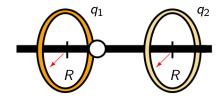
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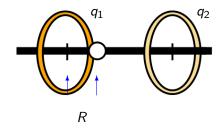
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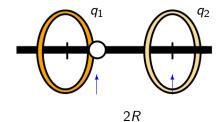
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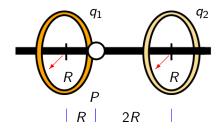


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Chapter 22 - Problem 23, 9th edition	Definition Before Math Calculations Check
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$$\left|\vec{E}\right|_{P,net} \equiv 0$$

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$$\left|\vec{E}\right|_{P,net} \equiv 0$$

What is the ratio  $q_1/q_2$ ?

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### Before Math

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### Before Math

By symmetry

$$\left|\vec{E}\right|_{P,net} \equiv |E_x|_{P,net}$$

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### Before Math

By symmetry

$$\left|\vec{E}\right|_{P,net} \equiv |E_x|_{P,net}$$

since the x-axis passes through the centre of each ring.

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#### Furthermore,

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#### Furthermore,

$$|E_x|_{P,net} = |E_{xP1} + E_{xP2}|$$

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Furthermore,

$$|E_x|_{P,net} = |E_{xP1} + E_{xP2}|$$

Since  $q_1$  and  $q_2$  are on *opposite* sides of *P*, then they must have the *same* signs on their charges for their fields to cancel.

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Furthermore,

$$|E_x|_{P,net} = |E_{xP1} + E_{xP2}|$$

Since  $q_1$  and  $q_2$  are on *opposite* sides of *P*, then they must have the *same* signs on their charges for their fields to cancel. Thus the *sign* of  $q_1/q_2$  is **positive**.

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Furthermore,

$$|E_x|_{P,net} = |E_{xP1} + E_{xP2}|$$

Since  $q_1$  and  $q_2$  are on *opposite* sides of *P*, then they must have the *same* signs on their charges for their fields to cancel.

Thus the sign of  $q_1/q_2$  is **positive**.

Also, since  $q_2$  is farther away, it has to be bigger to match the field of  $q_1$ , so the *magnitude* of  $q_1/q_2$  is **less than one**.

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SQR

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Furthermore,

$$|E_x|_{P,net} = |E_{xP1} + E_{xP2}|$$

Since  $q_1$  and  $q_2$  are on *opposite* sides of *P*, then they must have the *same* signs on their charges for their fields to cancel.

Thus the sign of  $q_1/q_2$  is **positive**.

Also, since  $q_2$  is farther away, it has to be bigger to match the field of  $q_1$ , so the *magnitude* of  $q_1/q_2$  is **less than one**. So.

 $0 < q_1/q_2 < 1$ 

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SQR

Definition Before Math Calculations Check

Furthermore,

$$|E_x|_{P,net} = |E_{xP1} + E_{xP2}|$$

Since  $q_1$  and  $q_2$  are on *opposite* sides of *P*, then they must have the *same* signs on their charges for their fields to cancel.

Thus the sign of  $q_1/q_2$  is **positive**.

Also, since  $q_2$  is farther away, it has to be bigger to match the field of  $q_1$ , so the *magnitude* of  $q_1/q_2$  is **less than one**. So.

$$0 < q_1/q_2 < 1$$

 $(q_2 = q_1 \equiv 0 \text{ is trivial})$ 

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SQR

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### Calculations

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# Calculations

# Since all points on each ring are at the same distance and angle from P,

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### Calculations

Since all points on each ring are at the same distance and angle from P, then each ring can be treated as a **point charge** at a distance R from the x-axis.

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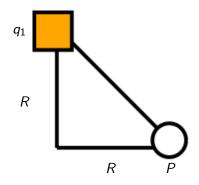
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# Ring 1

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# Ring 1

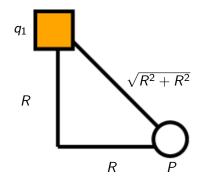


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# Ring 1

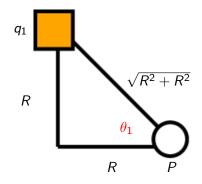


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# Ring 1



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$$\left|\vec{\mathcal{E}}_{P1}\right| = \frac{1}{4\pi\epsilon_0} \frac{q_1}{(R^2 + R^2)}$$

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$$\begin{vmatrix} \vec{E}_{P1} \end{vmatrix} = \frac{1}{4\pi\epsilon_0} \frac{q_1}{(R^2 + R^2)}$$
$$= \frac{1}{4\pi\epsilon_0} \frac{q_1}{2R^2}$$

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Definition Before Math Calculations Check

$$\begin{vmatrix} \vec{E}_{P1} \end{vmatrix} = \frac{1}{4\pi\epsilon_0} \frac{q_1}{(R^2 + R^2)}$$
$$= \frac{1}{4\pi\epsilon_0} \frac{q_1}{2R^2}$$

 $E_{xP1} = \vec{E}_{P1} \cos \theta_1$ 

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Definition Before Math Calculations Check

$$\begin{vmatrix} \vec{E}_{P1} \end{vmatrix} = \frac{1}{4\pi\epsilon_0} \frac{q_1}{(R^2 + R^2)}$$
$$= \frac{1}{4\pi\epsilon_0} \frac{q_1}{2R^2}$$

 $E_{xP1} = \vec{E}_{P1} \cos \theta_1$ 

$$= \vec{E}_{P1} \frac{R}{\sqrt{2R^2}}$$

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Definition Before Math Calculations Check

$$\begin{vmatrix} \vec{E}_{P1} \end{vmatrix} = \frac{1}{4\pi\epsilon_0} \frac{q_1}{(R^2 + R^2)}$$
$$= \frac{1}{4\pi\epsilon_0} \frac{q_1}{2R^2}$$

 $E_{xP1} = \vec{E}_{P1} \cos \theta_1$ 

$$= \vec{E}_{P1} \frac{R}{\sqrt{2R^2}}$$
$$= \vec{E}_{P1} \frac{1}{\sqrt{2}}$$

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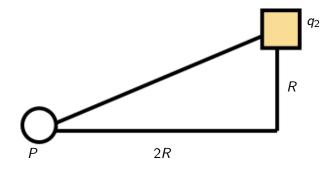
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# Ring 2

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# Ring 2



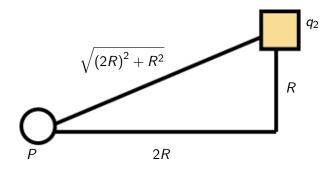
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# Ring 2



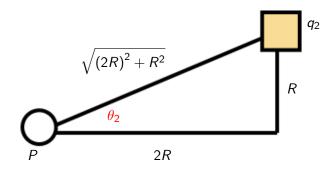
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# Ring 2



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$$\left|\vec{E}_{P2}\right| = \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + (2R)^2\right)}$$

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$$\begin{vmatrix} \vec{E}_{P2} \end{vmatrix} = \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + (2R)^2\right)}$$
$$= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + 4R^2\right)}$$

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$$\begin{aligned} \left| \vec{E}_{P2} \right| &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + (2R)^2\right)} \\ &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + 4R^2\right)} \\ &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{5R^2} \end{aligned}$$

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Definition Before Math Calculations Check

$$\vec{E}_{P2} = \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + (2R)^2\right)}$$
$$= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + 4R^2\right)}$$
$$= \frac{1}{4\pi\epsilon_0} \frac{q_2}{5R^2}$$

 $E_{\rm xP2} = \vec{E}_{\rm P2} \cos \theta_2$ 

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$$\begin{aligned} \left| \vec{E}_{P2} \right| &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + (2R)^2\right)} \\ &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + 4R^2\right)} \\ &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{5R^2} \end{aligned}$$

 $E_{\rm xP2} = \vec{E}_{\rm P2} \cos \theta_2$ 

$$= \vec{E}_{P2} \frac{2R}{\sqrt{5R^2}}$$

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$$\begin{aligned} \left| \vec{E}_{P2} \right| &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + (2R)^2\right)} \\ &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{\left(R^2 + 4R^2\right)} \\ &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{5R^2} \end{aligned}$$

 $E_{\rm xP2} = \vec{E}_{\rm P2} \cos \theta_2$ 

$$= \vec{E}_{P2} \frac{2R}{\sqrt{5R^2}}$$
$$= \vec{E}_{P2} \frac{2}{\sqrt{5}}$$

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Definition Before Math Calculations Check

$$|E_{xP1}| = |E_{xP2}|$$

means that

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Definition Before Math Calculations Check

$$|E_{xP1}| = |E_{xP2}|$$

means that

$$\vec{E}_{P1}\frac{1}{\sqrt{2}} = \vec{E}_{P2}\frac{2}{\sqrt{5}}$$

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$$|E_{xP1}| = |E_{xP2}|$$

means that

$$\vec{E}_{P1} rac{1}{\sqrt{2}} = \vec{E}_{P2} rac{2}{\sqrt{5}}$$

SO

$$\frac{1}{4\pi\epsilon_0} \frac{q_1}{(2R^2)} \frac{1}{\sqrt{2}} = \frac{1}{4\pi\epsilon_0} \frac{q_2}{(5R^2)} \frac{2}{\sqrt{5}}$$

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$$|E_{xP1}| = |E_{xP2}|$$

means that

$$\vec{E}_{P1} rac{1}{\sqrt{2}} = \vec{E}_{P2} rac{2}{\sqrt{5}}$$

SO

$$\frac{1}{4\pi\epsilon_0} \frac{q_1}{(2R^2)} \frac{1}{\sqrt{2}} = \frac{1}{4\pi\epsilon_0} \frac{q_2}{(5R^2)} \frac{2}{\sqrt{5}}$$

which reduces to

$$\frac{q_1}{(2)}\frac{1}{\sqrt{2}} = \frac{q_2}{(5)}\frac{2}{\sqrt{5}}$$

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$$|E_{xP1}| = |E_{xP2}|$$

means that

$$\vec{E}_{P1} \frac{1}{\sqrt{2}} = \vec{E}_{P2} \frac{2}{\sqrt{5}}$$

SO

$$\frac{1}{4\pi\epsilon_0} \frac{q_1}{(2R^2)} \frac{1}{\sqrt{2}} = \frac{1}{4\pi\epsilon_0} \frac{q_2}{(5R^2)} \frac{2}{\sqrt{5}}$$

which reduces to

$$\frac{q_1}{(2)} \frac{1}{\sqrt{2}} = \frac{q_2}{(5)} \frac{2}{\sqrt{5}}$$
$$\therefore \frac{q_1}{q_2} = \frac{4\sqrt{2}}{5\sqrt{5}} \approx 0.51$$

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Definition Before Math Calculations **Check** 

## Check

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Definition Before Math Calculations **Check** 

### Check

Since we determined that

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Definition Before Math Calculations **Check** 

### Check

Since we determined that

 $0 < q_1/q_2 < 1$ 

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Definition Before Math Calculations **Check** 

### Check

Since we determined that

 $0 < q_1/q_2 < 1$ 

we see that our answer fulfils that requirement.

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