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2. Vector notation for plane geometry problems

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Here we introduce some notation that is convenient to use in proving facts in plane geometry.

Suppose we have three points in the plane: P, Q, and R.

We write $\vec{0}$ for the vector of length 0, $\langle 0, 0 \rangle$.

We write $\overrightarrow{PQ}$ as the vector that connects P to Q. Note that the vector that connects Q to P is the vector $\overrightarrow{QP}$ so that $\overrightarrow{PQ} + \overrightarrow{QP} = \vec{0}$ as vectors.

For example, if P is the point $(1, 1)$ and Q is the point $(3, 2)$, then the vector $\overrightarrow{PQ}$ is given in coordinates by the vector that connects the point P to the point Q, which is $\langle 3 - 1, 2 - 1 \rangle = \langle 2, 1 \rangle$.

However, the real power of this notation is not in writing it out in coordinates, but in being able to do vector arithmetic without ever writing down the coordinates.

3.

1.0/1 point (graded)

What vector is equal to $\overrightarrow{PQ} + \overrightarrow{QR}$?

(Type `vec(PQ)` for the vector $\overrightarrow{PQ}$. Type `vec(0)` for the zero vector $\vec{0}$.)

vec(PR) ✔ **Answer:** vec(PR)

Solution:

The vector $\overrightarrow{PQ} + \overrightarrow{QR}$ is a vector that starts at the point P and ends at the point R, which is the vector $\overrightarrow{PR}$.

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Answers are displayed within the problem

4.

1.0/1 point (graded)

Take a triangle PQR in the plane. Find $\overrightarrow{PQ} + \overrightarrow{QR} + \overrightarrow{RP}$ as vectors.

(Type `vec(PQ)` for the vector $\overrightarrow{PQ}$. Type `vec(0)` for the zero vector $\vec{0}$.)

0 ✔ **Answer:** vec(0)

Solution:

$$\underbrace{\overrightarrow{PQ} + \overrightarrow{QR}}_{\rightarrow} + \underbrace{\overrightarrow{RP}}_{\rightarrow} = \vec{0}$$

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$\vec{PR}$ $-PR$

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5.

7.0/7 points (graded)

In this problem, we will show an example of how to use coordinate free vectors to prove a fact from plane geometry. We have written out some of the steps for you, and you will need to fill in other steps or reasoning to complete the argument.

On the next page, we will present a full solution of this type of argument as an example. The example presented uses the following fact.

Let P and Q be two points in space, and X the midpoint of the line segment connecting P to Q. Let O be an arbitrary fixed point.

Show that as vectors, $\vec{OX} = \frac{1}{2}(\vec{OP} + \vec{OQ})$.

Type `vec(OX)` for $\vec{OX}$ and similarly for other vectors defined from these defined points.

1. $\vec{PX} = \frac{1}{2}\vec{PQ}$ — Given

2. $\vec{OX} = \vec{OP} + \vec{PX}$ — Definition of vector addition.

3. $\vec{OX} = \vec{OP}+$ [vec(PQ)/2] ✔ **Answer:** vec(PQ)/2 — Substitute [1] ✔ **Answer:** 1 into [2] ✔ **Answer:** 2

4. $\vec{OQ} = \vec{OP} + \vec{PQ}$ — Definition of vector addition

5. $\vec{PQ} =$ [vec(OQ)-vec(OP)] ✔ **Answer:** vec(OQ)-vec(OP) — Rearrange 4.

6. $\vec{OX} = \vec{OP} + \frac{1}{2}($ [vec(OQ)-vec(OP)]) ✔ **Answer:** vec(OQ)-vec(OP) — Substitute [5] ✔ **Answer:** 5 into [3] ✔ **Answer:** 3

7. $\vec{OX} = \frac{1}{2}(\vec{OP} + \vec{OQ})$ — Rearrange 6.

Solution:

The full solution is worked out below.

1. $\vec{PX} = \frac{1}{2}\vec{PQ}$ — Given

2. $\vec{OX} = \vec{OP} + \vec{PX}$ — Definition of vector addition.

3. $\vec{OX} = \vec{OP} + \frac{1}{2}\vec{PQ}$ — Substitute 1. into 2.

4. $\vec{OQ} = \vec{OP} + \vec{PQ}$ — Definition of vector addition

5. $\vec{PQ} = \vec{OQ} - \vec{OP}$ — Rearrange 4.

6. $\vec{OX} = \vec{OP} + \frac{1}{2}(\vec{OQ} - \vec{OP})$ — Substitute 5. into 3.

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7. $\overrightarrow{OX} = \frac{1}{2}(\overrightarrow{OP} + \overrightarrow{OQ})$ Rearrange 6.

Please note that in general, there is more than one way to prove something. In order to make these problems, we are specifying a specific method and approach. But it is not the only one!

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