Higher

VECTORS

MEET RACHEL

Graduate Civil Engineer, Laing O'Rourke

SUBJECTS STUDIED AT SCHOOL

GCSEs in:

Maths • Physics • Biology • Chemistry • Music

English Language • English Literature • Italian • French

A Levels in:

Maths • Physics • Further maths • Music

FURTHER EDUCATION: MEng Civil Engineering (with a year in industry) Degree with First Class Hons from the University of Bath.

CAREER JOURNEY SO FAR

First discovered the world of engineering when winning a competition to build a bridge out of pasta at 16.

Received an Arkwright Engineering Scholarship with Balfour Beatty which enabled me to gain more experience in civil engineering during sixth form.

Completed a Masters degree in civil engineering at the University of Bath, with a year in industry.

Now a Graduate Civil Engineer with Laing O'Rourke.

FUTURE ASPIRATIONS

"

I am now looking forward to starting the Laing O'Rourke graduate programme in September 2021, helping to build the nuclear power station, Hinkley Point C, the largest project in Europe. I hope to gain more experience and continue working towards becoming a Chartered Civil Engineer. I would like to continue developing both my technical knowledge and management skills, to one day enable me to become a Project Manager, leading teams to build projects that make a difference to the world around us.

Q&A WITH RACHEL

What does your company/organisation do?

Laing O'Rourke is a global construction and engineering company that delivers projects for clients across the UK, Middle East and Australia. They work across a variety of sectors including healthcare, education, infrastructure, residential, defence, leisure and rail. Projects include the London 2012 Olympic and Paralympic Games, Crossrail, Thames Tideway, Hinkley Point C, the Atlantis Hotel in Dubai and Perth Stadium Station.

What types of activities do you do in your job?

As a Graduate Site Engineer I would be responsible for managing teams of operatives to complete construction tasks on the project. I would need to ensure that all tasks are properly managed and undertaken safely by completing risk assessments, method statements, work permits and inductions. I would also be required to ensure that we are building what is designed to a high standard and quality, as well as using surveying equipment to set out where things need to be built and check that they have been built to provide as-built surveys for clients.

What does a typical day at work look like for you?

Typically, I would arrive to work early at around 7am and check my emails as well as the weather to ensure that any plans don't need to be adjusted. I would then head out onto site and deliver the operative's working in my team with their Daily Activity Briefing, ensuring everyone knows what the plan for the day is. I would then complete some setting out and surveying as well as quality checks on work that has been completed to ensure it is up to standard and to sign it off for the next teams to come in and complete their work. I would also have some meetings throughout the day with other managers and engineers to ensure that we are all working together and to be informed of any changes. I would end the day completing any last minute paperwork and leaving the site around 6pm.

What are your favourite things about your job?

One of my favorite things about my job is that once you have been part of a project and it is finished you feel like there is a physical legacy you have left behind. It feels amazing being able to drive past projects that you've worked on and to be able to say "I built that!" I also love being part of projects that make a difference to people's lives, as well as being able to work with so many different people that I learn a lot from everyday. I love that everyday is different, which means that the work is both stimulating and challenging, which also means that it is really rewarding.

HOW RACHEL USES VECTORS AT WORK

"

- I use vectors to set out the exact positions of where things need to be built.
- I also use vectors to survey what has been built to calculate whether this is within tolerance (close enough) to where it was designed to be.
- By using vectors to both set out and survey, we are able to ensure that as more things on are project are built, they all fit together and prevent us from having to spend a lot of money and time re-building things and ensuring that we "build right first time."

ACTIVITIES

Problem 1

a)
The primary structure for a new secondary school is being built in Inverness. Column A has design co-ordinates (5.5m, 5m) and column B has design co-ordinates (11m, 10m). Find the vector *AB*.

b)
Your supervising engineer has asked you to measure that distance between these two columns on site using surveying equipment and you get a reading of 7.45m. You are then asked to confirm that this is within the 5mm tolerance set out in the specification. Confirm whether these columns are within the tolerance by calculating what the magnitude of the vector AB is and whether this is within 5cm of your on-site measurement of 7.45m?

Problem 2

There is a fear that the design for two of the water drainage pipes for a new hospital being built in Glasgow might clash (intersect) and if this is the case, will need to be re-designed. Your supervising engineer has done a preliminary check using the Building Information Model (BIM) and fears the two pipes might intersect at the point (-5, -1, 0).

A)

Check to see if pipeline 1 r = $\begin{pmatrix}3\\-1\\2\end{pmatrix}+\lambda\begin{pmatrix}4\\0\\1\end{pmatrix}$ passes through the point (-5,-1,0)

B)

Check to see if pipeline 2 r = $\begin{pmatrix}1\\-4\\3\end{pmatrix}+\mu\begin{pmatrix}-2\\1\\-1\end{pmatrix}$ passes through the point (-5,-1,0)

C)

Do the pipes need to be redesigned?

Solutions

Problem 1

a) Find the vector $\overrightarrow{AB}$.

$\overrightarrow{AB} = \overrightarrow{OA} + \overrightarrow{OB} = -\overrightarrow{AO} + \overrightarrow{OB} = -\begin{pmatrix}5.5\\5\end{pmatrix} + \begin{pmatrix}11\\10\end{pmatrix} = \begin{pmatrix}-5.5+11\\-5+10\end{pmatrix} = \begin{pmatrix}5.5\\5\end{pmatrix}$

b) Find magnitude of the vector $\overrightarrow{AB}$.

$|\overrightarrow{AB}| = \sqrt{(5.5^2)+(5^2)} = \sqrt{30.25+25} = \sqrt{55.25} = 7.43\text{m}.$

As 7.45m -7.43m = 0.02m < 0.05m, the columns are within tolerance.

Problem 2

A)

Answer: If the point (-5,-1,0) lies on the line $r = \begin{pmatrix}3\\-1\\2\end{pmatrix}+\lambda\begin{pmatrix}4\\0\\1\end{pmatrix}$, then $\begin{pmatrix}3\\-1\\2\end{pmatrix}+\lambda\begin{pmatrix}4\\0\\1\end{pmatrix} = \begin{pmatrix}-5\\-1\\0\end{pmatrix}$ for some value of λ. So $\lambda\begin{pmatrix}4\\0\\1\end{pmatrix} = \begin{pmatrix}-5\\-1\\0\end{pmatrix} - \begin{pmatrix}3\\-1\\2\end{pmatrix} = \begin{pmatrix}-8\\0\\-2\end{pmatrix}$. This equation is satisfied by $\lambda = -2$, so the point (-5,-1,0) lies on the line.

B)

: If the point (-5,-1,0) lies on the line $r = \begin{pmatrix}1\\-4\\3\end{pmatrix}+\mu\begin{pmatrix}-2\\1\\-1\end{pmatrix}$, then $\begin{pmatrix}1\\-4\\3\end{pmatrix}+\mu\begin{pmatrix}-2\\1\\-1\end{pmatrix} = \begin{pmatrix}-5\\-1\\0\end{pmatrix}$ for some value of μ. So $\mu\begin{pmatrix}-2\\1\\-1\end{pmatrix} = \begin{pmatrix}-5\\-1\\0\end{pmatrix} - \begin{pmatrix}1\\-4\\3\end{pmatrix} = \begin{pmatrix}-6\\3\\-3\end{pmatrix}$. This equation is satisfied by $\mu = 3$, so the point (-5,-1,0) lies on the line.

C)

Since the point (-5,-1,0) lies on both lines, it is the point where the two lines intersect and clash, and therefore the piplines should be redesigned to prevent them from clashing.