

# SETTING THE SCENE



**A**ll across the world, there exist abandoned towns and cities. Though the spaces are now uninhabited, the roads, buildings, land and utility systems that were once used to support a population are still in place.

Imagine one day you find yourself in a derelict countryside town, Fernfield, on the British coast. How do you think it came to be abandoned? What do you think it would look like? What do you think it would smell like?

Next, imagine you have all the kit you need including a phone full of helpful contacts and you are tasked with bringing this town back to life. Are you ready to give it a go?

The STEM puzzles and Creative Challenge in this pack will guide you through your task.

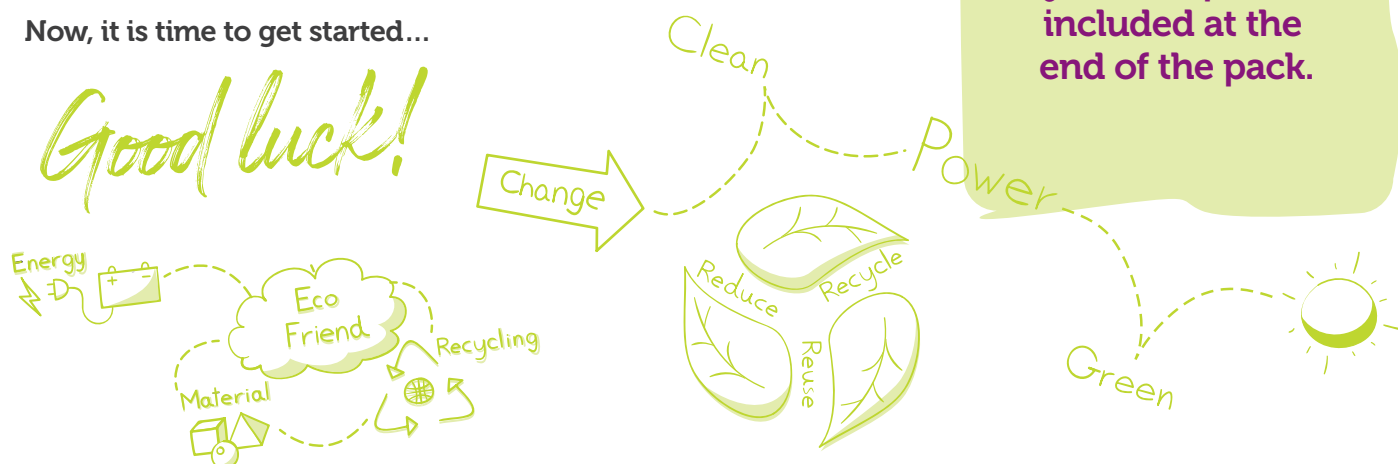
While we want you to rebuild this derelict town back to life, we also want you to do this in the most sustainable way possible. You will be introduced to some of the United Nations' Sustainable Development Goals (UN SDGs) to support you to do this along the way. The UN SDGs were created to help achieve a better and more sustainable future for all!

Now, it is time to get started...

At each stage of the task, you will meet a role model who will share some tips on how to get started with the puzzles and the Creative Challenge and also tell you a bit about their STEM job – they are looking forward to meeting you!

If their jobs interest you and you would like to find out some more about a career in STEM, there are some **additional resources** for you to explore, included at the end of the pack.

*Good luck!*



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# 1. WATER SUPPLY FOR FERNFIELD

# H<sub>2</sub>O

In the first stage of your task, you will need to get the town's access to clean water back up and running. You are happy about this because you are very thirsty after your long journey. Can you think of all the other ways you use water throughout your day? What would you do if you didn't have access to clean water?

**Did you know that only a certain amount of groundwater is allowed to be pumped?**

This is to make sure that our environment is protected. Luckily, it has been particularly wet season in Fernfield. There is lots of groundwater available, but it is not ready for use yet as it is still very dirty.

**Did you know that humans can only last 3 days without drinking water?**

Our water comes from many different sources, but it usually starts out as rain. This rain collects in rivers and streams to form 'groundwater' that is pumped to water treatment facilities. Although it seems like it is always raining in the United Kingdom, water sources are not unlimited – it can be very hard to ensure there is enough water for all its uses when it is an especially hot and dry year.

## So, we need to do some filtering!

**Stage 1: The water is screened.**

This is when the large items like leaves, sticks and stones are removed – that's the easy job! But what about all the teeny tiny harmful particles that need to be removed and that we can't see?

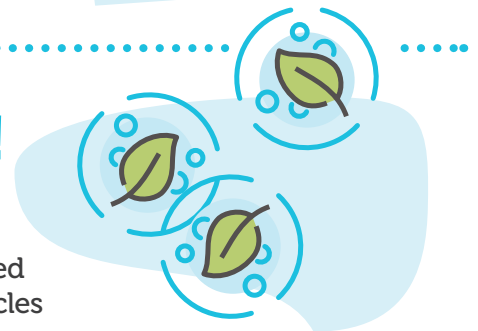
**Stage 2: Sand is used to remove these invisible particles.**

The particles are trapped in the sand as the water is passed through it!

**Stage 3: A small amount of chlorine is added.**

This kills any remaining bacteria still in the water.

**Stage 4: Now, the water is clean and safe enough to drink!**



The UN SDG 6 aims to ensure clean water and sanitation for all.

Find out more about this SDG [here](#)

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# PIPE PUZZLE

Can you work out what pipe pieces are needed to fix the town's water filtering network?

All the components of Fernfield's water filtering network are still in place but there are some parts of the pipe that are broken. Can you work with Jesie to find out what pipe pieces are needed to fix the filtering network?

Work your way through the four parts of the puzzle to restart Fernfield's water filtering network. The **switch codes** will help you work out what pipe pieces are missing; they'll also help you find six letters associated with each pipe piece. When unscrambled, these letters will spell a word – this is your final answer.

## Introducing Jesie

**Name and Job Title**  
Jesie Dyos,  
Process Scientist



### What do you do in your job?

My role manages the water quality across 12 sites in Thames Valley to ensure the water we provide our customers is safe for human consumption and protects public health. I get to review different treatment processes such as using ozone to improve taste and odour, filtration to remove bacteria from the water and, metals and pesticide removal. The role is reactive, dealing with failures or events and proactive, using innovation to identify new sources of water and how to supply an always-growing population.

### Why do you enjoy what you do?

I enjoy how diverse my role is as no two days are the same. I spent a vast majority of my time in the field, alongside the operational and sampling teams at different sites, looking for ways to improve resilience and to mitigate any risks or challenges.

### What subjects did you like at school?

I studied Biology, Chemistry and Geology at college and obtained an undergraduate degree in Marine Biology and a postgraduate degree in Aquatic Biology at the University of Portsmouth.

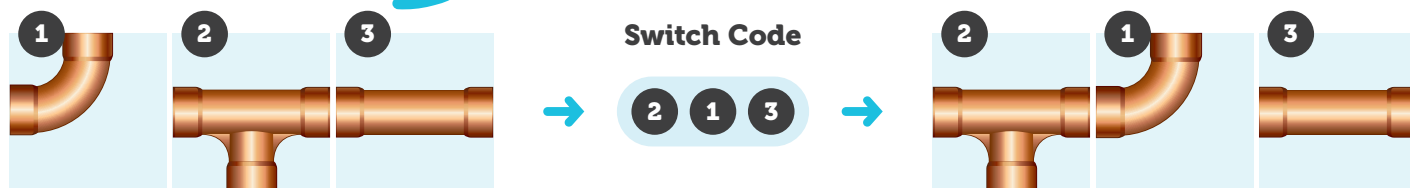
## Find the missing pipe pieces!

						Stage 1: Water Screening Tank
	1 ?		Stage 2: Sand Filtration Tank	2 ?		
	Stage 3: Chlorine Tank	4 ?		3 ?		
			5 ?			
				6 ?		Stage 4: Clean Water

Jesie has provided an example to show you how the switch codes work. Thank you Jesie!

**HINT!**  
Notice that each pipe has been labelled – this makes it easy to track each piece once the switch code has been applied.

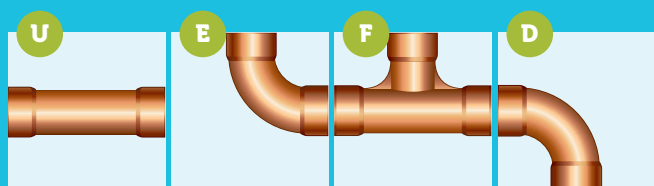
## Example



This sequence of pipes is in numerical order to start with but the sequence is reordered once a switch code is applied. This example has a switch code of 213 so the order of the pipes changes from 123 to 213 i.e. the first pipe is now in the second position, the second pipe is in the first position and the third pipe remains in the third position.

## Now it's your turn!

**Part 1:** Use the switch code to work out the new sequence. The pieces in the green squares are the first two missing pipe pieces.

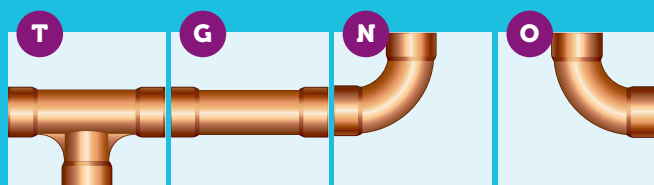


Switch Code

2 1 3 4



**Part 2:** Use the two switch codes to work out the new sequence. The pieces in the purple squares are the third and fourth missing pipe pieces.



Switch Code

3 2 1 4

Switch Code

1 4 2 3

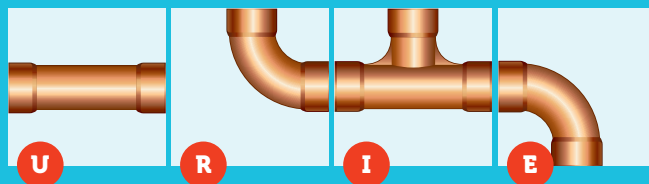


**Part 3:** This time, you must work backwards! Use the switch code to work out the original sequence. The pieces in the red squares are the last two missing pipe pieces.



Switch Code

2 1 3 4



**Part 4:** Unscramble the letters associated with the missing pipe pieces to spell a word.



The missing word is:



**HINT!**

The word can mean 'joining together' – just like we've done with this pipe system!

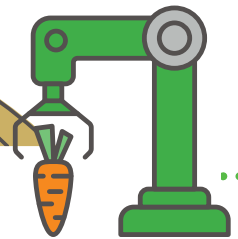
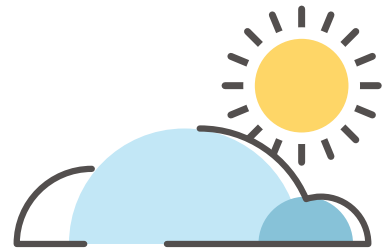
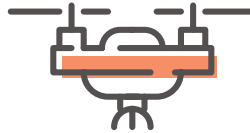


## 2. FOOD SUPPLY FOR FERNFIELD

**N**ow that you have successfully restored the clean water in Fernfield, you need to secure a reliable supply of local crops. The food you brought with you won't last long...

**Did you know lots of farms in the UK use automated process to help them harvest?**

This automation varies from fruit-picking robots and sorting machines to drones that are able to look how the crops are growing.



**W**e already have lots of land in and around Fernfield that is suitable for farming but let's see if there is anything in our supplies that can help us set up our very own variety of crop automation...

**You have a rummage through your belongings and... Aha!**



You find some fruit and vegetable seeds, a set of sprinklers and a water content sensor that is able to determine the amount of water in soil. It seems we have the tools to set an automated water system. You like the idea of this as watering the crops for a whole town on your own would be very tiring!



**The UN SDG 15 aims to protect, restore and promote the sustainable use of land-based ecosystems.**

Find out more about this SDG [here](#)

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# CROP PUZZLE

Can you automate a watering system to care for Fernfield's crops?

**W**e have everything we need but we still need to set it up. Can you work with Kirsty to write a code that will automate the watering system? She has started to write the code, but using the notes she has provided about the **Object**, **Variables** and **Rules**, can you help her complete it?

## Object

"I have created an **Object** to use in our code. It is called '**Plot**'. The Object (Plot) has **Variables** within it – these tell us information about the object."

## Introducing Kirsty

**Name and Job Title**  
Kirsty Carotti,  
Software Developer



### What do you do in your job?

I work with customers to develop and design websites that allow them to interact with large amounts of complicated data. Often I am given a problem and asked to find an efficient and effective solution – we will be doing the same as part of this puzzle!

### Why do you enjoy what you do?

I enjoy finding solutions to problems and helping people access their information in a way that works for them.

### What subjects did you like at school?

I was lucky enough to study Computing at school, and loved solving problems, but also enjoyed the theoretical side of Physics. I've always been quite creative and love to bring what I learnt studying Art and Art Graphics at school into my job.

## Variables for the Object 'Plot'

"Here are the **Variables** I have set for our Plot:

- **isPlanted** – this Variable tells us whether Plot has a crop planted or not. If **isPlanted = true** then the Plot has a crop planted; if **isPlanted = false** the Plot does not have a crop planted. The Variable **isPlanted** can only equal **true** or **false** i.e. Plot either has a crop planted or it doesn't. This means that the Variable **isPlanted** is of '**Boolean**' (**bool**) Type.
- **WaterContent** – this Variable tells us how much water is present in the Plot and it is given as a percentage. If **WaterContent = 100** this means that the water content of the soil is at its maximum, i.e. 100%. If **WaterContent = 100**, there is no need to water the Plot but if **WaterContent < 100**, the Plot needs to be watered. The Variable **WaterContent** can only equal a **number**. This means that the Variable **WaterContent** is of '**integer**' (**int**) Type.
- **isFertilized** – this Variable tells us whether the Plot has been fertilized or not. **isFertilized** can only equal **true** or **false** because either a Plot is fertilized or it is not. So, **isFertilized** is another Variable of '**Boolean**' (**bool**) Type."

## Now, translate into code...

With the knowledge you've already gained, can you fill in the Type for the Variable **isFullyGrown** in the list below?

### Plot – its Variables and Types

**isPlanted** (bool)

**isFullyGrown**

**WaterContent** (int)

**isFertilised** (bool)

When you code, you can use different symbols to compare Variables and these comparisons will return a **Boolean** – **true** or **false** – response.

Kirsty has helped explain these comparisons below:

Symbol	Meaning	Use	Example
<	Less Than	The symbol is used to compare two Variables of integer type.	The comparison, <code>2 &lt; 4</code> , would return <b>true</b> but the comparison, <code>5 &lt; 3</code> , would return <b>false</b> .
>	Greater Than	The symbol is used to compare two Variables of integer type and is the opposite of 'Less Than'.	The comparison, <code>5 &gt; 1</code> , would return <b>true</b> but the comparison, <code>9 &gt; 10</code> , would return <b>false</b> .
==	Equals	The symbols are used to determine whether two Variables of the same type have the same value.	If Variable <code>x = 7</code> and Variable <code>y = 7</code> , then the comparison, <code>x==y</code> , would return <b>true</b> . Likewise, if <code>isPlanted = true</code> , then the comparison, <code>isPlanted == false</code> , would return <b>false</b> .
!=	Not Equals	The symbols are used to determine whether two Variables of the same type do not have the same value and are the opposite of 'Equals'.	If Variable <code>x = 7</code> and Variable <code>y = 8</code> , then the comparison, <code>x!=y</code> , would return <b>true</b> . Likewise, if <code>isPlanted = true</code> , then the comparison, <code>isPlanted != false</code> , would return <b>true</b> .

### Kirsty says:

"Make sure you know the difference between '=' and '=='. A single '=' means you are assigning a value to a Variable but '==' means that you are determining whether the values of two Variables of the same Type are equal."

Now let's get to finishing the code so we can get these crops growing!

### Rules

"Finally, here are the **Rules** I have created for our Plot:

- 1 There are 10 Plots.
- 2 Each Plot can grow a fruit or vegetable as a Crop.
- 3 When the Crop is fully grown, it needs to be picked.
- 4 When a Plot is empty, a new Crop can be planted.
- 5 When the water content of the soil is less than 100%, the Crop needs to be watered."

# Fill in the gaps below to complete the code

You will need to use a mixture of numbers and the comparison symbols that Kirsty introduced to us. Some of the symbols have been used once or twice and some symbols have not been used at all. The Object definitions and Rules that Kirsty explained earlier will also help you to crack the code!

An Array is a list of multiple objects that are the same – in this case, Plot.

## HINT!

Did you know that computers start counting at 0 when we start counting at 1?

When a human and a computer count a list of Objects or an Array, the results would be different! Now try it for yourself. Count your fingers as you normally would and then again, starting from 0.



## Kirsty says:

<=

"This symbol is similar to < but it means **Less Than Or Equal To**."

```
Array <Plot> = [PlotA, PlotB, PlotC, PlotD, PlotE, PlotF, PlotG, PlotH, PlotI, PlotJ]
```

```
LOOP WHILE count <=
```

```
    IF Plot[count].isPlanted false THEN
```

```
        PlantCrop(Plot[count])
```

```
        Plot[count].isPlanted = true;
```

```
    IF Plot[count].Crop.isFullyGrown true THEN
```

```
        PickCrop(Plot[count])
```

```
        Plot[count].Crop.isFullyGrown = false;
```

```
    IF Plot[count].WaterContent 100 THEN
```

```
        WaterCrop(Plot[count])
```

```
        Plot[count].WaterContent = MeasureWaterContent(Plot)
```

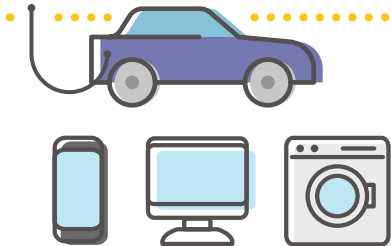
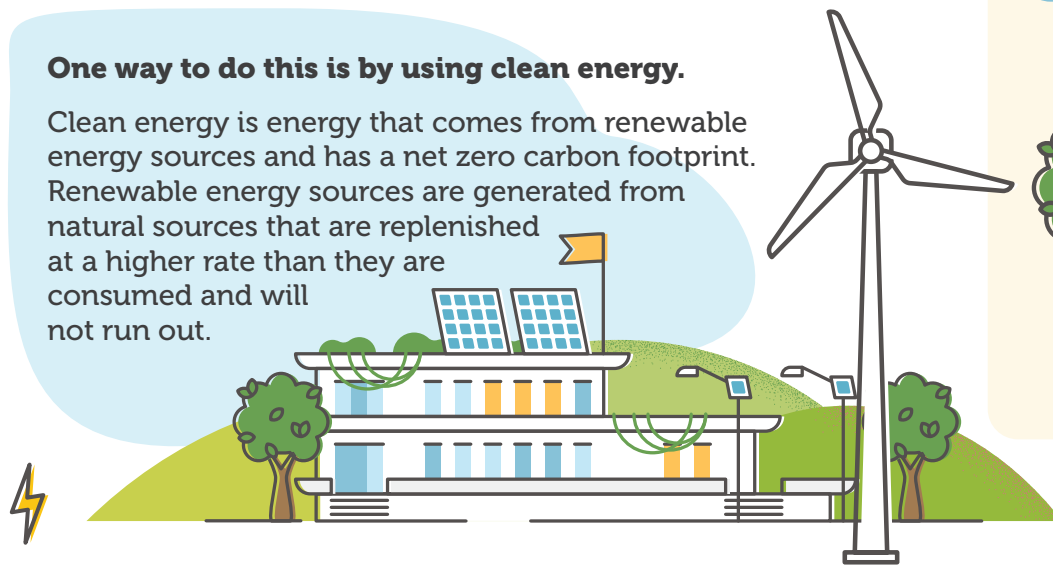


# 3. RENEWABLE ENERGY FOR FERNFIELD

**O**n the way back from setting up Fernfield's automated watering system, you notice an old school building. Eager to ensure that Fernfield's new residents have somewhere to learn, you are tasked with getting it ready to use again. Your first step is to ensure that the building can be powered sustainably.

**One way to do this is by using clean energy.**

Clean energy is energy that comes from renewable energy sources and has a net zero carbon footprint. Renewable energy sources are generated from natural sources that are replenished at a higher rate than they are consumed and will not run out.



**I**n the UK, we are working hard to increase the amount of electricity generated using renewables.

**Did you know that in 2020, in the UK, 43% of electricity came from renewable energy sources?**

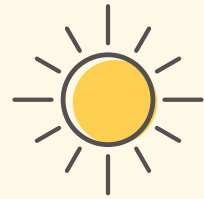
While this is good news for all of us, we still have a long way to go!



**The UN SDG 7 aims to ensure access to affordable and clean energy.**

Find out more about this SDG [here](#)

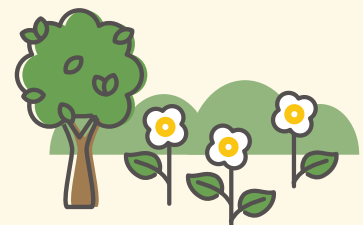
**Examples of renewable energy sources:**



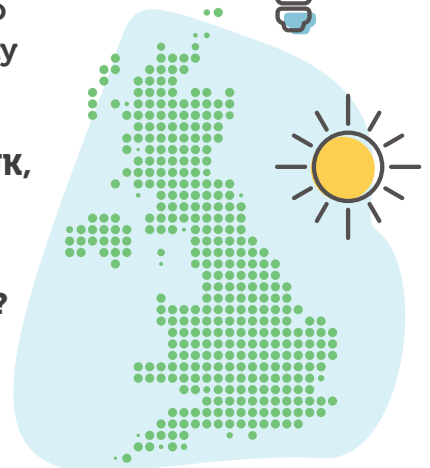
**Sunlight**



**Wind**



**Plants**



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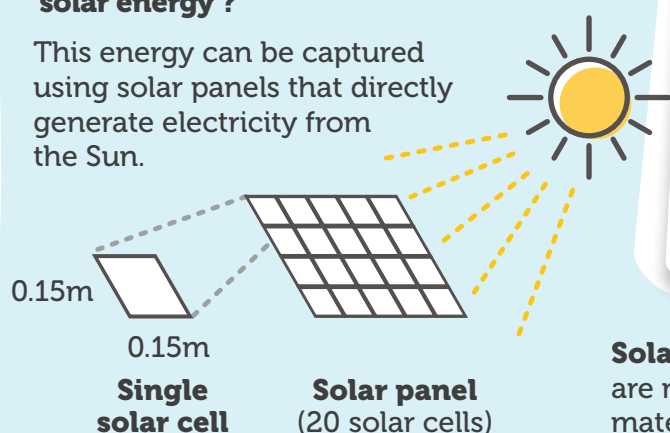
# ENERGY PUZZLE

Can you help power Fernfield's new school with renewable energy?

**N**ow we have found an appropriate school building, can you work with Muneebah to set up solar panels to generate power for the school?

## Did you know the Sun produces 'solar energy'?

This energy can be captured using solar panels that directly generate electricity from the Sun.



**Solar panels** are made of solar cells that are made from layers of semi-conducting material, most commonly silicon.

14  
**Si**  
Silicon

## Introducing Muneebah

**Name and Job Title**  
**Muneebah Quyyam,**  
**Senior Engineer**



### What do you do in your job?

I work closely with lots of different companies (clients) and use my maths and engineering skills to solve engineering problems. My job involves researching innovative renewable/low carbon technology to help industry reduce their carbon emissions. I have also worked on wind turbines to design the control system logic which helped keep the turbines running and I have also worked on rail projects that will impact the future of travel.

### Why do you enjoy what you do?

I enjoy problem solving and applying my skills in different ways. I love working as part of a team that has a great focus on sustainability and seeing the application of my work to real life engineering creates a real buzz!

### What subjects did you like at school?

I love Maths because it gives you the creative freedom to solve real-world problems in lots of different ways and the application of Maths are endless. I also thoroughly enjoy Chemistry, and my favourite memory at school includes doing experiments!

## OK, let's get started!

**Part**  
**1**

Answer the five questions (1a-1e) below to work out how many solar panels the school would need and how much money is needed to buy the solar panels. For each question, Muneebah has provided all the information you'll need or she's given you a helpful hint!

**Question 1a: Calculate the power (in kW) of a single solar panel made in the lab.**

$$\text{Power (kW)} = \left[ \frac{\% \text{ of solar power captured}}{100} \right] \times \text{solar power per area from the Sun} \left[ \frac{\text{kW}}{\text{m}^2} \right] \times \text{area of a solar panel (m}^2\text{)}$$

**Your answer:**

kW of solar power will be captured by a single solar panel.

## Info from Muneebah

- The solar panels are made up of 20 square solar cells. Each side of a single solar cell is 0.15m long.
- The solar panel is made in a lab and to determine its power, the solar panel is exposed to 1kW of sunlight per metre squared (i.e. 1kW/m<sup>2</sup>) for one hour.
- Only 15% of the Sun's energy is captured by the solar panel to generate electricity.
- 1kW is equal to 1000W.

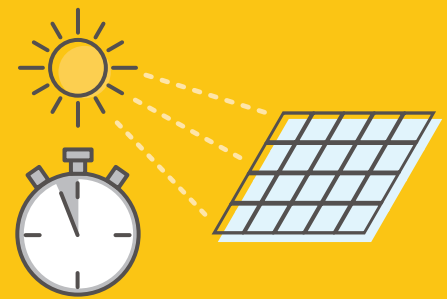
### HINT!

To start, work out the area of a single solar panel. Using the area and the other information provided will help you to answer this question.

**Question 1b:** Using your answer to 1a, calculate the solar energy generated by a single solar panel (in kWh) that has been exposed to sunlight for an hour.

Your answer:

                     kWh of solar energy is generated by a single solar panel after exposure to sunlight for an hour.



**HINT!**  
 $\text{Energy (kWh)} = \text{Power (kW)} \times \text{Time (h)}$

**Question 1c:** Calculate how much solar energy will be generated by a single solar panel per year, given the actual average solar energy from the Sun.

Your answer:

                     kWh of solar energy will be generated by a single solar panel per year, given the actual average solar energy from the Sun.

### Info from Muneebah

- Previously, the solar panel was being tested in the lab.
- Now take the average solar energy generated by the Sun per year as  $900 \text{ kWh/m}^2$ .
- Remember the solar panel is made up of 20 solar cells with each side  $0.15\text{m}$  long.
- Remember only 15% of the Sun's energy is captured by the solar panel.

**Question 1d:** The school will need to generate 50% of 5 MWh of electricity per year using solar panels. Using the solar energy (kWh) generated by a single solar panel (your answer to 1c), calculate how many solar panels the school would need.

Your answer:

                     solar panels are required to generate 50% of 5 MWh of electricity per year at the school.



**HINT!**  
 $1 \text{ MWh} = 1000 \text{ kWh}$

**Question 1e:** The school would like to pay for the solar panels in 4 equal instalments over the year. Calculate the total cost of purchasing the solar panels and then work out the amount required to pay per instalment.

Your answer:

£                      needs to be paid by the school per instalment.

### Info from Muneebah

- A solar panel costs £380.
- When you buy over 30 panels, a 5% discount is applied to the total price.

## Part 2

We need to solve another puzzle before the solar panels can be installed because we need to know when the school was built. Solve the KenKen puzzle below to find out what date this is! Muneebah has given you some information on how to solve KenKen puzzles.

When you have worked out the missing numbers in the puzzle to discover what values the coloured shapes have, use this information to enter the values for A, B, C, etc. into the answer panel below.

### HINT!

Start in the bottom left cage of the grid, solve the bottom rows and then work your way around the grid.

## Info from Muneebah

- Use each number between 1 and 7 only, once per row and once per column.
- The numbers in each heavily outlined set of squares, called 'cages', must combine to produce the target number in the top left corner using the mathematical operation indicated (+, -, x, ÷).
- Cages with just one square should be filled in with the target number that appears in the top left corner.
- A number can be repeated within a cage as long as it is not in the same row or column.

$$A = (\triangle \div \triangle) - \bullet$$

$$B = \color{green}{+} \div \color{purple}{\blacksquare}$$

$$C = (2 \times \color{blue}{\star} - \triangle) + (2 \times \bullet - \color{green}{+})$$

$$D = \color{blue}{\star} - \color{purple}{\blacksquare}$$

$$E = (\triangle + \color{red}{\blacklozenge}) \div \color{pink}{\heartsuit}$$

$$F = \color{pink}{\heartsuit} - \color{red}{\blacklozenge} - \bullet$$

$$G = ((\color{green}{+} + \color{purple}{\blacksquare}) \div \color{pink}{\heartsuit}) \times \bullet$$

$$H = ((\color{blue}{\star} + \color{purple}{\blacksquare}) \div \triangle) \times \color{pink}{\heartsuit} \times \bullet$$

56 x	7		6 +		16 +	
3 ÷	1 -	6 -	3 -		2	
2			15 +	5	5 +	5 -
2 -	3 +	1 -	6			
		2 ÷		2 ÷	3	13 +
12 +	5	2 -		4 -	3	
7		3 ÷		3 -	2	

### Did you know?

The school build was completed on the same day the United Nations' Sustainable Development Goals came into force.

Your answer:

The school in Fernfield was completed on:

A B / C D / E F G H

\_\_\_\_ / \_\_\_\_ / \_\_\_\_



# CREATIVE CHALLENGE



Well done! You've made it through answering all the STEM puzzles and helping Fernfield on its journey to revival. Now you know about some of the fundamentals that form the basis of a sustainable life for all, let's apply what you've learnt to create a city of your own.

In this final Creative Challenge, we would like you to develop and share your ideas on how to make a city sustainable. You can base your answer on any city (or town) around the world or you can make one up if you would like! You can submit your response to this challenge in whatever form\* you choose.

Some ideas might include:

- Using creative writing, such as a story or a poem.
- Using drawings and annotated diagrams.
- Using a collection of written descriptions of your ideas.

When developing your ideas, try to remember the themes we've explored through this puzzle pack, such as clean water and sanitation, locally sourcing your food in a way that protects land-related ecosystems and clean and affordable energy. However, don't let these limit you! We want to hear about the area(s) of sustainability that you are most excited and passionate about.

As well as evidence of innovative thinking, creativity and communication skills, when judging the Creative Challenge entries, our expert panel of judges will be looking for three key things:

1. **What is the problem you are solving?**  
Please ensure it is clear what issue you are tackling.
2. **What is your idea?**  
Please describe/draw the details of your brilliant idea!
3. **Why is this so important for people and our planet?**  
Please ensure you capture the benefits that your idea has for your chosen city and the people in it.

\* Please note: the response to the Creative Challenge should not exceed two sheets of A4 paper.



The UN SDG 11 aims to make cities and communities inclusive, safe, sustainable and resilient.

Find out more about this SDG [here](#)

## Introducing Isobel

### Name and Job Title

Isobel Vernon-Avery,  
City Strategy Consultant



### What do you do in your job?

I work with cities or people who are building cities to help them understand what digital technologies they need for people who live there and how to make sure the city is as sustainable as possible, for example through material reuse or nature-based solutions.

### Why do you enjoy what you do?

I enjoy the problem solving with other people in my company but also with people from other companies and communities. It is also great to feel like my job has purpose in helping with the climate crisis.

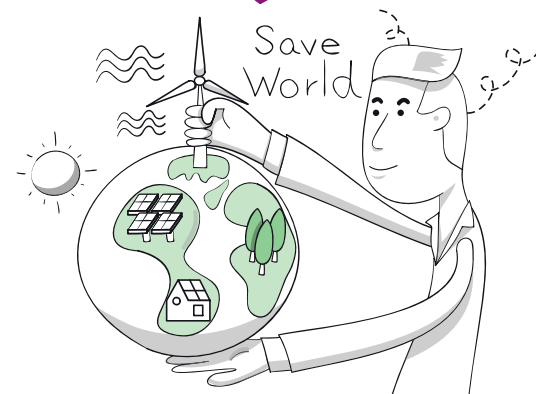
### What subjects did you like at school?

I enjoyed Physical Geography and Art – the connection between science and art is important to me as it helps us understand each other and also how we relate to complex topics. I also love the excitement of seeing and feeling things in real life, be it a volcano, a building or a painting.



You have free reign over this challenge. Remember, we want to see your design skills and creativity flow as much as possible!

SUSTAIN...





#### **WISE**

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