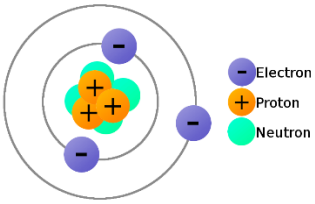
Lightning and Earthquakes (Level 3)

Description	Learners will explore the fascinating forces of nature and learn all about the causes and effects of lightning and earthquakes to design structures that can withstand these natural disasters.
Leading question	Can you build an earthquake or lightning-resistant house?
Subjects covered	Science, Math, Art and Design
Total time required	40-60 min a day for 5 days
Resources required	Balloon, tissue paper/paper, metal spoon, cardboard box, plastic cup, string, marker, toothpicks (or straws, branches, etc.), clay (or flour dough).
Learning outcomes:	By the end of this project, learners will be able to: Knowledge-Based Outcomes: 1. Identify the charges generated by the rubbing of different substances and observe the attraction and repulsion in those charges. 2. Show the electric transfer of charge. 3. Explain the causes, effects, protection measures of lightning, and the construction and working of lightning conductors. 4. Explain the causes, effects, safety measures and precautions of earthquakes. 21st Century Skill Outcomes: 1. Collaborate while seeking feedback on their designs and improving them based on it. 2. Think creatively while designing a lightning/ earthquake-resisting house. 3. Think critically while making inferences during experiments. 4. Communicate effectively in providing feedback and presenting the final project.
Previous Learning	Natural disasters
Supervision required	Medium

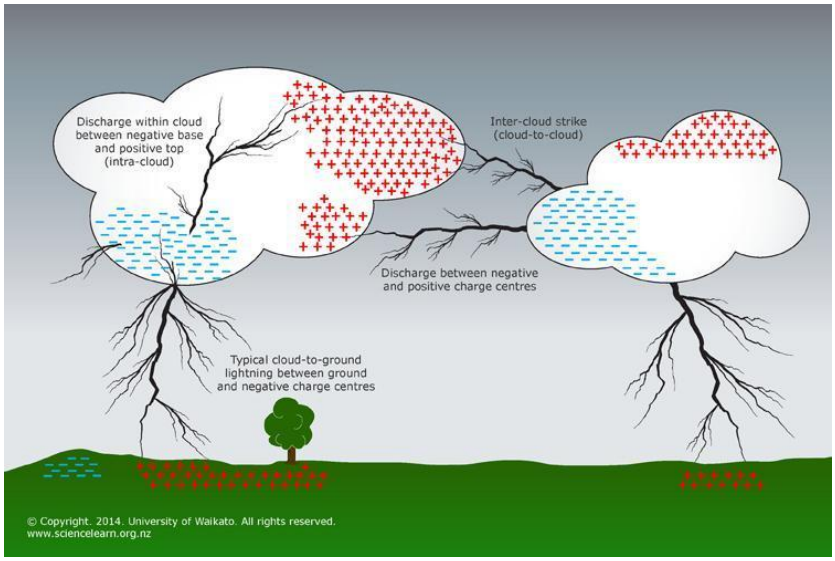
Day 1 -

Today, you will find out how lightning takes place.

Time	Activity and Description
10 minutes	**Introduction** What comes to your mind when you think of lightning? - Have you experienced a thunderstorm with lightning? - How did you and your family react?

	- What did you do? ***Note:*** *Ask learners to read a newspaper article (**Appendix 1**) titled "Global Lightning Deaths Surge". If they find it difficult to read it, please read the article for them.* Discuss: - Which place in the world has been discussed in the article? Which months are prone to lightning there? - How serious is the problem? Which words/phrases from the article indicate it? - Who is most affected? Why do you think so? - What is lightning made of? Why is it dangerous?
10 minutes	**Understanding Positive and Negative Charge** Have you ever been zapped when you touch a door knob or another person? It feels like a little electric shock and usually happens on cold and dry winter days. - Where is this shock coming from? - Why is it that sometimes you get zapped and sometimes you don't? It all has to do with **static electricity**, which can build up in some materials and then be transferred from one object to another. How is static electricity related to lightning? Let us find out! ***Note:*** *Guide learners to conduct the activity described below, based on the steps listed.* Materials: a blown-up balloon and small pieces of tissue paper Instructions: - Rub the balloon against your hair for 10 seconds. - Hold it near the pieces of tissue paper. What do you observe? *(The paper is attracted to the balloon.)*  Explanation: 1. All matter is made up of **atoms**, and all atoms are made up of **protons** (positive charge), **neutrons** (no charge), and **electrons** (negative charge). The charges (negative and positive) are usually balanced in each atom, so the atoms are not charged, and the object is not charged. Atoms always try to be in a neutral state.  2. Rubbing the balloon against your hair transfers electrons to the balloon, giving it a negative charge. The tissue paper has a neutral charge (neither positive nor negative). 3. Like charges repel: The negative charge in the balloon repels the negative charge in the tissue paper, making it temporarily positive.

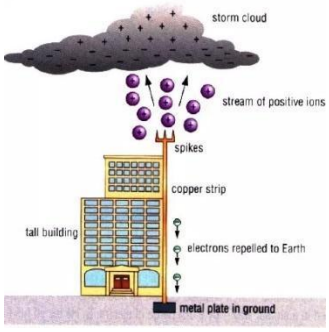
	4. Unlike charges attract: The tissue paper, being temporarily positively charged is attracted to the negatively charged balloon. We feel zapped when we touch a door knob or another person because of the difference in charges. When the objects come in contact, the charges flow and neutralise, and we experience it with a zap!
10 minutes	**Creating Sparks** Let's see if we can make our zap/ spark! Follow the steps below: - Rub the balloon on a woollen material for 2 to 3 minutes. (wool works best, but you can also rub it against your hair) - Get the balloon close to the metal spoon or object and when it is close enough, you will see a tiny spark jump from the balloon to the metal (if the room is dark enough). This happens really fast, in the blink of an eye! - Why do you think this happens? The metal spoon, being neutral, has an equal number of positive and negative charges. - The electric potential difference between the negatively charged balloon and the metal object causes the electrons to jump across the small gap between them, creating sparks. - These sparks occur as the excess electrons on the balloon seek to neutralize their charge by moving towards the positively charged metal object.
10 minutes	**How is this related to lightning?** During a storm, air current moves upward and water droplets downwards. - Positive charges accumulate near the upper edges of the cloud and negative charges near the lower edges. - As this charge separation continues, the charges become stronger. This can create lightning sparks within clouds or between clouds when electrons transfer from the negative to positive areas. - Sometimes the ground has a positive charge too and the electrons transfer from the cloud to the ground creating lightning. This process is called **electric discharge.** - **Electric discharge** refers to the movement of electric charge through a medium, often resulting in a visible flow of electricity or the release of energy. ***Note:*** *Challenge learners to explain using a diagram how lightning works. Some ways to support them are:* - *Inform them that they can draw a diagram of the lightning experiment above and label each object with different charges.* - *Inform them that they can then draw a diagram of clouds showing the positive and negative charges and how lightning is created.* - *You can draw an unlabeled diagram of this on the board and ask them to label it and draw the charges.*

	
At-home activities	Learners make a list of the precautions people take to be safe from a thunderstorm or lightning by interviewing their community. They should explain the scientific reasoning behind it.
Optional Numeracy Activity	- Learners can present the figures provided in the newspaper article (Appendix 1) as a bar graph. - Calculate the average number of deaths per year based on this data. - If the government provides $10,000 to each victim's family, calculate how much the government spent on it based on the death toll for different years. Calculate the average expenditure per year.

Day 2

Today, you will explore the need for lightning-resistant homes and ways to build them.

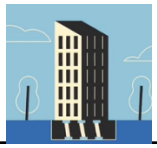
Time	Activity and Description
10 minutes	***Note:*** *Get learners to read the given news article.* ***Argentina: House catches fire due to lightning, property worth millions burnt to ashes*** *Buenos Aires, July 2022: A residence was engulfed in flames following a lightning strike in the Palermo neighbourhood of Buenos Aires, Argentina. Reports indicate that two rooms belonging to Pablo Fernandez were reduced to ashes due to the lightning-induced fire. Possessions valued at millions of pesos were also destroyed in the blaze.* 

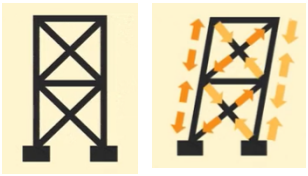
	Discuss: How do you think lightning can cause fires? 1. Electrical Surges: When a lightning bolt strikes a power line or utility pole near a home, it can produce a power surge that travels through the electrical wiring. This surge can overload electrical devices and cause them to overheat or malfunction, potentially leading to electrical fires. 2. Direct Strike: If lightning directly strikes a home, it can ignite flammable materials, such as the roof, insulation, or siding. The extreme heat generated by the lightning can cause these materials to catch fire.
10 minutes	**Lightning Precautions** ***Note:*** *Ask learners to* share their list of precautions with scientific reasoning from their home assignments. Below are a few examples: - *Switch off devices that need electricity and unplug them.* - *Do not take shelter under a tall tree.* - *Do not take shelter under an umbrella with a metallic end.* - *If you are in the water, get out and go inside a building.* Water and metal are conductors of electricity. So, it is important to stay away from them during lightning. - If lightning strikes near a power line, that energy can travel through that line, into your home and along any wires that are connected to an outlet. - If any part of your body is touching or close to a wire or cord that has extra voltage pulsating through it, you could suffer serious injuries. Based on the fact that lightning can cause fires, is there anything you would like to add to your list of precautions? *(For example:* - *Use surge protectors for electric devices to guard against power surges caused by lightning strikes.* - *Install smoke detectors)*
10 minutes	**Lightning Rods** Have you ever seen a lightning rod on a building? - What is its purpose? - How does it work?  Lightning rods are metal rods installed on buildings or structures. They have a pointed shape to attract lightning. - During a thunderstorm, the rod concentrates the electric field around it. - This creates a conductive path of least resistance for lightning. - The lightning rod is connected to a metal wire called a down conductor. - The down conductor carries the lightning current towards the ground.

	- A grounding system, typically a buried metal rod or plate, safely dissipates the lightning's energy into the ground. Therefore, lightning rods protect houses and buildings from lightning strikes by attracting lightning, diverting its impact to the rod, and then carrying it to the ground instead of letting it hit the roof of the house and cause fires or other damage. How can you make a lightning rod out of local materials? (*Refer to **Appendix 2** on how villages in West Bengal, India made their own lightning rods using bamboo.*
10 minutes	**Brainstorm: Build A Lightning Resistant House** Think about these questions: - Where would you place the lightning rod? (Highest point or next to the house?) - If you had to build a house that is lightning-resistant – would you use wood or steel? Why? - What would be the height of the house? - Other considerations? Would there be tall trees around? Electrical lines? Steel conducts current far better than wood. Properly grounded, a metal building permits lightning current to pass harmlessly through the framing and into the ground. On the other hand, wood offers so much resistance that current flashes outward, striking objects or people nearby. Plus, wood catches fire. The taller the building, the higher the chances of it being struck by lightning. ***Note:** Inform learners that for their final project, they can build a model of a lightning-resistant house. They can use different materials and test their resistance to lightning on day 4. If steel or wooden materials are not available, learners can create a house using cardboard and insert a metal wire representing the lightning rod.*
At-home activities	Interview family/community members to investigate if they ever experienced an earthquake. If yes, describe the experience. If not, collect information on how earthquakes are detected. Investigate if animals can detect earthquakes earlier than humans! Bring toothpicks (or straws/small branches), a plate, and clay (or flour dough) for the next class.
Optional Literacy Activity	**Letter Writing:** In 1995, the Great Hanshin earthquake struck Japan, affecting the city of Kobe and its surrounding areas. The devastation was immense, causing widespread destruction and claiming the lives of over 6,000 people. The city was shattered, and the scars of the disaster lingered for years to come, impacting lives and communities in profound ways. Write a letter to the residents of Kobe and the surrounding areas affected by the earthquake expressing your concern and offering support.

Day 3 –

Today, you will explore the need for earthquake-resistant structures and ways to build an earthquake-resistant tower.

Time	Activity and Description
10 minutes	**Introducing Earthquakes:** Do you see any connection between lightning and earthquakes? (*Although lightning and earthquakes may seem like unrelated natural phenomena, they share an intriguing connection through the release of energy. Both phenomena stem from powerful energy releases, albeit in different forms)* Have you ever experienced an earthquake or know someone who has? How did it feel like and what were the impacts? What do you think happens beneath the Earth's surface that causes an earthquake? *(Learners recall some of the core concepts they have learned about layers of earth and tectonic plates through the activity below.)* Let us understand this through a simple activity! To do this: - Hold your palms together. - Press your hands together as hard as you can. Your hands represent two of the Earth's plates. - Continue pressing very hard, but now try to slide one hand up and along the other. Keep trying to slide it until one hand breaks free. How hard was it to move your hands? When a hand broke free, did you feel the sudden release of energy? This is a little like an earthquake!
25 minutes	**Building An Earthquake-Resistant Tower** Now, we will design our own earthquake-resistant structures! Before we begin, let us think about how we will do this. - What features would an earthquake-resistant building show? - How would it be different from other buildings? For a structure to be earthquake-resistant, it needs to show three features: 1. <u>Symmetry and Regularity + Strong Structural Connections</u>: This helps distribute seismic forces more evenly and prevents the formation of weak points that could lead to structural failure during an earthquake. 2. <u>Adequate Foundation</u>: The foundation should be able to withstand the ground shaking. One way to do this is by making the base flexible, so that when the foundation moves the structure itself remains steady.   

	3. <u>Light and Flexible Materials</u>: Modern buildings are often constructed with structural steel, a component that comes in a variety of shapes and allows buildings to bend without breaking. Wood is also a surprisingly ductile material due to its high strength relative to its lightweight structure. Create a building with 3 floors using toothpicks and clay which is earthquake-resistant! - This means that when we place the structure on the plate and shake the plate for 10 seconds, the building should not collapse. - You cannot use tape! ***Note:*** *Encourage learners to experiment, test, and re-design the tower with different shapes and arrangements.* - Did your structure hold up? Why or why not? - Are triangular shapes stronger than squares? - What changes would you make to your structure? 
5 minutes	**Brainstorm: Final Project** ***Note:*** *Learners can also choose to present either an earthquake- or a lightning-resistant tower as their final project. They will present it on the final day and their presentation should also include precautions one can take during lightning/earthquakes.* Based on your, think about these questions: - What kind of a structure will you create? - What are some initial ideas on how it may look? *(Eg: Use LED lights to show lightning above the structure, etc.)* - Which materials would you use? ***Note:*** *Inform learners they will have time in the next class to build their project.*
At-home activities	Learners interview community members and refer to their textbooks to make a list of precautions to keep in mind in the event of an earthquake.

Day 4 –

Today, you will build the lightning or earthquake-resistant structure of your choice.

Time	Activity and Description
10 minutes	**Map Analysis** We know that earthquakes are caused when tectonic plates of the earth move towards or against each other. - There is a massive area in the Pacific Ocean known for its frequent earthquakes and volcanic activity. - Because it sees frequent volcanoes, it is known as the Pacific Ring of Fire. - Let us study a map showing the Pacific Ring of Fire and see what we find out!

	Note: *Ask learners to study the map given in* ***Appendix 3*** *and answer the questions below:* - *What does the dark red line indicate?* - *Can you trace the Pacific Ring of Fire and find out which tectonic plates meet to form it?* - *Why do you think the Pacific Ring of Fire experiences frequent earthquakes and volcanic activity?* *After taking responses, explain:* - The dark red line shows the Pacific Ring of Fire or the region that experiences frequent earthquakes and volcanoes. - The tectonic plates that meet to form the Pacific Ring of Fire are the Pacific Plate with the Indo-Australian Plate, the Philippine Plate, the Eurasian Plate, and the North American Plate; the Cocos Plate with the Caribbean Plate and the South American Plate; and the Nazca Plate with the South American Plate - The Pacific Ring of Fire experiences frequent volcanoes and earthquakes because it lies where tectonic plates meet each other. In this project, if you are building an earthquake-resistant structure, you need to make sure that your structure should survive the strong earthquake experiences along the Pacific Ring of Fire!
30 minutes	**Build The Final Project** Learners work on building the structure independently. They need to use scientific reasoning to explain why they made certain design choices. ***Note:*** *As learners work, support those who may need help.* *Remind learners that their presentations should also include at least 5 precautions.*
At-home activities	Learners present their structures to their friends/ elders and ask for feedback: - What did you like about working on your structure? - What went well? - What would you like to improve before the presentation? Learners prepare the materials needed to build their lightning/earthquake-resistant structure in the next class.

Day 5 –

Today, you will present your final structures, receive feedback on them, and reflect on the journey of this project!

Time	Activity and Description
30 minutes	**Project Presentation** Now, you will present your structure to your friends and family!

	***Note**: Learners present their structures.*
	- *Depending on the type of structure they have created, ask them to simulate:*
	  - *lightning using the spoon and balloon experiment, or*
	  - *an earthquake by shaking a table.*
	  - *While learners present, the audience must note down one thing they liked about the project.*
	  - *After each presentation, encourage the audience to share their feedback and add your own input too.*

10 minutes	**Reflection:** - What went well? - What could have been better? - What are my key takeaways from this project? - What do I want to explore further on this topic? Congratulate the learners on their efforts!

Additional enrichment activities:	- Learners can make a seismograph to see how it is used to record earthquakes and measure their strength. Refer to **Appendix 4** for instructions. They can also connect it to the plates in their final earthquake tower to see it work while shaking the plate to simulate an earthquake. - Instead of designing a structure that is only earthquake-/ lightning-resistant, learners can design a structure that is resistant to both.
Modifications for simplification	Learners can create their final projects in groups or pairs if it is too challenging to be done individually. If there are resource constraints, learners can also present a poster on how to make a house lightning/earthquake resistant.

ASSESSMENT CRITERIA

A majority of my learners were able to:
☐ Demonstrate an understanding of the concept of attraction and repulsion of charges.
☐ Explain how lightning and earthquakes are formed.
☐ Explain the scientific reasoning behind safety measures to protect ourselves from lightning/earthquakes.
☐ Create and present a lightning/earthquake-resistant structure that follows the criteria laid out for each type of disaster.

APPENDIX 1

Global Lightning Deaths Surge

By Imogen Matthews | 21 Nov 2023

The alarming surge in lightning-related deaths continues to cast a shadow over communities worldwide, shedding light on the devastating toll of climate change-induced extreme weather events. Recent data compiled by global meteorological organizations has revealed a staggering rise in fatalities, reminiscent of the tragic situation witnessed in Bihar, India.

The World Meteorological Organization (WMO) reported an estimated 5,500 lightning-related deaths globally in the past three years. This figure starkly emphasizes the urgency of addressing the growing threat posed by lightning strikes, particularly in vulnerable regions where resources and awareness remain limited.

In Bihar alone, where officials from the state Disaster Management Department (DMD) have been grappling with this mounting crisis, over 1100 lives were claimed by lightning strikes in the last three years. Despite extensive campaigns aimed at fostering awareness and prevention, lightning-related fatalities have emerged as a persistent challenge, predominantly affecting impoverished communities.

According to the DMD's records, the year 2022 witnessed 375 fatalities due to lightning strikes in Bihar. The majority of these incidents occurred during the monsoon season, with July registering 104 deaths, followed by 96 in September and 64 in June. The concerning trend highlights the vulnerability of regions during specific climatic periods, intensifying the risk for individuals in rural areas, particularly landless farm labourers, poor farmers, and cattle grazers.

The severity of the situation becomes evident when considering the statistics from previous years. In 2021, 280 lives were lost to lightning strikes in Bihar, while 2020 recorded 459 fatalities. The numbers have been distressingly high, with 253 deaths in 2019, 139 in 2018, 180 in 2017, and 114 in 2016, culminating in a staggering toll of 1,800 lives lost over the past seven years due to lightning strikes in the state.

The impact of these tragedies extends beyond the loss of lives, as families and communities grapple with the emotional and economic repercussions. Recognizing the gravity of the situation, the State government has provided compensation of Rs 4 lakh to the families of lightning strike victims, offering some financial relief amid these trying circumstances.

Efforts to address this crisis must be amplified on a global scale, emphasizing both prevention and support for vulnerable populations. The need for enhanced infrastructure, early warning systems, and targeted outreach programs in rural areas remains critical to mitigate the devastating impact of lightning-related incidents.

While immediate measures are imperative to save lives, the urgency also lies in addressing the root causes of climate change-induced extreme weather events. Collaborative action on a global scale is indispensable in confronting this pressing challenge and safeguarding communities from the escalating threat of lightning strikes.

The solemn reminder of lives lost to lightning strikes underscores the imperative for proactive measures, resource allocation, and international cooperation to prevent further tragedies on a global scale.

Sources: World Meteorological Organization, State Disaster Management Department (Bihar)

"This was confirmed by the official data of 2019, 2020, and 2021 as nearly 86% of victims were landless farm labourers, poor farmers and cattle grazers."

APPENDIX 2

BBC News: Lightning in India: A bolt from the blue that kills thousands (February 2022)

Villagers in West Bengal have cut lightning deaths by making cheap, homegrown lightning conductors. They use second-hand bicycle wheel rims, bamboo and metallic wires. The rim is fixed on the top of a bamboo pole - sometimes up to 30ft high and acting as the lightning rod - which is strapped to buildings, mainly community centres and local schools. A thick metal pipe or wire runs down the length of bamboo. This makes sure that the electricity generated will pass to the earth without causing any harm.

APPENDIX 3

EAA welcomes feedback on its projects in order to improve. For feedback please use this link
https://forms.gle/pVXs3vQEufuzSShs7

APPENDIX 4

1. Cut the lid or flaps off the cardboard box. Stand the box up.
2. Poke two holes opposite each other near the rim of the cup. Tie a piece of string, slightly longer than the length of the box, to each hole.
3. Poke two holes in the top of the box, making sure they are the same distance apart as the holes in the cup.
4. Push the two pieces of string through the holes and tie them together on the top of the box, so the cup hangs down inside the box. The bottom of the cup should be about an inch above the bottom of the box.
5. Poke a hole in the centre of the bottom of the cup. Remove the cap from the marker, and push the marker through the hole, so its tip just barely touches the bottom of the box.
6. Fill the cup with coins or other small weights, making sure the marker stays vertical.
7. Tape multiple strips of paper together to form one long strip
8. Cut two slits on opposite sides of the cardboard box, as close as possible to the bottom edge. The slits should be wide enough to pass the paper strip through one side, across the middle of the box, and out the other side.

9. Request a friend to keep pulling the strip from one side slowly while you shake the box with different intensities to see the seismograph work!