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Sample science lesson plans embedding a competency-based approach

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Introduction

A bank of resources has been created to support teachers to implement competency-based education principles into their teaching and assessment. These resources should be used together. You can view and download the following resources from cbseacademic.nic.in:

- Learning ladder for science
- Assessment specification for science
- Sample lesson plans

This document is a compilation of ten sample lesson plans for science from class VI to class X.

Using these sample lesson plans

You can use these lesson plans as they are written in your classes as you would any other lesson plan.

When you use the lesson plans, reflect on how:

- they place the student at the centre of learning
- they vary the teacher's role (e.g., as facilitator, mediator, assessor)
- they give students choice and/or autonomy
- they bring real-world problems or applications to the classroom
- they employ (informal) formative assessment
- they promote the use of higher order thinking skills
- they ensure all students are included in learning.

You can also use these plans as templates to develop your own learner-centred lessons that encourage students to develop their competencies and skills in your subject rather than merely accumulating knowledge.

What is competency-based education (CBE)?

There is no single global definition or unifying framework for CBE. However, an overarching principle is that competency-based education focuses on the student's demonstration of learning outcomes as central to the learning process.

There is also a focus on attaining proficiency in particular competencies to facilitate progression.

Self-paced, individualised learning is a further common theme as is the emphasis on the authenticity of the learning experience and real-world applications of knowledge and skills. Central to all definitions is the goal to empower students, providing a meaningful and positive learning experience.

Competency-based education within the context of languages is best articulated in the Council of Europe's Common European Framework of Reference for Languages, the CEFR[1]. Proficiency is described on a six-point scale which provide statements of what a language user can do at each of the levels: A1 (Breakthrough), A2 (Waystage), B1 (Threshold), B2 (Vantage), C1 (Advanced), C2 (Mastery).

A useful working definition of high-quality CBE in the context of K12 education is that developed by the Aurora Institute:

- Students are empowered daily to make important decisions about their learning experiences, how they will create and apply knowledge, and how they will demonstrate their learning.
- Assessment is a meaningful, positive, and empowering learning experience for students that yields timely, relevant, and actionable evidence.
- Students receive timely, differentiated support based on their individual learning needs.
- Students progress based on evidence of mastery, not seat time.
- Students learn actively using different pathways and varied pacing.
- Strategies to ensure equity for all students are embedded in the culture, structure, and pedagogy of schools and education systems.
- Rigorous, common expectations for learning (knowledge, skills, and dispositions) are explicit, transparent, measurable, and transferable.’[2]

1. CEFR framework. Published by the Council of Europe. Available at <https://www.coe.int/en/web/common-european-framework-reference-languages/home>.
2. Competency Works, 2019. What is Competency-based Education - An Updated Definition. [pdf] Published by: Aurora Institute. Available at: <https://aurora-institute.org/wp-content/uploads/what-is-competency-based-education-an-updated-definition-web.pdf>.

What are higher order thinking skills?

These are skills, such as analysis, evaluation and synthesis, that go beyond skills such as recall and understanding. These skills are designed to stretch secondary level students to develop the cognitive skills for further progression onto more advanced level study and prepare them for the workplace.

What does competency-based education look like?

Curriculum design: A core principle in the design of CBE curricula is that it should be grounded in real-world contexts covering topics with relevance to employment and daily life. Therefore, there is an emphasis on integrating higher order thinking skills, incorporating an interdisciplinary approach (linking within and between subjects), and including a focus on problem solving using learnt skills and knowledge. Subject content and developing mastery of the prerequisite knowledge remain key components of curriculum design.

There has also been a focus on integrating 21st century skills within secondary level qualification design, with explicit links to core skills such as numeracy, literacy and social and emotional skills development as well as global citizenship and developing global literacy to enable learners to be competent not only in the national context but also in the international labour market.

Teaching and learning: A general principle of CBE-oriented delivery comprises student-centred learning, with a focus on the teacher empowering the students to learn actively supported by feedback. Whilst traditional methods have emphasised the role of the teacher as the imparter of knowledge, and subsequently place emphasis on lecturing, dictation and drilling as techniques of classroom delivery, CBE seeks to place the student at the centre and actively engage the student in the learning process. CBE delivery is facilitated by the development of lesson plans based on learning outcomes and sharing learning outcomes with students at the outset to ensure mutual understanding of expectations. The use of formative assessment, particularly elements of peer and self-assessment, are key characteristics of competency-based approaches, where students are encouraged to reflect on their own work and identify areas for improvement

Assessment: Robust and valid assessment, allowing for evaluation of the full range of learning outcomes can be considered a core feature of good practice in CBE summative assessment. Data driven, CBE-oriented summative assessments should accurately gauge the extent to which the student can demonstrate the learning outcomes, including the key skills and knowledge on completion of the programme.

Assessing the application of knowledge and skills to real-world contexts and using authentic problems which draw on real-life data are key features of CBE assessment systems concerned with real world performance. Synoptic assessment is a further key feature of CBE. This encompasses the use of assessment tasks and questions which seek to assess multiple learning outcomes and/or topic areas from across the curriculum.

Competency-based assessments should be designed to be equitable[3], enabling evaluation of a wide range of ability levels of the target group of students, which at secondary level comprises a countrywide cohort aged 15 and 16. Maintaining a balance between accessibility on the one hand and providing opportunities to demonstrate higher order thinking skills on the other is one of the aspects to consider in designing competency-based secondary school level assessments.

3. Aurora Institute, 2017. How Systems of Assessment Aligned with Competency-based Education can Support Equity. [pdf] Published by: Aurora Institute. Available at: <https://aurora-institute.org/wp-content/uploads/how-systems-of-assessment-aligned-with-competency-based-education-can-support-equity-jan-2020-web.pdf>.

Reversible and Irreversible Changes

Learning Ladder Assessment Content	This lesson focuses on the highlighted part of the following assessment content: 6.1.11 Distinguish between reversible and non-reversible changes, both domestic and laboratory: • Changes of state (reversible) • Expansion and contraction (reversible) • Chemical reactions (variable) • Burning and combustion (non-reversible) • Developmental changes in organisms (non-reversible)
Lesson duration	40 minutes
Book reference	Science Textbook for Class IX, Chapter 1 Matter In Our Surroundings
Resources	The lesson should ideally be in a science laboratory or other suitable area which allows sufficient space for learners to do practical work in small groups • Video of burning paper or logs or a box of matches to use in the classroom • For practical activity, for each group: – heat proof test tubes, test tube holder – bunsen burner or spirit burner – solid zinc oxide, ice cubes, solid hydrated copper(II) sulphate, copper turnings – dropper – access to water • set of cards with changes described from everyday life and the laboratory

Time (mins)	Learning Outcomes What we want the learners to know, understand and be able to do.	Lesson Activities	Assessment How AfL strategies will be used How AOs will be embedded
10	This lesson focuses on the highlighted part of the following learning outcome: Classifies materials, organisms and processes based on observable properties, e.g., materials as soluble, insoluble, transparent, translucent and opaque; changes as can be reversed and cannot be reversed; plants as herbs, shrubs, trees, creeper, climbers; components of habitat as biotic and abiotic; motion as rectilinear, circular, periodic etc.	Introduce the lesson by talking to learners about what 'change' means and to think of examples of change. For example, they may talk about changing clothes or the weather changing. Explain that materials and substances can also change, and we will be exploring changes in materials and substances in this lesson. Either show a video of burning paper or wood logs or demonstrate striking matches. If using matches ensure learners are at a safe distance from the demonstration and that you place the hot extinguished matches in a pot of water or sand. Ask learners to discuss in pairs what they can see. Encourage learners to think of as many things as possible which are relevant to the change. Use questions to prompt discussion: • What is the appearance of the substance at the start? • What is the appearance of the substance at the end? • What observations did you make during the change? • How can you tell a change has taken place? As learners provide answers, write them on the board. Summarise the responses. Develop learner's thinking by asking • Can this change be reversed? • How can you tell? • Can we get the starting substances back again? Explain that some changes are 'reversible' and some are 'irreversible', and that burning is an example of an irreversible change. • Can you think of any other irreversible changes in everyday life? (e.g. boiling an egg) • Can you think of any reversible changes in everyday life? (e.g. boiling water, inflating a balloon, ironing clothes)	Share learning intentions Learners make and recall observations in real-life contexts to move learning forward

20	Ensure that learners follow appropriate safety protocols, aligned to your school policies, whilst carrying out experimental work. Explain to learners that they will work in small groups to heat different substances to see if a change occurs and if the change is reversible or irreversible. Each group should observe at least one of the following: 1. Heat zinc oxide in a test tube and observe the changes on heating and cooling. 2. Heat an ice cube in a test tube and observe the changes on heating and cooling. 3. Heat copper(II) sulphate and observe the changes on heating (Note: Prompt learners to notice the condensation at the top of the tube). AFTER COOLING, add water and observe what happens (the blue colour returns). 4. Heat a small piece of copper and observe the changes. Also explain that learners should develop their own table for their observations using the success criteria below: Record the appearance of each substance: • before the change • after the change • when a follow up action has been taken • they should highlight any permanent changes Conclude whether each change is reversible or irreversible. Also discuss observations and conclusions as a class. Use feedback and questioning to build on learners' observations and to develop learning. Ensure that the following points are covered: • Zinc oxide is white when cold, yellow when hot. This is an example of a reversible change and a thermal colour change. • Ice melts but can be re-frozen. This is an example of a reversible change and a change of state. • Hydrous copper(II) sulphate loses water when it is heated and becomes white. If the water is added the now anhydrous copper (II) sulphate becomes hydrated and the blue colour returns. This is an example of a reversible change and of dehydration and rehydration.	

	• Copper goes black when heated as it oxidises. It stays black on cooling (copper oxide is formed). This is an example of an irreversible change and a chemical reaction. • The combustion example from the starter activity can also be discussed as an example of an irreversible change and a chemical reaction.	
10	Give pairs of learners cards with changes described on them. They classify them as reversible or irreversible changes, e.g. • water turning to steam in a kettle • making ice from water in a freezer • burning petrol • frying an egg • heating zinc oxide • heating copper(II) sulphate • lighting a match • heating copper • adding salt to water Ask: What are the main differences between reversible and irreversible changes? Establish that for a reversible change you can get the original substances back in their original state easily. An irreversible change cannot be undone easily ('easily' meaning one action/step). All learners should be able to classify changes as reversible or irreversible. Some learners will be able to describe the differences between reversible and irreversible changes using ideas about state changes and whether the product formed is a new substance	Learners collaborate to check and develop learning Elicit understanding of learning

Key competencies

Collaboration

Communication

Critical Thinking

Microscopes and Cells

Learning Ladder Assessment Content	6.1.1 Distinguish a variety of plant types based on externally observable characteristics: • Herbs as non-woody plants that die down to the ground after flowering • Shrubs as woody plants with several main stems arising at or near the ground • Trees as relatively tall woody perennial plants with a single stem, branches. • Creepers as plants that grow along the ground or up surfaces by means or spreading stems.
Lesson duration	40 minutes
Book reference	Science Textbook for Class VI, Chapter 7 Getting to Know Plants
Resources	• At least two pictures of plants of each of the following different types: herb, shrub, tree, creeper, climber. Each picture should include the name of the plant and a short description. The descriptions should include average height, type of stem and growth pattern to support learners in identifying the types of plants, e.g. [herb] tomato – grows to about 0.5 m, stem is non-woody, dies back after flowering [tree] mango – grows over 30 m, single thick woody stem with branches, perennial plant that continues growing all year [shrub] lemon – grows to between 1 m and 2 m tall, several woody stems that grow from near the ground [creeper] morning glory – weak non-woody stems that grow along the ground covering large areas [climber] flame plant – weak non-woody stems that grow in masses spreading up walls Do not include the types of plants in the picture descriptions. • Worksheet with blank table to complete (see example at the end of this lesson plan) • Exit slips

Time (mins)	Learning Outcomes What we want the learners to know, understand and be able to do.	Lesson Activities	Assessment How AfL strategies will be used How AOs will be embedded
5	This lesson focuses on the highlighted part of the following learning outcome: • identifies materials and organisms, such as, plant fibres, flowers, on the basis of observable features, i.e., appearance, texture, function, aroma, etc. • classifies materials, organisms and processes based on observable properties, e.g., materials as soluble, insoluble, transparent, translucent and opaque; changes as can be reversed and cannot be reversed; plants as herbs, shrubs, trees, creeper, climbers; components of habitat as biotic and abiotic; motion as rectilinear, circular, periodic etc.	Start the lesson by organising the learners into groups of three or four. Each group lists reasons why plants are so important to humans. Allow discussion time and then take some responses. Possible responses could include ideas about providing food, building material, shelter. Ask: Are some plants better building materials than others? Which plants do you think builders use? Take some responses. Responses will depend on experiences, but learners are likely to think of wood and so mention trees. Other possibilities are materials used for roofing such as reeds or palm leaves. Explain that there are a variety of plant types all with different characteristics. Give the success criteria for the lesson. • Understand there are a variety of plant types based on externally observable characteristics. • Classify plants into the different groups.	Learners collaborate to draw on existing knowledge Share success criteria for the lesson
15		Place a number of plant pictures around the room. There should be at least two examples of each different type of plant (herb, shrub, tree, creeper, climber). Each picture should include the name of the plant and a short description. The descriptions should include average height, type of stem (woody or non-woody) and growth pattern (e.g. grows along the ground by spreading stems) to support learners in identifying the types of plants later. When introducing the activity, discuss words you have used in the descriptions that learners may not be familiar with (e.g. the idea of a 'woody' and 'non woody' stem, 'perennial'). Working in pairs, learners move around the room looking at each picture and reading its description. They fill in a table provided on a worksheet with as much information as possible. Make it clear that for some plants there will be empty columns because the information is not available in the pictures. Also explain that the last column should be left empty to be filled in later.	Build new learning by observation and collaboration Collect and record sufficient observations

15	After the activity, discuss how the plants that learners looked at can be classified into groups. Explain how plants are categorised into herbs, shrubs and trees on the basis of their size and the type of stem they have. Also, explain how some plants have a weak stem and are categorised as creepers or climbers depending on how they grow. Ask learners to look at their table and complete the last column with their partner by classifying each plant as herb, shrub, tree, creeper or climber. After a few minutes ask them to join with another pair to compare their results. Then groups feed back to the whole class to see if they are in agreement.	Supporting learners to evaluate their own learning Using discussion to elicit evidence of learning
5	Ask learners to answer the following questions on an 'exit slip' to hand in before they leave the lesson: 1. Write down one difference between herbs and shrubs. 2. Write down one difference between shrubs and trees. 3. Which type of plant can grow up the trunk of a tree? Expected answers: 1. Herbs have non-woody stems, but shrubs have woody stems or Herbs die back after flowering, but shrubs do not 2. Shrubs have several main stems while trees have a single stem 3. Climber Use the exit slips to inform your next lesson.	Use exit slips to elicit evidence of learning

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Possible worksheet table:

Plant name	Average height (m)	Type of stem (woody or non-woody)	Description of the way the plant grows	Type of plant

Acidic and Basic

Learning Ladder Assessment Content	7.1.1 Define acids, bases and salts
Lesson duration	40 minutes
Book reference	Science Textbook for Class VII, Chapter 5 Acids, Bases and Salts
Resources	The lesson should ideally be in a science laboratory or other suitable area which allows sufficient space for learners to do practical work in pairs. You will need: • apparatus and solutions for demonstration and practical work: acids and bases, blue and red litmus paper, droppers, tiles, labelled containers of vinegar, baking soda in water, toothpaste in water and aerated drink (e.g. cola) or • appropriate digital resources to demonstrate the concepts

Time (mins)	**Learning Outcomes** What we want the learners to know, understand and be able to do.	**Lesson Activities**	**Assessment** How AfL strategies will be used How AOs will be embedded
10	This lesson focuses on the highlighted part of the following learning outcome: Differentiates materials and organisms such as, digestion in different organisms; unisexual and bisexual flowers; conductors and insulators of heat; acidic, basic and neutral substances; images formed by mirrors and lenses, etc., on the basis of their properties, structure and function.	Start the lesson by asking learners to work in pairs to list five edible things which taste sour. Allow discussion time and then take some responses. Some possible responses are lemon, curd, vinegar, orange juice, raw mango. Ask: Why might these things taste sour? Take some responses. Then explain that these foods contain substances called 'acids' which give the sour taste. Give the success criteria for the lesson. • Understand the terms 'acidic', 'basic' and 'neutral'. • Test if a substance is acidic or basic.	Provide stimulus and use questioning to make connections with existing knowledge Share success criteria for the lesson

10	Show bottles of acids present in the science laboratory (or pictures of them), e.g. hydrochloric acid, sulphuric acid, acetic acid. Explain that laboratory acids can be harmful and should never be tasted. Draw attention to the hazard labels on the bottles and ask: • What does this label mean? • Why is it there? • Is it there on all chemical bottles? • How can acids be harmful? Explain the importance of paying attention to hazard labels and safety in the laboratory. Demonstrate a test to show the effect of acids on blue and red litmus paper. Afterwards, clarify understanding by asking: So how can we test if substances are acidic? Now, introduce the term 'basic' by referring to bases as the opposite of acids and substances that are soapy to touch. Show bottles of bases present in the science laboratory (or pictures of them), e.g. sodium hydroxide, potassium hydroxide, limewater. Also highlight some everyday bases, such as caustic soda and lime. Explain that, like acids, bases can be hazardous and it is important to take care. Demonstrate a test to show the effect of bases on blue and red litmus paper. Afterwards, clarify understanding by asking: So how can we test if substances are basic? Finally, introduce the term 'neutral' to describe substances which are neither acidic nor basic, such as water.	Build new learning by observation and responding to questions Reinforce new concepts by checking through questioning
10	Tell learners that you want them to work in pairs to test four labelled solutions to see if they are acidic, basic or neutral: vinegar, baking soda in water, toothpaste in water and an aerated drink. Ask them to record their predictions for each solution first (for colour changes of red and blue litmus paper and whether they think the solution is acidic, basic or neutral). Learners then do the tests and record their observations. While learners carry out the tests, observe how they handle the apparatus and take safety precautions. Ask learners to compare their observations with predictions and discuss. They then share their observations with the class.	Learners collaborate to apply their learning Learners predict to strengthen understanding and challenge misconceptions

15	Divide the class into groups of five or six. Ask them to discuss: • Where could we use litmus paper testing in daily life? • How could it help us to ensure safety in our surroundings?	Supporting learners in owning their own learning by making real life connections
	After five minutes, they join with another group to share their ideas. To conclude the lesson, ask learners to answer the following questions on an 'exit slip' to hand in before they leave the lesson: 1. What happens to the colours of litmus papers if a substance is acidic or basic? 2. What more would you like to know about acidic, basic and neutral substances or what are still confused about? Use the exit slips to inform your next lesson.	Use exit slips to elicit evidence of learning

Key competencies

Collaboration

Communication

Critical thinking

Respiration

Learning Ladder Assessment Content	This lesson focuses on the highlighted parts of the following assessment content. 7.2.10 Explain the structure and function of mammalian body parts: • Heart and circulatory system • Lungs • Digestive system (human and ruminant) • Skeletal system 7.2.12 Conduct investigations of the effect of exercise on heart and breathing rates, and explain outcomes in terms of the need for oxygen for respiration. 7.3.5 Measure pulse and breathing rates. Learners should already have covered 7.1.5 Identify examples of plant and animal organs and organ systems.
Lesson duration	40 minutes
Book reference	Science Textbook for Class VII, Chapter 10 Respiration in Organisms
Resources	Stopwatch, or wall clock with a second hand

Time (mins)	Learning Outcomes What we want the learners to know, understand and be able to do.	Lesson Activities	Assessment How AfL strategies will be used How AOs will be embedded
5	This lesson focuses on the highlighted part of the following learning outcomes. It concentrates on the effect of exercise on breathing rate, with the link to respiration. (Lungs and breathing will be covered in another lesson.)	Start the lesson by revisiting earlier learning related to 7.1.5 Identify examples of plant and animal organs and organ systems. Provide learners with the names of different organs in the body. Ask them to work in pairs to group the organs into the organ systems to which they belong. Select pairs to list the organs they have grouped and to explain their groupings.	Provide stimulus to make connections with prior learning

5	• conducts simple investigations to seek answers to queries, e.g., Can extract of coloured flowers be used as acid-base indicator? Do leaves other than green also carry out photosynthesis? Is white light composed of many colours? • explains processes and phenomena, e.g., processing of animal fibres; modes of transfer of heat; organs and systems in human and plants; heating and magnetic effects of electric current, etc. • writes word equation for chemical reactions, e.g., acid-base reactions; corrosion; photosynthesis; respiration, etc. • measures and calculates e.g., temperature; pulse rate; speed of moving objects; time period of a simple pendulum, etc.

5	Start a discussion with the following questions: 1. What is the function of the lungs? 2. What is the function of the circulatory system? 3. Where in the body does food enter the circulatory system? 4. Which gas is needed by the body to stay alive? Take some responses which may include: 1. To take in oxygen, to remove carbon dioxide, to breathe 2. To transport substances around the body 3. Digestive system 4. Oxygen Explain how respiration links the function of the lungs, circulatory system and digestive system. It is because oxygen and food in the form of glucose are needed for respiration. Explain that glucose is broken down in a controlled way by the cells to release energy, and that this requires oxygen and produces carbon dioxide and water. Introduce the word equation for respiration: glucose + oxygen $\longrightarrow$ carbon dioxide + water Ask learners to suggest how respiration is different from breathing. Responses may include: • Breathing involves the lungs • Respiration takes place in all cells • Breathing is a physical process, respiration is a chemical process • Breathing gets oxygen into the body which is then used in respiration • Breathing removes carbon dioxide from the body which is produced in respiration Give the success criteria for the rest of the lesson: • Understand the term 'respiration' (which has already been covered) • Explain the effect of exercise on breathing rate.	Build new learning by responding to questions Support learners by challenging misconceptions. Share success criteria for the lesson

15		Ask learners to sit very still and count the number of times they breathe in for 30 seconds. Time the 30 seconds for them. Learners then double their value to calculate their resting breathing rate (per minute). Ask: 1. What do you think would happen to your breathing rate if you exercised? 2. How could you find out which type of exercise has the biggest effect? Expected responses include: 1. Faster breath, deeper breaths 2. Try different exercises and count breaths, compare with when you are sitting still As a class, plan a simple investigation to find out which exercise (e.g. walking, jumping, jogging and standing) increases breathing rate the most. To help emphasise the need to control variables such as length of exercise and resting time between exercises, ask: 1. What will you measure? 2. What will you change? 3. What factors will you control? 4. How long will you exercise for? 5. How will you stay safe? Responses may include: 1. Number of breaths in 30 seconds 2. Type of exercise 3. How long you exercise, making sure you are breathing at your resting rate before exercising 4. Learners may provide a variety of times, but it is suggested that they exercise for a minimum of 2 minutes in the investigation 5. Choosing where you exercise carefully (away from others, away from furniture, outside of the classroom), wear appropriate footwear, do not exercise if you are not fit and healthy (this may be an issue if they have asthma or similar conditions) Finalise the plan as a class so that all groups follow the same method.	Support learners in owning their own learning by planning an investigation together Use questioning to develop scientific thinking

15	Learners carry out the planned investigation in groups of 3 or 4. There may only be time for each group to do one type of exercise and then record the difference between the resting breathing rate and the breathing rate after exercise for one individual. If so, ask the class to record their results together in one table. Use the class results to identify the type of exercise that resulted in the highest increase in breathing rate. Discuss reasons for the increase in breathing rate by selecting learners to answer questions, e.g.	Build new learning by collaborating in measuring and recording date when carrying out practical work safely
	1. Why do you think your breathing rate increased? 2. Which type of exercise do you think used the most energy? 3. Which gas do your muscles need during exercise? Which gas to they produce? 4. How will your body transport the gases to and from your lungs? Expected answers include: 1. Muscles need more oxygen, produce more carbon dioxide, or need more energy 2. The one where the breathing rate increased the most 3. Need oxygen, produce carbon dioxide 4. In the blood	Build new learning by responding to questions
5	Ask learners to write a short conclusion to explain the effect of exercise on breathing rate. They must include the words, 'respiration', 'lungs', 'muscle', 'energy', 'glucose', 'oxygen' and 'carbon dioxide'.	Interpret observations and write conclusions to elicit evidence of learning.

Key competencies

Collaboration

Communication

Critical thinking

Contact and Non-Contact Forces

Learning Ladder Assessment Content	8.1.8 Distinguish between contact and non-contact forces
Lesson duration	40 minutes
Book reference	Science Textbook for Class VIII, Chapter 11 Force and Pressure
Resources	• a pair of magnets for each small group or for demonstration (magnetic sticks from toy construction sets may be suitable) • two inflated balloons, string, plastic straws or other plastic strips, plastic bottle, cloth to charge Note: Practise charging prior to the lesson. Balloons and plastic may be charged with some fabrics and not others. Experiments with electric force are affected by high humidity and are best demonstrated in dry weather. • gravity statements (see examples below) on printed strips

Time (mins)	**Learning Outcomes** What we want the learners to know, understand and be able to do.	**Lesson Activities**	**Assessment** How AfL strategies will be used How AOs will be embedded
5	This lesson focuses on the highlighted part of the following learning outcome: Differentiates materials and organisms, such as, natural and human made fibres; contact and non-contact forces; liquids as electrical conductors and insulators; plant and animal cells; viviparous and oviparous animals, on the basis of their properties, structure and functions.	Start the lesson by asking learners to give examples of forces that: • push • pull • change the shape of an object. Discuss learners' answers briefly, particularly identifying where there is contact between two objects to transfer the force. Defer discussion of any examples that are non-contact forces until the end of the starter activity. Ask: Can you think of a force which does not involve contact? Gravity is the most likely response. Discuss briefly how we see the effects of gravity (e.g. gravity pulling a ball down to the ground after it has been thrown into the air).	Make connections with prior knowledge Use discussion to elicit evidence of prior learning

	Summarise that: • 'Contact forces' are those where two objects or materials are physically touching. • 'Non-contact forces' are those where two objects or materials are not physically touching.	
10	Explain that we are going to apply our thinking about contact and non-contact forces to magnets. In groups of 2 to 4, ask learners to move two magnets close to one another. What happens? Why? Ask them to reverse one magnet and try the same movement. What happens? Why? Establish that the magnets exert a pushing or pulling force on one another. Ask learners to hold one magnet in each hand and bring them close, but without touching. Can you feel the force? Can you see any contact transferring the force? Is magnetism a contact or non-contact force? Explain to learners that the area where we can observe or feel the force is known as the 'magnetic field'. Note: If magnets are not available for group work, use a volunteer to follow the instructions to give a class demonstration. An overhead projector can be used with the magnets on the glass surface, so learners can see the shadows of the magnets as they are moved.	Share learning intentions Learners collaborate to improve learning Use questioning that move learning forward
10	Explain that now we have considered magnetic force, we are going to consider static electric force. Demonstrate the force created by static electricity. Rub an inflated balloon on cloth and then place it by a wall or ceiling to show how it stays in position. What is happening? Do you think static electricity is a contact force or a non-contact force? Now charge a balloon that is suspended on a string. Bring another charged balloon close to the suspended balloon. Show how it repels the first balloon without making contact. Also demonstrate with plastic straws and an empty plastic bottle which you have charged by rubbing on a cloth. Each may either attract or repel the charged balloon depending on whether it has the same or opposite charge. Make sure the attraction or repulsion is evident without there being any contact between the objects.	Use models and questioning that move learning forward

	Ask: • What is happening? • What do you think now? Is static electricity a contact force or a non-contact force? • How do you know? Explain to learners that the area where we can observe or feel the force is known as the 'electric field'.	
5	Use discussion to link this lesson's learning to future work on pressure and the atmosphere. In groups of 3 or 4 ask learners to consider whether the following are contact or non-contact forces: • Air resistance slowing down a moving object. • The wind blowing, making the leaves on a tree move. Ask: If you think it is a contact force, what is making the contact? Establish that these are contact forces, and the contact is with the particles in the atmosphere.	Challenge existing ideas to lay the foundations for new learning
10	Organise learners into pairs and give each learner one of the following statements on a printed strip (both learners in each pair should have the same statement): • The force of gravity is stronger for a bigger mass. • The force of gravity gets weaker as the distance between two objects decreases. • All objects 'cause' and are affected by gravity. • Gravity causes objects to accelerate. • There could be a point between the earth and the moon where there is no gravitational pull to the earth or the moon. Is that point nearer the earth or the moon? Pairs start discussing how they would investigate their statement and their hypothesis. Emphasise that learners are only expected to plan an investigation, not conduct it. Explain that in the next lesson, you will give pairs time to discuss any new ideas they have between now and then, and then share their ideas with the rest of the class.	Activate learners as learning resources for one another Promote links to real-life experiences

Key competencies

Collaboration

Communication

Critical Thinking

Creative Thinking (homework activity)

Pressure

Learning Ladder Assessment Content	8.2.16 Apply pressure = force/area Notes: • Qualitative activities are used to introduce and deepen understanding of the quantitative concepts. • Direct and inverse proportion are covered in Class VIII Maths (8N4a Use direct and inverse proportion). It would be helpful to ensure that this has already been covered before this lesson.
Lesson duration	40 minutes
Book reference	Science Textbook for Class VIII, Chapter 11 Force and Pressure
Resources	rulers, sets of weights up to 10 newtons (masses up to 1 kg)

Time (mins)	**Learning Outcomes** What we want the learners to know, understand and be able to do.	**Lesson Activities**	**Assessment** How AfL strategies will be used How AOs will be embedded
5	This lesson prepares learners for the highlighted part of the following learning outcome in a subsequent lesson. It introduces the formula for calculating pressure starting with simple calculations using units N and cm2. Follow-on lessons will cover calculations with m2 and Pascals: • Conducts simple investigations to seek answers to queries, e.g., What are the conditions required for combustion? Why do we add salt and sugar in pickles and murabbas? Do liquids exert equal pressure at the same depth?	Use questioning to revisit prior learning on forces: • describe forces as pushes and pulls (8.2.14) • describe the effects of applying a force (8.2.15) For example: • What words can we use to describe the action of a force? (e.g. push, pull open, close, kick, hit) • What effects can forces have on objects? (e.g. move, accelerate, decelerate, change the shape of an object, attract and repel for non-contact forces) Write responses on the board so that learners can more easily build on others' knowledge.	Self-assessment and teacher assessment of prior knowledge by questioning

10	Introduce the topic of this lesson as pressure. Share the success criteria for the lesson: • pressure • Start using the formula for pressure Ask learners to work in pairs. One learner puts their hand flat on the table and places a ruler flat on the back of their hand. The other learner add weights carefully one at a time on top of the ruler as it rests on their partner's hand. Then ask them to turn the ruler through 90 degrees so that it is on its edge is on the back of their hand. They now slowly add weights on the ruler and compare how it feels. Ask: • Why does it feel different with more weights? (increased weight/force increases sensation) • Why does it feel different when the ruler is on its edge? (reduced area increases sensation) Explain to learners that this change in sensation is due to change in pressure. Increasing the force increased the pressure. Reducing the area of contact between the ruler and the hand increased the pressure.	Share success criteria for the lesson Use real-life observations to move learning forwards
10	Help learners to make connections between their observations in the previous activity and their everyday experiences. Ask them to work in pairs to identify real-life examples of: 1. using reduced area to increase pressure: (possible examples include: knife, fork, cheese cutter with wire, hypodermic needle, sewing needle) 2. using increased area to reduce pressure (possible examples include: wide car seat belts; wide tyres to make tractors less likely to sink in the mud; porters using a cloth on their head to carry a load; wide suitcase handles (compared to carrying a load tied by string) Pairs then share their ideas with the class.	Support learners in owning their learning by making real life connections Use learners as resources for one another to move learning forwards

15

Now link learners' observations and examples to the formula and definition for pressure. Write the formula on the board:

Pressure = force / area (with force in Newtons)

Reinforce how the formula reflects that pressure is increased by either increasing force (direct proportion) or reducing area (inverse proportion).

Establish how the formula relates to the word definition of pressure: Pressure is the amount of force that is applied to a surface per unit of area.

Demonstrate an example of using the formula to calculate the pressure exerted by a learner on the floor under their chair legs:

Application of the formula to meaningful real-life situations

Weight of chair is 300 N

Teacher modelling to move learning forwards

The end of each of the 4 legs is a square measuring 3 cm by 3 cm

So

Total area in contact with the floor = (4 × 3 × 3) cm^2 = 36 cm^2

Pressure = force / area = 300 N / 36 cm^2 = 8.3 N/cm^2 (1 d.p.)

Ask learners to calculate the pressure under the tyres of the following vehicles (in N per cm^2), where areas are given per tyre. Explain that we are assuming that the part of the tyre that is touching the ground is a square to make the calculations easier:

- Bicycle: 750 N, area = 25 cm^2 (5 cm × 5 cm)
- Motorbike (Honda 125): 2000 N, area 49 cm^2 (7 cm × 7 cm)
- Truck (Toyota Dyna): 40000 N, area = 400 cm^2 (20 cm × 20 cm)
- Tractor (Kubota M6060): 25000 N, area 625 cm^2 (25 cm × 25 cm)

Answers:

Bicycle 750 / (25 × 2) = 15 N/cm^2

Motorbike 2000 / (49 × 2) = 20.4 N/cm^2 (1 d.p.)

Truck 40000 / (400 × 4) = 25 N/cm^2

Tractor 25000 / (625 × 4) = 10 N/cm^2

To end the lesson, ask learners to discuss their results and what they show in groups of 3 or 4, and then share with the class.

Peer review of results and learners collaborating to improve understanding of how the quantitative results relate to qualitative learning earlier in the lesson

	• Which vehicle exerts the greatest pressure? Which exerts the smallest pressure? • Do any of your results surprise you? Why? (e.g. The bicycle exerts greater pressure than the tractor even though the tractor is much heavier.) • Why does the tractor exert less pressure than the bicycle even though the tractor is heavier?	Use questioning and discussion to elicit evidence of learners' understanding

Key competencies

Collaboration

Communication

Creative Thinking

Melting Points

Learning Ladder Assessment Content	This lesson focuses on the highlighted part of the assessment content: 9.6.3 Analyse temperature-time graphs to identify melting and boiling points It builds on: 9.1.1 Definition of matter as solid, liquid and gas and the characteristics of each: shape, volume density and particle diagrams.
Lesson duration	40 minutes
Book reference	Science Textbook for Class IX, Chapter 1 Matter In Our Surroundings
Resources	• Access to outside area for starter activity The rest of the lesson should be in a science laboratory: • For practical activity, for each group: – Bunsen burner, tripod, gauze, heat resistant mat – beaker (250 cm3) – heat proof boiling tube containing stearic acid and thermometer – clamp stand – stopwatch which reads seconds. – safety goggles – access to water.

Time (mins)	Learning Outcomes What we want the learners to know, understand and be able to do.	Lesson Activities	Assessment How AfL strategies will be used How AOs will be embedded
10	This lesson focuses on the highlighted part of the following learning outcomes: Classifies materials, objects, organisms, phenomena, and processes, based on properties or characteristics, such as, classification of plants and animals under various hierarchical sub-groups, natural resources, classification of matter based on their states (solid/liquid/gas) and composition (element/ compound/ mixture), etc. Analyses and interprets graphs and figures such as, distance-time and velocity-time graphs, computing distance, speed, acceleration of objects in motion, boiling and melting points of a mixture to identify the appropriate method of separation, crop yield after use of fertilisers, etc.	This activity works best outside in an open area. Ask learners to work as a single group to model the arrangement and movement of particles in a solid, a liquid and a gas. Each learner represents a particle. Start the activity by asking learners to represent a solid, then proceed to give them the following instructions: • Melt! (learners should represent a liquid) • Freeze! (learners should represent a solid) • Melt! (learners should represent a liquid) • Evaporate! (learners should represent a gas) • Condense! (learners should represent a liquid) • Freeze! (learners should represent a solid) Observe, question and discuss their models, drawing attention to these factors: • In a solid the particles only vibrate and do not move from place to place. They are arranged in a regular fashion • In a liquid, particles are random but can move around each other. The particles are still close together. • In a gas, the particles move quickly and spread out over a large area. For challenge you could an extra instruction at the end: • Sublimate!' (learners should move to represent a gas) If this challenge is used, explain that sublimation is the change of state from a solid to a gas with no intermediate liquid stage. The opposite of sublimation is deposition where a gas changes directly into a solid. Also for extra challenge, you could ask: • Which state has the most energy? (The energy of the particles increases as they change from solid to liquid to gas.)	Show prior understanding through modelling Use challenges to move learning forward

20	Move to the science laboratory. Explain how learners have modelled changes of state and these changes of state are associated with changes in temperature and therefore energy. Highlight how we can also observe this experimentally and by direct observation. Explain that learners are going to work in small groups to observe heating stearic acid, measure its temperature and thereby determine its melting point. Elicit that the melting point of a substance is the temperature when the substance changes state from solid to liquid.	
	Share success criteria for the practical activity, that are appropriate for your learners' previous experiences, for example: • handle of hot apparatus safely • record measurements in a table with clear headings and units • reads thermometer at eye level with bulb in stearic acid. • draw a graph has linear axes and include units. • plot points on graph with small crosses • draw curve of best fit. Ensure that learners follow appropriate safety protocols, aligned to your school policies, whilst carrying out experimental work.	Share success criteria Peer or self-assessment opportunities
	Ask learners to put 150 cm3 of water into a 250 cm3 beaker and heat it (on a tripod and gauze over a Bunsen burner) until the water begins to boil. They then take a boiling tube containing the stearic acid and a thermometer (pre-pared by teacher or laboratory technician), and using a clamp stand, lower the boiling tube into the beaker. Learners then measure the temperature at regular intervals (30 seconds) until the stearic acid begins to melt. They record their measurements and times so they can create a temperature–time graph later. Once melted, learners remove the stearic acid from the beaker and turn off the Bunsen burner.	Learners collaborate to measure and record experimental results
	After learners have recorded their results in a table and as graph, ask them to look at their graphs and discuss the following questions:	Discussion of results and conclusions to move learning forwards

	• What happens to the temperature as the stearic acid changes state? • What the melting point of stearic acid? • (Challenge question) Why does the temperature stays constant during changes of state? (the supplied energy is used for the change of state, no energy is used for an increase in temperature of the substance) Encourage use of ideas about energy to explain what happens when stearic acid melts and when it changes back to a solid.	
10	To conclude the lesson, learners to develop a mind map for stearic acid as a liquid and as a solid. Ask learners to draw particle diagrams to represent stearic acid as a liquid and as a solid. They surround the diagrams with a mind map which includes these ideas: • state changes • arrangement of particles • movement of particles • energy • temperature. All learners should be able to describe state changes in terms of arrangement and movement of particles. Some learners will be able to describe state changes in terms of temperature changes and energy.	Elicit understanding of learning

Key competencies

Collaboration

Communication

Critical Thinking

Microscopes and Cells

Learning Ladder Assessment Content	This lesson focuses on the highlighted parts of the following assessment content: 9.2.7 Explain how to prepare stained temporary mounts of • onion peel, • human cheek cells and record observations and draw their labelled diagrams.
Lesson duration	40 minutes
Book reference	Science Textbook for Class IX, Chapter 5 The Fundamental Units of Life
Resources	A diagram of a typical plant cell with different structures (from Class VIII learning) labelled with letters • For each pair or small group of learners: • small piece of onion – at least one leaf from an aquatic plant with almost transparent leaves that show up the chloroplast – microscope – two microscope slides and two cover slips – mounting needle – bottle of iodine solution with dropper **Note**: If aquatic plants are not available, provide a micrograph image of leaf cells showing chloroplast. This can be printed from the internet and learners can make their own drawing from the image. (a good source is https://www.sciencephoto.com)

Time	Learning Outcomes	Lesson Activities	Assessment
(mins)	What we want the learners to know, understand and be able to do.		How AfL strategies will be used How AOs will be embedded
10	This lesson focuses on the highlighted part of the following learning outcome: • plans and conducts investigations or experiments to arrive at and verify the facts, principles, phenomena or to seek answers to queries on their own, such as, how does speed of an object change? How do objects float/sink when placed on the surface of a liquid? Is there any change in mass when	Start the lesson by showing learners a diagram of a typical plant cell from a leaf. The diagram should be labelled with letters. Ask learners to recall their Class VIII learning to match the letters on the diagram to the correct name for each structure. Ask: 1. Do you think all plant cells look the same and have the same structures? Explain your answer. 2. How do you think you can find out? Take some response which, depending on prior knowledge, may include:	Self- and teacher-assessment of prior learning Learners share prior knowledge through discussion, moving learning forwards
	chemical reaction takes place? What is the effect of heat on the state of substances? What is the effect of compression on different states of matter? Where are stomata present in different types of leaves? Where are growing tissues present in plants?	Take some response which, depending on prior knowledge, may include: 1. No, because different parts of the plant look different and have different functions. 2. Look at cells from different parts of a plant using a microscope. Show learners a microscope and ask them to name its different parts and recall how to use the microscope (learners used a microscope in Class VIII). Give the success criteria for the lesson: • Understand how to prepare stained temporary mounts of onion cells. • Record observations with a labelled diagram.	Share success criteria for the lesson

20	Demonstrate how to prepare a temporary mount of an onion cell stained with iodine solution. Emphasise the safety precautions required and how to dispose of the slide after use. For example: • take care with the iodine solution because it stains • when moving the lens on the microscope, take care not to move the objective lens too close to the cover slip – if they smash the cover slip it could damage the objective lens. • the best way to dispose of the microscope slide is not to try and take it apart but to just drop the whole thing into a beaker of water so that the cells and cover slip wash off the microscope slide. Then demonstrate how to mount the leaves of an aquatic plant (or provide the learners with a micrograph image).	Modelling to move learning forwards
	Learners then work in pairs to produce their own temporary slide to observe. They individually produce an annotated drawing of the two types of cells they observe. The drawing should include the magnification.	Develop new skills, and make and record observations
	Learners then individually write a summary that identifies the differences in the structures of the two types of cells and suggests a reason for the differences. (The expected reason would be that onions grow underground and do not photosynthesise; it is the green leaves above ground that require the chloroplasts for photosynthesis.)	Present an explanation based on observations

10	Learners swap their annotated drawings with a peer who assesses the drawings. They check if the drawings: • are in pencil • have no sketching just single lines • have no gaps or overlaps in the lines • have no shading • have cells drawn to a good size – at least 15 mm in length • include only a few cells with no circle around them representing the field of view • include magnification • have all structures labelled. Circulate as learners assess drawings to observe and discuss their evaluations. Pairs then come together to discuss how they could make improvements. Advice may include: • Not using shading • Try to draw continuous line with no gaps or overlaps • Only draw a few cells • Make sure each cell has its own cell wall, not a picture that looks like a brick wall • Chloroplast in leaf cells should be circles not dots	Peer assessment based on success criteria, which moves learning forward

Key competencies

Collaboration

Communication

Chemical Reactions and Equations

Learning Ladder Assessment Content	This lesson focuses on the highlighted parts of the following assessment content: 10.1.1 Define types of chemical reactions: combination, decomposition, displacement, double displacement, precipitation, neutralization, oxidation and reduction. 10.6.1 Write balanced word and symbol equations, including phase information for common examples of combination, decomposition, displacement, double displacement, precipitation, neutralization, oxidation and reduction reactions. It also supports learners' development towards writing balanced word and symbol equations for 10.6.1.
Lesson duration	40 minutes
Book reference	Science Textbook for Class X, Chapter 1 Chemical Reactions and Equations
Resources	• Photographs of chemical reactions to show on board, e.g. fireworks, burning fire, metal reacting with an acid The teacher demonstration should be in a science laboratory. • For teacher demonstration: – magnesium ribbon – Bunsen burner – heat proof watch glass – tongs – heat proof mat • An atom modelling kit for each small group

Time	Learning Outcomes	Lesson Activities	Assessment
(mins)	What we want the learners to know, understand and be able to do.		How AfL strategies will be used How AOs will be embedded
5	This lesson focuses on the highlighted part of the following learning outcome: Differentiates materials, objects, organisms, phenomena, and processes, based on, properties and characteristics, such as, autotrophic and heterotrophic nutrition, biodegradable and non-biodegradable substances, various types of reactions, strong and weak acids and bases, acidic, basic, and neutral salts using different indicators, real and virtual images, etc.	To start the lesson show photographs of chemical reactions such as: • fireworks • burning fire (e.g. gas stove or wood fire) • metal reacting with an acid. Using Think–Pair–Share, ask learners to think about and discuss the following question: How can you tell a chemical reaction is happening? Share ideas from the pairs use discussion to elicit the following key ideas: • new substances are formed • starting substances are depleted • an energy change happens Write these ideas on the board. Establish that some of these can be observed as the generation of heat, sound and/or light, visible changes (e.g. a substance going from white to black), the evolution of a gas (e.g. bubbles forming).	Discussion to develop each other's learning
15		The next part of the lesson requires a laboratory for your demonstration. Ensure you and learners follow appropriate safety protocols, aligned to your school policies, during the demonstration. In particular, learners should not observe the reaction directly. They need look at a point to the side of the magnesium to avoid creating 'white spots' on the retina. Explain that you are going to demonstrate a chemical reaction by burning magnesium. Tell them that afterwards you will ask them to share descriptions for each stage. You will be looking at their quality of observations. Ask learners to also think about what shows that a chemical reaction is happening while they are observing. Show learners a piece of shiny metal magnesium ribbon. Burn the magnesium over a heat proof watch glass. Show learners the white ash.	Share success criteria

	Ask learners to share their observations, which should include: • shiny grey metal at start • white ash at the end • light and heat given out. Use the following questions to discuss the demonstration of the chemical reaction • What substances are reacting? (magnesium and oxygen in the air) • How can you tell that the starting substances are depleted? • How can you tell new substances are formed? • How can you tell an energy change happens? Reinforce the key ideas: starting substances depleted, new substances formed, energy change.	Self-assessment of observations Questioning and discussion to move learning forwards
10	Show how the reaction can be represented using a word equation by writing on the board: magnesium + oxygen → magnesium oxide Reinforce that this reaction is: • a combustion (where a substance acts as fuel and burns in the presence of oxygen) – in this case the magnesium gains oxygen to form an oxide. • an oxidation reaction – as a substance has gained oxygen • a combination reaction – as two substances have combined to form a single product.	

10	Explain to learners that they will now use atom modelling kits to visualise the reaction. After distributing the modelling kits, designate one colour to be magnesium and one colour to be oxygen. Ask learners to demonstrate the reaction by using the modelling kit and combining the 'atoms'. Observe what learners do and note if any learners first prepare an oxygen molecule by joining two oxygen atoms together. Once learners have completed their task, identify any learners who have created an oxygen molecule using two atoms. Ask these learners to explain why they used two atoms of oxygen. Clarify to the class that oxygen in the air exists as a diatomic molecule so is made of two oxygen atoms (O2) – 'di' meaning two. Explain that magnesium oxide, the product of the reaction, is one atom of magnesium and one atom of oxygen (MgO). Ask: • Given oxygen is diatomic, how many molecules of magnesium oxide would one molecule of oxygen produce? (2) • How many atoms of magnesium are needed? (2)	Use equations and modelling kits to move learning forwards Use modelling kits to move learning forwards Use other learners as a resource for learning
	Ask learners to repeat the atom modelling task with this new information. They should take two atoms of magnesium, create one molecule of oxygen using two atoms, and then break the oxygen molecule and form two molecules of magnesium oxide. To conclude tell learners that in the next lesson they will use what they have learned today to develop a balanced symbol equation for the reaction.	Questioning and remodelling to move learning forwards Share future learning intentions

Key competencies

Collaboration

Communication

Critical Thinking

Measuring Electric Current and Potential Difference

Learning Ladder Assessment Content	10.7.4 Understand how to measure, current and potential difference using a multimeter or ammeter and voltmeter. Note: This lesson builds on learning in previous lessons relating to: 10.2.16 Explain how to determine the equivalent resistance of two resistors when connected in series and in parallel.
Lesson duration	40 minutes
Book reference	Science Textbook for Class X, Chapter 12 Electricity
Resources	• low voltage D.C. power supply or batteries • connecting leads • resistors (with known value) 3 per group • voltmeters and ammeters, or multimeters Note: If multimeters are used on the incorrect setting, particularly current setting to attempt to measure potential difference/voltage, it is likely that an internal fuse will blow and the multimeter will no longer work.

Time (mins)	Learning Outcomes What we want the learners to know, understand and be able to do.	Lesson Activities	Assessment How AfL strategies will be used How AOs will be embedded
5	This lesson focuses on the highlighted part of the following learning outcome: Handles tools and laboratory apparatus properly; measures physical quantities using appropriate apparatus, instruments, and devices, such as, pH of substances using pH paper, electric current and potential difference using ammeter and voltmeter, etc.	Revisit learning from Class VII on 7.3.2 Measure current and voltage in simple series and parallel circuits, ensuring that learners recall the correct connections for an ammeter and voltmeter in series and parallel circuit. Give learners circuit diagrams where V or A is omitted from the voltmeter and ammeter symbols, and ask them to determine where the voltmeter or ammeter should be connected. Then arrange the learners in groups of 4 to discuss their decisions.	Self and peer assessment of prior learning

10	The following activity gives learners practice in taking accurate measurements using a multimeter or voltmeter and ammeter. If using a multimeter Organise learners into groups of 2 to 4. Each group draws simple circuit diagrams using: • 2 resistors in series • 2 resistors in parallel Learners use prior learning to calculate the resistance for each combination and record this on their circuit diagram. They then construct each circuit and measure the resistance for the circuit using a multimeter on the resistance (ohms) setting. Learners record and compare their measurements with their calculated values. If appropriate, or as an extension, learners can calculate the percentage difference between their calculated and measured values. If using voltmeter and ammeter As above, but for the measuring part of the activity, learners measure the current flowing through the circuit from the power supply or battery and the potential difference or voltage across the complete circuit. They then calculate the resistance of each circuit using R = V/I ohms. Discuss accuracy of measurements as a class, e.g. for multimeters: • How close were your measurements to your calculations? • Do you think the difference was due to human error? • How could you check? (e.g. repeating the measurements and checking the calculations, using different equipment) Learners should be able to measure or determine values which are within 10% of the calculated values. Discrepancies of up to 20% can be due to the manufacturing tolerance of the resistors being used – the least expensive 100 ohm resistor could actually be between 80 and 120 ohms.	Learners collaborate to improve learning Extension task for extra challenge as appropriate Support learners in owning their own learning

20	The following activity uses measurements taken with a voltmeter, ammeter or multimeter to determine the relationship between resistance, current and potential difference in series and parallel circuits. Series circuit Organise learners into groups of 2 to 4. Ask learners to draw the circuit diagram for a series circuit which includes three resistors. Under each resistor they record its resistance (resistors with known values should be given). Learners then make the circuit they have drawn. They use a voltmeter or multimeter set to measure voltage, to determine the potential difference (or voltage) across the circuit and record this. Learners then measure the potential difference (or voltage) across each resistor and record this under the resistors on their circuit diagram. Questions to ask: • What do the potential differences across the resistors add up to? • How does that compare with the potential difference across the circuit? • Which value of resistance has the largest potential difference across it? Parallel circuit Ask learners to draw the circuit diagram for a parallel circuit including three resistors. Under each resistor they record its resistance (resistors with known values should be given). Learners use an ammeter, or multimeter set to measure current, to determine the current leaving the power supply or battery and flowing through the whole circuit, and record this. Learners then determine the current through each resistor, connecting the ammeter into the individual branches of the circuit. They record the current under each resistor on their circuit diagram. Questions to ask: • What does the current through the individual resistors add up to? • How does that compare with the current through the entire circuit?	Learners collaborate to improve learning Questioning to stimulate problem solving and critical thinking

	• Which value of resistance has the largest current flowing through it? • Is the resistor with the highest current the largest or smallest value of resistance? • Is there a pattern in the values of resistance and current?	Questioning to stimulate problem solving and critical thinking
5	Use a cloze passage to summarise observations and understanding, e.g. In a series circuit, the .... is shared across the resistors. The largest resistor has the .... potential difference across it. The individual potential differences add up to that of the .... In a parallel circuit, the total .... is split through the resistors. The largest resistor has the .... current through it. The individual currents add up to .... supplied to the circuit. Answers In a series circuit, the potential difference (or voltage) is shared across the resistors. The largest resistor has the largest potential difference across it. The individual potential differences add up to that of the power supply (or battery). In a parallel circuit, the total current is split through the resistors. The largest resistor has the lowest current through it. The individual currents add up to the total current supplied to the circuit.	Self- and teacher-assessment of learning

Key competencies

Collaboration

Critical Thinking

Creative Thinking (by identification of patterns or relationships from observations or measurements)

Learning to Learn