Free Quality School Education

Ministry of Basic and Senior Secondary Education

Lesson Plans for

Senior Secondary *Mathematics*

SSS I

Term I

STRICTLY NOT FOR SALE

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Please see final page for further information.

Foreword

These Lesson Plans and the accompanying Pupils' Handbooks are essential educational resources for the promotion of quality education in senior secondary schools in Sierra Leone. As Minister of Basic and Senior Secondary Education, I am pleased with the professional competencies demonstrated by the writers of these educational materials in English Language and Mathematics.

The Lesson Plans give teachers the support they need to cover each element of the national curriculum, as well as prepare pupils for the West African Examinations Council's (WAEC) examinations. The practice activities in the Pupils' Handbooks are designed to support self-study by pupils, and to give them additional opportunities to learn independently. In total, we have produced 516 lesson plans and 516 practice activities – one for each lesson, in each term, in each year, for each class. The production of these materials in a matter of months is a remarkable achievement.

These plans have been written by experienced Sierra Leoneans together with international educators. They have been reviewed by officials of my Ministry to ensure that they meet the specific needs of the Sierra Leonean population. They provide step-by-step guidance for each learning outcome, using a range of recognized techniques to deliver the best teaching.

I call on all teachers and heads of schools across the country to make the best use of these materials. We are supporting our teachers through a detailed training programme designed specifically for these new lesson plans. It is really important that the Lesson Plans and Pupils' Handbooks are used, together with any other materials they may have.

This is just the start of educational transformation in Sierra Leone as pronounced by His Excellency, the President of the Republic of Sierra Leone, Brigadier Rtd Julius Maada Bio. I am committed to continue to strive for the changes that will make our country stronger and better.

I do thank our partners for their continued support. Finally, I also thank the teachers of our country for their hard work in securing our future.

Mr. Alpha Osman Timbo

Minister of Basic and Senior Secondary Education

The policy of the Ministry of Basic and Senior Secondary Education, Sierra Leone, on textbooks stipulates that every printed book should have a lifespan of three years.

To achieve thus, DO NOT WRITE IN THE BOOKS.

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Introduction

to the Lesson Plans

These lesson plans are based on the National Curriculum and the West Africa Examination Council syllabus guidelines, and meet the requirements established by the Ministry of Basic and Senior Secondary Education.

1. The lesson plans will not take the whole term, so use spare time to review material or prepare for examinations.
2. Teachers can use other textbooks alongside or instead of these lesson plans.
3. Read the lesson plan before you start the lesson. Look ahead to the next lesson, and see if you need to tell pupils to bring materials for next time.
4. Make sure you understand the learning outcomes, and have teaching aids and other preparation ready – each lesson plan shows these using the symbols on the right.
5. If there is time, quickly review what you taught last time before starting each lesson.
6. Follow the suggested time allocations for each part of the lesson. If time permits, extend practice with additional work.
7. Lesson plans have a mix of activities for the whole class and for individuals or in pairs.
8. Use the board and other visual aids as you teach.
9. Interact with all pupils in the class – including the quiet ones.
10. Congratulate pupils when they get questions right! Offer solutions when they don't, and thank them for trying.

Learning outcomes

Preparation

KEY TAKEAWAYS FROM SIERRA LEONE'S PERFORMANCE IN WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION – GENERAL MATHEMATICS[1]

This section, seeks to outline key takeaways from assessing Sierra Leonean pupils' responses on the West African Senior School Certificate Examination. The common errors pupils make are highlighted below with the intention of giving teachers an insight into areas to focus on, to improve pupil performance on the examination. Suggestions are provided for addressing these issues.

Common errors

1. Errors in applying principles of BODMAS
2. Mistakes in simplifying fractions
3. Errors in application of Maths learned in class to real-life situations, and vis-a-versa.
4. Errors in solving geometric constructions.
5. Mistakes in solving problems on circle theorems.
6. Proofs are often left out from solutions, derivations are often missing from quadratic equations.

Suggested solutions

1. Practice answering questions to the detail requested
2. Practice re-reading questions to make sure all the components are answered.
3. If possible, procure as many geometry sets to practice geometry construction.
4. Check that depth and level of the lesson taught is appropriate for the grade level.

[1] This information is derived from an evaluation of WAEC Examiners' Reports, as well as input from their examiners and Sierra Leonean teachers.

FACILITATION STRATEGIES

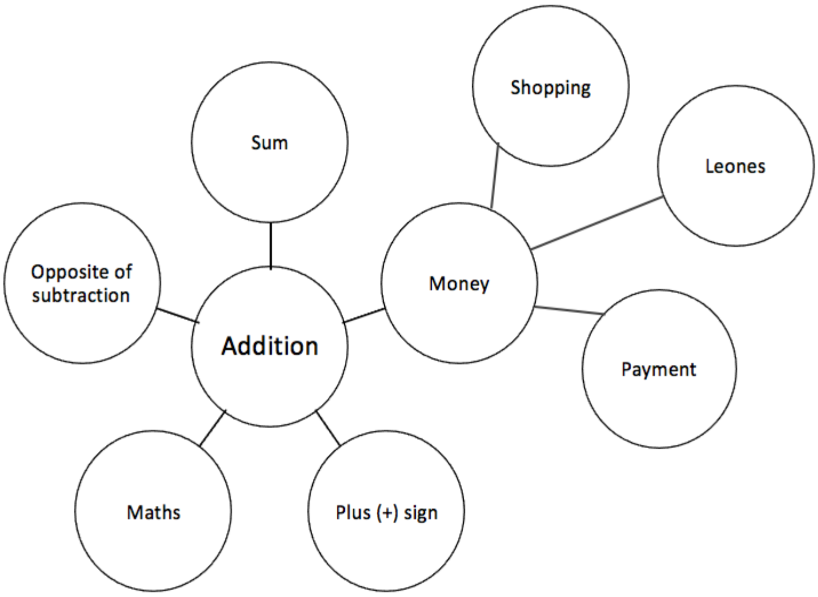
This section includes a list of suggested strategies for facilitating specific classroom and evaluation activities. These strategies were developed with input from national experts and international consultants during the materials development process for the Lesson Plans and Pupils' Handbooks for Senior Secondary Schools in Sierra Leone.

Strategies for introducing a new concept

- **Unpack prior knowledge:** Find out what pupils know about the topic before introducing new concepts, through questions and discussion. This will activate the relevant information in pupils' minds and give the teacher a good starting point for teaching, based on pupils' knowledge of the topic.
- **Relate to real-life experiences:** Ask questions or discuss real-life situations where the topic of the lesson can be applied. This will make the lesson relevant for pupils.
- **K-W-L:** Briefly tell pupils about the topic of the lesson, and ask them to discuss 'What I **k**now' and 'What I **w**ant to know' about the topic. At the end of the lesson have pupils share 'What I **l**earned' about the topic. This strategy activates prior knowledge, gives the teacher a sense of what pupils already know and gets pupils to think about how the lesson is relevant to what they want to learn.
- **Use teaching aids from the environment:** Use everyday objects available in the classroom or home as examples or tools to explain a concept. Being able to relate concepts to tangible examples will aid pupils' understanding and retention.
- **Brainstorming:** Freestyle brainstorming, where the teacher writes the topic on the board and pupils call out words or phrases related that topic, can be used to activate prior knowledge and engage pupils in the content which is going to be taught in the lesson.

Strategies for reviewing a concept in 3-5 minutes

- **Mind-mapping:** Write the name of the topic on the board. Ask pupils to identify words or phrases related to the topic. Draw lines from the topic to other related words. This will create a 'mind-map', showing pupils how the topic of the lesson can be mapped out to relate to other themes. Example below:



- **Ask questions:** Ask short questions to review key concepts. Questions that ask pupils to summarise the main idea or recall what was taught is an effective way to review a concept quickly. Remember to pick volunteers from all parts of the classroom to answer the questions.
- **Brainstorming:** Freestyle brainstorming, where the teacher writes the topic on the board and pupils call out words or phrases related that topic, is an effective way to review concepts as a whole group.
- **Matching:** Write the main concepts in one column and a word or a phrase related to each concept in the second column, in a jumbled order. Ask pupils to match the concept in the first column with the words or phrases that relate to in the second column.

Strategies for assessing learning without writing

- **Raise your hand:** Ask a question with multiple-choice answers. Give pupils time to think about the answer and then go through the multiple-choice options one by one, asking pupils to raise their hand if they agree with the option being presented. Then give the correct answer and explain why the other answers are incorrect.
- **Ask questions:** Ask short questions about the core concepts. Questions which require pupils to recall concepts and key information from the lesson are an effective way to assess understanding. Remember to pick volunteers from all parts of the classroom to answer the questions.
- **Think-pair-share:** Give pupils a question or topic and ask them to turn to seatmates to discuss it. Then, have pupils volunteer to share their ideas with the rest of the class.
- **Oral evaluation:** Invite volunteers to share their answers with the class to assess their work.

Strategies for assessing learning with writing

- **Exit ticket:** At the end of the lesson, assign a short 2-3 minute task to assess how much pupils have understood from the lesson. Pupils must hand in their answers on a sheet of paper before the end of the lesson.
- **Answer on the board:** Ask pupils to volunteer to come up to the board and answer a question. In order to keep all pupils engaged, the rest of the class can also answer the question in their exercise books. Check the answers together. If needed, correct the answer on the board and ask pupils to correct their own work.
- **Continuous assessment of written work:** Collect a set number of exercise books per day/per week to review pupils' written work in order to get a sense of their level of understanding. This is a useful way to review all the exercise books in a class which may have a large number of pupils.
- **Write and share:** Have pupils answer a question in their exercise books and then invite volunteers to read their answers aloud. Answer the question on the board at the end for the benefit of all pupils.
- **Paired check:** After pupils have completed a given activity, ask them to exchange their exercise books with someone sitting near them. Provide the answers, and ask pupils to check their partner's work.
- **Move around:** If there is enough space, move around the classroom and check pupils' work as they are working on a given task or after they have completed a given task and are working on a different activity.

Strategies for engaging different kinds of learners

- For pupils who progress faster than others:
  - Plan extension activities in the lesson.
  - Plan a small writing project which they can work on independently.
  - Plan more challenging tasks than the ones assigned to the rest of the class.
  - Pair them with pupils who need more support.

- For pupils who need more time or support:
  - Pair them with pupils who are progressing faster, and have the latter support the former.
  - Set aside time to revise previously taught concepts while other pupils are working independently.
  - Organise extra lessons or private meetings to learn more about their progress and provide support.
  - Plan revision activities to be completed in the class or for homework.
  - Pay special attention to them in class, to observe their participation and engagement.

Lesson Title: Review of Numbers and Numerations	**Theme:** Numbers and Numeration	
Lesson Number: M1-L001	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcomes By the end of the lesson, pupils will be able to: 1. Identify prime numbers and prime factors. 2. Calculate LCM and HCF.	**Preparation** None	

Opening (*3 minutes)*

1. Review factors by asking pupils to list the factors of 20 and 45.
2. Have pupils volunteer to give the factors, and list their answers on the board. (Answers: 20: 1, 2, 4, 5, 10, 20; 45: 1, 3, 5, 9, 15, 45)
3. Write on the board: Write down the first 5 multiples of 20.
4. Allow pupils to brainstorm and call out their answers. Write them on the board. (Answers: 20, 40, 60, 80, 100)
5. Explain that in today's lesson pupils will revise how to identify prime numbers and prime factors and also learn how to calculate LCM and HCF. These are topics from JSS.

Teaching and Learning *(20 minutes)*

1. Explain **prime numbers**:
    - Prime numbers are numbers that are greater than 1 and cannot be divided evenly by any other number except 1 and itself.
    - Zero and 1 are not considered prime numbers.
    - When talking about prime numbers, we are referring to whole numbers.
2. Write on the board: Identify the prime numbers between 0 and 30.
3. Ask pupils to volunteer to answer. (Answer: 2, 3, 5, 7, 11, 13, 17, 19, 23, and 29)
4. Explain **prime factors:**
    - A prime factor is a prime number that divides exactly into another given number.
    - Every positive integer has its own unique set of prime factors.
5. Write on the board: What are the prime factors of 12?
6. Ask pupils to volunteer to answer. (Answers: 2 and 3)
7. Write on the board: Write down the prime factors of: a. 40 and b. 50.
8. Ask pupils to work with seatmates to write the prime factors. Invite volunteers to write the answers on the board. (Answers: $\text{a}. 2, 5$; $\text{b}. 2, 5$)
9. Explain **LCM:**
    - Learning to find prime factors of numbers will help you find the least common multiple (LCM) and the highest common factor (HCF) of numbers.

- We are going to use prime factorisation to find the LCM. The prime factorisation of a number is the list of all prime numbers that result in the given number when multiplied together.
- To find the LCM:
    - Find the prime factorisation of each number.
    - Find the prime factors that appear in **any one** of the prime factorisations.
    - Find the product of these primes using each prime the most number of times that it appears in **any one** of the prime factorisations.

10. Write on the board: Find the least common multiple of 24 and 60.
11. Invite a volunteer to write the prime factorisation of 24. (Answer: $24 = 2 \times 2 \times 2 \times 3$)
12. Invite a volunteer to write the prime factorisation of 60. (Answer: $60 = 2 \times 2 \times 3 \times 5$)
13. Have a pupil volunteer to identify the prime factors of 24 and 60. (Answer: $2, 3, 5$)
14. Explain:
    - There are three 2s (in 24 and two 2s in 60)
    - There is only one 3 (in 24 and in 60)
    - There is only one 5 (in 60)
15. Ask pupils to multiply these prime factors in their exercise books. Invite a volunteer to write the answer on the board. (Answer: $LCM = 2 \times 2 \times 2 \times 3 \times 5 = 120$)
16. Explain **HCF:**
    - We are going to use prime factorisation in finding the highest common factor (HCF) of 2 or more numbers.
    - Find the prime factors that appear in **both** of the prime factorisations.
    - Multiply the prime factors that occur in both numbers. Multiply each common prime factor the least number of times it appears in any one of the prime factorisations.
    - The HCF is the largest of all the common factors.
17. Write on the board: Find the HCF of 20 and 30
18. Remind pupils to use prime factorisation (the same as above in finding the LCM) to find the HCF.
19. Ask volunteers to list the prime factorisation of 20 and 30. (Answers: $20 = 2 \times 2 \times 5$ and $30 = 2 \times 3 \times 5$)
20. Ask a volunteer to identify the prime factors that are common with the two numbers. (Answer: 2 and 5)
21. Ask pupils to multiply the common prime numbers in their exercise books. Invite a volunteer to write the answer on the board. (Answer: $HCF = 2 \times 5 = 10$)

Practice *(15 minutes)*

1. Write the following three problems on the board:

a. Write down the prime factors of 35, 50 and 80.
b. Find the least common multiple (LCM) of 18, 30 and 45.
c. Find the highest common factor (HCF) of 24, 36 and 48.

2. Ask pupils to solve the problems in their exercise books.
3. After 10 minutes, ask them to discuss their answers with seatmates.
4. Review the answers with them and clear up any misconceptions.

Solutions:

a. $35: 5,7; \quad 50: 2, 5; \quad 80: 2, 5$

b. $18 = 2 \times 3 \times 3$
$30 = 2 \times 3 \times 5$
$45 = 3 \times 3 \times 5$
$LCM = 2 \times 3 \times 3 \times 5 = 90$

c. $24 = 2 \times 2 \times 2 \times 3$
$36 = 2 \times 2 \times 3 \times 3$
$48 = 2 \times 2 \times 2 \times 2 \times 3$
$HCF = 2 \times 2 \times 3 = 12$

Closing *(2 minutes)*

1. Have 2-3 pupils volunteer to explain prime numbers, prime factors and the difference between LCM and HCF in their own words.
2. For homework, have pupils do the practice activity PHM1-L001 in the Pupil Handbook.

Lesson Title: Addition and subtraction of fractions	**Theme:** Numbers and Numeration	
Lesson Number: M1-L002	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to add and subtract fractions, including word problems.	**Preparation** Write some examples of fractions on the board. (Example: $\frac{5}{6}, \frac{3}{4}, \frac{2}{3}, \frac{2}{5}, \frac{3}{6}, \frac{4}{7}$)	

Opening (*3 minutes)*

1. Invite a volunteer to circle the fractions with the same denominator. (Answer: $\frac{5}{6}, \frac{3}{6}$)
2. Ask pupils to call out examples of the types of fractions. Write the fractions they call out on the board. Make sure pupils understand which ones are proper, improper and mixed. (Example answer: proper ($\frac{1}{4}$), improper ($\frac{7}{3}$) and mixed ($1\frac{3}{5}$))
3. Tell pupils that they are going to review how to add and subtract fractions, including word problems.

Teaching and Learning *(22 minutes)*

1. Explain:
    - To add and subtract fractions, you must have a common denominator.
    - Fractions that have common denominators are called “like fractions”.
    - Fractions that have different denominators are called “unlike fractions”.
    - To add or subtract like fractions, simply add or subtract the numerators and keep the same (or like) denominator.
    - To add or subtract unlike fractions, first change all denominators to the lowest common multiple of the denominators.
2. Write the following two problems on the board: a. $\frac{1}{8}+\frac{3}{8}$; b. $\frac{1}{2}+\frac{1}{3}$
3. Ask pupils to volunteer to explain how to work problem a. (Example answer: Add the numerators together and keep the same denominator.)
4. Write the solution on the board: $\frac{1}{8}+\frac{3}{8}=\frac{4}{8}$
5. Remind pupils of how to simplify their answers (divide the numerator and denominator by a common factor): $\frac{1}{8}+\frac{3}{8}=\frac{4}{8}=\frac{4\div4}{8\div4}=\frac{1}{2}$
6. Ask pupils to explain how to work problem b. (Example answer: Find the LCM of 2 and 3, and change the denominators of both fractions to their LCM)
7. Write the solution on the board:
   Step 1. Find the LCM of 2 and 3:
   2 and 3 are prime numbers already, so we don’t need to use prime factorisation.
   Multiply the prime numbers: $LCM = 2 \times 3 = 6$

   Step 2. Change both denominators to the LCM:

$$\frac{1}{2}=\frac{1\times3}{2\times3}=\frac{3}{6} \quad \text{and} \quad \frac{1}{3}=\frac{1\times2}{3\times2}=\frac{2}{6}$$

Step 3. Add the fractions with common denominators:

$$\frac{3}{6}+\frac{2}{6}=\frac{5}{6}$$

8. Write the following problem on the board: Simplify $2\frac{1}{5}-1\frac{3}{4}$
9. Ask pupils to work with seatmates to convert the mixed fractions to improper fractions, and rewrite the problem. (Answer: Convert the fractions: $2\frac{1}{5}=\frac{2\times5+1}{5}=\frac{11}{5}$ and $1\frac{3}{4}=\frac{1\times4+3}{4}=\frac{7}{4}$. Rewrite the problem: $\frac{11}{5}-\frac{7}{4}$)
10. Ask pupils to state the LCM of the denominators of fractions, 5 and 4. (Answer: 20)
11. Explain the solution step by step to pupils:

$2\frac{1}{5}-1\frac{3}{4}$	$=$	$\frac{11}{5}-\frac{7}{4}$	Convert to improper fractions
	$=$	$\frac{44}{20}-\frac{35}{20}$	Change each denominator to the LCM, 20
	$=$	$\frac{44-35}{20}$	Subtract the numerators
	$=$	$\frac{9}{20}$	

12. Write another problem on the board: A school wants to make a new playground in an empty field. They give the job of planning the playground to a group of pupils. The pupils decide to use $\frac{1}{4}$ of the playground for a basketball court and $\frac{3}{8}$ for a football field. How much of the playground is left?
13. Explain:
    - When solving word problems, make sure to understand the question.
    - Use common sense when thinking about how to solve word problems.
    - Here are some key words to look for in word problems:
        - Addition words: sum, total, more than
        - Subtraction words: difference, less than, how much more than
14. Ask 2-3 pupils to volunteer to explain the process they will use to solve this problem, and discuss as a class.
15. Write the following on the board:
    Step 1. Find the total area used by the basketball court and football field
    Step 2. Find the area of the playground left
16. Ask pupils to give the operation to be used for each step. (Answers: Step 1 is addition (“total”); Step 2 is subtraction (“left”))
17. Ask a volunteer to give the problem for step 1. (Answer: $\frac{1}{4}+\frac{3}{8}$)
18. Ask a volunteer to give the LCM of the denominators. (Answer: 8)
19. Solve the problem on the board and explain each step to them.
    Step 1.

$$\frac{1}{4}+\frac{3}{8} = \frac{2}{8}+\frac{3}{8}$$ Change each denominator to the LCM, 8

$$= \frac{2+3}{8}=\frac{5}{8}$$ Add the numerators

Step 2.

$$1-\frac{5}{8} = \frac{1}{1}-\frac{5}{8}$$ Subtract the area used from 1 whole

$$= \frac{8}{8}-\frac{5}{8}$$ Change each denominator to the LCM, 8

$$= \frac{8-5}{8}=\frac{3}{8}$$ Subtract the numerators

20. Explain: $\frac{3}{8}$ of the playground is left for other purposes.

Practice (*10 minutes)*

1. Write the following three problems on the board:
   a. Simplify $7\frac{1}{3}+2\frac{1}{9}$
   b. If a cup of sugar weighs $15\frac{1}{2}$ ounces and a cup of beans weighs $12\frac{3}{4}$ ounces, how much more does the sugar weigh?
   c. Three sides of a triangular piece of land measures $\frac{1}{4}, \frac{3}{4}$, and $\frac{1}{2}$ kilometres. How much fencing will be needed to enclose the area?
2. Ask pupils to copy and solve the questions in their exercise books.

Closing *(5 minutes)*

1. Invite 3 pupils to the board simultaneously to write their solutions to the practice exercises. Other pupils should check their work.
   Solutions:
   a. Simplify $7\frac{1}{3}+2\frac{1}{9}$:
   Pupils may convert to improper fractions and add. Alternatively, they may add the whole number and fraction parts separately, then combine them. Accept either method.

Method 1, convert to improper:

$$\begin{aligned} 7\tfrac{1}{3}+2\tfrac{1}{9} &= \tfrac{22}{3}+\tfrac{19}{9} \\ &= \tfrac{66}{9}+\tfrac{19}{9} \\ &= \tfrac{66+19}{9} \\ &= \tfrac{85}{9} \end{aligned}$$

Method 2, add parts separately:

$$\begin{aligned} 7\tfrac{1}{3}+2\tfrac{1}{9} &= (7+2)+\left(\tfrac{1}{3}+\tfrac{1}{9}\right) \\ &= 9+\left(\tfrac{3}{9}+\tfrac{1}{9}\right) \\ &= 9\tfrac{3+1}{9} \\ &= 9\tfrac{4}{9} \end{aligned}$$

$$= \quad 9\frac{4}{9}$$

b. The phase “how much more” tells us to subtract:

$$15\frac{1}{2} - 12\frac{3}{4} = \frac{31}{2} - \frac{51}{4}$$

$$= \frac{62}{4} - \frac{51}{4}$$

$$= \frac{62-51}{4}$$

$$= \frac{11}{4}$$

$= 2\frac{3}{4}$ ounces more

c. Add the lengths of the 3 sides to find the perimeter of the triangle, which is the length needed for fencing:

$$\frac{1}{4} + \frac{3}{4} + \frac{1}{2} = \frac{1}{4} + \frac{3}{4} + \frac{2}{4}$$

$$= \frac{6}{4}$$

$$= \frac{3}{2}$$

$= 1\frac{1}{2}$ kilometres

2. For homework, have pupils do the practice activity PHM1-L002 in the Pupil Handbook.

Lesson Title: Multiplication and division of fractions	**Theme:** Numbers and Numeration	
Lesson Number: M1-L003	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to multiply and divide fractions, including word problems.	**Preparation** None	

Opening (*3 minutes)*

1. Write the following problem on the board: Simplify $3\frac{1}{6} + 2\frac{1}{3}$.
2. Allow pupils to solve the problem quickly in their exercise books.
3. Invite a volunteer to write the solution on the board.
   Solution:

$$\begin{aligned}
3\tfrac{1}{6} + 2\tfrac{1}{3} &= \tfrac{19}{6} + \tfrac{7}{3} && \text{Convert to improper fractions} \\
&= \tfrac{19}{6} + \tfrac{14}{6} && \text{Change each denominator to the LCM, 6} \\
&= \tfrac{33}{6} && \text{Add the numerators} \\
&= 5\tfrac{3}{6} && \text{Convert to a mixed fraction} \\
&= 5\tfrac{1}{2} && \text{Simplify}
\end{aligned}$$

4. Share with pupils that they are going to learn multiplication and division of fractions, including word problems.

Teaching and Learning *(24 minutes)*

1. Explain **multiplication of fractions:**
   - When multiplying fractions, simply multiply the numerators (top numbers of the fractions) together and multiply the denominators (bottom numbers of the fractions) together.
   - It is a good practice to check to see if any of the numbers can cancel first.
   - Cancelling is done when the numerator and denominator can be divided evenly by a common factor.
   - Canceling can happen top-to-bottom and/or diagonally but **never** across.
2. Write the following problem on the board: Simplify $\frac{35}{40} \times \frac{100}{1000}$
3. Ask pupils if they notice anything that can be canceled. (Example answer: 100 can be canceled from the right fraction)
4. Write the solution the board:

$$\begin{aligned}
\tfrac{35}{40} \times \tfrac{100}{1000} &= \tfrac{35}{40} \times \tfrac{1}{10} && \text{Cancel (divide by) 100 from right fraction} \\
&= \tfrac{7}{8} \times \tfrac{1}{10} && \text{Cancel 5 from the left fraction}
\end{aligned}$$

$$= \frac{7}{80}$$

5. Explain: You do not need to cancel before multiplying, but it makes the problem easier. If you do not cancel before multiplying, you will do more simplifying of the solution.
6. Solve the problem on the board without simplifying first: $\frac{35}{40} \times \frac{1}{10} = \frac{3500}{40000} = \frac{35}{400} = \frac{7}{80}$
7. Explain:
   - We can multiply mixed numbers.
   - Change mixed numbers into improper fractions then multiply as before.
8. Write the following problem on the board: Multiply $4\frac{1}{3} \times 1\frac{7}{8}$
9. Ask pupils to work with seatmates to convert the mixed fractions to improper fractions and rewrite the problem.
10. Invite a volunteer to rewrite the problem on the board. (Answer: convert the fractions: $4\frac{1}{3} = \frac{3\times4+1}{3} = \frac{13}{3}$ and $1\frac{7}{8} = \frac{1\times8+7}{8} = \frac{15}{8}$. Rewrite the problem: $\frac{13}{3} \times \frac{15}{8}$).
11. Ask a volunteer to explain where it is possible to cancel in the problem (Answer: 3 can be canceled from the left denominator and right numerator.)
12. Write the solution on the board:
    Solution:

$\frac{13}{3} \times \frac{15}{8}$	$=$	$\frac{13}{1} \times \frac{5}{8}$	Cancel (divide by) 3
	$=$	$\frac{13\times5}{1\times8}$	Multiply
	$=$	$\frac{65}{8}$	
	$=$	$8\frac{1}{8}$	Change to a mixed fraction

13. Explain **division of fractions:**
    - When dividing fractions, invert (turn over) the fraction to the right of the division symbol.
    - Cancel (if possible) then multiply.
14. Write the following problem on the board: Divide: $\frac{5}{8} \div \frac{15}{16}$.
15. Ask a volunteer to explain how to solve the problem. (Answer: invert the fraction to the right and cancel if possible)
16. Write the multiplication on the board: $\frac{5}{8} \div \frac{15}{16} = \frac{5}{8} \times \frac{16}{15}$
17. Ask volunteers to describe any numbers that can be canceled. (Answer: 5 can be canceled from the left numerator and right denominator; 8 can be canceled from the left denominator and right numerator.)
18. Write the solution on the board:

$\frac{5}{8} \div \frac{15}{16}$	$=$	$\frac{5}{8} \times \frac{16}{15}$	Change to multiplication
	$=$	$\frac{1}{1} \times \frac{2}{3}$	Cancel 5 and 8
	$=$	$\frac{2}{3}$	

19. Write another problem on the board: Simplify $5\frac{2}{5} \div 1\frac{8}{10}$
20. Ask volunteers to explain how to solve the problem. (Answer: change the mixed fractions to improper fractions, simplify if possible, then multiply).
21. Write the solution on the board:

$5\frac{2}{5} \div 1\frac{8}{10}$		$\frac{27}{5} \div \frac{18}{10}$	Convert to improper fractions
	$=$	$\frac{27}{5} \times \frac{10}{18}$	Change to multiplication
	$=$	$\frac{3}{1} \times \frac{2}{2}$	Cancel 5 and 9
	$=$	3×1	
	$=$	3	

22. Write another problem on the board: Deborah baked a cake and brought $\frac{1}{2}$ of it for her 6 friends. If she shares it equally, how much of the cake does each friend get?
23. Explain:
    - When solving word problems, make sure to understand the question.
    - Here are key words to look for in word problems:
        - Multiplication words: product, times.
        - Division words: quotient, per, for each, average.
24. Ask a volunteer to explain how to work out the problem. (Answer: Divide $\frac{1}{2}$ by 6.)
25. Write the solution on the board:

$\frac{1}{2} \div 6$	$=$	$\frac{1}{2} \div \frac{6}{1}$	Write 6 as a fraction
	$=$	$\frac{1}{2} \times \frac{1}{6}$	Multiply by the inverse of 6
	$=$	$\frac{1\times1}{2\times6}$	
	$=$	$\frac{1}{12}$	

Each friend gets $\frac{1}{12}$ of the cake.

26. Write another problem on the board: Issa has a bucket that holds $2\frac{1}{4}$ gallons of water. If he goes to the pump 5 times, how much water can he bring?
27. Ask pupils to work with seatmates to write the problem using numbers and symbols.
28. Invite a volunteer to write it on the board. (Answer: $2\frac{1}{4} \times 5$)
29. Ask pupils to work with seatmates to solve the problem.
30. Invite a volunteer to write the solution on the board.

Solution:

$2\frac{1}{4} \times 5$	$=$	$\frac{9}{4} \times \frac{5}{1}$	Convert to improper fraction
	$=$	$\frac{9\times5}{4\times1}$	Multiply

$= \frac{45}{4}$

$= 11\frac{1}{4}$ Convert to a mixed fraction

Practice (*10 minutes)*

1. Write the following three problems on the board:
   a. Simplify $5\frac{5}{7} \times \frac{14}{15}$
   b. Simplify $6\frac{2}{3} \div 1\frac{1}{6}$
   c. If 3 boxes of milk weigh $6\frac{1}{2}$ pounds altogether, find the weight per box.
2. Ask pupils to copy and solve the questions in their exercise books.

Closing *(3 minutes)*

1. Invite 3 pupils to the board to write their solutions together to the practice exercises. Other pupils should check their work.
   Solutions:
   a.

$5\frac{5}{7} \times \frac{14}{15}$	$=$	$\frac{40}{7} \times \frac{14}{15}$	Convert to improper fraction
	$=$	$\frac{8}{1} \times \frac{2}{3}$	Cancel 7 and 5
	$=$	$\frac{16}{3}$	Multiply
	$=$	$5\frac{1}{3}$	Convert to a mixed fraction

   b.

$6\frac{2}{3} \div 1\frac{1}{6}$	$=$	$\frac{20}{3} \div \frac{7}{6}$	Convert to improper fractions
	$=$	$\frac{20}{3} \times \frac{6}{7}$	Multiply by the inverse of $\frac{7}{6}$
	$=$	$\frac{20}{1} \times \frac{2}{7}$	Cancel 3
	$=$	$\frac{40}{7}$	Multiply
	$=$	$5\frac{5}{7}$	Convert to a mixed fraction

   c.

$6\frac{1}{2} \div 3$	$=$	$\frac{13}{2} \div \frac{3}{1}$	Convert to an improper fraction and write 3 as a fraction
	$=$	$\frac{13}{2} \times \frac{1}{3}$	Multiply by the inverse of 3

$$= \frac{13}{6}$$

$$= 2\frac{1}{6}$$ Pounds per box.

2. For homework, have pupils do the practice activity PHM1-L003 in the Pupil Handbook.

Lesson Title: Addition and subtraction of decimals	**Theme:** Numbers and Numeration	
Lesson Number: M1-L004	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to add and subtract decimals, including word problems.	**Preparation** None	

Opening *(2 minutes)*

1. Write 376.492 on the board.
2. Ask a pupil to identify the place value of each digit in the number.
   (Answer: 3 hundreds, 7 tens, 6 ones, 4 tenths, 9 hundredths, 2 thousandths).
3. Share with the pupils that they are going to review how to add and subtract decimals.

Teaching and Learning *(20 minutes)*

1. Explain:
   - The numbers on the left of the decimal point are whole numbers and those on the right of it are the fractional part.
   - When adding or subtracting decimal numbers, always arrange the numbers vertically according to place value.
   - The decimal points must be lined up together vertically.
2. Write on the board: Add $0.47 + 47 + 6.47$
3. Ask pupils to work with seatmates to arrange these in a vertical addition problem.
4. Invite a volunteer to the board to write the vertical addition problem.
5. Explain to pupils that for any empty spaces in the set of numbers, we write zero, which makes it possible for us to line up the decimal points.
6. Solve the addition problem on the board.
   Solution:

$$\begin{array}{cccccc} & {}^{1} & & & {}^{1} & \\ & 0 & 0 & . & 4 & 7 \\ & 4 & 7 & . & 0 & 0 \\ + & 0 & 6 & . & 4 & 7 \\ \hline & 5 & 3 & . & 9 & 4 \end{array}$$

7. Explain:
   - We arrange the numbers in the same way for subtraction.
   - In subtracting decimals, one decimal number may have more decimal places than the other.
   - Always remember to add zeros to the decimal with less decimal places to make the digits equal in number.
   - In subtracting decimals, the greater number must be at the top.
8. Write the following on the board: Subtract 0.0364 from 0.969

9. Ask pupils to work with seatmates to arrange these in a vertical subtraction problem.
10. Invite a volunteer to come to the board and arrange the numbers.
11. Solve the subtraction problem on the board.
    Solution:

$$
\begin{array}{rcccccc}
 & & & & & 8 & \\
 & 0 & . & 9 & 6 & \cancel{9} & {}^{1}0 \\
- & 0 & . & 0 & 3 & 6 & 4 \\
\hline
 & 0 & . & 9 & 3 & 2 & 6
\end{array}
$$

12. Write the following problem on the board: Mrs. Leigh weighs her suitcase to get ready for her holidays. It weighs 7.314 kg. She takes out shoes that weigh 2.006 kg. How heavy is her suitcase now?
13. Allow the pupils to brainstorm and explain whether it is addition or subtraction that is involved. (Answer: subtraction; the weight is reduced because she takes out shoes)
14. Ask pupils to work with seatmates to write and solve the vertical subtraction problem.
15. Invite a volunteer to the board to solve the problem.
    Solution:

$$
\begin{array}{rcccccc}
 & & & & 0 & \\
 & 7 & . & 3 & \cancel{1} & {}^{1}4 \\
- & 2 & . & 0 & 0 & 6 \\
\hline
 & 5 & . & 3 & 0 & 8
\end{array}
$$

16. Write another problem on the board: Foday runs 7.6 km on Monday, 6.54 km on Tuesday, 3.45 km on Wednesday, 4.56 km on Thursday and 2.75 km on Friday. Find the total distance that he runs.
17. Ask pupils to work with seatmates to write and solve the vertical subtraction problem.
18. Invite a volunteer to the board to solve the problem.
    Solution:

$$
\begin{array}{rcccl}
 & {}^{2} & {}^{2} & & \\
 & 7 & .6 & 0 & \\
 & 6 & .5 & 4 & \\
 & 3 & .4 & 5 & \\
 & 4 & .5 & 6 & \\
+ & 2 & .7 & 5 & \\
\hline
 & 24 & .9 & 0 & \text{km.}
\end{array}
$$

19. Explain: Foday runs 24.90 kilometres during the week.

Practice *(15 minutes)*

1. Write the following four problems on the board:
   a. Add 0.376, 34, and 0.3.

b. John and Issa are farmers. John grew 12.6 kg of pepper on his farm. Issa grew 2.56 kg less than John. How much did Issa grow?
c. I have 2 bags of candy. One weighs 64.1 g and the other weighs 8.9 g. How much do they weigh altogether?
d. Fatu collected 45.6 ml of rain on Sunday. 6.7 ml of water evaporated overnight. How much rain was left in the cup on Monday?

2. Ask pupils to work with seatmates.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite one pair to write the solution on the board and explain.

Solutions:

a. 34.676 b. 10.04 kg c. 73.0 g d. 38.9 ml

0 . 3 7 6 3 4 . 0 0 0 + 0 . 3 0 0 3 4 . 6 7 6	5 1 2 . $\cancel{6}$ $^{1}0$ - 2 . 5 6 1 0 . 0 4	1 1 6 4 . 1 + 8 . 9 7 3 . 0	3 14 $\cancel{4}$ $\cancel{5}$. $^{1}6$ - 6 . 7 3 8 . 9

Closing *(3 minutes)*

1. Ask pupils to be creative. Ask them to write their own story that includes a problem that involves addition and subtraction of decimals.
2. Ask them to solve the problem in their story.
3. Ask pupils to share their story with a fellow pupil.
4. For homework, have pupils do the practice activity PHM1-L004 in the Pupil Handbook.

Lesson Title: Multiplication and division of decimals	**Theme:** Numbers and Numeration	
Lesson Number: M1-L005	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to multiply and divide decimals, including word problems.	**Preparation** Write the problem in Opening on the board.	

Opening *(3 minutes)*

1. Write a review question on the board: Find the difference between 9.28 and 2.31.
2. Allow pupils to answer in their exercise books.
3. Invite a volunteer to the board to write out the solution.
   Solution:

$$\begin{array}{cccccc} & 8 & & & \\ & \cancel{9} & . & {}^{1}2 & 8 \\ - & 2 & . & 3 & 1 \\ \hline & 6 & . & 9 & 7 \end{array}$$

4. Share with pupils that they are now going to review how to multiply and divide decimals, including word problems.

Teaching and Learning *(24 minutes)*

1. Explain: To multiply a decimal number by a power of ten (such as 10, 100, or 1000), we must shift the decimal point to the right according to number of zeros.
2. Write the following problem on the board: Solve 0.376×100
3. Ask a volunteer to explain how to solve the problem. (Answer: Shift the decimal 2 places to the right.)
4. Write the answer on the board. (Answer: 37.6)
5. Explain: To divide a decimal number by a power of ten, shift the decimal point to the left according to the number of zeros.
6. Write the following problem on the board: Solve $39.45 \div 10$
7. Ask a volunteer to explain to solve the problem. (Answer: Shift the decimal 1 place to the left.)
8. Write the answer on the board. (Answer: 3.945)
9. Write another problem on the board: Solve 0.346×1.2
10. Explain:
    - It will be easier to omit the decimal points and treat the numbers as whole numbers.
    - Then, multiply the whole numbers.
    - After multiplying, count the number of decimal places in the numbers in the question and make sure that your answer has the same number of decimal places.

11. Do the multiplication on the board:

$$\begin{array}{ccccc} & & & 1 & \\ & & 3 & 4 & 6 \\ & \times & & 1 & 2 \\ \cline{2-5} & & 6 & 9 & 2 \\ + & 3 & 4 & 6 & \\ \hline & 4 & 1 & 5 & 2 \end{array}$$

12. Ask a pupil to tell the total number of decimal places in the question. (Answer: 4)
13. Invite another pupil to come to the board and put the decimal place in the answer. (Answer: 0.4152)
14. Write the following problem on the board: Solve $0.245 \div 0.5$
15. Explain:
    - When dividing decimals, the divisor (the second number, 0.5 in this case) should be a whole number.
    - To make the divisor a whole number, shift the decimal place to the right.
    - Shift the decimal in the dividend (0.245) by the same number of decimal places.
    - Once the divisor is a whole number, solve by long division.
16. Rewrite the problem: $0.245 \div 0.5 = 2.45 \div 5$
17. Write it as a long division problem, and solve. Explain each step to pupils:

$$\begin{array}{ccccc} & 0 & . & 4 & 9 \\ \cline{2-5} 5 & 2 & . & 4 & 5 \\ - & 2 & & 0 & \\ \cline{1-4} & & & 4 & 5 \\ & & - & 4 & 5 \\ \cline{3-5} & & & & 0 \end{array}$$

18. Write another problem on the board: Mary harvested 62.8 kg of cassava from her farm. She wants to share it equally among her 4 brothers and sisters. How much will she give to each of her siblings?
19. Ask pupils to work with seatmates to write the Maths problem for this story.
20. Ask a volunteer to share their problem with the class. (Answer: $62.8 \div 4$)
21. Explain: When we read “share equally” we know it is division. Mary wants to **divide** her cassava harvest.
22. Ask pupils to work with seatmates to solve the problem.
23. Invite a volunteer to write the solution on the board:

$$\begin{array}{ccccc} & 1 & 5 & . & 7 \\ \cline{2-5} 4 & 6 & 2 & . & 8 \\ - & 4 & & & \\ \cline{1-2} & 2 & 2 & & \\ - & 2 & 0 & & \\ \cline{1-3} & & 2 & & 8 \\ & - & 2 & & 8 \\ \cline{2-5} & & & & 0 \end{array}$$

Practice *(10 minutes)*

1. Write the following two questions on the board:
    a. Fatu sold 37.5 kg of tomatoes at the market. If she had 15 customers, how much did each customer buy on average?
    b. Bentu reads 6.5 pages of her favorite book each day. How many pages would she read in 30 days?
2. Ask pupils to solve the problems in their exercise books. If needed, discuss the operations used for each problem (a: division; b: multiplication).
3. Walk around to check for understanding and clear misconceptions.
   Solutions:
    a. Each customer bought an average of 2.5 kg:

$$
\begin{array}{r}
2.5 \\
15 \overline{)\,37.5} \\
-30 \\
\hline
7\;\;5 \\
-7\;\;5 \\
\hline
0
\end{array}
$$

    b. Bentu reads 195 pages in 30 days:

$$
\begin{array}{r}
{}^{1} \\
6.\;5 \\
\times\; 3\;\;0 \\
\hline
1\;9\;5.\;0
\end{array}
$$

Closing *(3 minutes)*

1. Write on the board:
    a. 3.4786×100
    b. $256.7 \div 100$
2. Give pupils 1 minute to solve the problems in their exercise books.
3. Ask 2 volunteers to give their answers and an explanation. (Answers: a. 347.86, the decimal point shifts to the right 2 places; b. 2.567, the decimal place shifts to the left 2 places.)
4. For homework, have pupils do the practice activity PHM1-L005 in the Pupil Handbook.

Lesson Title: Conversion of fractions, percentages, and decimals	Theme: Numbers and Numeration	
Lesson Number: M1-L006	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to convert between fractions, percentages, and decimals.	**Preparation** None	

Opening (*2 minutes)*

1. Ask a pupil to explain in his/her own words the meaning of percentage. (Example answers: percentage means out of a hundred; it is a part of one whole).
2. Invite volunteers to write a few examples of fractions, percentages and decimal numbers on the board. (Example answers: $\frac{3}{4}, 20\%, 0.423$)
3. Share with pupils that they are going to learn how to convert between fractions, percentages and decimals.

Teaching and Learning *(20 minutes)*

1. Write these questions on the board:
   a. Convert $\frac{3}{4}$ to a percentage.
   b. Convert 20% to a fraction.
2. Explain:
   - To convert a fraction to a percentage, multiply the fraction by 100 and then simplify.
   - To convert a percentage to a fraction, divide the percentage by 100 and then reduce the fraction to its lowest terms.
3. Show the first conversions for pupils to see. (Solutions: a. $\frac{3}{4} = \frac{3}{4} \times 100\% = 3 \times 25\% = 75\%$; b. $20\% = \frac{20}{100} = \frac{2}{10} = \frac{1}{5}$)
4. Write the following two questions on the board:
   a. Convert $\frac{2}{5}$ to a percentage.
   b. Convert 45% to a fraction.
5. Ask pupils to work with seatmates.
6. Invite 2 volunteers to solve the problems on the board. (Solutions: a. $\frac{2}{5} = \frac{2}{5} \times 100\% = 2 \times 20\% = 40\%$; b. $45\% = \frac{45}{100} = \frac{9}{20}$).
7. Write the following questions on the board:
   a. Convert $\frac{5}{8}$ to decimal.
   b. Convert 0.25 to a fraction.
8. Explain:
   - To convert fractions to a decimal, divide the numerator by the denominator. The answer is the decimal number result.

- To convert a decimal to a fraction follow these steps:
  - Write down the decimal divided by 1, like this: $\frac{decimal}{1}$
  - Multiply both the top and bottom by 10 for every number after the decimal point. (For example, if there are two numbers after the decimal point, then use 100, if there are three then use 1000, and so on.)
  - Simplify (or reduce) the fraction.

9. Demonstrate the conversion on the board for pupils to see.

   Solutions:

   a. $\frac{5}{8} = 0.625 \rightarrow$

$$\begin{array}{r|llll} & 0. & 6 & 2 & 5 \\ \cline{2-5} 8 & 5. & 0 & 0 & 0 \\ - & 4 & 8 & & \\ \cline{2-3} & & 2 & 0 & \\ & - & 1 & 6 & \\ \cline{3-4} & & & 4 & 0 \\ & & - & 4 & 0 \\ \cline{4-5} & & & & 0 \end{array}$$

   b. $0.25 = \frac{0.25}{1} = \frac{0.25 \times 100}{100} = \frac{25}{100} = \frac{1}{4}$

10. Write the following two questions on the board:
    a. Convert $\frac{3}{4}$ to a decimal.
    b. Convert 0.035 to a fraction in its lowest term.
11. Ask pupils to work with seatmates.
12. Invite 2 volunteers to solve the problems on the board.

    Solutions:

    a. $\frac{3}{4} = 0.75 \rightarrow$

$$\begin{array}{r|lll} & 0. & 7 & 5 \\ \cline{2-4} 4 & 3. & 0 & 0 \\ - & 2 & 8 & \\ \cline{2-3} & & 2 & 0 \\ & - & 2 & 0 \\ \cline{3-4} & & & 0 \end{array}$$

    b. $0.035 = \frac{0.035}{1} = \frac{0.035 \times 1000}{1000} = \frac{35}{1000} = \frac{7}{200}$.

13. Write the following two problems on the board:
    a. Convert 55% to a decimal.
    b. Convert 0.45 to a percentage.
14. Explain:
    - To convert a percentage to a decimal, divide by 100. Remember that the decimal place moves 2 spaces to the left.
    - To convert a decimal to a percentage, multiply by 100. Remember that the decimal place moves 2 spaces to the right.

15. Demonstrate the conversion on the board for pupils to see. (Solutions: a. $55\% = \frac{55}{100} = 0.55$. b. $0.45 = 0.45 \times 100\% = 45\%$)
16. Write the following two questions on the board:
    a. Convert 7% to a decimal.
    b. Convert 0.9 to a percentage.
17. Ask pupils to work with seatmates.
18. Invite 2 volunteers to solve the problems on the board. (Solutions: a. $7\% = \frac{7}{100} = 0.07$; b. $0.9 = 0.9 \times 100\% = 90\%$)

Practice (*15 minutes)*

1. Write the following four problems on the board:
   a. Express 40% as a fraction.
   b. Express $\frac{7}{20}$ as a percentage and a decimal.
   c. Express 52% as a decimal and as a fraction.
   d. Convert 0.625 to a percentage.
2. Ask pupils to solve the problems in their exercise books.
3. After 10 minutes, ask them to discuss the answers with seatmates.
4. Review the solutions with them and clear any misconceptions.
   Solutions:
   a. $40\% = \frac{40}{100} = \frac{2}{5}$
   b. Percentage: $\frac{7}{20} = \frac{7}{20} \times 100\% = 7 \times 5\% = 35\%$; Decimal: $\frac{7}{20} = 0.35$ (see below)

$$
\begin{array}{r|lll}
 & 0. & 3 & 5 \\ \cline{2-4}
20 & 7. & 0 & 0 \\
- & 6 & 0 & \\ \cline{2-3}
 & 1 & 0 & 0 \\
- & \ 1 & 0 & 0 \\ \cline{2-4}
 & & & 0
\end{array}
$$

   c. Decimal: $52\% = \frac{52}{100} = 0.52$; Fraction: $52\% = \frac{52}{100} = \frac{13}{25}$
   d. $0.625 = 0.625 \times 100\% = 62.5\%$

Closing *(3 minutes)*

1. Ask the following questions and allow pupils to discuss:
   a. How will you convert a fraction to a percentage?
   b. How will you convert a decimal to a percentage?
   c. How will you convert a percentage to a fraction?
2. For homework, have pupils do the practice activity PHM1-L006 in the Pupil Handbook.

Lesson Title: Finding the percentage of a quantity	**Theme:** Numbers and Numeration	
Lesson Number: M1-L007	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to find the percentage of a quantity (including word problems).	**Preparation** Write the problem in Opening on the board.	

Opening (*4 minutes)*

1. Write on the board: Convert the following to fractions: a. 18% b. 25%
2. Ask volunteers to solve in their exercise books.
3. Invite two volunteers to come to the board one at a time to solve. (Answer: $a. 18\% = \frac{18}{100} = \frac{9}{50}$; $b. 25\% = \frac{25}{100} = \frac{1}{4}$).
4. Share with the pupils that they are going to learn how to find the percentage of a quantity, including word problems.

Teaching and Learning *(15 minutes)*

1. Write the following questions on the board:
    a. Find 20% of 90 mangos.
    b. Mary gave 30% of her 40 oranges to her sister. How many oranges did she give away?
2. Explain:
    - To find a percentage of a quantity, we express the percentage as a fraction and multiply the fraction by the given quantity.
3. Ask pupils to look at problem a. Write the solution on the board: $20\%\ of\ 90$ mangos $= \frac{20}{100} \times 90 = \frac{1}{5} \times 90 = 18$ mangos
4. Ask volunteers to describe the steps needed to solve question b. (Answer: Convert 30% to a fraction and multiply it by 40 oranges.)
5. Ask pupils to work with seatmates to solve b. (Answer: $30\%\ of\ 40 = \frac{30}{100} \times 40 = 12$ oranges).
6. Write another problem on the board: Margaret was given Le 500,000.00 to do shopping for the re-opening of schools. She spent 15% of this amount on uniforms and 25% on books. How much was left for her to purchase other school items?
7. Explain:
    - First we find how much was spent on each of the items in the question.
    - Then we subtract the sum from the total amount given to her.
8. Ask pupils to work with seatmates to find how much was spent on uniforms.
9. Invite a volunteer to write the solution on the board. (Answer: Uniforms $= \frac{15}{100} \times 500{,}000 = 15 \times 5{,}000 = Le\ 75{,}000$)

10. Ask pupils to work with seatmates to find out how much was spent on books.
11. Invite a volunteer to write the solution on the board. (Answer: Books = $\frac{25}{100} \times 500{,}000 = 25 \times 5{,}000 = Le\ 125{,}000.00$).
12. Ask pupils to work with seatmates to find how much has already been spent altogether.
13. Invite a volunteer to the board to show the solution. (Answer: Total spent = $Le\ 75{,}000.00 + Le\ 125{,}000.00 = Le\ 200{,}000.00$).
14. Ask pupils to work with seatmates to find how much money Margaret has left for other school items.
15. Invite a volunteer to the board to show the solution. (Answer: Money left = $Le\ 500{,}000.00 - Le\ 200{,}000.00 = Le\ 300{,}000.00$)
16. If there is time, show pupils another method of solving the same problem:

    Step 1. Find the total amount spent: Margaret spent 15% on uniforms and 25% on books. This means she spends $15\% + 25\% = 40\%$ in total.

    Step 2. Find the percentage left: $100\% - 40\% = 60\%$.

    Step 3. Find the amount left by multiplying the percentage left by the total amount she had: Amount left = $\frac{60}{100} \times 500{,}000 =$ Le 300,000.00

Practice *(20 minutes)*

1. Write the following three problems on the board:
   d. What is $15\frac{1}{2}\%$ of Le 90,000.00?
   e. John was given the sum of Le 600,000.00 to go shopping at the market. He spent 10% of the amount on provisions, 25% on electrical items and 20% on vegetables. How much was left after he purchased the items?
   f. Fatu sells exercise books in a shop near the school. At the re-opening of school she had 600 exercise books. If she has sold 45% of them, how many does she have left?
2. Ask pupils to copy and solve the questions in their exercise books.
3. Invite 2 volunteers to the board at the same time to write their solutions to the practice exercises. Other pupils should check their work.
   Solutions:
   a. $\frac{15.5}{100} \times 90{,}000 = \frac{155}{1{,}000} \times 90{,}000 = 155 \times 90 = Le\ 13{,}950.00$
   b. There are 2 ways to solve this problem. Accept either method shown below.
   Method 1: Find the cost of each type of item, the subtract all the costs from the total he had:

      Cost of provisions; $\frac{10}{100} \times 600{,}000 = Le\ 60{,}000.00$

      Cost of electrical items: $\frac{25}{100} \times 600{,}000 = Le\ 150{,}000.00$

      Cost of vegetables: $\frac{20}{100} \times 600{,}000 = Le\ 120{,}000.00$

Total amount spent: $Le\ 60{,}000.00 + Le\ 150{,}000.00 + Le\ 120{,}000.00 = Le\ 330{,}000.00$
Amount left $= Le\ 600{,}000.00 - Le\ 330{,}000.00 = Le\ 270{,}000.00$

Method 2: Subtract the percentages he spent to find the percentage he has left. Multiply by the amount he had to find how much he has left.

Percentage spent: $10\% + 25\% + 20\% = 55\%$

Percentage left: $100\% - 55\% = 45\%$

Amount left: $\frac{45}{100} \times 600{,}000 =$ Le 270,000.00

c. Exercise books sold: $\frac{45}{100} \times 600 = 45 \times 6 = 270$
Exercise books left: $600 - 270 = 330$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L007 in the Pupil Handbook.

Lesson Title: Express one quantity as a percentage of another	Theme: Numbers and Numeration	
Lesson Number: M1-L008	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to express one quantity as a percentage of another (including word problems).	**Preparation** None	

Opening (*2 minutes)*

1. Allow pupils to brainstorm and give some basic unit conversions. For example, ask:
    a. How many grammes make 1 kilogramme? (Answer: 1,000 g = 1 kg).
    b. How many metres make 1 kilometre? (Answer: 1,000 m = 1 km).
2. Share with the pupils that they are going to learn how to express one quantity as a percentage of another, including word problems.

Teaching and Learning *(20 minutes)*

1. Write the following problems on the board:
    a. In a bag containing 250 mangos, 30 became rotten. What percentage of the mangos became rotten?
    b. Express 30 grammes as a percentage of 1 kilogramme.
2. Explain:
    - To express one quantity as a percentage of another, make sure that both quantities are expressed in the same units.
    - Write the given quantity as a fraction of the total and multiply it by 100%. Then simplify.
3. Solve the first problem on the board: percentage of rotten mangos $= \frac{30}{250} \times 100\% = 12\%$.
4. Explain:
    - In the second example, the units of the quantities are not the same. We should always make sure that the units are the same.
    - The second quantity is in kilogrammes. Always convert the bigger units to the smaller one to avoid complications.
5. Write on the board: 1 kg = 1,000 g.
6. Explain: Because 1 kilogramme is equal to 1,000 grammes, we want to calculate 30 grammes as a percentage of 1,000 grammes.
7. Ask a volunteer to give the fraction needed to solve the problem. (Answer: $\frac{30}{1,000}$).
8. Write on the board: $\frac{30}{1,000} \times 100\% = 3\%$.
9. Write on the board: Express 35 cm as a percentage of 2 metres.

10. Ask a volunteer to describe the first step to take. (Answer: Convert the bigger units (metres) to the smaller units (centimetres))
11. Ask pupils to work with seatmates to convert 2 metres to centimetres.
12. Invite a volunteer to write the conversion on the board. (Answer: $2 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 200 \text{ cm}$)
13. Ask pupils to express 35 cm as a percentage of 200 cm.
14. Invite a volunteer in the class to solve the problem on the board. (Answer: $\frac{35}{200} \times 100 = 17.5\%$ or $17\frac{1}{2}\%$).
15. Write another problem on the board: Foday obtained 30 marks out of 40 in a test. Convert this test mark into a percentage.
16. Ask pupils to work with seatmates to solve the problem.
17. Invite a volunteer to write the solution on the board. (Answer: $\frac{30}{40} \times 100\% = \frac{3}{4} \times 100\% = 3 \times 25\% = 75\%$)

Practice (*15 minutes)*

1. Write the following three problems on the board:
   a. What percentage is 12 out of 50?
   b. Juliet bought 3 metres of fabric. She will use 240 cm to make a dress. What percentage of the fabric will she use?
   c. Abass buys a new mountain bike for Le 1,500.00 and a helmet for Le 60.00. Express the price of the helmet as a percentage of the price of the mountain bike.
2. Ask pupils to copy and solve the questions in their exercise books.

Closing *(3 minutes)*

1. Invite 3 pupils to the board together to write their solutions to the practice exercises. Other pupils should check their work.
   Solutions:
   a. $\frac{12}{50} \times 100\% = 12 \times 2\% = 24\%$
   b. Convert 3 m to cm: $3 \text{ m}. \times \frac{100 \text{ cm}}{1 \text{ m}} = 300 \text{ cm}$
      Find 240 cm as a percentage of 300 cm: $\frac{240}{300} \times 100 = \frac{240}{3} = 80\%$
   c. $\frac{60}{1{,}500} \times 100 = \frac{60}{15} = 4\%$
2. For homework, have pupils do the practice activity PHM1-L008 in the Pupil Handbook.

Lesson Title: Percentage change	Theme: Numbers and Numeration	
Lesson Number: M1-L009	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to calculate percentage increase and decrease (including word problems).	**Preparation** None	

Opening (*4 minutes)*

1. Read this story: I collected Le 50,000.00 this morning and spent 10% of this amount on transportation to school. Can someone tell me how much is left?
2. Allow the pupils to think carefully, then ask volunteers to describe how to solve the problem. (Answer: Calculate 10% of Le 50,000.00. Then, subtract this amount from Le 50,000.00 to find the amount that is left.)
3. Ask pupils to solve the problem with seatmates.
4. Invite a volunteer to write the answer on the board. Two methods are shown below. Accept **one** method, and move on to Teaching and Learning.

   Method 1. Amount spent = $\frac{10}{100} \times 50{,}000 = \text{Le } 5{,}000.00$. Amount remaining = $50{,}000 - 5{,}000 = \text{Le } 45{,}000.00$

   Method 2. Percentage remaining = $100\% - 10\% = 90\%$. Amount remaining = $\frac{90}{100} \times 50{,}000 = \text{Le } 45{,}000.00$

5. Share with pupils that they are going to learn how to calculate percentage increase and decrease, including word problems.

Teaching and Learning *(20 minutes)*

1. Write the following questions on the board:
   a. The cost of petrol increased from Le 4,500.00 to Le 6,300.00 per litre. Calculate the percentage increase.
   b. A new health centre was built in a particular town and the number of babies dying per month decreased from 20 to 8. Calculate the percentage decrease.
2. Explain:
   - Percentage change is all about comparing old to new values.
   - We express the change in quantity as a fraction of the original quantity and then multiply by 100.
   - It is important to note that, when the new value is greater than the old value, it is percentage increase. Otherwise it is a decrease.
3. Write on the board: $\text{percentage change } = \frac{\text{change in quantity}}{\text{original quantity}} \times 100$
4. Solve question a. on the board:
   Change in quantity: $6{,}300 - 4{,}500 = Le\ 1{,}800.00$

Percentage increase = $\frac{1,800}{4,500} \times 100 = 40\%$

5. Ask a volunteer to give the change in quantity in question b. above. (Answer: $20 - 8 = 12$).
6. Solve on the board: Percentage decrease = $\frac{12}{20} \times 100 = 60\%$
7. Explain: We can also find the amount of a quantity after a given percentage increase or decrease.
8. Write on the board:
   a. Increase a length of 80 cm by 30%.
   b. A book cost Le 90,000.00 last week. This week, the price decreased by 10%. What is the price now?
9. Explain:
   - One hundred is always considered as the original value. When we increase, we add to 100 and when we decrease, we subtract from 100.
   - After adding or subtracting, divide by 100 and multiply by the original quantity.
10. Write the solution for question a. on the board:
    Solution:

$$\begin{aligned} \text{The new length} &= \frac{100+30}{100} \times 80 \text{ cm} \\ &= \frac{130}{100} \times 80 \text{ cm} \\ &= 104 \text{ cm} \end{aligned}$$

11. Ask pupils to work with seatmates to solve b. Support them as needed. (For example, remind them to **subtract** 10 from 100 instead of adding.)
12. Invite a volunteer to write the solution for question b. on the board:
    Solution:

$$\begin{aligned} \text{The new cost} &= \frac{100-10}{100} \times 90,000 \\ &= \frac{90}{100} \times 90,000 \\ &= Le\ 81,000.00 \end{aligned}$$

13. Write another problem on the board: A man bought a piece of land for Le 500,000.00. Ten years later, the value of the land had increased by 60%. Calculate the new value of the land.
14. Ask pupils to work with seatmates to solve the problem.
15. Invite a volunteer to solve the problem on the board:

$$\begin{aligned} \text{The new value} &= \frac{100+60}{100} \times 500,000 \\ &= \frac{160}{100} \times 500,000 \\ &= Le\ 800,000.00 \end{aligned}$$

Practice (*15 minutes)*

1. Write the following 3 problems on the board:
   d. A pair of socks increased from Le 5,000.00 to Le 6,000.00. What is the percentage change?
   e. There were 160 candies in the box yesterday, but now there are 116. What is the percentage change?
   f. Mohamed bought a book for Le 60,000.00. He sold it for 15% more than he paid for it. How much money did he sell it for?
2. Ask pupils to copy and solve the questions in their exercise books.
3. Invite 3 volunteers to the board to write their solutions to the practice exercises. Other pupils check their work.
   Solutions:
   a. Change in quantity: $6{,}000 - 5{,}000 = 1{,}000$;
      Percentage change: $\frac{1{,}000}{5{,}000} \times 100 = \frac{1}{5} \times 100 = 20\%$ increase
   b. Change in quantity: $160 - 116 = 44$
      Percentage change: $\frac{44}{160} \times 100 = 27.5\%$ decrease
   c. Selling price= $\frac{100+15}{100} \times 60,000 = \frac{115}{100} \times 60,000 = Le\ 690{,}000.00$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L009 in the Pupil Handbook.

Lesson Title: Real world use of fractions	**Theme:** Numbers and Numeration	
Lesson Number: M1-L010	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to solve real-life problems using fractions.	**Preparation** None	

Opening (*3 minutes)*

1. Write on the board: Solve $\frac{2}{3}+\frac{7}{12}-\frac{3}{4}$.
2. Allow pupils 1 minute to solve it on their own.
3. Invite 1 volunteer to solve the problem on the board. (Answer: $\frac{2}{3}+\frac{7}{12}-\frac{3}{4}=\frac{8}{12}+\frac{7}{12}-\frac{9}{12}=\frac{8+7-9}{12}=\frac{6}{12}=\frac{1}{2}$).
4. Share with pupils that they are going to learn how to solve real-life problems using fractions.

Teaching and Learning *(20 minutes)*

1. Ask pupils to give instances in which fractions are used in everyday life. Allow them to brainstorm for 2 minutes.
2. Explain:
   - In construction, a carpenter that wants to build a table might need to have it six feet two and a quarter inches long ($6'\ 2\ \frac{1}{4}''$).
   - In cooking, you need to measure things when you follow a recipe. You have half-cups, quarter of a teaspoon, and a whole bunch of other measurements.
   - Fractions can be used in science as it helps you in counting things. Let's say you are working with colonies of bacteria. You will need to count the numbers of different bacteria in a dish. You could get 6 of one species, 3 of another species, and 4 of a third species. As a fraction it can be $\frac{6}{13},\frac{3}{13}$ and $\frac{4}{13}$ in that dish.
3. Write the following problem on the board: If I wanted to make four times as much cake for my daughter's party, what could I do to find the amount of sugar needed if I know one recipe requires $1\frac{2}{3}$ cups of sugar?
4. Ask a volunteer in the class to explain how to solve the problem. (Answer: Multiply $1\frac{2}{3}\times 4$. We know this from the word "times" in the problem.)
5. Ask pupils to work with seatmates to solve the multiplication problem.
6. Invite a volunteer to write the solution on the board. (Answer: $1\frac{2}{3}\times 4=\frac{5}{3}\times 4=\frac{20}{3}=6\frac{2}{3}$ cups of sugar).

7. Write another problem on the board: You are driving along and see that your tank is only $\frac{3}{8}$ full. The tank holds 14 gallons of gas. Your car goes $22\frac{1}{2}$ miles for every gallon of gas. How far can you drive before you run out of gas?
8. Solve the problem together with the pupils:
   Step 1. Find how much gas you have:
   $\frac{3}{8} \times 14 = \frac{42}{8}$ gallons
   - Explain that this can be left as an improper fraction because it is not the final answer, and we will use it in the next step.

   Step 2. Find how far you can go with $\frac{42}{8}$ gallons.

   $$\begin{aligned} \frac{42}{8} \times 22\frac{1}{2} &= \frac{42}{8} \times \frac{45}{2} && \text{Multiply (gallons)} \times \text{(miles/gallon) to get miles} \\ &= \frac{21}{8} \times \frac{45}{1} && \text{Cancel 2} \\ &= \frac{21}{8} \times \frac{45}{1} \\ &= \frac{945}{8} = 118\frac{1}{8} \end{aligned}$$
9. Write another problem on the board: Martha spent $\frac{4}{9}$ of her salary on food and shopping. What fraction of her salary does she have left?
10. Ask volunteers to explain how to solve this problem. (Answer: Subtract the amount spent, $\frac{4}{9}$, from 1. The 1 represents Martha's whole salary.)
11. Ask pupils to work with seatmates to solve the problem.
12. Invite a volunteer to solve on the board. (Answer: $1 - \frac{4}{9} = \frac{9}{9} - \frac{4}{9} = \frac{5}{9}$).
13. Explain that she has $\frac{5}{9}$ of her salary left.

Practice (*13 minutes)*

1. Write the following 2 problems on the board:
   a. This weekend, I am planning on having a movie marathon with three of my favourite movies. Each of the movies lasts $1\frac{3}{4}$ hours. How much time will it take for me to watch all three movies?
   b. Sam had 120 teddy bears in his toy store. He sold $\frac{2}{3}$ of them at Le 12,000.00 each. How much money did he receive?
2. Ask pupils to solve the problems in their exercise books.
3. Ask them to check their answers with their seatmates if they finish working. Walk around to check for understanding and clear any misconceptions.

Closing *(4 minutes)*

1. Invite two pupils to the board together to write the answers to the practice problems. Ask other pupils to check their answers.

Solutions:

a. Multiply:

$$
\begin{aligned}
1\tfrac{3}{4} \times 3 &= \tfrac{7}{4} \times 3 \\
&= \tfrac{21}{4} \\
&= \tfrac{21}{4} \\
&= 5\tfrac{1}{4} \text{ hours}
\end{aligned}
$$

I will take 5 hrs. 15 minutes to watch the three movies.

b. Multiply to find the number of teddy bears sold:

$$
\begin{aligned}
\tfrac{2}{3} \times 120 &= \tfrac{2\times 120}{3} \\
&= \tfrac{240}{3} \\
&= 80 \text{ teddy bears}
\end{aligned}
$$

Multiply by the price of each bear to find the amount received:

$$80 \times Le\ 12{,}000.00 \quad = \quad Le\ 960{,}000.00$$

Sam received Le 960,000.00.

2. For homework, have pupils do the practice activity PHM1-L010 in the Pupil Handbook.

Lesson Title: Real world use of decimals	**Theme:** Numbers and Numeration	
Lesson Number: M1-L011	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to: solve real-life problems using decimals.	**Preparation** None	

Opening (*3 minutes)*

1. Write the following problem on the board: John has $\frac{1}{2}$ cup of sugar, and his brother gave him $\frac{1}{4}$ cup more. How much sugar did he have in all?
2. Allow pupils 1 minute to solve the problem on their own.
3. Invite a volunteer to solve the problem on the board. (Answer: $\frac{1}{2}+\frac{1}{4}=\frac{2}{4}+\frac{1}{4}=\frac{3}{4}$).
4. Share with the pupils that they are going to learn real-life problems using decimals.

Teaching and Learning *(20 minutes)*

1. Ask pupils to give instances in which decimals are used in everyday life. Allow them to brainstorm for 2 minutes.
2. Explain:
   - These are some of the ways that we can find decimals in real-life situations.
     - When measuring weight on scales, especially the digital ones. (Example: 3.46 kg)
     - Prices are sometimes given with Leones and cents. (Example: Le 5.50)
     - Report cards, especially when showing average grades. (Example: 58.4%)
     - Medical doctors use decimals often. (Example: reading the patient's temperature or measuring their weight)
3. Write the following problem on the board: If 4 mangos weigh 1.2 kg, what is the weight of 10 mangos?
4. Ask volunteers to explain how to solve the problem. Encourage them to share ideas.
5. Explain: We first divide 1.2 by 4 to find the weight of each mango. We then multiply the result by 10 to find the weight of 10 mangos.
6. Solve the problem on the board together with pupils.

   Step 1. Find the weight of 1 mango:

   $1.2 \div 4 = 0.3$ kg →

   $$\begin{array}{r} 0\,.\,3 \\ 4\overline{)1\,.\,2} \\ -\ 1\ \ 2 \\ \hline 0 \end{array}$$

   Step 2. Find the weight of 10 mangos:

   $10 \times 0.3 = 3$ kg

7. Write another problem on the board: Bentu's child has a temperature of 38.7°C. Normal body temperature is 37°C. How much should the child's temperature be reduced to be normal?
8. Ask volunteers to explain how to solve the problem. Encourage them to share ideas. (Answer: Subtract normal body temperature from the child's temperature to find the difference.)
9. Solve the problem on the board together with pupils:

$38.7 - 37 = 1.7$ →
$$\begin{array}{r} 38.7 \\ -\ 37.0 \\ \hline 1.7 \end{array}$$

10. Write another problem on the board: There are two Maths books. The book Best Maths is in a pile of 4, which weighs 2.6 kg in total. The book Easy Maths is in a pile of 6, which weighs 3.6 kg in total. Which book is heavier?
11. Ask volunteers to explain how to solve the problem. Encourage them to share ideas. (Answer: Divide each total weight by the number of books in the pile. This gives the individual weight of each book. Then, compare them.)
12. Solve the problems on the board together with pupils (see division below):

    Best Maths: $2.6 \div 4 = 0.65$ kg

    Easy Maths: $3.6 \div 6 = 0.6$ kg

$$\begin{array}{r} 0.65 \\ 4 \overline{)\,2.60} \\ -\ 2\ 4 \\ \hline 20 \\ -\ 20 \\ \hline 0 \end{array} \qquad \begin{array}{r} 0.6 \\ 6 \overline{)\,3.6} \\ -\ 3\ 6 \\ \hline 0 \end{array}$$

13. Ask a volunteer to choose which is heavier and explain why. (Answer: Best Maths is heavier, because $0.65 > 0.6$.)
14. Write the following problem on the board: Mohamed owns a bakery. Each day, he uses 12.5 kg flour.
    a. How much flour does he use in 1 week?
    b. If flour costs Le 15, 000.00 per kg, how much does he spend on flour in 1 week?
15. Ask volunteers to explain how to solve the problem. Encourage them to share ideas. (Answers: For part a., multiply the number of days by the amount he uses in 1 day. For part b., multiply the number of kg he needs by the cost per kg.)
16. Ask pupils to work with seatmates to solve the problem.
17. Invite 2 volunteers to come to the board and solve parts a. and b., and explain their answers

    Solutions and explanations:

    a. Multiply the amount per day by 7 days: $12.5 \times 7 = 87.5$ kg

$$\begin{array}{rrr} ^{1} & ^{3} & \\ 1 & 2. & 5 \\ \times & & 7 \\ \hline 8 & 7. & 5 \end{array}$$

b. Multiply the amount of flour he uses by the cost per kg: $87.5 \times 15{,}000$
   Note that for the multiplication, we can remove zeros from 15,000 and write them in the answer after solving:

$$\begin{array}{rrrrr} & & ^{3} & ^{2} & \\ & & 8 & 7 & 5 \\ & \times & & 1 & 5 \\ \hline & 4 & 3 & 7 & 5 \\ + & 8 & 7 & 5 & \\ \hline 1 & 3 & 1 & 2 & 5 \end{array}$$

   Put the zeros back: 13125000
   There is 1 decimal place (in 87.5). Write it in the answer: 1312500.0
   Answer: Mohamed spends Le 1,312,500.00 on flour each week.

Practice (*15 minutes)*

1. Write the following two problems on the board:
   a. A newborn baby weighs 6.5 pounds. He gains an average of 1.2 pounds each week for the first 3 weeks. How much does he weigh after 3 weeks?
   b. If 8 pawpaw weigh 3.6 kg. What is the weight of 15 pawpaw?
2. Allow pupils 10 minutes to solve the problems in their exercise books. If needed, discuss how to solve each problem as a class.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite two pupils to come to the board together and write their answers.
   Solutions:
   a. Weight gained: $3 \times 1.2 = 3.6$ pounds
      Weight after 3 weeks: $6.5 + 3.6 = 10.1$ pounds

$$\begin{array}{rr} 1. & 2 \\ \times & 3 \\ \hline 3. & 6 \end{array} \qquad\qquad \begin{array}{rrrr} & ^{1} & & \\ & 6 & . & 5 \\ + & 3 & . & 6 \\ \hline 1 & 0 & . & 1 \end{array}$$

   b. Divide to find the weight of each pawpaw: $3.6 \div 8 = 0.45$ kg
      Multiply to find the weight of 15 pawpaw: $0.45 \times 15 = 6.75$ kg

$$\begin{array}{r|l} & 0\,.\,4\,5 \\ \hline 8 & 3\,.\,6\,0 \\ - & 3\,2 \\ \hline & 4\,0 \\ & -4\,0 \\ \hline & 0 \end{array}$$

$$\begin{array}{rrrr} & & {}^{2} & \\ & & 4 & 5 \\ & \times & 1 & 5 \\ \hline & 2 & 2 & 5 \\ + & 4 & 5 & \\ \hline & 6 & 7 & 5 \end{array}$$

Closing *(2 minutes)*

1. Ask pupils to write down 2 ways they use decimals in real life situations.
2. Ask volunteers to share their ideas with the class if there is time.
3. For homework, have pupils do the practice activity PHM1-L011 in the Pupil Handbook.

Lesson Title: Approximation of whole numbers	**Theme:** Numbers and Numeration	
Lesson Number: M1-L012	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcomes By the end of the lesson, pupils will be able to round numbers up to tens, hundreds, thousands, millions, billions and trillions.	**Preparation** Write the numbers in Opening and the table in Practice on the board.	

Opening (*2 minutes)*

1. Review place value system with pupils. Write the following numbers on the board with the given digits underlined: **4**56, **6**001, 76**5**9.
2. Ask pupils to write the place value of the underlined numbers in their exercise books.
3. Ask 3 volunteers to give their answers (Answer: 4: hundreds; 6: thousands; 5: tens).
4. Share with the pupils that they are going to learn how to round numbers up to tens, hundreds, thousands, millions, billions and trillions.

Teaching and Learning *(20 minutes)*

1. Explain:
   - Rounding makes numbers easier to work with.
   - The place of the digits is important in rounding up.
   - In the case of rounding up to the nearest tens, the ones place is of particular importance.
   - If the digit in the ones place is between 0 and 4, round down to the nearest ten.
   - If the digit in the ones place is between 5 and 9, round up to the nearest ten.
   - Other digits follow the same rule. Look at the digit to the right of the number whose place you want to round up to. If this digit is 0-4, round down. If it is 5-9, round up; i.e. take it as 1 and add to the next digit before it.
2. Write the following problem on the board: Round 2,547 cm:
   a. To the nearest 10 cm b. to the nearest 100 cm c. to the nearest 1000 cm.
3. Ask a volunteer which number is in the tens place in 2,547? (Answer: 4).
4. Ask pupils to look at the digit in the ones place.
5. Discuss: When rounding up to the nearest 10 cm, will we round up or down? (Answer: the last unit is 7, which is greater than 5 so we round up.)
6. Ask a volunteer to round the number to the nearest 10cm. (Answer: $2{,}547 \text{ cm} = 2{,}550 \text{ cm}$ to the nearest ten).
7. Ask volunteers to describe how to round b. (Answer: The tens unit is 4, which is less than 5. Therefore, to round to the nearest 100 we round **down**. Replace the tens and ones digits with zeros.)

8. Invite a volunteer to write the answer on the board. (Answer: $2{,}547\text{ cm} = 2{,}500\text{ cm}$ to the nearest 100 cm).
9. Ask pupils to work with seatmates to round c.
10. Ask a volunteer to explain how to round c. and write the answer on the board. (Answer: The hundreds digit is 5, so we round **up**. Increase the thousands digit by 1 and replace the last three digits by zeros. $2{,}547\text{ cm} = 3{,}000\text{ cm}$ to the nearest 1000cm).
11. Explain:
    - The following words are related to rounding numbers: estimate, roughly, approximately, close enough, around.
    - Rounded numbers are easier to remember and to use.
12. Write another problem on the board: Approximate $7{,}852{,}785$ to the nearest million.
13. Ask volunteers to explain how to solve this problem. Allow discussion. (Answer: 8 is the digit in the hundred thousands place, which is greater than 5. Round up by adding 1 to the 7 in the millions place. The remaining numbers are replaced with zeros.)
14. Invite a volunteer to come to the board and write out the answer. (Answer: $7{,}852{,}785 = 8{,}000{,}000$ to the nearest million).
15. Write another problem on the board: Round $1{,}036{,}478{,}244$ to the nearest billion.
16. Ask pupils to work with seatmates to round the number to the nearest billion.
17. Ask volunteers to explain their answer and write the answer on the board. (Answer: 0 is the digit in the hundred millions column, so we round down and replace all the other numbers with zeros; $1{,}036{,}478{,}244 = 1{,}000{,}000{,}000$ to the nearest billion).

Practice (*15 minutes)*

1. Write on the board: Round each number in the table to the given numbers of places:

Number	To the Nearest Ten	To the Nearest Hundred	To the Nearest Thousand	To the Nearest Million	To the Nearest Billion	To the Nearest Trillion
76		X	X	X	X	X
604			X	X	X	X
5,876				X	X	X
2,628,547					X	X
1,809,725,116						X
4,874,700,396,259						

2. Ask the pupils to copy and complete the table in their exercise books.
3. Explain that they should fill each empty box. Boxes with X do not need to be filled. If needed, write a few answers in the table so pupils understand.
4. After 10 minutes, invite several volunteers to come to the board together and write the answers in the table.

Answers:

Number	To the Nearest Ten	To the Nearest Hundred	To the Nearest Thousand	To the Nearest Million	To the Nearest Billion	To the Nearest Trillion
76	80	X	X	X	X	X
604	600	600	X	X	X	X
5,876	5,880	5,900	6,000	X	X	X
2,628,547	2,628,550	2,628,500	2,629,000	3,000,000	X	X
1,809,725,116	1,809,725,120	1,809,725,100	1,809,725,000	1,810,000,000	2,000,000,000	X
4,874,700,396,259	4,874,700,396,260	4,874,700,396,300	4,874,700,396,000	4,874,700,000,000	4,875,000,000,000	5,000,000,000,000

Closing *(3 minutes)*

1. Briefly review the approximation of numbers. Read the problems below aloud. Ask pupils to write the answers down in their exercise books:
   a. Round 756 to the nearest ten.
   b. Round 13,146 to the nearest thousand.
   c. Round 4,261,900 to the nearest ten thousand.
2. Ask pupils to hold their answers up to show you before leaving class. Check for understanding. (Answers: a. 760; b. 13,000; c. 4,260,000)
3. For homework, have pupils do the practice activity PHM1-L012 in the Pupil Handbook.

Lesson Title: Approximation in everyday life	**Theme:** Numbers and Numeration	
Lesson Number: M1-L013	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to round numbers in everyday life.	**Preparation** Write the problem in Opening on the board.	

Opening (*3 minutes)*

1. Write the following problem on the board: Approximate the number 7,568 to the nearest ten, hundred and thousand.
2. Ask pupils to quickly write the answers in their books.
3. Ask 3 volunteers to call out their answers one at a time. (Answer: 7,568 to the nearest ten is 7,570; to the nearest hundred is 7,600; and to the nearest thousand is 8,000).
4. Share with pupils that they are going to learn how to round up numbers in everyday life.

Teaching and Learning *(20 minutes)*

1. Ask pupils to give different ways they can approximate numbers in real life. Allow them to brainstorm for 2 minutes.
2. Explain:
    - Sometimes, you may find it helpful to know, roughly, the answer to a sum.
    - You may be in a shop, and want to know broadly what you're going to have to pay.
    - You may need to know roughly how much money you need to cover a couple of bills.
    - You may also want to know what the right answer to a more complicated calculation is likely to be, approximately, to check that your detailed work is correct.
3. Write the following problem on the board: You want to buy five watches that cost Le 203,500.00 each. When you go to buy them the cost is Le 1,217,500.00. Is that right?
4. Explain: We will round 203,500 to a whole number that is easy to multiply in our heads. Round it to the nearest 100 thousand and use this amount: Le 200,000.00.
5. Ask volunteers to explain: What is the **estimate** of the five watches if each cost is Le 203,500? (Answer: Five watches at Le 203,500.00 each is about 5 times 200,000, or about Le 1,000,000.00.)
6. Explain:

- The estimated cost is much cheaper than the actual cost at the shop. The shop owner charged Le 1,217,500.00, which is more than 5 times the cost of each watch.
- With rounding, we can quickly understand that the cost is not correct.

7. Explain:
   - Estimation involves rounding, and can be considered as "slightly better than an educated guess".
   - Estimation is finding a number that is close enough to the right answer. In everyday life, when we do not need to have an exact calculation, we can save time by estimating.
   - When estimating, always round the given numbers first. Then perform the calculation.
8. Write on the board: You want to plant a row of flowers. The row is 58.3 cm long. The plants should be 6 cm apart. How many flower plants do you need?
9. Solve the problem on the board together with the pupils:
   Step 1. Round 58.3 to the nearest ten: $58.3 \rightarrow 60$
   Step 2. Divide the total distance by the distance between each plant: $60 \div 6 = 10$
   Answer: 10 plants is enough.
10. Write another problem on the board: You want to cover the floor of a rectangular room. You want to quickly find the area before going to the market. If the room is 4.1 metres long and 2.75 metres wide, estimate the area of the room.
11. Ask volunteers to explain how to solve the problem. Allow discussion. (Answer: Round the length and width, and use the rounded values to find an estimate of the floor's area. Multiply length times width.)
12. Write the formula for area of a rectangle on the board: $A = l \times w$
13. Ask pupils to solve the problem with seatmates.
14. Invite a volunteer to write the solution on the board and explain.
    Solution:
    Step 1. Round the values: $4.1 \rightarrow 4\text{ m}$ and $2.75 \rightarrow 3\text{ m}$
    Step 2. Calculate area: $A = 4 \times 3 = 12\text{ m}^2$
15. Explain:
    - The area of 12 m^2 is only an estimate.
    - Although it is not the exact figure, it will help us to buy enough material to cover the floor.

Practice (*15 minutes)*

1. Write the following 2 problems on the board:
   a. Three women started a business selling goods together in the market. In one week, the 3 women made Le 320,500.00, Le 290,000.00 and Le 185,000.00 in sales. Approximately how much money did they make in total?

b. Mrs. Bangura wants to build a fence around her yard. If her yard is 28.9 metres long and 21.5 metres wide, approximately how much fencing will she need?

2. Ask pupils to solve the problems in their exercise books.
3. Walk around and check their work for accuracy, and clear any misconceptions. Remind them of the formula for the perimeter of a rectangle if needed ($P = l + l + w + w$ or $P = 2l + 2w$).
4. Invite volunteers to come to the board and write the solutions.
   Solutions:
   a. Estimated values: $Le\ 300{,}000.00$, $Le\ 300{,}000.00$ and $Le\ 200{,}000.00$
      Calculation: $300{,}000 + 300{,}000 + 200{,}000 = Le\ 800{,}000.00$
   b. Estimated values: $30\ \mathrm{m}$ and $20\ \mathrm{m}$
      Calculation: $P = 2(30) + 2(20) = 60 + 40 = 100\ \mathrm{m}^2$

Closing *(2 minutes)*

1. Discuss: Which occupations come across “estimate” for work to be done? (Example answers: builder, plumber, mechanic, or other tradesperson).
2. For homework, have pupils do the practice activity PHM1-L013 in the Pupil Handbook.

Lesson Title: Conversion from any other base to base ten	**Theme:** Number and Numeration	
Lesson Number: M1-L014	**Class:** SSS1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to convert from any other base to base 10.	**Preparation** None	

Opening *(3 minutes)*

1. Write on the board: 2134
2. Ask pupils to work with seatmates to expand it according to the place value system.
3. Invite a volunteer to write the answer on the board. (Answer: $2 \times 1000 + 1 \times 100 + 3 \times 10 + 4 \times 1$)
4. Explain that today's lesson is on conversion from any other base to base ten.

Teaching and Learning *(25 minutes)*

1. Explain:
   - Numbers are usually written in base 10, like the example on the board.
   - Numbers can also be written in other bases. For example "base two", "base three", and so on.
2. Write on the board: 1101_{two} 213_{four}
3. Explain:
   - To indicate bases other than base 10, a subscript is added at the bottom right of the number, as in these examples.
   - Note that in any base, the highest digit is one less than the base. For example:
     - The highest digit in base two is 1. Base two has only two digits, 0 and 1.
     - The highest digit in base three is 2. Base three has only three digits, 0, 1, and 2.
4. Refer back to the example on the board.
5. Write 2134 with powers of 10 on the board: $2134 = (2 \times 10^3) + (1 \times 10^2) + (3 \times 10^1) + (4 \times 10^0)$
6. Follow this pattern to expand numbers in other bases.
7. Write on the board: 2112_{three}
8. Expand this number just like we did for the number in base ten.
9. Write on the board: $2112_{\text{three}} = (2 \times 3^3) + (1 \times 3^2) + (1 \times 3^1) + (2 \times 3^0)$
10. Explain:
    - To convert from any other base to base ten, first expand each digit. Each digit of the number must be converted using powers of the base you are converting from.

- The ones digit is multiplied by the base number to the power of 0. The powers on the base increase as you move to the left.

11. Write the following problem on the board: Convert 1101_{two} to base ten.
12. Write the number for each digit of 1101_{two} on the board:

$$\overset{3}{1}\ \overset{2}{1}\ \overset{1}{0}\ \overset{0}{1}$$

13. Write the expansion on the board with powers of 2: $1101_{two} = (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0)$
14. Show the simplification on the board:

$$\begin{aligned} 1101_{two} &= (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\ &= (1 \times 8) + (1 \times 4) + (0 \times 2) + (1 \times 1) \\ &= 8 + 4 + 0 + 1 \\ 1101_{two} &= 13_{\text{ten}} = 13 \end{aligned}$$

15. Write on the board: Convert 342_{eight} to base ten.
16. Ask pupils to work with seatmates to expand 342_{eight} using powers, where 8 is the base.
17. Invite a volunteer to write the expansion on the board. (Answer: $342_{\text{eight}} = (3 \times 8^2) + (4 \times 8^1) + (2 \times 8^0)$)
18. Ask pupils to work with seatmates to simplify.
19. Invite a volunteer to write the solution on the board:

$$\begin{aligned} 342_{\text{eight}} &= (3 \times 8^2) + (4 \times 8^1) + (2 \times 8^0) \\ &= (3 \times 64) + (4 \times 8) + (2 \times 1) \\ &= 192 + 32 + 2 \\ 342_{\text{eight}} &= 226_{\text{ten}} = 226 \end{aligned}$$

20. Write another problem on the board: Convert 11.001_{two} to base ten.
21. Explain: The numbers before the decimal point can be numbered from 0 upwards and the ones after the decimal point can be numbered from -1 downwards.
22. Write the number for each digit of 11.001_{two} on the board:

$$\overset{1}{1}\ \overset{0}{1}\ .\ \overset{-1}{0}\ \overset{-2}{0}\ \overset{-3}{1}$$

23. Solve the problem on the board together with pupils:
    Step 1. Expand the numbers: $(1 \times 2^1) + (1 \times 2^0) + (0 \times 2^{-1}) + (0 \times 2^{-2}) + (1 \times 2^{-3})$
    Step 2. Simplify the powers: $(1 \times 2) + (1 \times 1) + \left(0 \times \frac{1}{2}\right) + \left(0 \times \frac{1}{4}\right) + \left(1 \times \frac{1}{8}\right)$
    Step 3. Remove the brackets: $2 + 1 + 0 + 0 + \frac{1}{8}$
    Step 4. Write the result: $3\frac{1}{8} = 3.125$
24. Write another problem on the board: Convert 20.21_{three} to base ten.
25. Ask pupils to work with seatmates to write the expansion.
26. Invite a volunteer to write the expansion on the board. (Answer: $54.21_{\text{three}} = (2 \times 3^1) + (0 \times 3^0) + (2 \times 3^{-1}) + (1 \times 3^{-2})$)

27. Ask pupils to work with seatmates to simplify.
28. Invite a volunteer to write the solution on the board:

$$\begin{aligned} 20.21_{\text{three}} &= (2\times 3^1)+(0\times 3^0)+(2\times 3^{-1})+(1\times 3^{-2}) \\ &= (2\times 3)+(0\times 1)+(2\times \tfrac{1}{3})+(1\times \tfrac{1}{9}) \\ &= 6+0+\tfrac{2}{3}+\tfrac{1}{9} \\ &= 6+\tfrac{6}{9}+\tfrac{1}{9} \\ 20.21_{\text{three}} &= 6\tfrac{7}{9} = 6.78 \end{aligned}$$

Practice *(11 minutes)*

1. Write the following two problems on the board:
   a. Convert 4023_{six} to base ten.
   b. Convert 12.04_{five} to base ten.
2. Ask pupils to solve the problems individually.
3. Invite volunteers to come to the board and write their solutions. All other pupils should check their work.

   Solutions:

   a.

$$\begin{aligned} 4023_{\text{six}} &= (4\times 6^3)+(0\times 6^2)+(2\times 6^1)+(3\times 6^0) \\ &= (4\times 216)+(0\times 36)+(2\times 6)+(3\times 1) \\ &= 864+0+12+3 \\ 4023_{\text{six}} &= 879_{\text{ten}} = 879 \end{aligned}$$

   b.

$$\begin{aligned} 12.04_{\text{five}} &= (1\times 5^1)+(2\times 5^0)+(0\times 5^{-1})+(4\times 5^{-2}) \\ &= (1\times 5)+(2\times 1)+\left(0\times \tfrac{1}{5}\right)+\left(4\times \tfrac{1}{25}\right) \\ &= 5+2+0+\tfrac{4}{25} \\ 12.04_{\text{five}} &= 7\tfrac{4}{25} = 7.16 \end{aligned}$$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L014.

Lesson Title: Conversion from base 10 to any other bases	**Theme:** Numbers and Numeration	
Lesson Number: M1-L015	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to convert numbers from base 10 to any other base.	**Preparation** None	

Opening *(2 minutes)*

1. Ask a pupil to explain in his/her own words the steps involved in converting other bases to base ten. (Answer: First expand the number using powers of the base you are converting from, and then simplify.)
2. Explain that today's lesson is on conversion from base ten to other bases.

Teaching and Learning *(20 minutes)*

1. Write on the board:
   a. Convert 30_{ten} to base four
   b. Convert 226_{ten} base eight
2. Explain:
   a. To convert from base ten to any other base, repeatedly divide the base ten number by the base you are converting to.
      - As you divide, write down the remainder at each stage of the division.
      - Continue dividing until nothing is left. That is when it gets to zero.
      - The answer is obtained by reading the remainders upwards.
3. Solve problem a. on the board, explaining each step:

$4 \mid 30$	Divide 30 by 4, write the answer (7 rem 2) on the next line
$7\ rem\ 2$	Divide 7 by 4, write the answer (1 rem 3) on the next line
$1\ rem\ 3$	Divide 1 by 4, write the answer (0 rem 1) on the next line
$0\ rem\ 1$	
$30_{\text{ten}} = 132_{\text{four}}$	Read the remainders upwards, and write it in base 4.

4. Solve problem b. on the board. Ask volunteers to describe each step before doing it:

$$\begin{array}{r|l} 8 & 226 \\ \hline & 28\ rem\ 2 \\ \hline & 3\ rem\ 4 \\ \hline & 0\ rem\ 3 \\ \hline \end{array}$$

$$226_{\text{ten}} = 342_{\text{eight}}$$

5. Write another example on the board: Convert 105 to base two.
6. Remind pupils that when numbers are not written with any base, they are actually in base 10.
7. Solve it on the board. Ask volunteers to describe each step before doing it:

$$\begin{array}{r|l} 2 & 105 \\ \hline & 52\ rem\ 1 \\ \hline & 26\ rem\ 0 \\ \hline & 13\ rem\ 0 \\ \hline & 6\ rem\ 1 \\ \hline & 3\ rem\ 0 \\ \hline & 1\ rem\ 1 \\ \hline & 0\ rem\ 1 \\ \hline \end{array}$$

$$105_{\text{ten}} = 1101001_{\text{two}}$$

8. Write 2 more problems on the board:
   a. Convert 372_{ten} to base eight.
   b. Convert 431 to base 3.
9. Ask pupils to solve the problems with seatmates.
10. Invite volunteers to write the solutions on the board. All other pupils should check their work.

    Solutions:

a.

$$\begin{array}{r|l} 8 & 372 \\ \hline & 46\ rem\ 4 \\ \hline & 5\ rem\ 6 \\ \hline & 0\ rem\ 5 \\ \hline \end{array}$$

$$372_{\text{ten}} = 564_{\text{eight}}$$

b.

$$\begin{array}{r|l} 3 & 431 \\ \hline & 143\ rem\ 2 \\ \hline & 47\ rem\ 2 \\ \hline & 15\ rem\ 2 \\ \hline & 5\ rem\ 0 \\ \hline & 1\ rem\ 2 \\ \hline & 0\ rem\ 1 \\ \hline \end{array}$$

$$431_{\text{ten}} = 120222_{\text{three}}$$

Practice *(13 minutes)*

1. Write 3 problems on the board:
   a. Convert 29 to base two.
   b. Convert 206 to base five.
   c. Convert 904 to base four.
2. Ask pupils to solve the problems independently in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.

Closing *(5 minutes)*

1. Review the three questions given in the practice section.
2. Invite 3 pupils to write out their solutions together on the board. All other pupils should check their work.

   Solutions:

   a.
$$\begin{array}{r|l} 2 & 29 \\ \hline & 14\ rem\ 1 \\ \hline & 7\ rem\ 0 \\ \hline & 3\ rem\ 1 \\ \hline & 1\ rem\ 1 \\ \hline & 0\ rem\ 1 \\ \hline \end{array}$$

$$29_{\text{ten}} = 11101_{\text{two}}$$

   b.
$$\begin{array}{r|l} 5 & 206 \\ \hline & 41\ rem\ 1 \\ \hline & 8\ rem\ 1 \\ \hline & 1\ rem\ 3 \\ \hline & 0\ rem\ 1 \\ \hline \end{array}$$

$$206_{\text{ten}} = 1311_{\text{five}}$$

   c.
$$\begin{array}{r|l} 4 & 904 \\ \hline & 226\ rem\ 0 \\ \hline & 56\ rem\ 2 \\ \hline & 14\ rem\ 0 \\ \hline & 3\ rem\ 2 \\ \hline & 0\ rem\ 3 \\ \hline \end{array}$$

$$904_{\text{ten}} = 32020_{\text{four}}$$

3. For homework, have pupils do the practice activity PHM1-L015 in the Pupil Handbook.

Lesson Title: Practice conversion between bases	**Theme:** Numbers and Numeration	
Lesson Number: M1-L016	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to convert from one base to another base.	**Preparation** None	

Opening *(6 minutes)*

1. Write two review questions on the board:
    a. Convert 49_{ten} to base five.
    b. Convert 213_{four} to base ten.
2. Ask pupils to work with seatmates to find the solutions.
3. Invite two volunteers to come to the board to write the solutions.
   Solutions:

a.
$$\begin{array}{r|l} 5 & 49 \\ \hline & 9\ rem\ 4 \\ \hline & 1\ rem\ 4 \\ \hline & 0\ rem\ 1 \\ \hline \end{array} \uparrow$$

$$49_{\text{ten}} = 144_{\text{five}}$$

b.
$$\begin{aligned} 213_{\text{four}} &= (2\times 4^2)+(1\times 4^1)+(3 \times 4^0) \\ &= (2\times 16)+(1\times 4)+(3\times 1) \\ &= 32+4+1 \\ 213_{\text{four}} &= 37_{\text{ten}} \end{aligned}$$

4. Explain that today's lesson is on conversion from one base to any other base.

Teaching and Learning *(20 minutes)*

1. Write this question on the board: Convert 324_{five} to base three.
2. Explain:
    - To convert from one base to another, follow these steps:
        - Step I: Convert the given base to base ten.
        - Step II: Convert your answer in base ten to the required base.
3. Ask volunteers to give the 2 steps to solve the problem on the board. (Answer: Convert 324_{five} to base 10, then convert the result to base 3.)
4. Solve the problem on the board and explain each step:
   Step 1. Convert to base 10:

$$\begin{aligned} 324_{\text{five}} &= (3\times 5^2)+(2\times 5^1)+(4\times 5^0) \\ &= (3\times 25)+(2\times 5)+(4\times 1) \\ &= 75+10+4 \\ 324_{\text{five}} &= 89_{\text{ten}} \end{aligned}$$

Step 2. Convert the result to base 3:

$$\begin{array}{r|l} 3 & 89 \\ \hline & 29\ rem\ 2 \\ \hline & 9\ rem\ 2 \\ \hline & 3\ rem\ 0 \\ \hline & 1\ rem\ 0 \\ \hline & 0\ rem\ 1 \\ \hline \end{array} \uparrow$$

$$324_{\text{five}} = 10022_{\text{three}}$$

5. Write another problem on the board: Convert 307_{eight} to base six.
6. Ask volunteers to describe the steps to solve the problem. (Answer: Convert 307_{eight} to base 10, then convert the result to base 6.)
7. Ask pupils to work with seatmates to solve the problem. Walk around and support them as needed.
8. Invite a volunteer to come to the board and complete step 1: convert 307_{eight} to base ten.
   Solution:

$$\begin{aligned} 307_{\text{eight}} &= (3 \times 8^2) + (0 \times 8^1) + (7 \times 8^0) \\ &= (3 \times 64) + (0 \times 8) + (7 \times 1) \\ &= 192 + 0 + 7 \\ 307_{\text{eight}} &= 199 \end{aligned}$$

9. Invite another volunteer to come to the board to convert the answer to base six.
   Solution:

$$\begin{array}{r|l} 6 & 199 \\ \hline & 33\ rem\ 1 \\ \hline & 5\ rem\ 3 \\ \hline & 0\ rem\ 5 \\ \hline \end{array} \uparrow$$

$$307_{\text{eight}} = 531_{\text{six}}$$

10. Write the answer on the board: $307_{\text{eight}} = 531_{\text{six}}$
11. Write another problem on the board: Convert 1221_{three} to base five.
12. Ask pupils to work with seatmates to solve the problem. Walk around and support them as needed.
13. Invite a volunteer to come to the board and complete step 1: convert 1221_{three} to base ten.

Solution:

$$\begin{aligned} 1221_{\text{three}} &= (1\times 3^3)+(2\times 3^2)+(2\times 3^1)+(1 \\ &\qquad \times 3^0) \\ &= (1\times 27)+(2\times 9)+(2\times 3)+(1\times 1) \\ &= 27+18+6+1 \\ 307_{\text{eight}} &= 52_{ten} \end{aligned}$$

14. Invite another volunteer to come to the board to convert 52_{ten} to base 5.
    Solution:

$$\begin{array}{r|l} 5 & 52 \\ \hline & 10\ rem\ 2 \\ \hline & 2\ rem\ 0 \\ \hline & 0\ rem\ 2 \\ \hline \end{array} \uparrow$$

$$1221_{\text{three}} = 202_{\text{five}}$$

Practice *(10 minutes)*

1. Write the following 2 problems on the board:
    a. Convert 11111_{two} to base six
    b. Convert 501_{six} to base eight
2. Ask pupils to solve the problems independently in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.

Closing *(4 minutes)*

1. Review the questions given in the practice section.
2. Ask 4 pupils to write out each step of the solutions on the board. All other pupils should check their work.
   Solutions:
   a. **Step 1.** Convert to base 10

$$\begin{aligned} 11111_{\text{two}} &= (1\times 2^4)+(1\times 2^3)+(1\times 2^2)+(1\times 2^1)+(1 \\ &\qquad \times 2^0) \\ &= (1\times 16)+(1\times 8)+(1\times 4)+(1\times 2)+(1\times 1) \\ &= 16+8+4+2+1 \\ 307_{\text{eight}} &= 31_{\text{ten}} \end{aligned}$$

Step 2. Convert 31_{ten} to base 6

$$\begin{array}{r|l} 6 & 31 \\ \hline & 5\ rem\ 1 \\ \hline & 0\ rem\ 5 \\ \hline \end{array}$$

$11111_{two} = 51_{\text{six}}$

b. **Step 1.** Convert to base 10

$$\begin{aligned} 501_{\text{six}} &= (5 \times 6^2) + (0 \times 6^1) + (1 \times 6^0) \\ &= (5 \times 36) + (0 \times 6) + (1 \times 1) \\ &= 180 + 0 + 1 \\ 501_{\text{six}} &= 181_{\text{ten}} \end{aligned}$$

Step 2. Convert to base 8

$$\begin{array}{r|l} 8 & 181 \\ \hline & 22\ rem\ 5 \\ \hline & 2\ rem\ 6 \\ \hline & 0\ rem\ 2 \\ \hline \end{array}$$

$501_{six} = 265_{\text{eight}}$

3. For homework, have pupils do the practice activity PHM1-L016 in the Pupil Handbook.

<table>
<tr><td>Lesson Title: Addition and subtraction of number bases</td><td colspan="2">Theme: Numbers and Numeration</td></tr>
<tr><td>Lesson Number: M1-L017</td><td>Class: SSS 1</td><td>Time: 40 minutes</td></tr>
<tr><td>Learning Outcome
By the end of the lesson, pupils will be able to perform addition and subtraction operations on number bases involving number bases other than base 10 including, binary numbers.</td><td colspan="2">Preparation
None</td></tr>
</table>

Opening *(4 minutes)*

1. Review Addition and Subtraction of base ten numerals. Write the following 2 problems on the board:

$$\text{a.}\quad \begin{array}{rrrr} & 8 & 4 & 7 \\ + & 3 & 9 & 6 \\ \hline \end{array} \qquad\qquad \text{b.}\quad \begin{array}{rrrrr} & 7 & 3 & 0 & 4 \\ - & 1 & 9 & 6 & 8 \\ \hline \end{array}$$

2. Ask pupils to solve the problems independently in their exercise books.
3. Invite 2 volunteers to write the solutions on the board. All other pupils should check their work.
   Solutions:

$$\text{a.}\quad \begin{array}{rrrr} & {}^{1}8 & {}^{1}4 & 7 \\ + & 3 & 9 & 6 \\ \hline 1 & 2 & 4 & 3 \end{array} \qquad\qquad \text{b.}\quad \begin{array}{rrrrr} & {}^{6}\cancel{7} & {}^{1}3 & {}^{7}\cancel{8} & {}^{1}4 \\ - & 1 & 9 & 6 & 8 \\ \hline & 5 & 4 & 1 & 6 \end{array}$$

4. Explain that today's lesson is on addition and subtraction of numbers in other bases.

Teaching and Learning *(25 minutes)*

1. Explain:
   - The method we use to add and subtract in base 10 is the same we use for other bases.
   - When "borrowing" care must be taken, that is, the number we borrow is equal to the number we are working in.
2. Write the following questions on the board:

$$\text{a.}\quad \begin{array}{rrrr} & 3 & 1 & 1_{\text{four}} \\ + & 2 & 1 & 3_{\text{four}} \\ \hline \end{array} \qquad\qquad \text{b.}\quad \begin{array}{rrrrrr} & 1 & 1 & 0 & 1 & 0_{\text{two}} \\ + & & 1 & 0 & 1 & 1_{\text{two}} \\ \hline \end{array}$$

3. Solve problem a. on the board, explaining each step, starting on the right side:
   Step 1. $1 + 3 = 4$, we have 1 four and no remainder. Write 0 underneath, carry 1.
   Step 2. $1 + 1 + 1 = 3$, write 3

$$\begin{array}{rrrr} {}^{1} & & {}^{1} & \\ & 3 & 1 & 1_{\text{four}} \\ + & 2 & 1 & 3_{\text{four}} \\ \hline 1 & 1 & 3 & 0_{\text{four}} \end{array}$$

Step 3. $3 + 2 = 5$, we have 1 four and remainder 1. Write 1 underneath and carry 1.
Step 4. Bring down the 1 you carried.

4. Solve problem b on the board, explaining each step:
Step 1. 0+1=1, write 1 underneath.
Step 2. 1+1=2, we have 1 two and no remainder, write 0 and carry 1.
Step 3. 1+0+0=1, write 1
Step 4. 1+1=2, we have 1 two and no remainder, write 0 and carry 1.
Step 5. Write 1 underneath.

$$\begin{array}{cccccc} & {}^{1} & {}^{1} & & {}^{1} & \\ & 1 & 1 & 0 & 1 & 0_{\text{two}} \\ + & & 1 & 0 & 1 & 1_{\text{two}} \\ \hline 1 & 0 & 0 & 1 & 0 & 1_{\text{two}} \end{array}$$

5. Write the following subtraction problem on the board: $314_{\text{five}} - 24_{\text{five}} =$
6. Solve the subtraction problem, explaining each step. Start on the right side of the equation:
Step 1. 4-4=0, write 0
Step 2. We have $1 - 2$. We need to borrow 1 from the next column and convert it to base we are working in. We borrow one 5 and add it to the 1. In the middle column we now have$5 + 1 - 2 = 4$. Write 4.
Step 3. The next column is 3-1=2. Write 2 underneath.

$$\begin{array}{cccc} & {}^{2}\cancel{3} & {}^{5+}1 & 4_{\text{five}} \\ - & & 2 & 4_{\text{five}} \\ \hline & 2 & 4 & 0_{\text{five}} \end{array}$$

7. Write another subtraction problem on the board: $11101_{\text{two}} - 1011_{\text{two}} =$
8. Ask volunteers to explain each step. As they explain, write the steps on the board.
Step 2. 1-1=0, write 0.
Step 2. We have 0-1. We need to borrow 1 from the next column and convert it to base two. We now have $2 + 0 - 1 = 1$. Write 1.
Step 3. We subtracted 1 from this column, so we are left with 0. We have $0 - 0 = 0$. Write 0.
Step 4. 1-1=0, write 0.
Step 5. Write 1 underneath.

$$\begin{array}{cccccc} & 1 & 1 & {}^{0}\cancel{1} & {}^{2+}0 & 1_{\text{two}} \\ - & & 1 & 0 & 1 & 1_{\text{two}} \\ \hline & 1 & 0 & 0 & 1 & 0_{\text{two}} \end{array}$$

9. Write one addition and one subtraction problem on the board:

a.
$$\begin{array}{cccc} & 1 & 4 & 4_{\text{six}} \\ + & 2 & 3 & 2_{\text{six}} \\ \hline \end{array}$$

b.
$$\begin{array}{cccc} & 4 & 4 & 3_{\text{five}} \\ - & 2 & 2 & 4_{\text{five}} \\ \hline \end{array}$$

10. Ask pupils to work with seatmates to solve the problems.
11. Invite two volunteers to come to the board and show the solutions:
Solutions: a. 420_{six} b. 214_{five}

a.
$$\begin{array}{cccc} & {}^{1} & {}^{1} & \\ & 1 & 4 & 4_{\text{six}} \\ + & 2 & 3 & 2_{\text{six}} \\ \hline & 4 & 2 & 0_{\text{six}} \end{array}$$

b.
$$\begin{array}{cccc} & 4 & {}^{3}\cancel{4} & {}^{5+}3_{\text{five}} \\ - & 2 & 2 & 4_{\text{five}} \\ \hline & 2 & 1 & 4_{\text{five}} \end{array}$$

Practice *(10 minutes)*

1. Write the following two problems on the board:
   a. Subtract: $1333_6 - 414_6$
   b. Evaluate $122_3 + 111_3 + 102_3$
2. Ask pupils to solve the problems individually.
3. Walk around to check for understanding and support them as needed. For example, tell them that in problem b. the 3 numbers can all be added vertically, as with base 10.
4. Invite volunteers to come to the board and write their solutions. All other pupils should check their work.

Solutions:

a.

$$\begin{array}{rrrrr} & {}^{0}\cancel{1} & {}^{6+}3 & {}^{2}\cancel{3} & {}^{6+}3_6 \\ - & & 4 & 1 & 4_6 \\ \hline & & 5 & 1 & 5_6 \end{array}$$

b.

$$\begin{array}{rrrrr} & {}^{1} & {}^{1} & {}^{1} & \\ & & 1 & 2 & 2_3 \\ & & 1 & 1 & 1_3 \\ & + & 1 & 0 & 2_3 \\ \hline & 1 & 1 & 1 & 2_3 \end{array}$$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L017 in the Pupil Handbook.

Lesson Title: Multiplication of number bases	**Theme:** Numbers and Numeration	
Lesson Number: M1-L018	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to perform the multiplication of numbers involving number bases other than base 10, including binary numbers.	**Preparation** None	

Opening *(4 minutes)*

1. Write the following multiplication problem with base ten numerals on the board: 324×13
2. Ask pupils to solve the problem in their exercise books.
3. Invite a volunteer to write the solution on the board:

$$\begin{array}{ccccc} & & & {\scriptstyle 1} & \\ & & 3 & 2 & 4 \\ \times & & & 1 & 3 \\ \hline & & 9 & 7 & 2 \\ + & 3 & 2 & 4 & \\ \hline & 4 & 2 & 1 & 2 \end{array}$$

4. Explain to the class that today's lesson is on the multiplication of numbers involving number bases other than base 10, including binary numbers.

Teaching and Learning *(20 minutes)*

1. Write the following questions on the board:
   a. $101_2 \times 11_2$
   b. $23_{\text{five}} \times 12_{\text{five}}$
   c. $121_{\text{three}} \times 22_{\text{three}}$
2. Explain: To multiply numbers in other bases, we follow a similar process as we did for numbers in base ten.
3. Solve the examples on the board for pupils to see.
4. Solve problem a. on the board, explaining each step, starting from the right side:

   Step 1. Multiply each digit in the top number (101) by the 1 on the right side of the bottom number.
   Step 2. Multiply each digit in the top number (101) by the 1 on the left side of the bottom number.
   Step 3. Add the result, following the rules for adding numbers in base 2.

$$\begin{array}{ccccc} & & 1 & 0 & 1_2 \\ \times & & & 1 & 1_2 \\ \hline & & 1 & 0 & 1 \\ + & 1 & 0 & 1 & \\ \hline & 1 & 1 & 1 & 1_2 \end{array}$$

5. Explain:
   - Multiplying numbers in base 2 is straightforward, because it does not involve carrying.

- Multiplying numbers in other bases requires carrying. It is more complicated.

6. Solve problem b. on the board, explaining each step, starting from the right side:

   Step 1. Multiply each digit in the top number (23) by the 2 on the right side of the bottom number:
   - $2 \times 3 = 6$, we have 1 five and remainder 1. Write 1 (the remainder) underneath and carry 1 five to the next column.
   - $2 \times 2 + 1 = 5$, we have 1 five and no remainder. Write 0 and carry 1.
   - Carry the 1 down.

$$
\begin{array}{ccccc}
 & {\scriptstyle 1} & {\scriptstyle 1} & \\
 & & 2 & 3_{\text{five}} \\
 & \times & 1 & 2_{\text{five}} \\
\cline{2-4}
 & 1 & 0 & 1 \\
+ & 2 & 3 & \\
\hline
 & 3 & 3 & 1_{\text{five}}
\end{array}
$$

   Step 2. Multiply each digit in the top number (23) by the 1 on the left side of the bottom number:
   - $3 \times 1 = 3$, write 3.
   - $2 \times 1 = 2$, write 2.

   Step 3. Add the numbers, as in the previous lesson.

7. Solve problem c on the board, explaining each step, starting from the right side:

   Step 1. Multiply each digit in the top number (121) by the 2 on the right side of the bottom number:
   - $1 \times 2 = 2$, write 2.
   - $2 \times 2 = 4$, we have 1 three remainder 1, write 1 and carry 1.
   - $1 \times 2 + 1 = 3$, we have 1 three and no remainder, write 0, carry 1.
   - Carry the 1 down.

$$
\begin{array}{cccccc}
 & & {\scriptstyle 1} & {\scriptstyle 1} & & \\
 & & & 1 & 2 & 1_{\text{three}} \\
 & & \times & & 2 & 2_{\text{three}} \\
\cline{3-6}
 & & 1 & 0 & 1 & 2 \\
+ & 1 & 0 & 1 & 2 & \\
\hline
 & 1 & 1 & 2 & 0 & 2_{\text{three}}
\end{array}
$$

   Step 2. Multiply each digit in the top number (121) by the 2 on the left side of the bottom number:
   - $1 \times 2 = 2$, write 2.
   - $2 \times 2 = 4$, we have 1 three remainder 1, write 1 and carry 1.
   - $1 \times 2 + 1 = 3$, we have 1 three and no remainder, write 0 and carry 1.
   - Carry the 1 down.

   Step 3. Add the numbers, as in the previous lesson.

8. Write two more examples on the board:
   a. $201_3 \times 2_3$
   b. $132_{\text{four}} \times 32_{\text{four}}$
9. Ask pupils to work with seatmates to solve the problems.
10. Invite two volunteers to come to the board and show the solutions:

a.

$$\begin{array}{rrrr} {}^{1} & & & \\ & 2 & 0 & 1_3 \\ \times & & & 2_3 \\ \hline 1 & 1 & 0 & 2 \end{array}$$

b.

$$\begin{array}{rrrrrr} & & {}^{1} & {}^{2} & {}^{1} & \\ & & & 1 & 3 & 2_4 \\ & & \times & & 3 & 2_4 \\ \hline & & & {}^{4+}3 & 3 & 0 \\ + & 1 & 1 & 2 & 2 & \\ \hline & 1 & 2 & 2 & 1 & 0_4 \end{array}$$

Practice *(15 minutes)*

1. Write the following 3 problems on the board:
   a. $423_5 \times 22_5$
   b. $1011_2 \times 11_2$
   c. $65_7 \times 41_7$
2. Ask pupil to solve the problems individually in their exercise books.
3. Invite two volunteers to come to the board one at a time to write their solutions.
   Solutions:

a.

$$\begin{array}{rrrrrr} & & & {}^{1} & {}^{1} & \\ & & & 4 & 2 & 3_5 \\ & & \times & & 2 & 2_5 \\ \hline & & 1 & 4 & 0 & 1 \\ + & 1 & 4 & 0 & 1 & \\ \hline & 2 & 0 & 4 & 1 & 1_5 \end{array}$$

b.

$$\begin{array}{rrrrrr} & & 1 & 1 & 0 & 1_2 \\ & & \times & & 1 & 1_2 \\ \hline & {}^{1} & 1 & 1 & 0 & 1 \\ + & 1 & 1 & 0 & 1 & \\ \hline 1 & 0 & 0 & 1 & 1 & 1_2 \end{array}$$

c.

$$\begin{array}{rrrrr} & & & 6 & 5_7 \\ & \times & & 4 & 1_7 \\ \hline & & & 6 & 5 \\ + & 3 & 5 & 6 & \\ \hline & 3 & 6 & 5 & 5_7 \end{array}$$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L018 in the Pupil Handbook.

Lesson Title: Division of number bases	**Theme:** Numbers and Numeration	
Lesson Number: M1-L019	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to perform the division of numbers involving number bases other than base 10, including binary numbers.	**Preparation** None	

Opening *(4 minutes)*

1. Write the following question on the board: Convert 1011_{two} to base ten.
2. Ask pupils to work on the problem in their exercise books.
3. Invite a volunteer to write the solution on the board:

   Solution:

$$\begin{aligned} 1{,}011_{\text{two}} &= (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= (1 \times 8) + (0 \times 4) + (1 \times 2) + (1 \times 1) \\ &= 8 + 0 + 2 + 1 \\ &= 11_{\text{ten}} \\ 1{,}011_{\text{two}} &= 11_{\text{ten}} \end{aligned}$$

4. Explain to the class that today, we are going to perform division of number bases including binary numbers.

Teaching and Learning *(20 minutes)*

1. Write the following problem on the board: $101010_{\text{two}} \div 111_{\text{two}}$
2. Explain the steps to solve this type of problem:
   - Convert the numbers to base ten.
   - Do the division in base ten.
   - Convert your final answer to base two.
3. Demonstrate these steps on the board for pupils to see.

   Step 1. Convert both numbers to base 10:

$$\begin{aligned} 101{,}010_{\text{two}} &= (1 \times 2^5) + (0 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) \\ &= (1 \times 32) + (0 \times 16) + (1 \times 8) + (0 \times 4) + (1 \times 2) + (0 \times 1) \\ &= 32 + 8 + 2 \\ &= 42_{\text{ten}} = 42 \\ 111_{\text{two}} &= (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= 4 + 2 + 1 \\ &= 7_{\text{ten}} = 7 \end{aligned}$$

   Step 2. Divide the numbers in base 10: $42 \div 7 = 6$

   Step 3. Convert the result to base 2: $6_{\text{ten}} = 110_{\text{two}}$ →

   Step 4. Write the answer: $101{,}010_{\text{two}} \div 111_{\text{two}} = 110_{\text{two}}$

$$\begin{array}{r|l} 2 & 6 \\ \hline & 3\ rem\ 0 \\ \hline & 1\ rem\ 1 \\ \hline & 0\ rem\ 1 \\ \hline \end{array}$$

4. Explain: We can also divide numbers in different bases.
5. Write the following problem on the board:
   If $302_{\text{four}} \div 1{,}010_{\text{two}} = \text{Q}_{\text{two}}$, find the value of Q.
6. Explain the steps to solve this type of problem:
   - Convert the numbers to base ten.
   - Do the division in base ten.
   - Convert the result to base 2, which is the base given for the answer.
7. Ask pupils to work with seatmates to convert both numbers in the problem to base 10.
8. Invite two volunteers to come to the board each to do the conversions to base ten.
   Solutions:

$$\begin{aligned} 302_{\text{four}} &= (3 + 4^2) + (0 \times 4^1) + (2 \times 4^0) \\ &= (3 \times 16) + (0 \times 4) + (2 \times 1) \\ &= 48 + 2 \\ &= 50_{\text{ten}} = 50 \\ 1010_{\text{two}} &= (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) \\ &= 8 + 2 \\ &= 10_{\text{ten}} = 10 \end{aligned}$$

9. Write the division on the board: $50 \div 10 = 5$
10. Ask pupils to work with seatmates to convert the result to base 2.
11. Invite a volunteer to write the solution on the board.
    Solution:

$$\begin{array}{r|l} 2 & 5 \\ \hline & 2\ rem\ 1 \\ \hline & 1\ rem\ 0 \\ \hline & 0\ rem\ 1 \\ \hline \end{array} \uparrow$$

$$5_{\text{ten}} = 101_{\text{two}}$$

12. Explain to pupils that in the problem, $Q = 101$
13. Write another problem on the board: Evaluate $1310_4 \div 10_2$. Give your answer in base 4.
14. Ask pupils to work with seatmates to solve the problem.
15. Invite volunteers to come to the board to write different parts of the solution.
    Solution:
    Convert to base 10:

$$\begin{aligned} 1{,}310_4 &= (1 + 4^3) + (3 + 4^2) + (1 \times 4^1) + (0 \times 4^0) \\ &= (1 \times 64) + (3 \times 16) + (1 \times 4) + (0 \times 1) \\ &= 64 + 48 + 4 \\ &= 116_{\text{ten}} = 116 \\ 10_{\text{two}} &= (1 \times 2^1) + (0 \times 2^0) \end{aligned}$$

$$= \quad 2$$
$$= \quad 2_{\text{ten}} = 2$$

Divide: $116 \div 2 = 58$

Convert to base 4:

$$\begin{array}{r|l} 4 & 58 \\ \hline & 14\ rem\ 2 \\ \hline & 3\ rem\ 2 \\ \hline & 0\ rem\ 3 \\ \hline \end{array} \uparrow$$

$$58_{\text{ten}} = 322_{\text{four}}$$

Therefore: $1{,}310_4 \ \div \ 10_2 = 322_{\text{four}}$

Practice *(15 minutes)*

1. Write the following two problems on the board:
   a. Evaluate $2402_5 \ \div 13_5$
   b. Evaluate $20211_3 \ \div \ 22_3$
2. Ask pupils to solve the problems individually in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.
4. After 10 minutes, invite two volunteers to go to the board simultaneously and write their answers. All other pupils check their own work.

   Solutions:

a.
$$\begin{aligned} 2{,}402_5 &= (2 \times 5^3) + (4 \times 5^2) + (0 \times 5^1) + (2 \times 5^0) \\ &= (2\times125) + (4\times25) + (0\times5) + (2\times1) \\ &= 250 + 100 + 0 + 2 \\ &= 352 \\ 13_5 &= (1 \times 5^1) + (3 \times 5^0) \\ &= 5 + 3 \\ &= 8 \end{aligned}$$

$$2{,}402_5 \ \div 13_5 = 352 \div 8 = 44$$

$$\begin{array}{r|l} 5 & 44 \\ \hline & 8\ rem\ 4 \\ \hline & 1\ rem\ 3 \\ \hline & 0\ rem\ 1 \\ \hline \end{array} \uparrow$$

Answer: $2{,}402_5 \ \div 13_5 = 134_5$

$$44_{\text{ten}} = 134_{\text{five}}$$

b.

$$
\begin{aligned}
20{,}211_3 &= (2 \times 3^4) + (0 \times 3^3) + (2 \times 3^2) + (1 \times 3^1) + (1 \times 3^0) \\
&= 162 + 0 + 18 + 3 + 1 \\
&= 184
\end{aligned}
$$

$$
\begin{aligned}
22_3 &= (2 \times 3^1) + (2 \times 3^0) \\
&= 6 + 2 \\
&= 8
\end{aligned}
$$

$184 \div 8 = 23$

$$
\begin{array}{r|l}
3 & 23 \\ \hline
 & 7\ rem\ 2 \\ \hline
 & 2\ rem\ 1 \\ \hline
 & 0\ rem\ 2 \\ \hline
\end{array}
$$

$23_{\text{ten}} = 212_{\text{three}}$

Answer: $20{,}211_3 \div 22_3 = 212_3$

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L019 in the Pupil Handbook.

Lesson Title: Basic equations involving number bases	**Theme:** Numbers and Numeration	
Lesson Number: M1-L020	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to solve basic equations involving number bases.	**Preparation** None	

Opening *(4 minutes)*

1. Write the following problem on the board: Convert 124_5 to a number in base three.
2. Ask pupils to solve the problem in their exercise books.
3. Invite 2 volunteers to write the 2 steps of the solution on the board.
   Solution:
   Step 1. Convert to base 10:
$$\begin{aligned} 124_5 &= (1 \times 5^2) + (2 \times 5^1) + (4 \times 5^0) \\ &= (1 \times 25) + (2 \times 5) + (4 \times 1) \\ &= 25 + 10 + 4 \\ 124_5 &= 39_{10} \end{aligned}$$
   Step 2. Convert the result to base 3:
$$\begin{array}{r|l} 3 & 39 \\ \hline & 13 \; rem \; 0 \\ \hline & 4 \; rem \; 1 \\ \hline & 1 \; rem \; 1 \\ \hline & 0 \; rem \; 1 \\ \hline \end{array} \uparrow$$
$$124_5 = 39_{10} = 1110_3$$
4. Explain to pupils that today's lesson is on solving basic equations involving number bases.

Teaching and Learning *(20 minutes)*

1. Write the following problem on the board: If $25_x = 17_{10}$, find the value of x.
2. Explain:
   - When you are given equations involving number bases to solve, change the base on both sides of the equation to base ten. Then you will have an equation to solve for x.
   - In this problem, the right-hand side is already in base 10.
3. Solve the problem on the board, explaining each step:
   Step 1. Convert 25_x from base x to base ten on the board, leaving it equal to 17:
$$\begin{aligned} 25_x &= (2 \times x^1) + (5 \times x^0) &= 17 \\ &= 2x + 5 &= 17 \end{aligned}$$

Step 2. Solve for x in the equation:

$$\begin{aligned} 2x + 5 &= 17 \\ 2x &= 17 - 5 && \text{Transpose 5} \\ 2x &= 12 \\ x &= \tfrac{12}{2} && \text{Divide throughout by 2} \\ x &= 6 \end{aligned}$$

4. Write another problem on the board: If $34_x = 10{,}011_2$, find the value of x.
5. Explain:
   - This problem is different, because the right hand side is in base 2.
   - We must convert both sides to base 10.
6. Solve the problem on the board, explaining each step:

   Step 1. Convert the left hand side from base x to base 10:

$$\begin{aligned} 34_x &= (3 \times x^1) + (4 \times x^0) \\ &= 3x + 4 \end{aligned}$$

   Step 2. Convert the right hand side from base 2 to base 10:

$$\begin{aligned} 10{,}011_2 &= (1 \times 2^4) + (0 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= 16 + 0 + 0 + 2 + 1 \\ &= 19 \end{aligned}$$

   Step 3. Set the two sides equal and solve for x:

$$\begin{aligned} 3x + 4 &= 19 \\ 3x &= 19 - 4 && \text{Transpose 4} \\ 3x &= 15 \\ x &= \tfrac{15}{3} && \text{Divide throughout by 3} \\ x &= 5 \end{aligned}$$

7. Write another problem on the board: Find the value of x for which $365_{seven} + 43_x = 217_{ten}$
8. Explain:
   - Remember that we need to change both sides of the equation to base 10.
   - You may convert each term to base 10 separately. Convert 365_{seven} to base 10, then convert 43_x to base 10.
9. Ask pupils to work with seatmates to convert both terms to base 10.
10. Invite 2 volunteers to write the conversions on the board.

   Solutions:

$$\begin{aligned} 365_7 &= (3 \times 7^2) + (6 \times 7^1) + (5 \times 7^0) \\ &= (3 \times 49) + (6 \times 7) + (5 \times 1) \\ &= 147 + 42 + 5 \\ &= 194 \end{aligned}$$

$$\begin{aligned} 43_x &= (4 \times x^1) + (3 \times x^0) \\ &= 4x + 3 \end{aligned}$$

11. Write the equation on the board with all terms in base 10: $194 + 4x + 3 = 217$
12. Ask pupils to work with seatmates to solve this equation for x.
13. Invite a volunteer to come to the board and write the solution.
Solution:

$$\begin{aligned} 194 + 4x + 3 &= 217 && \\ 4x &= 217 - 194 - 3 && \text{Collect like terms} \\ 4x &= 20 && \\ x &= \tfrac{20}{4} && \text{Divide throughout by 4} \\ x &= 5 && \end{aligned}$$

14. Write another problem on the board: Find the number x such that $24_x = 16_{10}$
15. Ask pupils to work with seatmates to solve the problem.
16. Invite a volunteer to come to the board and write the solution.
Solution:
Convert 24_x to base 10:

$$\begin{aligned} 24_x &= (2 \times x^1) + (4 \times x^0) &&= 16 \\ &= 2x + 4 &&= 16 \end{aligned}$$

Solve for x:

$$\begin{aligned} 2x + 4 &= 16 && \\ 2x &= 16 - 4 && \text{Transpose 4} \\ 2x &= 12 && \\ x &= \tfrac{12}{2} && \text{Divide throughout by 2} \\ x &= 6 && \end{aligned}$$

Practice *(15 minutes)*

1. Write the following 2 problems on the board:
   a. $43_x = 23$
   b. $312_{four} + 52_x = 96_{ten}$
2. Ask the pupils to do the work in their exercise books. Allow them to do their work with seatmates.
3. Walk around to check for understanding and clear any misconceptions.
4. Ask 2 pupils to write their solutions on the board. All other pupils should check their own work.
Solutions:
a.
Convert 43_x to base 10:

$$\begin{aligned} 43_x &= (4 \times x^1) + (3 \times x^0) &&= 23 \\ &= 4x + 3 &&= 23 \end{aligned}$$

Solve for x:

$$\begin{aligned} 4x + 3 &= 23 && \\ 4x &= 23 - 3 && \text{Transpose 3} \end{aligned}$$

$$
\begin{aligned}
4x &= 20 \\
x &= \frac{20}{4} && \text{Divide throughout by 4} \\
x &= 5
\end{aligned}
$$

b.

Convert 312_{four} and 52_x to base 10:

$$
\begin{aligned}
312_4 &= (3 \times 4^2) + (1 \times 4^1) + (2 \times 4^0) \\
&= (3 \times 16) + (1 \times 4) + (2 \times 1) \\
&= 48 + 4 + 2 \\
&= 54
\end{aligned}
$$

$$
\begin{aligned}
52_x &= (5 \times x^1) + (2 \times x^0) \\
&= 5x + 2
\end{aligned}
$$

Write the entire equation in base 10: $54 + 5x + 2 = 96$

Solve for x:

$$
\begin{aligned}
54 + 5x + 2 &= 96 \\
5x &= 96 - 54 - 2 && \text{Collect like terms} \\
5x &= 40 \\
x &= \frac{40}{5} && \text{Divide throughout by 4} \\
x &= 8
\end{aligned}
$$

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L020 in the Pupil Handbook.

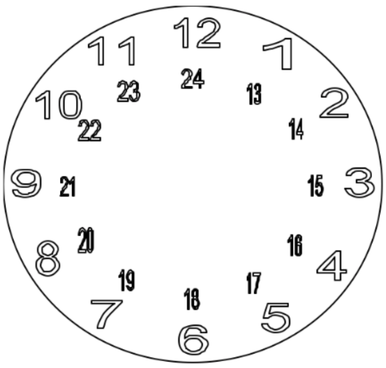
Lesson Title: Introduction to modular arithmetic	**Theme:** Numbers and Numeration	
Lesson Number: M1-L021	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to describe and interpret cyclical events.	**Preparation** Draw the clock from Teaching and Learning on the board.	

Opening *(2 minutes)*

1. Write the following problem on the board: Write down the digits that exist in base 8.
2. Allow the pupils to write their answers in their exercise books.
3. Ask volunteers to call out their answers. (Answer: 0, 1, 2, 3, 4, 5, 6, 7)
4. Explain that today's lesson is how to describe and interpret cyclical events. This is the first lesson on modular arithmetic.

Teaching and Learning *(25 minutes)*

1. Draw a clock on the board as shown, with digits up to 24 drawn inside the digits 1-12:



2. Explain:
   - Think of the face of a clock.
   - The numbers go from 1 to 12, but when you get to 13, it becomes 1 o'clock again.
   - Think of how the 24-hour clock numbering works. So 13 is 1 o'clock, 14 is 2 o'clock, 15 is 3 o'clock, and so on.
   - This can keep going, so when you get to "25 o' clock", you are actually back around to where 1 o'clock is on the clock face (and also where 13 o'clock was).
3. Explain:
   - Modular arithmetic deals with cycles of a certain number. The clock is a cycle of 12.

- When we go around the clock the second time, we can divide the digits by 12 and they will count up as shown on the board. In that cycle, we will have 1 remainder "something" for each digit.
- If we go around the clock again, we will have 2 remainder "something".
- We can continue cycling around the clock, and convert each digit to this form.

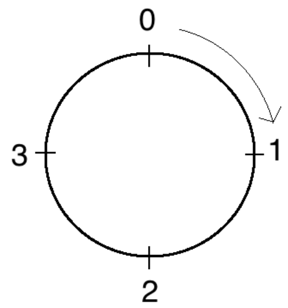
4. Write on the board: $\frac{A}{B} = Q \text{ remainder } R$.
5. Explain:
   - A is the dividend, B is the divisor, Q is the quotient and R is the remainder.
   - When we divide two integers, we have a remainder. Sometimes the remainder is zero.
   - The idea of remainder is important in cyclical events, and it will be used throughout the lessons on modular arithmetic.
6. Write the following on the board and make sure that pupils understand how to find a remainder:

   $13 \div 12 = 1 \text{ remainder } 1$
   $14 \div 12 = 1 \text{ remainder } 2$
   $15 \div 12 = 1 \text{ remainder } 3$
7. Write the following on the board: Fatu travels to 4 villages to sell her goods. She travels to them in a cycle, one after the other. The villages are shown in the table below.

Day number	**Village**
0	Bomi
1	Zimmi
2	Sengama
3	Fairo

8. Discuss and allow pupils to share ideas:
   a. If Fatu is in Bomi today, in how many days will she be in Sengama? (Answer: 2 days)
   b. Where will Fatu be in 3 days? (Answer: Fairo)
   c. Where will she be in 5 days? (Answer: Zimmi)
9. Explain:
   - We will draw a cycle and use it to do the calculations for this problem.
   - We write 0 at the top of the cycle and continuing clockwise writing integers 1, 2, --- up to one less than the number in the cycle.
   - There are 4 villages in this cycle, so they are numbered 0-3.
   - As a cycle, the clock would have numbers from 0 to 11, not from 1 to 12.

10. Draw the cycle on the board:



11. Explain:
    a. We can count clockwise around this cycle to find where Fatu will be in a given number of days.
12. Pointing to the cycle on the board, start at 0 and count up to identify the answers to the following questions:
    a. Where will Fatu be in 3 days? (Answer: Sengama)
    b. Where will Fatu be in 5 days? (Answer: Zimmi)
    c. Where will Fatu be in 11 days? (Answer: Fairo)
13. Explain:
    a. We can also divide and use the remainder to find where Fatu will be in a given number of days.
    b. This is especially useful for larger numbers of days. Let's try it with 11 days.
14. Write on the board: $11 \div 4 = 2 \text{ remainder } 3$
15. Explain:
    a. We divide the number of days (11) by the number of villages she travels to (4).
    b. The remainder tells us where she will be in 11 days. Look for 3 in the cycle. It is Fairo, so that is where she will be.
16. Write another question on the board: Where will Fatu be in 16 days?
17. Solve the problem by counting up to 16 on the cycle. (Answer: Bomi)
18. Ask pupils to solve the problem with seatmates using division. Remind them to divide, and use the remainder to find where Fatu will be in 16 days.
19. Invite a volunteer to write the solution on the board. (Answer: $16 \div 4 = 4 \text{ remainder } 0$; Fatu will be in Bomi.)

Practice *(12 minutes)*

1. Write the following problem on the board:

   Five members of a family take turns watering the crops in their garden. The cycle they use to plan their schedule is shown below. Today it is the mother's turn to water the crops.

Day number	Family member
0	Mother
1	Father
2	Ama
3	Foday
4	Hawa

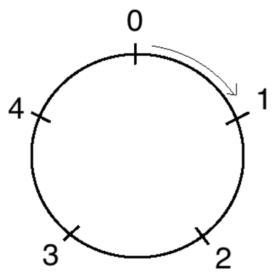
Complete the following:

a. Draw a cycle for the problem.
b. Use the cycle to answer:
   i. Who will water the crops in 3 days?
   ii. Who will water the crops in 5 days?
   iii. Who will water the crops in 12 days?
c. Use division to find:
   i. Who will water the crops in 10 days?
   ii. Who will water the crops in 17 days?

2. Ask pupils to work with seatmates to complete the problem.
3. Walk around to check for understanding and clear misconceptions. Draw the cycle on the board if needed.
4. Invite volunteers to write the answers on the board.

Answers:

a.



b.
   i. Foday
   ii. Mother
   iii. Ama

c.
   i. $10 \div 5 = 2 \text{ remainder } 0$; Mother
   ii. $17 \div 5 = 3 \text{ remainder } 2$; Ama

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L021 in the pupil handbook.

Lesson Title: Simplest form of a given modulo	**Theme:** Numbers and Numeration

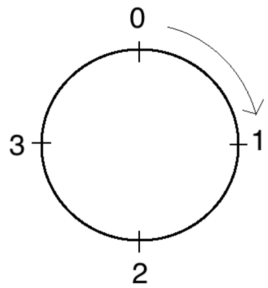
Lesson Number: M1-L022	Class: SSS 1	Time: 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to reduce numbers to their simplest form with a given modulo.	**Preparation** Write the problem in Opening on the board.	

Opening *(3 minutes)*

1. Write the following problem on the board: If there are 7 events in a cycle, what numbers would you use to represent them?
2. Ask volunteers to share their ideas and discuss until arriving at the correct answer. (Answer: 0, 1,2 , 3, 4, 5, 6,)
3. Explain that today's lesson is to reduce numbers to their simplest forms within a given modulo.

Teaching and Learning *(26 minutes)*

1. Explain: The concept of cycles applies to an operation that we call modulo. It is abbreviated as "mod".
2. Write on the board: $A \bmod B = R$
3. Read the statement aloud so pupils understand how it is read: "A modulo B is equal to R".
4. Explain:
   - Any cyclical event that can be written as a division problem with a remainder can also be written in modulo form.
   - The digits in a modulo start with zero. In modulo 12, the digits are 0 through 11.
5. Write the following problem on the board: Write in modulo form: $14 \div 12 = 1 \text{ remainder } 2$
6. Write the answer on the board: $14 \bmod 12 = 2$
7. Explain:
   - The dividend is written on the left side of "mod" and the divisor is on the right.
   - The remainder after dividing is the answer to the modulo.
8. Write on the board: What is $8 \bmod 4$?
9. Ask a volunteer to give the digits in modulo 4. (Answer: 0, 1, 2, 3)
10. Draw a cycle on the board with numbers 0, 1, 2, 3:



11. Explain: To find 8 mod 4, we use a cycle of 4. Count up to 8 in a clockwise direction.
12. Count 8 digits in the clockwise direction, and find the digit you land on. (Answer: 0)
13. Write the answer on the board: $8 \bmod 4 = 0$
14. Explain:
    - This means that there is a remainder of 0 when we divide 8 by 4. It divides perfectly.
    - We can recognise this because $8 \div 4 = 2$ with no remainder.
15. Explain:
    - In the previous class, we used division to find what would happen later in a cycle.
    - We will also use division to solve modulo problems. We will not normally draw cycles to solve the problems.
16. Write on the board: Simplify $25 \bmod 4$
17. Write the solution on the board: $\frac{25}{4} = 6 \text{ remainder } 1$, therefore $25 \bmod 4 = 1$
18. Write 2 more problems on the board:
    a. Simplify $20 \bmod 5$.
    b. Simplify $8 \bmod 5$.
19. Ask volunteers to describe how to solve each problem. As they explain the steps, write the solutions on the board.
    Solutions:
    a. $\frac{20}{5} = 4 \text{ remainder } 0$, therefore $20 \bmod 5 = 0$
    b. $\frac{8}{5} = 1 \text{ remainder } 3$, therefore $8 \bmod 5 = 3$
20. Explain: If the number is less than the modulo, we leave it as it is.
21. Write an example on the board: Simplify $2 \bmod 5$
22. Write the solution: $\frac{2}{5} = 0 \text{ remainder } 2$, therefore $2 \bmod 5 = 2$
23. Write another example on the board: Simplify $4 \bmod 7$
24. Ask a volunteer to give the answer without doing any calculation. (Answer: 4)
25. Explain: The modulo of a negative number is obtained by adding the modulo to the number until we get a positive number.
26. Write the following 2 examples on the board:
    a. Simplify $-2 \bmod 4$.
    b. Simplify $-7 \bmod 5$.

27. Solve problem a. on the board, explaining:
    - Add the modulo to the negative number: $-2+4=2$
    - The problem is complete because a positive number has been obtained.
    - $-2 \text{ mod } 4 = 2$
28. Solve problem b. on the board, explaining:
    - Add the modulo to the negative number: $-7+5=-2$
    - The result is negative, so add again: $-2+5=3$
    - $-7 \text{ mod } 5 = 3$
29. Write the following problems on the board:
    a. Simplify $57 \text{ mod } 7$.
    b. Simplify $-4 \text{ mod } 9$.
    c. Simplify $32 \text{ mod } 12$.
    d. Simplify $-10 \text{ mod } 3$.
30. Ask pupils to work with seatmates to solve the problems.
31. Invite volunteers to write their answers on the board and explain.
    Solutions:
    a. $\frac{57}{7} = 8 \text{ remainder } 1$, therefore $57 \text{ mod } 7 = 1$
    b. $-4+9=5$, therefore $-4 \text{ mod } 9 = 5$
    c. $\frac{32}{12} = 2 \text{ remainder } 8$, therefore $32 \text{ mod } 12 = 8$
    d. $-10+3=-7 \rightarrow -7+3=-4 \rightarrow -4+3=-1 \rightarrow -1+3=2$, therefore $-10 \text{ mod } 3 = 2$

Practice *(10 minutes)*

1. Write the following four problems on the board: Simplify:
    a. $75 \text{ mod } 9$
    b. $-5 \text{ mod } 16$
    c. $66 \text{ mod } 4$
    d. $-7 \text{ mod } 2$
2. Ask pupils to solve the problems independently in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.
4. Ask volunteers to call out their answers. All other pupils to check their answers. (Answers: a. 3; b. 11; c. 2; d. 1)

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L022 in the pupil handbook.

Lesson Title: Operations in various moduli	**Theme:** Numbers and Numeration	
Lesson Number: M1-L023	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to add, subtract and multiply numbers in various moduli.	**Preparation** Write the problem in Opening and empty tables on the board.	

Opening *(2 minutes)*

1. Write a problem on the board: Simplify $68 \bmod 7$.
2. Ask pupils to solve the problem in their exercise books.
3. Allow a volunteer to give the answer and explain. (Answer: $68 \bmod 7 = 5$, because 5 is the remainder when 68 is divided by 7.).
4. Explain to the pupils that today's lesson is on addition, subtraction and multiplication of numbers in various moduli.

Teaching and Learning *(25 minutes)*

1. Write on the board:
    a. $2 \oplus 3 \pmod 4$
2. Explain:
    - This problem says "2 plus 3 in modulo 4".
    - The symbol is a "plus" sign with a circle around it. This is used to show addition of modular arithmetic.
3. Write additional problems on the board:
    b. $9 \ominus 2 \pmod 5$
    c. $2 \otimes 4 \pmod 3$
4. Explain:
    - These are the symbols for subtraction and multiplication.
    - For addition, subtraction and multiplication, calculate as in ordinary arithmetic and convert the result to the given modulus.
5. Solve problem a. on the board, explaining each step:

    Step 1. Add the digits: $2 + 3 = 5$

    Step 2. Convert the result to modulus 4:

    $5 = (4 \times 1 + 1)$ The remainder is 1 when 4 divides 5.

    $5 = 1 \pmod 4$

    Answer: $2 \oplus 3 \pmod 4 = 1 \pmod 4$
6. Solve problem b. on the board, explaining each step:

    Step 1. Subtract the digits: $9 - 2 = 7$

    Step 2. Convert the result to modulus 5:

    $7 = (5 \times 1 + 2)$ The remainder is 2 when 5 divides 7.

    $7 = 2 \pmod 5$

Answer: $9 \ominus 2 \pmod 5 = 2 \pmod 5$

7. Solve problem c. on the board, explaining each step:

   Step 1. Multiply the digits: $2 \times 4 = 8$

   Step 2. Convert the result to modulus 3:

   $8 = (3 \times 2 + 2)$ The remainder is 2 when 3 divides 8.

   $8 = 2 \pmod 3$

   Answer: $2 \otimes 4 \pmod 3 = 2 \pmod 3$

8. Write 3 more problems on the board:
   a. $4 \oplus 5 \pmod 5$
   b. $4 \otimes 8 \pmod 5$
   c. $12 \ominus 2 \pmod 8$
9. Ask pupils to work with seatmates to solve the problems.
10. Remind them of the 2 steps: Apply the operation, then convert to the given modulus.
11. Invite 3 volunteers to write the solutions on the board and explain.

    Solutions:
    a. $4 \oplus 5 \pmod 5 \rightarrow 4 + 5 = 9 \rightarrow 9 = (5 \times 1 + 4) \rightarrow$ Answer: $4 \pmod 5$
    b. $4 \otimes 8 \pmod 5 \rightarrow 4 \times 8 = 32 \rightarrow 32 = (5 \times 6 + 2) \rightarrow$ Answer: $2 \pmod 5$
    c. $12 \ominus 2 \pmod 8 \rightarrow 12 - 2 = 10 \rightarrow 10 = (8 \times 1 + 2) \rightarrow$ Answer: $2 \pmod 8$
12. Explain:
    - It is possible to perform division in modular arithmetic. However, it is not so simple. At times you will find more than one answer, while at other times you will find no answer.
    - Division in modular arithmetic is not covered in this course.
13. Write the following problem on the board:
    a. Draw addition and multiplication tables for modulo 5.
    b. Use your tables to evaluate:
       i. $3 \oplus 4 \pmod 5$ iii. $4 \otimes 3 \pmod 5$
       ii. $(2 \oplus 3) \oplus 4 \pmod 5$ iv. $3 \otimes (4 \oplus 2) \pmod 5$
14. Explain:
    - Addition and multiplication tables for modulo look like the tables that you are used to.
    - The values are obtained by first adding or multiplying the numbers before converting to the given modulo. In other words, only remainders are recorded in the table.
15. Draw the empty tables on the board:

$+$	**0**	**1**	**2**	**3**	**4**
0					
1					
2					
3					
4					

$\times$	**0**	**1**	**2**	**3**	**4**
0					
1					
2					
3					
4					

16. Work as a class to fill in the tables. It is not necessary to write the work for each addition or multiplication problem. Ask questions to arrive at the remainder, then write it in the box. For example, ask:
    - What is 0 plus 1? (Answer: 1)
    - What is the remainder when 5 divides 1? (Answer: 1)
    - Write “1” in the box for $0+1$.
17. If this process takes a long time, fill several boxes with pupils, then copy the others from the tables below.

$+$	**0**	**1**	**2**	**3**	**4**
0	0	1	2	3	4
1	1	2	3	4	0
2	2	3	4	0	1
3	3	4	0	1	2
4	4	0	1	2	3

$\times$	**0**	**1**	**2**	**3**	**4**
0	0	0	0	0	0
1	0	1	2	3	4
2	0	2	4	1	3
3	0	3	1	4	2
4	0	4	3	2	1

18. Explain:
    - Now we will use the tables to solve the arithmetic problems in part b.
    - Apply BODMAS. If there are brackets, perform the expression in the brackets first.
19. Solve the first 2 problems together with the pupils. Point out the solution to each addition and multiplication problem in the charts on the board.
    i. $3 \oplus 4 \pmod 5 = 2 \pmod 5$
    ii. $(2 \oplus 3) \oplus 4 \pmod 5 = 0 \oplus 4 = 4 \pmod 5$
20. Ask pupils to solve the last 2 problems with seatmates. Remind them to use the charts on the board.
21. Invite 2 volunteers to write the solutions on the board.
    iii. $4 \otimes 3 \pmod 5 = 2 \pmod 5$
    iv. $3 \otimes (4 \oplus 2) \pmod 5 = 3 \otimes 1 = 3 \pmod 5$

Practice *(12 minutes)*

1. Write the following two problems on the board:
    a. Simplify $8 \otimes 5 \pmod 6$
    b. Complete the addition and multiplication tables for arithmetic modulo 4.

$+$	**0**	**1**	**2**	**3**
0	0		2	3
1	1	2	3	
2	2	3	0	
3	3			

$\times$	**0**	**1**	**2**	**3**
0	0	0	0	0
1	0		2	3
2	0	2		
3	0		2	

    c. Use the tables to evaluate: $3 \otimes (2 \oplus 3) \pmod 4$
2. Ask pupils to solve the problems in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.

4. Invite three pupils to come to the board and write the solutions.
   Solutions:
   a. $8 \otimes 5 \pmod 6$ → $8 \times 5 = 40$ → $40 = (6 \times 6 + 4)$ → Answer: $4 \pmod 6$
   b. Completed tables:

$+$	**0**	**1**	**2**	**3**
0	0	1	2	3
1	1	2	3	0
2	2	3	0	1
3	3	0	1	2

$\times$	**0**	**1**	**2**	**3**
0	0	0	0	0
1	0	1	2	3
2	0	2	0	2
3	0	3	2	1

   c. $3 \otimes (2 \oplus 3) \pmod 4 = 3 \otimes 1 = 3 \pmod 4$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L023 in the pupil handbook.

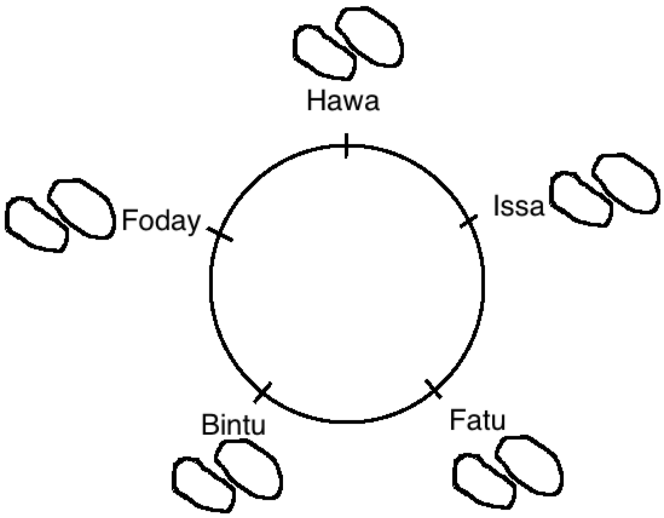
Lesson Title: Modular arithmetic in real-life situations	**Theme:** Numbers and Numeration	
Lesson Number: M1-L024	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to apply modular arithmetic to real-life situations.	**Preparation** None	

Opening *(2 minutes)*

1. Write the following problem on the board: Simplify $10 \bmod 3$
2. Ask pupils to write the answer in their exercise books.
3. Ask a volunteer to give the answer. (Answer: $10 \bmod 3 = 1$)
4. Explain that today's lesson is on how to solve real word problems using modular arithmetic.

Teaching and Learning *(20 minutes)*

1. Write the following problem on the board: If I have 14 mangos, and I want to divide them evenly among 5 pupils, how many mangos would each person get? How many are left?
2. Ask the pupils to explain how to solve their problem, not what the answer is.
3. Write the names of 5 pupils on the board like a clock face. Draw a mango next to each name as you "deal" out the mangos.
   Example:



4. After dealing 2 mangos to each pupil, there are not enough left to share around again. Ask the pupils what the remainder is.
5. Write on the board: $\frac{14}{5} = 2 \text{ remainder } 4$
6. Explain:

- Each pupil gets 2 mangos, and there are 4 remaining.
- We can write this in modular form as well.

7. Write on the board: $14 \bmod 5 = 4$.
8. Write another problem on the board: I had 34 apples that I divided evenly among 4 friends. I ate the left over apples. How many apples did I eat?
9. Ask the pupils to solve the problem in their exercise books.
10. Invite one pupil to write the solution on the board. They may write it as a division problem or in modulo 4. If they do not write the modulo, write it on the board:

$$\frac{34}{4} = 8 \text{ remainder } 2 \text{ or } 34 \bmod 4 = 2$$

Answer: I ate 2 apples.

11. Write another problem on the board: If it is March now, what month will it be 28 months from now?
12. Explain:
    - Number the months as you would with calendar dates. March is month 3.
    - We will be working in modulo 12, since there are 12 months.
    - We will solve an addition problem, because we are going forward 28 months from month 3. ($3 + 28$)
    - Since a year contains 12 months, then we divide by 12 (the modulo) and look at the remainder.
13. Write on the board: $3 \oplus 28 \pmod{12}$
14. Ask pupils to simplify in their exercise books.
15. Invite a volunteer to write the solution on the board.

Solution:

$$3 \oplus 28 \pmod{12} = 31 \pmod{12}$$
$$\frac{31}{12} = 2 \text{ remainder } 7$$
$$31 \pmod{12} = 7$$

16. Explain: The month that comes 28 months after March is month number 7, or July.
17. Write another problem on the board: Using a regular deck of 52 cards, I dealt all the cards in the deck to Abass, Juliet and myself for a game. Were the cards dealt evenly?
18. Ask pupils to brainstorm and solve the problem with seatmates.
19. Ask a volunteer to give the answer and explain.

Solution:

Since there are 52 cards among 3 people, find $52 \pmod 3$.

$$\frac{52}{3} = 17 \text{ remainder } 1$$

Therefore $52 \pmod 3 = 1$

No, the cards were not dealt evenly. There is 1 remaining after dividing them evenly between 3 people.

Practice *(17 minutes)*

1. Write the following 3 problems on the board:
    a. A bag of 82 oranges was shared between 6 people. How many oranges remained? Write the result in modulo 6.
    b. If this month is November, what month will it be 34 months from now?
    c. Today is Monday; what day will it be in 13 days?
2. Ask the pupils to solve the problems in their exercise books with seatmates.
3. Invite volunteers to write the solutions on the board and explain.
4. Allow discussion, and make sure all pupils understand.
   Solutions:
    a. $\frac{82}{6} = 13 \text{ remainder } 4.$
       4 oranges remained, and this can be written $82 \bmod 6 = 4$
    b. This month is number 11 of 12 months, so we have the addition problem: $11 \oplus 34 \pmod{12}$
       Solving, we have $45 \pmod{12} = 9$
       It will be September, which is the 9th month.
    c. Since the week starts on Sunday, let Monday be day 2 out of 7. We have the addition problem: $2 \oplus 13 \pmod{7}$
       Solving, we have $15 \pmod{7} = 1$
       In 13 days it will be the first day of the week, which is Sunday.

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L024 in the pupil handbook.

Lesson Title: Rational and irrational numbers	Theme: Numbers and Numeration	
Lesson Number: M1-L025	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcomes By the end of the lesson, pupils will be able to: 1. Define rational and irrational numbers. 2. Classify numbers as rational or irrational.	**Preparation** None	

Opening *(2 minutes)*

1. Review different sets of numbers.
2. Ask volunteers to give the first 5 examples of Natural numbers. (Answer: 1,2,3,4,5)
3. Ask volunteers to give the first 5 whole numbers. (Answer: 0,1,2,3,4)
4. Ask volunteers to list positive and negative integers. (Answer: …, -3, -2, -1, 0, 1, 2, 3, …)
5. Explain to the class that today's lesson is on classifying Rational and Irrational numbers.

Teaching and Learning *(23 minutes)*

1. Explain: A rational number can be expressed as a fraction $\frac{\mathrm{P}}{\mathrm{Q}}$ where P and Q are integers and Q is not zero.
2. Write on the board: Rational number: $\frac{\mathrm{P}}{\mathrm{Q}}$ where P and Q are integers and Q is not zero.
3. Explain **rational numbers:**
    a. **Proper fractions**, **improper fractions,** and **mixed fractions** are all rational.
    b. **Integers** are rational. For integers, the value of Q in the denominator is 1.
    c. **Decimal numbers** are rational if they are **terminating** or **recurring**. This is because terminating or recurring decimals can be written as fractions. If they continue forever, they are not rational.
    d. The square root of **perfect square** numbers are rational because they can be written as integers. In other words, $\sqrt{4}$ is rational because it equals 2.
4. Give a few examples of rational numbers, and ask volunteers to list a few examples. Write them on the board. (Example answers: $\frac{1}{2}, 8, \frac{5}{3}, \sqrt{4}, 7\frac{1}{9}, -12, \frac{\sqrt{64}}{\sqrt{25}}, 6.25, 0.\overline{318}$).
5. Explain: When determining whether a decimal is a rational number, we must determine whether it terminates or repeats.
6. Write on the board: $\frac{3}{4} = 0.75$ and $\frac{2}{3} = 0.66\cdots = 0.\bar{6}$

7. Explain: These are both rational numbers. 0.75 terminates, and $0.\bar{6}$ continues on forever, but it is recurring. The line above the 6 tells us it repeats.
8. Explain **irrational numbers:**
   - An irrational number is a number that is not rational.
   - An irrational number cannot be expressed as a fraction with integer values in the numerator and denominator.
   - When an irrational number is expressed in decimal form, it goes on forever without repeating.
   - The square root of any numbers that are not perfect square numbers are irrational.
9. Give a few examples of irrational numbers, and ask volunteers to list a few examples. Write them on the board. (Example answers: $\sqrt{3},\ -\sqrt{27}, \frac{\sqrt{13}}{\sqrt{2}},\ 3+\sqrt{5}, 0.131331333\ldots$)
10. Ask pupils to consider the number π (pi). This is used in circle calculations. Ask them to give pi as a decimal to as many digits as they know. (Example: 3.14159…)
11. If a member of the class has a calculator, ask them to find the π button and press it. Ask them to read out the digits. (Example: 3.141592653…)
12. Explain:
    a. The number π goes on forever. Scientists have found billions of digits for π.
    b. When you see π written as a fraction such as $\frac{22}{7}$, this is just an approximation. It is not exactly π.
13. Write the following problem on the board: Does each number appear to be rational or irrational?
    a. $\sqrt{2}$
    b. $x = 0.123456789101112\ldots\ldots$
    c. $y = 2.131131131131\ldots.$
    d. 4π
    e. $\frac{\sqrt{16}}{2}$
14. Discuss each example with pupils. Allow them to share ideas, and guide them to the correct answer.
    Answer:
    a. **Irrational** – 2 is not a perfect square.
    b. **Irrational** – Although there is a pattern in the decimal representation of x, there is no sequence of digits that repeats. Therefore, x appears to be irrational.
    c. **Rational** – y appears to be rational since the sequence 131 repeats.
    d. **Irrational** – If we multiply any number by pi, the result will be irrational.
    e. **Rational** – The numerator is a perfect square, so this number can be simplified: $\frac{\sqrt{16}}{2} = \frac{4}{2} = 2$.
15. Write another problem on the board: Determine whether each number is rational or irrational:

a. $\sqrt{3}$ b. $\sqrt{16}$ c. $\sqrt{20}$ d. $\frac{\sqrt{4}}{\sqrt{9}}$ e. $\frac{\sqrt{4}}{\sqrt{5}}$

16. Ask pupils to work with seatmates.
17. Ask 5 volunteers to give their answers and explain.

Answers:

a. Irrational because 3 is not a perfect square;
b. Rational because $\sqrt{16} = 4$;
c. Irrational because 20 is not a perfect square;
d. Rational because it can be simplified $\frac{\sqrt{4}}{\sqrt{9}} = \frac{2}{3}$;
e. Irrational because simplifying gives $\sqrt{5}$ in the denominator: $\frac{\sqrt{4}}{\sqrt{5}} = \frac{2}{\sqrt{5}}$.

Practice *(10 minutes)*

1. Write on the board: Determine whether each number is rational or irrational:
   a. $\sqrt{21}$ b. $0.232323\cdots$ c. $\sqrt{16}$ d. $\frac{\pi}{2}$ e. $\sqrt{200}$ f. $\frac{213}{9}$
2. Allow pupils to solve the problem independently in their exercise books. Allow them to discuss with seatmates if needed.
3. Walk around to check for understanding and clear any misconceptions.

Closing *(5 minutes)*

1. Review the questions in the practice. Ask volunteers to give the answers and explain.
   Answers:
   a. Irrational because 21 is not a perfect square;
   b. Rational because it is recurring: $0.\overline{23}$;
   c. Rational because $\sqrt{16} = 4$;
   d. Irrational because it includes pi;
   e. Irrational because 200 is not a perfect square;
   f. Rational because it is a fraction with integers and the denominator is not zero.
2. For homework, have pupils do the practice activity PHM1-L025 in the Pupil Handbook.

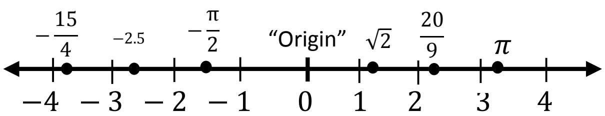
Lesson Title: Real numbers on a number line	**Theme:** Numbers and Numeration	
Lesson Number: M1-L026	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to locate integers, fractions, and decimals on the number line.	**Preparation** Write the problem in Opening and a number line on the board.	

Opening *(3 minutes)*

1. Review rational and irrational numbers. Write the following question on the board: Determine whether each number is rational or irrational:
   $0.325, 0.6666\ldots, 0.7323343455\ldots$
2. Allow volunteers to call out their answers. (Answer: 0.325 is a rational number because it is a terminating decimal; 0.6666… is a rational number because it is recurring decimal; 0.7323343455… is an irrational number it is a non-terminating non-recurring decimal).
3. Explain to them that today they are going to learn how to locate real numbers on a number line.

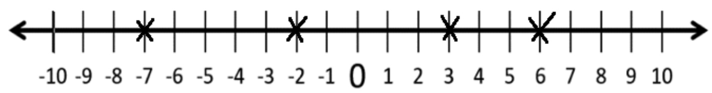
Teaching and Learning *(22 minutes)*

1. Explain:
   - Real numbers include all rational and irrational numbers.
   - Real numbers can be positive, negative or zero.
   - There are types of numbers that are not real. Numbers that are not real include imaginary numbers and infinity.
2. Give a few examples of real numbers, and ask volunteers to list a few examples. Write them on the board. (Example answers: 1, 12.38, -0.865, $\frac{3}{4}$, π, 198).
3. Draw a number line on the board:

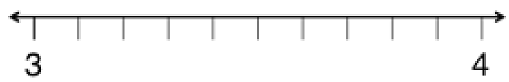


4. Explain:
   - Any point that can be identified on a number line is a Real Number. Each of these numbers is real.
   - The graph of each real number is shown as a dot at the appropriate point on the number line.
   - Sometimes, it is easier to graph a number by considering its decimal. For example, we know that π is approximately 3.14. Since 3.14 is a little more than 3, we graph π a little to the right of the 3 mark on the number line.
   - Remember that larger numbers always lie to the right of smaller numbers on the number line.

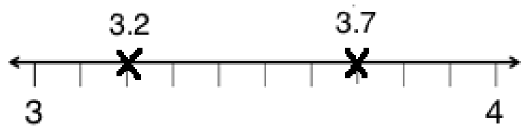
5. Write the following problem on the board: Mark the following real numbers on a number line: $-7, -2, 3, 6$
6. Draw a number line on the board from -10 to 10.
7. Invite volunteers to come to the board and mark each integer with an x.
Answer:



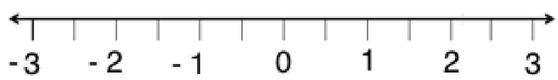
8. Write another problem on the board: Represent 3.2 and 3.7 on a number line.
9. Explain:
   - Both of these numbers are between 3 and 4.
   - We can show them more easily by using a different scale. We can draw the number line between 3 and 4, marking each tenth.
10. Draw the number line on the board:



11. Invite volunteers to come to the board and mark 3.2 and 3.7.
Answer:

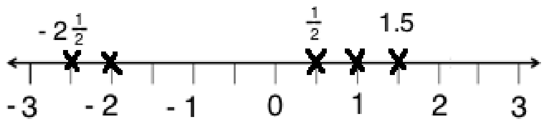


12. Write another problem on the board: Represent the following numbers on a number line $-2\frac{1}{2}, -2, \frac{1}{2}, 1, 1.5$
13. Explain:
   - We need to determine an appropriate scale to graph these numbers. They are all between -3 and 3.
   - We can graph them accurately by showing -3 to 3 on a number line and using marks to show whole numbers and halves.
14. Draw a number line on the board, as shown:

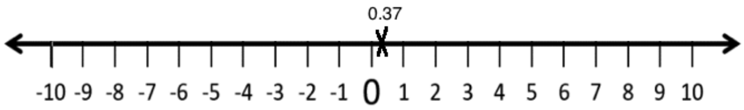


15. Ask pupils to work with seatmates to show the set of numbers on the number line in their exercise books.
16. Invite a volunteer to graph the numbers on the board.

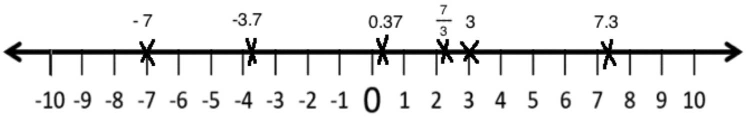
Answer:



17. Write another problem on the board: Graph the following numbers on a number line: $-7, 3, 0.37, \frac{7}{3}, -3.7$, 7.3
18. Explain:
    - We can show all of these on a number line from -10 to 10.
    - For the decimals and fractions, we will show approximately where they are.
19. Draw a number line from -10 to 10 on the board, and mark 0.37:

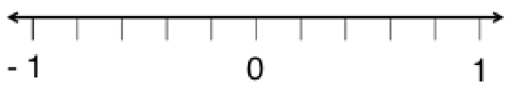


20. Ask pupils to work with seatmates to finish marking the points.
21. Invite volunteers to come to the board to show the answers.
    Answers:



Practice *(14 minutes)*

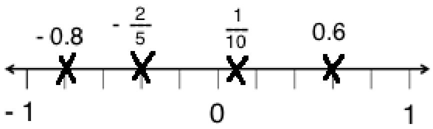
1. Write the following 2 problems on the board:
    a. Represent the following fractions on the number line below: $-\frac{2}{5}, \frac{1}{10}$, 0.6, and -0.8.



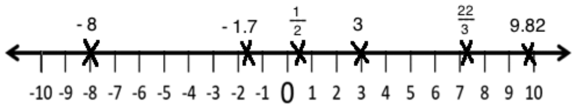
    b. Represent -8, -1.7, $\frac{1}{2}$, 3, $\frac{22}{3}$ and 9.82 on a number line with whole numbers from -10 to 10.
2. Ask pupils to solve the problems individually in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite volunteers to write the solutions on the board.

Solutions:

a.



b.



Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L026 in the Pupil Handbook.

Lesson Title: Comparing and ordering rational numbers	**Theme:** Numbers and Numeration	
Lesson Number: M1-L027	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to compare and order rational numbers.	**Preparation** None	

Opening *(2 minutes)*

1. Ask a volunteer to explain what is a rational number? (Answer: Rational numbers are numbers which can always be written as a fraction).
2. Ask 5 volunteers each to give an example of a rational number. Write them on the board as they say them. (Example answers: $\frac{1}{3}, -\frac{7}{5}, 1, \sqrt{9}, 1.3333 \ldots\ldots$).
3. Explain to pupils that today's lesson will be on how to compare and order rational numbers.

Teaching and Learning *(20 minutes)*

1. Explain: The procedure for comparing rational numbers is as follows:
   - Express the given rational numbers as common fractions with the same denominator.
   - Compare the numerators.
     - For positive numbers, the rational number with a larger numerator is larger.
     - For negative numbers, the rational number with a smaller numerator is larger.
     - Positive numbers are always larger than negative numbers.
2. Write different fractions on the board with the same denominators $\frac{1}{7}, \frac{3}{7}, \frac{5}{7}, \frac{2}{7}$
3. Explain: We can compare the numerators using the sign $<$ since the denominators are the same.
4. Arrange the numbers from the smallest to the largest on the board: $\frac{1}{7} < \frac{2}{7} < \frac{3}{7} < \frac{5}{7}$.
5. Explain:
   - This is what we call ordering, or arranging the numbers in ascending or increasing order of size, starting with the smallest.
   - Similarly, we can compare the numbers using the sign $>$
6. Arrange the numbers from largest to smallest on the board: $\frac{5}{7} > \frac{3}{7} > \frac{2}{7} > \frac{1}{7}$.
7. Explain: This is what we call ordering, or arranging the numbers in descending or decreasing order of size, starting with the largest.
8. Write different fractions where the denominators are not the same: $\frac{1}{3}, \frac{1}{2}, \frac{2}{5}, \frac{1}{4}$.
9. Explain:

- Since the denominators are not the same, write them with the same denominator.
- One way of finding a common denominator is to multiply all the denominators.
- Another way is to find the LCM of the denominators and use that as the denominator. We will use the first method in this lesson.

10. Ask a volunteer to multiply all the denominators. (Answer: $3 \times 2 \times 5 \times 4 = 120$).
11. Change the first fraction to a fraction with denominator 120 on the board: $\frac{1}{3} = \frac{1\times 40}{3\times 40} = \frac{40}{120}$
12. Ask pupils to work with seatmates to change the other fractions to have denominator 120. Ask volunteers to write the answers on the board. (Answers: $\frac{1}{2} = \frac{1\times 60}{2\times 60} = \frac{60}{120}$; $\frac{2}{5} = \frac{2\times 24}{5\times 24} = \frac{48}{120}$; $\frac{1}{4} = \frac{1\times 30}{4\times 30} = \frac{30}{120}$).
13. Arrange the numbers on the board in ascending order: $\frac{30}{120} < \frac{40}{120} < \frac{48}{120} < \frac{60}{120}$
14. Rewrite the numbers as the original fractions: $\frac{1}{4} < \frac{1}{3} < \frac{2}{5} < \frac{1}{2}$.
15. Explain: If the rational number is a decimal fraction, change the decimal to common fractions.
16. Write the following problem on the board: Arrange $-8.23, -8.32, -8.30$.
17. Change the decimals to fractions on the board: $-\frac{823}{100}$; $-\frac{832}{100}$; $-\frac{830}{100}$
18. Arrange the fractions in descending order: $-\frac{823}{100} > -\frac{830}{100} > -\frac{832}{100}$
19. Remind pupils that for negative numbers, the value gets smaller (descends) as the numerators get larger.
20. Invite a volunteer rewrite this with the given decimals in descending order: $-8.23 > -8.30 > -8.32$.
21. Explain: When rational numbers are given in different forms to compare, change all the rational numbers to the form $\frac{a}{b}$ before ordering.
22. Write another problem on the board: Arrange the following rational numbers in ascending order: $0.2, \frac{1}{4}, 30\%, 10$.
23. Solve the problem on the board together with pupils.

    Step 1. Express the numbers as fractions: $0.2 = \frac{2}{10} = \frac{1}{5}$; $\frac{1}{4}$; $\frac{30}{100} = \frac{3}{10}$; $\frac{10}{1}$

    Step 2. Multiply all the denominators of the fractions: $5 \times 4 \times 10 \times 1 = 200$

    Step 3. Divide each numerator by 200: $\frac{200}{5} = 40$; $\frac{200}{4} = 50$; $\frac{200}{10} = 20$; $\frac{200}{1} = 200$.

    Step 4. Convert the fractions to like fractions: $\frac{1}{5} = \frac{1\times 40}{5\times 40} = \frac{40}{200}$; $\frac{1}{4} = \frac{1\times 50}{4\times 50} = \frac{50}{200}$; $\frac{3}{10} = \frac{3\times 20}{10\times 20} = \frac{60}{200}$; $\frac{10}{1} = \frac{10\times 200}{1\times 200} = \frac{2000}{200}$.

    Step 5. Arrange the fractions in ascending order: $\frac{40}{200} < \frac{50}{200} < \frac{60}{200} < \frac{2000}{200}$

    Step 6. Write the given numbers in ascending order: $0.2 < \frac{1}{4} < 30\% < 10$

Practice *(15 minutes)*

1. Write the following two problems on the board:
   Arrange the following rational numbers in ascending order:
    a. $0.3, 50\%, \frac{1}{4}, 0.15$
    b. $-\frac{2}{5}, -45\%, -3, -2\frac{1}{2}, -1.2$
2. Ask pupils to work with seatmates but to solve the problems in their exercise books.
3. After 10 minutes, invite two pupils to come to the board, write their answers, and explain how they found them. (Answer: a. $0.15 < \frac{1}{4} < 0.3 < 50\%$; b. $-3 < -2\frac{1}{2}, < 1.2 < -45\% < -\frac{2}{5}$)

Closing *(3 minutes)*

1. Write the following problem on the board: Arrange these fractions in descending order of size: $\frac{5}{6}, 1, -\frac{1}{6}$.
2. Ask pupils to solve the problem individually.
3. Allow volunteers to call out their answers. (Answer: $1 > \frac{5}{6} > -\frac{1}{6}$).
4. For homework, have pupils to do the practice activity PHM1-L027 in the Pupil Handbook.

Lesson Title: Approximating of decimals	**Theme:** Numbers and Numeration	
Lesson Number: M1-L028	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to round decimals to a given number of decimal places.	**Preparation** None	

Opening *(3 minutes)*

1. Write the following problem on the board: Arrange the following decimals in ascending order: $0.401, 0.403, 0.399, 0.397, 0.41$.
2. Allow pupils to solve the problem.
3. Ask a volunteer to call out the answer. (Answer: $0.397, 0.399, 0.401, 0.403, 0.41$).
4. Explain that today's lesson is to round decimals to a given number of decimal places.

Teaching and Learning *(25 minutes)*

1. Write on the board: $0.345, 2.001, 97.020$
2. Explain decimal places:
    a. Decimal places (d.p.) are the digits that come after the decimal point.
    - Each of the numbers on the board have 3 decimal places.
    - To number the places (1st, 2nd, 3rd, …), start at the decimal point and count to the right. For example, in the number 0.345, 3 is in the 1st decimal place, 4 is in the 2nd decimal place, 5 is in the 3rd decimal place.
    - The 1st decimal place is the tenths digit, the 2nd is the hundredths, the 3rd is the thousandths, and so on.
3. Label the decimal places in 0.345 on the board:

0	.	3	4	5
		Tenths	Hundredths	Thousandths

4. Explain rounding of decimals:
    - A common way to approximate a decimal is to reduce the number of decimal places it has.
    - The decimal is given "correct to" a stated number of decimal places.
    - If the digit after the decimal place you want is less than 5 just discard the decimal places you do not want.
    - If this digit is 5 or more add 1 to the digit in the last place you want.
5. Write the following problem on the board: Correct 9.23564 to: a. 1 d.p. b. 3 d.p.

6. Solve a. on the board: $9.23564 = 9.2$
7. Explain: The 1st d.p. is 2 but the digit after it (i.e. the 2nd d.p.) is 3, which is less than 5. Therefore, we leave 2 as it is.
8. Solve b. on the board: $9.23564 = 9.236$
9. Explain: The 3rd d.p. is 5 but the digit after that it (i.e. the 4th d.p.) is 6, which is more than 5. Therefore, we add 1 to 5 to give 6 in the 3rd d.p.
10. Write another problem on the board: Round 4.4325 to: a. the nearest hundredths b. the nearest thousandths
11. Discuss: Which decimal place is the hundredths? (Answer: the 2nd d.p.) Which decimal place is the thousandths? (Answer: the 3rd d.p.)
12. Ask volunteers to explain how to solve the problems. As they explain, write the answers on the board. (Answers: a. $4.4325 = 4.43$; b. $4.4325 = 4.433$)
13. Write additional problems on the board:
    a. Correct 215.56 to 1 d.p.
    b. Correct 0.12948 to 2 d.p.
    c. Approximate 2.41958 to 3 d.p.
    d. Round 4.9995 to i. the nearest hundredths ii. the nearest thousandths
14. Ask pupils to work with seatmates to solve the problems.
15. Invite volunteers to write the answers on the board. (Answers: a. $215.56 = 215.6$; b. $0.12948 = 0.13$; c. $2.41958 = 2.420$; d. i. $4.9995 = 5.00$; ii. $4.9995 = 5.000$)

Practice *(11 minutes)*

1. Write the following four problems on the board:
    a. Approximate 0.456356 to 4d.p.
    b. Correct 79.924 to 1d.p.
    c. Round 1.2600081 to the nearest thousandths place.
    d. Correct 10.101010 to 5d.p.
2. Ask pupils to solve the problems individually in their exercise books. They may discuss with seatmates as needed.
3. Walk around as they solve the problems and clear any misconceptions.
4. Ask volunteers to call out their answers (Answers: a. 0.4564; b. 79.9; c. 1.260; d. 10.10101).

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L028 in the Pupil Handbook.

Lesson Title: Recurring decimals as common fractions	**Theme:** Numbers and Numeration	
Lesson Number: M1-L029	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to convert recurring decimals into common fractions.	**Preparation** None	

Opening *(3 minutes)*

1. Write the following problem on the board: Change $\frac{3}{4}$ to decimal.
2. Allow pupils to brainstorm the problem and write their answers.
3. Invite a volunteer to write the solution on the board.
   Solution:

$$\frac{3}{4} = \quad \begin{array}{r|rrr} & 0. & 7 & 5 \\ \cline{2-4} 4 & 3. & 0 & \\ - & 2 & 8 & \\ \cline{2-3} & & 2 & 0 \\ & - & 2 & 0 \\ \cline{2-4} & & & 0 \end{array}$$

4. Explain to pupils that today's lesson is on converting recurring decimals into common fractions.

Teaching and Learning *(22 minutes)*

1. Explain:
   - Some fractions give terminating decimals. The problem on the board is an example.
   - In this example, the division works out exactly and the decimal comes to an end (i.e. terminates).
2. Write the following problem on the board: Change $\frac{2}{9}$ to a decimal.
3. Explain:
   - In some cases the division does not stop nor terminate, and the same digits are repeated indefinitely.
   - We say that the digits recur, and that the decimal is a recurring, or a repeating decimal.
   - In a recurring decimal, a digit or group of digits is repeated forever.
   - Repeating numbers are shown with a line over the repeating numbers. In other cases, dots are used to show the repeating pattern. Three dots are placed after the numbers.
4. Ask pupils to work with seatmates to change $\frac{2}{9}$ to a decimal.
5. After 1-2 minutes, invite a volunteer to write the answer on the board. Stop them after 3 decimal places.

Solution:

$$\frac{2}{9} = \begin{array}{r|lllll} & 0. & 2 & 2 & 2 \\ \hline 9 & 2. & 0 & & \\ - & 1 & 8 & & \\ \cline{2-3} & & 2 & 0 & \\ & - & 1 & 8 & \\ \cline{2-4} & & & 2 & 0 \\ & & - & 1 & 8 \\ \cline{3-5} & & & & 2 \end{array}$$

6. Explain that the 2s repeat forever as it does not terminate.
7. Write on the board: $\frac{2}{9} = 0.222 \ldots = 0.\overline{2}$
8. Explain:
   - We have converted a fraction to a recurring decimal. We can also convert a recurring decimal to a fraction.
   - To do this, multiply the recurring decimal by the smallest power of ten which will produce another number with the same repeating pattern of digits in the decimal places.
   - Subtract the smaller number from the larger number and then eliminate the digits in the decimal places.
9. Write the following problem on the board: Convert 3.222 … to the form $\frac{\mathrm{a}}{\mathrm{b}}$.
10. Solve the problem on the board. Allow pupils to be involved.
    Solution:
    Step 1. Let $\mathrm{r} = 3.222 \ldots$ (1)
    Step 2. Multiply both sides by 10.
    $10\mathrm{r} = 32.222 \ldots$ (2)
    Step 3. Subtract equation (1) from (2).
    $$10r - \mathrm{r} = (32.22222\ldots) - (3.2222222\ldots.)$$
    $$9r = 29$$
    Step 4. Divide both sides by 9.
    $$\frac{\cancel{9}\mathrm{r}}{\cancel{9}} = \frac{29}{9}$$
    $$r = \frac{29}{9} = 3\frac{2}{9}$$
11. Write 2 more problems on the board: Convert the recurring decimals to fractions:
    a. $0.272727 \ldots$ b. $2.\overline{54}$
12. Solve problem a. on the board. Allow pupils to be involved.
    Solution:

r	$=$	$0.272727 \ldots$	(1)	
$100r$	$=$	$27.2727 \ldots$	(2)	Multiply by 100 because 2 digits repeat
$100r - r$	$=$	$27.2727 \ldots - 0.2727 \ldots$		Subtract (2) – (1)

$99r$	$=$	27	Simplify
$\frac{99r}{99}$	$=$	$\frac{27}{99}$	Divide throughout by 99
r	$=$	$\frac{3}{11}$	Simplify

13. Ask pupils to solve question b. with seatmates.
14. Walk around to check for understanding and clear misconceptions.
15. Invite a volunteer to write the solution on the board. Support them as needed.

Solution:

r	$=$	$2.\overline{54}$ (1)	
$100r$	$=$	$254.\overline{54}$ (2)	Multiply by 100 because 2 digits repeat
$100r - r$	$=$	$254.\overline{54} - 2.\overline{54}$	Subtract (2) – (1)
$99r$	$=$	252	Simplify
$\frac{99r}{99}$	$=$	$\frac{252}{99}$	Divide throughout by 99
r	$=$	$\frac{28}{11} = 2\frac{6}{11}$	Simplify

Practice *(14 minutes)*

1. Write the following two problems on the board:
   a. Write $0.8888 \ldots$ in the from $\frac{\mathrm{a}}{\mathrm{b}}$, where a and b are integers and $b \neq 0$.
   b. Write $0.\overline{1}$ as a fraction.
2. Ask pupils to solve the problem in their exercise books. Allow them to discuss with seatmates as needed.
3. Invite volunteers to write the solutions on the board.

Solutions:

a.

r	$=$	$0.8888 \ldots$ (1)	
$10r$	$=$	$8.8888 \ldots$ (2)	Multiply by 10 because 1 digit repeats
$10r - r$	$=$	$8.8888 \ldots - 0.8888 \ldots$	Subtract (2) – (1)
$9r$	$=$	8	Simplify
$\frac{9r}{9}$	$=$	$\frac{8}{9}$	Divide throughout by 99
r	$=$	$\frac{8}{9}$	Simplify

b.

r	$=$	$0.\overline{1}$ (1)	
$10r$	$=$	$1.\overline{1}$ (2)	Multiply by 10 because 1 digit repeats
$10r - r$	$=$	$1.\overline{1} - 0.\overline{1}$	Subtract (2) – (1)
$9r$	$=$	1	Simplify
$\frac{9r}{9}$	$=$	$\frac{1}{9}$	Divide throughout by 99
r	$=$	$\frac{1}{9}$	Simplify

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L029 in the Pupil Handbook.

Lesson Title: Operations on real numbers	**Theme:** Numbers and Numeration	
Lesson Number: M1-L030	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to perform operations on real numbers.	**Preparation** Write the problem in Opening on the board.	

Opening *(3 minutes)*

1. Review addition and subtraction of negative numbers. Write on the board:
$$-10-(-5)+(-5)=$$
2. Ask pupils to solve the problem in their exercise books.
3. Invite a volunteer to solve the problem on the board. (Answer: -10)
   Solution:
$$\begin{aligned} -10-(-5)+(-5) &= -10+5-5 \\ &= -10+0 \\ &= -10 \end{aligned}$$
4. Remind pupils if needed:
   - Subtracting two negative numbers is the same as adding.
   - Adding a negative number to a positive number is the same as subtracting.
5. Explain to pupils that today's lesson is on operations on real numbers.

Teaching and Learning *(22 minutes)*

1. Explain:
   a. The four simple operations in Mathematics are addition, subtraction, multiplication, and division.
   - Today we will discuss how different operations are performed, and the properties they have.
2. Write the following on the board:
   - Let $*$ and Δ represent operations.
   - Commutative property: $a*b=b*a$
   - Associative property: $a*(b*c)=(a*b)*c$
   - Distributive property: $a*(b\Delta c)=(a*b)\Delta(a*c)$
3. Explain each property:
   - The commutative property means that the order does not matter. a or b can come first. Addition and multiplication are commutative.
   - The associative property means that it doesn't matter which operation is performed first when combining 3 or more terms. Addition and multiplication are associative.

- The distributive property is used when there are 2 different operations that combine 3 different terms.

4. Write example problems that use each property:
   a. $2 \times 3 = 3 \times 2 =$
   b. $2 + (4 + 3) = (2 + 4) + 3 =$
   c. $3 \times (2 + 4) = (3 \times 2) + (3 \times 4) =$
5. Solve each equation of a. on the board: $2 \times 3 = 6$ and $3 \times 2 = 6$
6. Explain:
   a. This demonstrates the commutative property. It doesn't matter which order we multiply in.
7. Ask pupils to work with seatmates to solve both equations for b. and c. They should check that they get the same answer both ways.
8. Invite 2 volunteers to write the answers on the board. (Answers: b. 9; c. 18)
9. Write the following problem on the board:
   The operation $*$ is defined as $m * n = m + n + mn$.
   Evaluate $3 * 4$.
10. Explain:
    a. In this case the operation is not simply to add, subtract, divide or multiply.
    b. The operation given by the star means that we should perform the right side of the equation, $m + n + mn$.
    c. We can do this if we are given any 2 numbers for m and n. In this case, we are given 3 and 4.
11. Write the solution on the board and explain:

$3 * 4$	$=$	$3 + 4 + 3(4)$	Substitute the values of m and n
	$=$	$3 + 4 + 12$	Remove bracket
	$=$	19	Add

12. Write the following on the board: Using the same operation, evaluate $4 * 3$.
13. Write the solution on the board:

$4 * 3$	$=$	$4 + 3 + 4(3)$	Substitute the values of m and n
	$=$	$4 + 3 + 12$	Remove bracket
	$=$	19	Add

14. Discuss: Compare the 2 answers we got by applying the operation. What property do you see?
15. Write on the board: $3 * 4 = 19$ and $4 * 3 = 19$. Therefore, $3 * 4 = 4 * 3$
16. Explain to pupils that the operation is **commutative**.
17. Write another problem on the board: The operation $*$ defined as $m * n = m + n + mn$. Show that $2 * (3 * 4) = (2 * 3) * 4$. What property does the operation have?
18. Explain to pupils that they need to perform the operation in the bracket first.
19. Write the solution of $2 * (3 * 4)$ on the board by performing the operation in the bracket first:

$$
\begin{aligned}
2 * (3 * 4) &= 2 * [3 + 4 + 3(4)] \\
&= 2 * 19 \\
&= 2 + 19 + 2(19) \\
&= 2 + 19 + 38 \\
&= 59
\end{aligned}
$$

20. Ask pupils to work with seatmates to find the solution of $(2 * 3) * 4$. This is the right-hand side of the equation given in the problem.
21. Invite a volunteer to write the solution on the board.

    Solution:

$$
\begin{aligned}
(2 * 3) * 4 &= [2 + 3 + 2(3)] * 4 \\
&= (5 + 6) * 4 \\
&= 11 * 4 \\
&= 11 + 4 + 11(4) \\
&= 15 + 44 \\
&= 59
\end{aligned}
$$

22. Discuss:
    a. What are the two answers? (Answer: Both answers are 59. $2 * (3 * 4) = 59$ and $(2 * 3) * 4 = 59$.)
    b. What property does this operation have? (Answer: The operation $*$ is associative.)
23. Write the following problem on the board:

    The operation $*$ is defined on the set of real numbers by $m * n = \frac{m-n}{n}$; $n \neq 0$.

    Evaluate $3 * (5 * 2)$.
24. Ask pupils to work with seatmates to solve the problems in their exercise books.
25. Walk round to check for understanding and clear any misconceptions.
26. Invite any volunteers to write the solution on the board.

    Solution:

$$
\begin{aligned}
3 * (5 * 2) &= 3 * \left(\frac{5-2}{2}\right) && \text{Perform the operation in bracket first} \\
&= 3 * \frac{3}{2} \\
&= \frac{3-\frac{3}{2}}{\frac{3}{2}} \\
&= \frac{3}{2} \div \frac{3}{2} \\
&= \frac{3}{2} \times \frac{2}{3} \\
&= 1
\end{aligned}
$$

Practice *(14 minutes)*

1. Write the following two problems on the board:
    a. The operation $*$ is defined over the set of real numbers by $a * b = \frac{a+b}{a-b}$.

       Find: (i) $6 * 2$ (ii) $2 * -4$

b. The operation $\odot$ is defined over the set of real numbers by $a \odot b = a + b - ab$. Find $3 \odot -6$.

2. Ask the pupils to solve the problems independently in their exercise books.
3. Walk round to check for understanding and clear any misconceptions.
4. Invite volunteers to come to the board to show their solutions.

Solutions:

a. i. $6 * 2 = \frac{6+2}{6-2} = \frac{8}{4} = 2$ ii. $2 * -4 = \frac{2+(-4)}{2-(-4)} = \frac{2-4}{2+4} = \frac{-2}{6} = -\frac{1}{3}$

b.
$$\begin{aligned} 3 \odot -6 &= 3 + (-6) - (3)(-6) \\ &= 3 - 6 + 18 \\ &= 15 \end{aligned}$$

Closing *(1 minute)*

1. For home work, have pupils do the practice activity PHM1-L030 in the Pupil Handbook.

Lesson Title: Order of operations (BODMAS)	**Theme:** Numbers and Numeration	
Lesson Number: M1-L031	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to apply the order of operations (BODMAS) to solve mathematical problems.	**Preparation** None	

Opening *(3 minutes)*

1. Write on the board: $10 - 3 \times 3$
2. Give pupils 1 minute to find the answer. They may share ideas with seatmates.
3. Allow pupils to call out their answers. Some pupils may say 21 (incorrect), while other pupils say 1 (correct). Encourage all answers.
4. Invite a volunteer who answered 1 to solve the problem on the board. (Answer: multiply first: $3 \times 3 = 9$, then subtract: $10 - 9 = 1$)
5. Explain to pupils that today's lesson is on applying BODMAS to solve mathematical problems. We must follow the correct order of operations to get the correct answer.

Teaching and Learning *(20 minutes)*

1. Ask pupils to tell us what the letters of BODMAS stand for? (Answer: Bracket, Of, Division, Multiplication, Addition and Subtraction)
2. Explain:
   - When working problems which have more than one operation (of, $\times, +, -$ and $\div$), we use BODMAS.
   - This tells us the order in which we should work the operations in a Maths problem.
   - The term "of" represents the multiplication sign, which includes powers.
3. Write the following problem on the board: Simplify $7 + (6 + 5^2) \times 3$.
4. Explain the steps on the board to pupils and make sure they understand.
   Solution:

$7 + (6 + 5^2) \times 3$	$= 7 + (6 + 25) \times 3$	Start inside brackets, using "of" first.
	$= 7 + (31) \times 3$	Add inside the brackets.
	$= 7 + 93$	Multiply
	$= 100$	Add

5. Write another problem on the board: Evaluate $3 + 6 \times (5 + 4) \div 3 - 7$ using the order of operations.
6. Explain the steps on the board to pupils and make sure they understand.
   Solution:

$3 + 6 \times (5 + 4) \div 3 - 7$	$= 3 + 6 \times 9 \div 3 - 7$	Bracket
	$= 3 + 6 \times 3 - 7$	Division

$= 3 + 18 - 7$ Multiplication
$= 21 - 7$ Addition
$= 14$ Subtraction

7. Write the following problem on the board: Evaluate $\left(2\frac{1}{3} + 4\frac{1}{2}\right) \div 8\frac{1}{5}$
8. Ask pupils to solve the problem with seatmates.
9. Invite a volunteer to perform the operation in the bracket first on the board:
$$2\frac{1}{3} + 4\frac{1}{2} = \frac{7}{3} + \frac{9}{2} = \frac{14+27}{6} = \frac{41}{6}$$
10. Invite another volunteer to solve $\frac{41}{6} \div 8\frac{1}{5}$ on the board:
$$\frac{41}{6} \div 8\frac{1}{5} = \frac{41}{6} \div \frac{41}{5} = \frac{41}{6} \times \frac{5}{41} = \frac{5}{6}$$
11. Write the following problem on the board: Evaluate $\left(3\frac{1}{2} + 7\right) \div \left(4\frac{1}{3} - 3\right)$.
12. Ask pupils to solve the problem with seatmates.
13. Invite a volunteer to solve the problem on the board. Allow the other pupils to be involved.
Solution:

$\left(3\frac{1}{2} + 7\right) \div \left(4\frac{1}{3} - 3\right)$	$= \left(\frac{7}{2} + 7\right) \div \left(\frac{13}{3} - 3\right)$	Convert mixed to improper fractions
	$= \left(\frac{7+14}{2}\right) \div \left(\frac{13-9}{3}\right)$	Solve inside brackets
	$= \frac{21}{2} \div \frac{4}{3}$	Divide
	$= \frac{21}{2} \times \frac{3}{4}$	
	$= \frac{63}{8} = 7\frac{7}{8}$	

Practice *(16 minutes)*

1. Write the following problems on the board:
   a. Evaluate $150 \div (6 + 3 \times 8) - 5$
   b. Evaluate $\frac{1}{2} + \frac{1}{4}$ of $\frac{2}{3} \div \frac{5}{6}$
   c. Evaluate $6 + 2^3 - 4 \times 8$
2. Ask pupils to solve the problems independently in their exercise books. They may discuss with seatmates if needed.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite volunteers from the class to solve the problems on the board.

Solutions:

a.

$150 \div (6 + 3 \times 8) - 5$	$= 150 \div (6 + 24) - 5$	Multiply inside brackets
	$= 150 \div 30 - 5$	Add inside brackets
	$= 5 - 5$	Divide
	$= 0$	Subtract

b.

$\frac{1}{2} + \frac{1}{4} \text{ of } \frac{2}{3} \div \frac{5}{6}$	$= \frac{1}{2} + \left(\frac{1}{4} \times \frac{2}{3}\right) \div \frac{5}{6}$	Multiply ("of")
	$= \frac{1}{2} + \frac{2}{12} \div \frac{5}{6}$	
	$= \frac{1}{2} + \frac{1}{6} \div \frac{5}{6}$	Simplify the fraction
	$= \frac{1}{2} + \frac{1}{6} \times \frac{6}{5}$	Divide
	$= \frac{1}{2} + \frac{1}{5}$	
	$= \frac{5+2}{10} = \frac{7}{10}$	Add

c.

$6 + 2^3 - 4 \times 8$	$= 6 + 8 - 4 \times 8$	Power ("of")
	$= 6 + 8 - 32$	Multiply
	$= 14 - 32$	Add
	$= -18$	Subtract

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L031 in the Pupil Handbook.

<table>
<tr><td>Lesson Title: Index notation</td><td colspan="2">Theme: Numbers and Numeration</td></tr>
<tr><td>Lesson Number: M1-L032</td><td>Class: SSS 1</td><td>Time: 40 minutes</td></tr>
<tr><td>Learning Outcomes
By the end of the lesson, pupils will be able to:
1. Identify the index and base in index notation.
2. Identify that the index indicates the number of times the base is multiplied by itself.</td><td colspan="2">Preparation
Write the problem in Opening on the board.</td></tr>
</table>

Opening *(3 minutes)*

1. Write on board: $3 \times 3 \quad 7 \times 7 \quad 8 \times 8 \quad 10 \times 10$
2. Give pupils 1 minute to calculate the answers.
3. Ask volunteers to call out each answer, and write them on the board. (Answer: $9, 49, 64, 100$)
4. Explain to the pupils that today's lesson is on index notation, or number with powers.

Teaching and Learning *(20 minutes)*

1. Write on the board: 7^3
2. Explain:
   - This is read as: "Seven raised to the power of 3"
   - We refer to the big number as the "base". The small 3 is referred to as the "power" or the index.
3. Label the numbers on the board: $\text{base} \rightarrow 7^{3 \leftarrow \text{power/index}}$
4. Ask pupils to think about 7^3 and give their ideas about what it means. Encourage their participation.
5. Explain: The power of a number says how many times to use the number in multiplication.
6. Write the expansion on the board: $7^3 = 7 \times 7 \times 7$
7. Write on the board: 1^2
8. Ask pupils to write the answer in their exercise books.
9. Allow them to share ideas, and invite one pupil to write the answer on the board. (Answer: $1^2 = 1 \times 1 = 1$)
10. Write on the board: Write $2 \times 2 \times 2 \times 2 \times 2$ in index notation.
11. Ask pupils to share their ideas about how to write this. (Answer: "2 raised to the power 5" or "2 to the power 5")
12. Ask one volunteer to write the answer on the board. (Answer: 2^5)
13. Write on the board: 3^{-2}

14. Explain:
    - If you see a negative number as a power, the expression can be written as a fraction.
    - The expression is moved to the denominator, and the power is made positive. The numerator is 1.
15. Rewrite the expression on the board: $3^{-2} = \frac{1}{3^2}$
16. Write the general rule on the board: $\mathrm{a}^{-\mathrm{n}} = \frac{1}{\mathrm{a}^{\mathrm{n}}}$
17. Write another problem on the board: Write 12^{-7} as a fraction.
18. Ask pupils to solve the problem with seatmates. Invite a volunteer to write the answer on the board. (Answer: $12^{-7} = \frac{1}{12^7}$)
19. Write on the board. Simplify $2 \times 2 \times 2 \times 3 \times 3$
20. Discuss: How could we write this expression in index form?
21. Allow pupils to share their ideas, then explain:
    - There are two bases, 2 and 3.
    - We rewrite each base with the power being the number of times its multiplied. The two indices are multiplied by each other.
22. Write the answer on the board: $2^3 \times 3^2$
23. Write 2 problems on the board:
    - Simplify:$4 \times 4 \times 4 \times 5 \times 9 \times 9$
    - Expand:$3^5 \times 8^2$
24. Ask pupils to work with seatmates to solve the problems.
25. Invite volunteers write the answers on the board. (Answers: a. $4^3 \times 5 \times 9^2$; b. $3 \times 3 \times 3 \times 3 \times 3 \times 8 \times 8$)

Practice *(14 minutes)*

1. Write the following two problems on the board:
    a. Expand the following: (i) 8^4 (ii) 5^6 (iii) $3^5 \times 4^2 \times 8$
    b. Write in index form: (i) $7 \times 7 \times 7 \times 7 \times 7$
       (ii) $3 \times 3 \times 5 \times 5 \times 5 \times 6 \times 6$
       (iii) $4 \times 12 \times 12 \times 25 \times 25 \times 25 \times 25$
    c. Write as a fraction: (i) 2^{-18} (ii) 3^{-8}
2. Ask pupils to work with seatmates.
3. Walk around to check for understanding and clear misconceptions.
4. Invite volunteers to give their answers to the problems on the board. (Answers: a. (i) $8 \times 8 \times 8 \times 8$, (ii) $5 \times 5 \times 5 \times 5 \times 5 \times 5$, (iii) $3 \times 3 \times 3 \times 3 \times 3 \times 4 \times 4 \times 8$; b. (i) 7^5 (ii) $3^2 \times 5^3 \times 6^2$, (iii) $4 \times 12^2 \times 25^3$; c. (i) $\frac{1}{2^{18}}$, (ii) $\frac{1}{3^8}$)

Closing *(3 minutes)*

1. Write on the board: Simplify $3 \times 3 \times 3 + 5 \times 5$
2. Ask pupils to think about the problem before solving it. Ask them to write the answer in their exercise books.
3. Ask any volunteer to call out the answer. (Answer: $3^3 + 5^2$)
4. Explain that we can’t add two indices with different bases. We cannot simplify the expression any further.
5. For homework, have pupils do the practice activity PHM1-L032 in the Pupil Handbook.

Lesson Title: First and second laws of indices	**Theme:** Numbers and Numeration	
Lesson Number: M1-L033	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcomes By the end of the lesson, pupils will be able to: 1. Identify the first law of indices ($a^m \times a^n = a^{m+n}$) and multiply two or more indices. 2. Identify the second law of indices ($a^m \div a^n = a^{m-n}$) and divide two or more indices.	**Preparation** None	

Opening *(2 minutes)*

1. Write on board: $5^2 \times 5$
2. Ask pupils to brainstorm and solve the problem.
3. Invite a volunteer to write the answer on the board. (Answer: $5\times 5 \times 5 = 125$, or 5^3, or $5^3 = 125$)
4. Explain to the pupils that today's lesson is on multiplication and division of indices.

Teaching and Learning *(25 minutes)*

1. Write on the board: Simplify $3^2 \times 3^5$
2. Explain the **first law of indices:** When multiplying two or more indices with the same base, simply add the powers. This is the first law of indices.
3. Write on the board: $a^m \times a^n = a^{m+n}$
4. Explain the formula:
   - This is the formula for the first law of indices.
   - m and n are the power of a and a is the base. This rule only works if the bases are the same.
5. Simplify the problem on the board: $3^2 \times 3^5 = 3^{2+5} = 3^7$
6. Write another problem on the board: Simplify $r^3 \times r^4 \times r^5$
7. Discuss: Ask pupils to explain how they think this can be solved. Allow them to share their ideas.
8. Solve on the board: $r^3 \times r^4 \times r^5 = r^{3+4+5} = r^{12}$
9. Write another problem on the board: $10x^4y \times 2x^3y^2$
10. Explain:
    - When there are coefficients (numbers) before the variables, multiply those together.
    - When there are multiple variables, add the powers of each of them separately.
11. Solve on the board: $10x^4y \times 2x^3y^2 = (10 \times 2)x^{4+3}y^{1+2} = 20x^7y^3$

12. Write 2 more problems on the board: Simplify: a. $4^8 \times 4^7$ b. $3p^4 \times 2p^{12}$
13. Ask pupils to work with seatmates to solve the problems.
14. Invite 2 volunteers to write the solutions on the board. (Solutions: a. $4^8 \times 4^7 = 4^{8+7} = 4^{15}$; b. $3p^4 \times 2p^{12} = 6p^{4+12} = 6p^{16}$)
15. Write the following problem on the board: $3^6 \div 3^2$
16. Explain the **second law of indices:** When we divide two or more indices, we subtract the powers to get the answer. This is the second law of indices.
17. Write on the board: $\mathrm{a}^{\mathrm{m}} \div \mathrm{a}^{\mathrm{n}} = \mathrm{a}^{\mathrm{m-n}}$
18. Explain the formula:
    - This is the formula for the second law of indices.
    - m and n are the power of a, and a is the base. This rule only works if the bases are the same.
19. Simplify the problem on the board: $3^6 \div 3^2 = 3^{6-2} = 3^4$
20. Explain: I will show you why this is true. When we write the division problem as a fraction and expand the indices, 3s cancel from the numerator and denominator.
21. Write on the board and make sure pupils understand:

$$
\begin{aligned}
3^6 \div 3^2 &= \frac{3^6}{3^2} && \text{Write as a fraction} \\
&= \frac{3\times3\times3\times3\times3\times3}{3\times3} && \text{Expand} \\
&= \frac{3\times3\times3\times3\times\cancel{3\times3}}{\cancel{3\times3}} && \text{Cancel 3s} \\
&= 3\times3\times3\times3 && \text{Simplify} \\
&= 3^4
\end{aligned}
$$

22. Write another problem on the board: Simplify $\frac{a^9}{a^3}$
23. Discuss: Ask volunteers to explain how to solve the problem. Allow them to share their ideas.
24. Explain: Fractions are the same as division. We simply follow the second law of indices and subtract the indices.
25. Solve on the board: $\frac{a^9}{a^3} = a^9 \div a^3 = a^{9-3} = a^6$
26. Write another problem on the board: $8b^5a^3 \div 4b^3a$
27. Explain:
    - When there are coefficients (numbers) before the variables, divide those.
    - When there are multiple variables, subtract the powers of each of them separately.
28. Solve on the board: $8b^5a^3 \div 4b^3a = (8 \div 4)b^{5-3}a^{3-1} = 2b^2a^2$
29. Write 2 more problems on the board: Simplify: a. $3^{12} \div 3^7$ b. $\frac{16xy^7}{8xy^3}$
30. Ask pupils to work with seatmates to solve the problems.
31. Invite 2 volunteers to write the solutions on the board. (Solutions: a. $3^{12} \div 3^7 = 3^{12-7} = 3^5$; b. $\frac{16xy^7}{8xy^3} = 16xy^7 \div 8xy^3 = 2x^{1-1}y^{7-4} = 2x^0y^3 = 2y^3$)
32. Write another problem on the board: $3^6 \times 3^{-2}$

33. Ask pupils if they can think of another way to write this expression. After allowing them to share their ideas, write on the board: $3^6 \times 3^{-2} = 3^6 \times \frac{1}{3^2}$
34. Explain: Recall that a negative power can be changed to a fraction.
35. Solve the problem on the board using division: $3^6 \times 3^{-2} = 3^6 \times \frac{1}{3^2} = \frac{3^6}{3^2} = 3^6 \div 3^2 = 3^{6-2} = 3^4$
36. Solve the same problem again using multiplication: $3^6 \times 3^{-2} = 3^{6+(-2)} = 3^{6-2} = 3^4$

Practice *(12 minutes)*

1. Write the following on the board:

   Simplify the following expressions:
   a. $2^3 \times 2^4 \times 2^5$
   b. $10p^5 \div 5p^2$
   c. $\frac{24x^5y^4}{8x^4y}$
   d. $a^5 \times a^{-3}$
2. Ask pupils to solve the problems in their exercise books. Allow them to discuss the problem with seatmates if needed.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite three volunteers to write out their solutions on the board. Allow the other pupils to check their answers, and explain as needed.
   Solutions:
   a. $2^3 \times 2^4 \times 2^5 = 2^{3+4+5} = 2^{12}$
   b. $10p^5 \div 5p^2 = 2p^{5-2} = 2p^3$
   c. $\frac{24x^5y^4}{8x^4y} = 24x^5y^4 \div 8x^4y = 3x^{5-4}y^{4-1} = 3xy^3$
   d. $a^5 \times a^{-3} = a^{5+(-3)} = a^{5-3} = a^2$ **or** $a^5 \times a^{-3} = a^5 \times \frac{1}{a^3} = \frac{a^5}{a^3} = a^{5-3} = a^2$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L033 in the Pupil Handbook.

Lesson Title: Third and fourth laws of indices	**Theme:** Numbers and Numeration	
Lesson Number: M1-L034	**Class:** SSS 2	**Time:** 40 minutes
Learning Outcomes By the end of the lesson, pupils will be able to: 1. Identify and apply the third law of indices $(a^0 = 1)$expressions that contain indices. 2. Identify and apply the fourth law of indices $[(a^x)^y = a^{xy}]$.	**Preparation** Write the problem in Opening on the board.	

Opening *(4 minutes)*

1. Revise the previous lesson. Write the following problem on board: Simplify $64x^6 \div 8x^4$.
2. Ask pupils to solve the problem in their exercise books.
3. Invite a volunteer to write the answer on the board. (Answer: $64x^6 \div 8x^4 = (64 \div 8)x^{6-4} = 8x^2$)
4. Explain to the pupils that today's lesson is on the next 2 laws of indices. These are raising a number to the power of zero, and raising an index to another power.

Teaching and Learning *(20 minutes)*

1. Write on the board: Simplify 8^0
2. Explain: Any non-zero number raised to the power zero is equal to 1.
3. Write on the board: For any positive number x, we define $x^0 = 1$
4. Invite a volunteer to write the answer of 8^0 on the board. (Answer: $8^0 = 1$)
5. Explain:
    - Zero to the power of zero is often said to be "an indeterminate form", because it could have several different values.
    - We could also think of 0^0 having the value 0, because zero to any power (other than zero power) is zero.
6. Write the following problem on the board: Simplify$\left(\frac{1}{5}\right)^0$.
7. Ask volunteers to describe the steps to solve the problem. As they explain, work it on the board. (Answer: $\left(\frac{1}{5}\right)^0 = \frac{1^0}{5^0} = \frac{1}{1} = 1$)
8. Write another problem on the board: Simplify $\mathrm{r}^9 \div \mathrm{r}^9$
9. Ask pupils to work with seatmates to solve the problem. Remind them to use the second law of indices.
10. Invite a volunteer to write the solution on the board. (Answer: $\mathrm{r}^9 \div \mathrm{r}^9 = \mathrm{r}^{9-9} = \mathrm{r}^0 = 1$)
11. Write a problem on the board: Simplify $(2^2)^3$
12. Explain:

- Since "powers of powers" involve expressions with brackets, it's important to remember that everything inside the brackets is raised to the outside power.
- If a power is raised to another power, multiply the indices.

13. Write the general form on the board: $(\mathrm{a}^{x})^{y} = \mathrm{a}^{xy}$
14. Simplify the problem given on the board: $(2^2)^3 = 2^{2\times 3} = 2^6$
15. Write the following problem on the board: Simplify $(2a^2b^3)^2$.
16. Explain that each number and variable inside the bracket is raised to the power outside the bracket.
17. Solve on the board: $(2a^2b^3)^2 = 2^2a^{2\times 2}b^{3\times 2} = 4a^4b^6$
18. Write another problem on the board: Simplify $(a^{-2})^3$
19. Discuss: How do you think we will solve this problem?
20. Allow pupils to share ideas, then explain: We can multiply the exponents as usual. Use the rules for multiplying negative numbers. A negative times a positive gives a negative.
21. Solve on the board: $(a^{-2})^3 = a^{-2\times 3} = a^{-6} = \frac{1}{a^6}$
22. Write the following 2 problems on the board: a. $(2x^4)^3$ b. $(4^3)^2 \times 4^{-6}$
23. Ask pupils to work with seatmates to solve the problems.
24. Invite 2 volunteers to write the solutions on the board. (Answers: a. $(2x^4)^3 = 2^3x^{4\times 3} = 8x^{12}$; b. $(4^3)^2 \times 4^{-6} = 4^{3\times 2} \times 4^{-6} = 4^6 \times 4^{-6} = 4^{6+(-6)} = 4^0 = 1$)

Practice *(15 minutes)*

1. Write the following on the board: Simplify the following expressions:
   a. 0.678^0
   b. $7^9 \div 7^9$
   c. $(2x^4y^3)^2$
   d. $(3^4)^{-2}$
   e. $(y^2)^6 \div y^{12}$
2. Ask pupils to solve the problems independently in their exercise books. Allow them to discuss with seatmates if needed.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite four pupils, one at a time, to write their answers on the board. Ask the other pupils to check their work.
   Solutions:
   a. $0.678^0 = 1$
   b. $7^9 \div 7^9 = 7^{9-9} = 7^0 = 1$
   c. $(2x^4y^3)^2 = 2^2x^{4\times 2}y^{3\times 2} = 4x^8y^6$
   d. $(3^4)^{-2} = 3^{4\times(-2)} = 3^{-8} = \frac{1}{3^8}$
   e. $(y^2)^6 \div y^{12} = y^{2\times 6} \div y^{12} = y^{12} \div y^{12} = y^{12-12} = y^0 = 1$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L034 in the Pupil Handbook.

<table>
<tr><td>Lesson Title: Simplifying indices</td><td colspan="2">Theme: Numbers and Numeration</td></tr>
<tr><td>Lesson Number: M1-L035</td><td>Class: SSS 1</td><td>Time: 40 minutes</td></tr>
<tr><td>Learning Outcome
By the end of the lesson, pupils will be able to apply multiple laws of indices to simplify expressions that contain indices.</td><td colspan="2">Preparation
Write the problems in Opening on the board.</td></tr>
</table>

Opening *(5 minutes)*

1. Write the following problems on the board:
   a. Simplify: $(a^4)^5$; b. Simplify: $2^4 \times 2 \times 2^3$; c. Simplify: $\mathrm{y}^6 \div \mathrm{y}^6$
2. Ask pupils to solve the problems independently in their exercises books.
3. Invite volunteers to write the answers on the board. (Answers: a.$(a^4)^5 = a^{4\times5} = a^{20}$; b. $2^4 \times 2 \times 2^3 = 2^{4+1+3} = 2^8$; c. $y^6 \div y^6 = y^{6-6} = y^0 = 1$)
4. Explain to pupils that today's lesson is on multiple laws of indices to simplify expressions that contain indices.

Teaching and Learning *(18 minutes)*

1. Review the different law of indices:
   - When multiplying two or more indices with the same base, simply add the powers ($a^m \times a^n = a^{m+n}$).
   - When we divide two or more indices, we subtract the powers to get the answer ($a^m \div a^n = a^{m-n}$).
   - Any non-zero number raised to the power zero is equal to 1 ($x^0 = 1$).
   - If a power is raised to another power, multiply the indices ($(a^x)^y = a^{xy}$).
2. Write the following problem on the board: Simplify $2a \times (3\mathrm{a})^2$.
3. Discuss: What is the first step in solving this problem? (Answer: Apply BODMAS; simplify the bracket first.)
4. Simplify the bracket on the board: $2a \times (3\mathrm{a})^2 = 2a \times 3^2\mathrm{a}^2 = 2a \times 9\mathrm{a}^2$
5. Ask volunteers to give the next step. (Answer: Multiply; the coefficients and variables need to be multiplied.)
6. Finish solving the problem on the board: $2a \times 9a^2 = (2 \times 9)a \times a^2 = 18a^{1+2} = 18a^3$
7. Write another problem on the board: Simplify $(Z^4)^3 \div Z^{12}$
8. Ask volunteers to describe what steps are needed. Solve the problem on the board as they give the steps:

$$
\begin{array}{rcll}
(Z^4)^3 \div Z^{12} & = & Z^{4\times3} \div Z^{12} & \text{Apply the fourth law of indices} \\
& = & Z^{12} \div z^{12} & \\
& = & Z^{12-12} & \text{Apply the second law of indices} \\
& = & Z^0 & \\
& = & 1 & \text{Apply the third law of indices}
\end{array}
$$

Write another problem on the board: Simplify: $\frac{75a^2b^{-2}}{5a^3b^{-3}}$.

9. Discuss: How can we rewrite this problem? (Answer: As a horizontal division problem: $75a^2b^{-2} \div 5a^3b^{-3}$)
10. Ask pupils to work with seatmates to solve the problem.
11. Invite a volunteer to write the solution on the board.

Solution:

$$\begin{aligned}
\frac{75a^2b^{-2}}{5a^3b^{-3}} &= 75a^2b^{-2} \div 5a^3b^{-3} \\
&= (75 \div 5)(a^2 \div a^3)(b^{-2} \div b^{-3}) \\
&= 15a^{2-3}b^{-2-(-3)} \\
&= 15a^{-1}b^{-2+3} \\
&= 15a^{-1}b^1 \\
&= \frac{15b}{a}
\end{aligned}$$

12. Write a problem on the board: Simplify $\frac{8^3\times8^2\times8^8}{8^6\times8^3}$
13. Explain:
    - First, simplify the numerator and the denominator separately by multiplying.
    - Second, divide to find the final answer.
14. Ask pupils to work with seatmates to solve the problem.
15. Invite a volunteer to write the solution on the board.

Solution:

$\frac{8^3\times8^2\times8^8}{8^6\times8^3} = \frac{8^{3+2+8}}{8^{6+3}}$ Simplify the numerator and denominator

$= \frac{8^{13}}{8^9}$

$= 8^{13-9} = 8^4$ Apply the second law

Practice *(16 minutes)*

1. Write the following three problems on the board:
    a. Simplify $(4a^8 \times 5a^2)^2$
    b. Simplify $\frac{8x^6y^3}{2x^6y^3}$
    c. Simplify $(27 \times 3^{-2})(8 \times 2^{-3})$
2. Ask pupils to think about the problems before solving them independently in their exercise books.
3. Allow them to discuss the problems with seatmates if needed.
4. Walk around to check for understanding and clear any misconceptions.
5. Invite three volunteers, one at a time, to solve the problems on the board.

Solutions:

a. $$(4a^8 \times 5a^2)^2 = ((4 \times 5)a^{8+2})^2$$
$$= (20a^{10})^2$$
$$= 20^2 a^{10\times 2}$$
$$= 400a^{20}$$

b. $$\frac{8x^6y^3}{2x^6y^3} = 8x^6y^3 \div 2x^6y^3$$
$$= (8 \div 2)(x^6 \div x^6)(y^3 \div y^3)$$
$$= 4x^{6-6}y^{3-3}$$
$$= 4x^0y^0$$
$$= 4 \times 1 \times 1$$
$$= 4$$

c. $$(27 \times 3^{-2})(8 \times 12^{-3}) = (3^3 \times 3^{-2})(2^3 \times 2^{-3})$$
$$= 3^{3-2} \times 2^{3-3}$$
$$= 3 \times 2^0$$
$$= 3 \times 1$$
$$= 3$$

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L035 in the Pupil Handbook.

Lesson Title: Fractional indices – Part 1	Theme: Numbers and Numeration	
Lesson Number: M1-L036	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to simplify expressions that contain fractional indices.	**Preparation** Write the problem in Opening on the board.	

Opening *(3 minutes)*

1. Write the following problem on the board: Find the square root of the following numbers:

   a. $\sqrt{4}$ b. $\sqrt{25}$ c. $\sqrt{100}$
2. Allow pupils to brainstorm for 1 minute.
3. Ask three volunteers to call out their answers. (Answers: a. 2; b. 5; c. 10)
4. Explain that the calculation of the square root of a number means you are actually using a fraction exponent/index.
5. Write on the board: $\sqrt{4} = 4^{\frac{1}{2}}$
6. Explain that today's lesson is on simplifying expressions that contain fractional indices. Pupils will see how these are related to square roots.

Teaching and Learning *(24 minutes)*

1. Write the following problem on the board: Simplify the following: a. $9^{\frac{1}{2}} \times 9^{\frac{1}{2}}$ b. $8^{\frac{1}{3}} \times 8^{\frac{1}{3}} \times 8^{\frac{1}{3}}$
2. Ask pupils to work with seatmates to simplify the expressions. Remind them to use the first law of indices.
3. Invite 2 volunteers to write the answers on the board. (Answers: a. $9^{\frac{1}{2}} \times 9^{\frac{1}{2}} = 9^{\frac{1}{2}+\frac{1}{2}} = 9$; b. $8^{\frac{1}{3}} \times 8^{\frac{1}{3}} \times 8^{\frac{1}{3}} = 8^{\frac{1}{3}+\frac{1}{3}+\frac{1}{3}} = 8$)
4. Explain:
   - The square root of 9 or $9^{\frac{1}{2}}$ is 3 and that $3 \times 3 = 9$. In another way ask: "What number can you multiply by itself two times to get 9?" The number is 3.
   - $8^{\frac{1}{3}}$ is another way of asking: "What can you multiply by itself three times to get 8? The number is 2 because $2 \times 2 \times 2 = 8$.
5. Write on the board: $\sqrt[n]{x} = x^{\frac{1}{n}}$
6. Explain:
   - This is the general formula for fractional indices with a numerator of 1
   - The power $\frac{1}{n}$ is another way of asking: "What number can you multiply by itself n times to get x?
7. Write the following problem on the board: Simplify $125^{\frac{1}{3}}$.

8. Ask a volunteer to give the number that can be multiplied by itself three times to get 125. (Answer: 5)
9. Write the solution on the board: Answer: $125^{\frac{1}{3}} = 5^{3\times\frac{1}{3}} = 5^1 = 5$
10. Write another problem on the problem. Simplify $256^{\frac{1}{4}}$.
11. Ask pupils to work with seatmates to solve the problem.
12. Invite a volunteer to write the answer on the board. (Answer: $256^{\frac{1}{4}} = 4^{4\times\frac{1}{4}} = 4^1 = 4$)
13. Write on the board: $\sqrt[n]{x^m} = x^{\frac{m}{n}}$
14. Explain:
    - This is the general formula for a fractional index whose numerator is not 1.
    - There are two ways to simplify the fractional indices whose numerator is not 1. You can either apply the numerator first or the denominator, m or n.
15. Write the following problem on the board: Simplify $8^{\frac{2}{3}}$
16. Solve on the board applying the numerator first. Explain each step:

    Solution:

$8^{\frac{2}{3}}$	$= \sqrt[3]{(8)^{\mathbf{2}}}$	Apply the formula
	$= \sqrt[3]{64}$	Calculate the square of 8
	$= 64^{\frac{1}{3}}$	
	$= 4^{3\times\frac{1}{3}}$	Find a number that gives 64 when multiplied by itself 3 times (the cube root)
	$= 4^1 = 4$	

17. Solve the same problem again, applying the denominator first. Explain each step:

$8^{\frac{2}{3}}$	$= \sqrt[3]{(8)^2}$	
	$= (\sqrt[3]{8})^2$	Apply the denominator (cube root) first
	$= (2)^2$	Find the cube root of 8
	$= 4$	Square of 2

18. Explain: We reached the same answer, 4, by applying both the numerator and denominator of the fraction first.
19. Write the following problem on the board: Simplify $27^{\frac{2}{3}}$
20. Ask pupils to solve the problem with seatmates.
21. Allow them to either apply the numerator first or the denominator.
22. Walk around to check for understanding and clear misconceptions.
23. Invite volunteers to write the answer on the board. Find volunteers who solved both ways, and have both ways shown on the board. If no pupils solved it using one of the methods, write it on the board yourself.

    Solutions:

    Numerator first: $27^{\frac{2}{3}} = \sqrt[3]{(27)^{\mathbf{2}}} = \sqrt[3]{729} = 729^{\frac{1}{3}} = 9^{3\times\frac{1}{3}} = 9$

    Denominator first: $27^{\frac{2}{3}} = \sqrt[3]{(27)^{\mathbf{2}}} = (\sqrt[3]{27})^2 = 3^2 = 9$
24. Explain:

- The numbers you are working with may get very large if you apply the numerator first.
- In many cases, it is better to apply the denominator first because you will have smaller numbers to work with.

Practice *(12 minutes)*

1. Write three problems on the board: Simplify the following:
    a. $16^{\frac{1}{4}}$
    b. $100^{\frac{1}{2}}$
    c. $32^{\frac{2}{5}}$
2. Ask pupils to work independently to find the answers in their exercise books. Allow them to discuss with seatmates if needed.
3. Walk around to check for understanding and clear misconceptions.
4. Invite volunteers to come to the board to write the answers. Other pupils should check their work.
   Solutions:
    a. $16^{\frac{1}{4}} = 2^{4\times\frac{1}{4}} = 2^1 = 2$
    b. $100^{\frac{1}{2}} = 10^{2\times\frac{1}{2}} = 10$
    c. Denominator first: $32^{\frac{2}{5}} = \sqrt[5]{(32)^{\mathbf{2}}} = (\sqrt[5]{32})^2 = 2^2 = 4$ (If needed, show pupils that $\sqrt[5]{32} = 32^{\frac{1}{5}} = 2$ because $2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$.)

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L036 in the Pupil Handbook.

Lesson Title: Fractional indices – Part 2	**Theme:** Numbers and Numeration	
Lesson Number: M1-L037	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to simplify more complicated expressions that contain fractional indices.	**Preparation** None	

Opening *(2 minutes)*

1. Write the following problem on the board: Simplify $81^{\frac{3}{4}}$
2. Ask pupils to solve the problem in their exercise books.
3. Invite a volunteer to write the solution on the board. (Solution: Solving by applying the denominator first: $81^{\frac{3}{4}} = \sqrt[4]{(81)^{\mathbf{3}}} = (\sqrt[4]{81})^3 = 3^3 = 27$)
4. Explain that today's lesson is on more complicated expressions that contain fractional indices.

Teaching and Learning *(22 minutes)*

1. Write the following problem on the board: Simplify $\left(\frac{16}{25}\right)^{\frac{1}{2}}$
2. Discuss: Ask pupils if they know of another way to write this expression.
3. Allow them to discuss, then write on the board: $\frac{16^{\frac{1}{2}}}{25^{\frac{1}{2}}}$
4. Explain:
    - Remember that the exponent applies to both the numerator and the denominator.
    - The numerator and denominator can be simplified separately. Each one uses the information from the previous lesson.
5. Solve the problem on the board: $\left(\frac{16}{25}\right)^{\frac{1}{2}} = \frac{16^{\frac{1}{2}}}{25^{\frac{1}{2}}} = \frac{4^{2\times\frac{1}{2}}}{5^{2\times\frac{1}{2}}} = \frac{4^1}{5^1} = \frac{4}{5}$
6. Write the following rule on the board: $\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^{n}$
7. Explain:
    - Any negative power of the quotient of two numbers is the reciprocal of the number raised to the same positive index, i.e. provided $a \neq 0 \; and \; b \neq 0$.
8. Write a problem on the board: Simplify $\left(\frac{8}{125}\right)^{-\frac{1}{3}}$
9. Write the solution on the board. Explain each step
   Solution:

$\left(\frac{8}{125}\right)^{-\frac{1}{3}} = \left(\frac{125}{8}\right)^{\frac{1}{3}}$	Reciprocal of the number raised to the same positive index.

$= \frac{(125)^{\frac{1}{3}}}{(8)^{\frac{1}{3}}}$ Apply the power to the numerator and denominator.

$= \frac{(5)^{3\times\frac{1}{3}}}{(2)^{3\times\frac{1}{3}}}$ Find numbers that can be multiplied by themselves three times to have 125 and 8 respectively.

$= \frac{5^1}{2^1}$

$= \frac{5}{2}$ Any number raised to the power 1 is the number itself.

$= 2\frac{1}{2}$ Change to a mixed fraction.

10. Write another problem on the board: Simplify $625^{\frac{3}{4}} \times 5^{\frac{1}{2}} \div 25$.
11. Explain: When you see multiple fractional powers in a problem, work each fractional power separately. Then, apply BODMAS to the result.
12. Ask pupils to solve the problem with seatmates.
13. Invite a volunteer to write the answer on the board. (Answer: $625^{\frac{3}{4}} \times 5^{\frac{1}{2}} \div 25 = \sqrt[4]{625^3} \times 5^{\frac{1}{2}} \div 5^2 = 5^3 \times 5^{\frac{1}{2}} \div 5^2 = 5^{3+\frac{1}{2}-2} = 5^{1\frac{1}{2}}$).
14. Write another problem on the board: Simplify $\left(\frac{27}{125}\right)^{-\frac{1}{3}} \times \left(\frac{4}{9}\right)^{\frac{1}{2}}$.
15. Explain: Solve each fractional power separately, then multiply the results together.
16. Ask pupils to work with seatmates to find the answer.
17. Walk around to check for understanding and clear misconceptions.
18. Invite a volunteer to solve the first part of the question $\left(\frac{27}{125}\right)^{-\frac{1}{3}}$on the board.

    (Answer: $\left(\frac{27}{125}\right)^{-\frac{1}{3}} = \left(\frac{125}{27}\right)^{\frac{1}{3}} = \frac{(5)^{3\times\frac{1}{3}}}{(3)^{3\times\frac{1}{3}}} = \frac{5}{3}$)
19. Ask another volunteer to solve the other part of the question $\left(\frac{4}{9}\right)^{\frac{1}{2}}$on the board.

    (Answer: $\left(\frac{4}{9}\right)^{\frac{1}{2}} = \frac{(2)^{2\times 1/2}}{(3)^{2\times 1/2}} = \frac{2}{3}$)
20. Invite another volunteer to multiply the two answers on the board. (Answer:$\frac{5}{3} \times \frac{2}{3} = \frac{10}{9} = 1\frac{1}{9}$)
21. Tell them that the answer is $1\frac{1}{9}$.
22. Write another problem on the board: Simplify $27^{\frac{2}{3}} \times 64^{\frac{1}{3}} \div 81^{\frac{1}{4}}$.
23. Ask volunteers to explain the steps needed to solve the problem. (Answer: Apply each fractional power, then multiply and divide the result.)
24. Ask pupils to solve the problem with seatmates.
25. Walk around to check for understanding and clear misconceptions.
26. Invite a volunteer to write the solution on the board.

Solution:

$$27^{\frac{2}{3}} \times 64^{\frac{1}{3}} \div 81^{\frac{1}{4}}. \quad = \sqrt[3]{27^2} \times (4)^{3\times\frac{1}{3}} \div (3)^{4\times\frac{1}{4}}$$
$$= 3^2 \times 4 \div 3$$
$$= 3^{2-1} \times 4$$
$$= 3 \times 4$$
$$= 12$$

Practice *(15 minutes)*

1. Write the following two problems on the board: Simplify the following:
   a. $\left(\frac{16}{81}\right)^{-\frac{1}{4}}\left(\frac{4}{9}\right)^{\frac{1}{2}}\left(\frac{3}{2}\right)^{0}$
   b. $\left(\frac{8}{125}\right)^{-\frac{1}{3}}\left(\frac{1}{16}\right)^{\frac{1}{4}}$
2. Ask pupils to solve the problem independently in their exercise books.
3. Walk around to check for understanding and clear misconceptions.
4. Invite volunteers to write the answers on the board.

   Answers:

   a.
$$\left(\frac{16}{81}\right)^{-\frac{1}{4}}\left(\frac{4}{9}\right)^{\frac{1}{2}}\left(\frac{3}{2}\right)^{0} = \left(\frac{81}{16}\right)^{\frac{1}{4}}\left(\frac{4}{9}\right)^{\frac{1}{2}}\left(\frac{3}{2}\right)^{0}$$
$$= \frac{(3)^{4\times\frac{1}{4}}}{(2)^{4\times\frac{1}{4}}} \times \frac{(2)^{2\times\frac{1}{2}}}{(3)^{2\times\frac{1}{2}}} \times 1$$
$$= \frac{\cancel{3}}{\cancel{2}} \times \frac{\cancel{2}}{\cancel{3}} \times 1$$
$$= 1$$

   b.
$$\left(\frac{8}{125}\right)^{-\frac{1}{3}}\left(\frac{1}{16}\right)^{\frac{1}{4}} = \left(\frac{125}{8}\right)^{\frac{1}{3}}\left(\frac{1}{16}\right)^{\frac{1}{4}}$$
$$= \frac{(5)^{3\times\frac{1}{3}}}{(2)^{3\times\frac{1}{3}}} \times \frac{1}{(2)^{4\times\frac{1}{4}}}$$
$$= \frac{5}{2} \times \frac{1}{2}$$
$$= \frac{5}{2} \times \frac{1}{2}$$
$$= \frac{5}{4} = 1\frac{1}{4}$$

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L037 in the Pupil Handbook.

Lesson Title: Simple equations using indices – Part 1	**Theme:** Numbers and Numeration	
Lesson Number: M1-L038	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to solve simple equations that involve indices.	**Preparation** Write the problem in Opening on the board.	

Opening *(3 minutes)*

1. Review raising numbers to a power. Write the following problem on the board:
   Find the values of the following numbers:
   a. 2^6 b. 3^5 c. 4^4
2. Ask pupils to solve the problems independently in their exercise books.
3. Invite volunteers to write their answers on the board. (Answer: a. 64 b. 243 c. 256)
4. Explain that today's lesson is on simple equations that involve indices.

Teaching and Learning *(23 minutes)*

1. Explain: To solve exponential equations, you need to have equations with comparable exponential expressions on either side of the "equals" sign, so you can compare the powers and solve.
2. Write on the board: If $\mathrm{a}^x = \mathrm{a}^y$ then $x = y$, provided a is not -1, 0 or 1.
3. Explain: We always use this fact to solve such equations with indices. You will see an example.
4. Write the following problem on the board: Solve $5^x = 5^3$
5. Explain:
   - If the bases are the same, then the powers must be equal.
   - Since the bases (5 in each case) are the same, then the only way the two expressions could be equal is for the powers to also be the same. The variable x must be equal to 3.
6. Write the answer on the board: $x = 3$
7. Write the following problem on the board: Solve $10^{1-x} = 10^4$
8. Discuss: How do you think we will solve this problem for the variable x?
9. Allow pupils to share ideas, then explain: Because the bases are the same, we can set the powers equal to one another.
10. Solve the problem on the board.
    Solution:
    $10^{1-x} = 10^4$
    $1 - x = 4$ Since the bases are the same, then powers are equal
    $1 - 4 = x$ Collect like terms
    $-3 = x$
    Then the solution is: $x = -3$

11. Check the solution by substituting $x = -3$ into the original equation.

Check:

$$\begin{aligned} 10^{1-(-3)} &= 10^4 \\ 10^{1+3} &= 10^4 \\ 10^4 &= 10^4 \end{aligned}$$

12. Explain: To check your answer, substitute the value of x. If the right and left-hand sides of the equation are the same, your answer is correct.
13. Explain:
    - Not all exponential equations are given in terms of the same base on either side of the "equals" sign.
    - Sometimes we first need to convert one side or the other (or both) to some other base before we can set the powers equal to each other.
14. Write the following problem on the board: Solve $3^x = 9$
15. Discuss: How do you think we will solve this problem for the variable x?
16. Allow pupils to share ideas, then explain:
    - We must make the bases the same. We can write the 9 on the right-hand side with a base of 3.
    - Use the fact that $3^2 = 9$.
17. Solve the problem on the board:

Solution:

$$\begin{aligned} 3^x &= 9 && \\ 3^x &= 3^2 && \text{Convert the right hand side of the equation} \\ x &= 2 && \text{Set the exponents equal} \end{aligned}$$

18. Write another problem on the board: Solve $3^{2x-1} = 27$
19. Invite a volunteer to write 27 as a power of 3 on the board. (Answer: $27 = 3^3$)
20. Ask pupils to explain the steps needed to solve for x. Solve the problem on the board as they explain.

Solution:

$$\begin{aligned} 3^{2x-1} &= 27 && \\ 3^{2x-1} &= 3^3 && \text{Convert the right hand side of the equation} \\ 2x - 1 &= 3 && \text{Set the exponents equal} \\ 2x &= 3 + 1 && \text{Transpose } -1 \\ 2x &= 4 && \\ x &= \tfrac{4}{2} = 2 && \text{Divide throughout by 2} \end{aligned}$$

21. Ask pupils to work with seatmates to check that the solution is correct by substituting the value of x.
22. Invite a volunteer to write their work on the board.

Check:

$$\begin{aligned} 3^{2(2)-1} &= 27 \\ 3^{4-1} &= 27 \\ 3^3 &= 27 \end{aligned}$$

23. Write another problem on the board: Solve $4^{x+1} = \frac{1}{64}$
24. Remind pupils that $\frac{1}{64} = 64^{-1}$.
25. Ask pupils to solve the problem with seatmates.
26. Invite a volunteer to write the answer on board.

Answer:

$$\begin{aligned} 4^{x+1} &= \frac{1}{64} \\ 4^{x+1} &= 64^{-1} \\ 4^{x+1} &= 4^{3(-1)} \\ 4^{x+1} &= 4^{-3} \\ x+1 &= -3 \\ x &= -3-1 \\ x &= -4 \end{aligned}$$

27. Write another problem on the board: Solve $2^x = -4$
28. Ask pupils what power of the positive number "2" could possibly yield a negative number? (Answer: A number can never go from positive to negative by applying powers)
29. Explain:
    - Exponentiation simply doesn't work that way. A positive number raised to a power is always a positive number.
    - So the answer here is "no solution".

Practice *(13 minutes)*

22. Write the following three problems on the board:
    - If $3^{x+1} = 9^4$, find the value of x.
    - If $64^y = 16$, find the value of y.
    - If $3^{x-2} = \frac{1}{81}$, find x.
23. Ask pupils to work independently to solve the problems in their exercise books.
24. Allow pupils to discuss their answer with seatmates when they finish.
25. Invite volunteers to write the solutions on the board and explain them to the class.

Solutions:

a. $$\begin{aligned} 3^{x-1} &= 9^4 \\ 3^{x+1} &= 3^{2(4)} \\ 3^{x+1} &= 3^8 \\ x+1 &= 8 \\ x &= 8-1 \\ x &= 7 \end{aligned}$$

b. $$\begin{aligned} 64^y &= 16 \\ 4^{3y} &= 4^2 \\ 3y &= 2 \\ y &= \frac{2}{3} \end{aligned}$$

c. $$\begin{aligned} 3^{x-2} &= \frac{1}{81} \\ 3^{x-2} &= 81^{-1} \\ 3^{x-2} &= 3^{4(-1)} \\ 3^{x-2} &= 3^{-4} \\ x-2 &= -4 \\ x &= -2 \end{aligned}$$

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L038 in the Pupil Handbook.

Lesson Title: Simple equations using indices – Part II	**Theme:** Numbers and Numeration	
Lesson Number: M1-L039	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to solve simple equations that involve indices.	**Preparation** None	

Opening *(3 minutes)*

1. Revise the previous lesson. Write on the board: Solve: $10^{2-x} = 10^6$
2. Ask pupils to solve the problem in their exercise books.
3. Invite a volunteer to write the solution on the board.
   Solution:

$$\begin{aligned} 10^{2-x} &= 10^6 \\ 2-x &= 6 \\ 2-6 &= x \\ x &= -4 \end{aligned}$$

4. Explain that today's lesson is also on simple equations that involve indices.

Teaching and Learning *(21 minutes)*

1. Review key points on simple equations of indices from the previous lesson.
2. Explain:
   - Exponential equations are equations in which variables occur as exponents.
   - If 2 indices are set equal and the bases are equal, then the powers must also be equal.
3. Write on the board to remind pupils: If $\mathrm{a}^x = \mathrm{a}^y$ then $x = y$, provided a is not 0.
4. Write on the board: Solve the exponential equation $3^{2n+1} = 81$
5. Solve on the board, explaining each step.
   Solution:

$3^{2\mathrm{n}+1}$	$=$	81	Original equation
$3^{2\mathrm{n}+1}$	$=$	3^4	Rewrite 81 as 3^4 so each side has the same base
$2n+1$	$=$	4	Set the powers equal to each other
$2n$	$=$	3	Subtract 1 from each side
n	$=$	$\frac{3}{2}$	Divide each side by 2

6. Ask pupils to check the solution in their exercise books by substituting the value of n.
7. Invite a volunteer to write their work on the board.
   Check:

$3^{2\mathrm{n}+1}$	$= 81$	Original equation

$$\begin{aligned} 3^{2\left(\frac{3}{2}\right)+1} &= 81 \quad \text{Subtsitute } \tfrac{3}{2} \text{ for } n \\ 3^{3+1} &= 81 \quad \text{Simplify} \\ 3^4 &= 81 \\ 81 &= 81 \end{aligned}$$

8. Write another problem on the board: Solve the exponential equation $4^{2x} = 8^{x-1} \times 4$.
9. Ask a volunteer to give the first step needed. (Answer: Make the bases the same; change both sides to a base of 2.)
10. Explain:
    - Although there are 3 terms in this equation, the steps are not much different.
    - Change all of the terms to have the same base, then use the laws of indices to solve for x.
11. Ask pupils to work with seatmates to change all terms to have a base of 2.
12. Invite a volunteer to write their work on the board.
    Answer:
    $$\begin{aligned} 4^{2x} &= 8^{x-1} \times 4 \\ 2^{2(2x)} &= 2^{3(x-1)} \times 2^2 \qquad \text{Use } 4 = 2^2 \text{ and } 8 = 2^3 \end{aligned}$$
13. Ask volunteers to give the next steps needed to solve the equation. (Answer: Simplify the right-hand side so there is only one index, then set the powers equal and solve for x.)
14. Solve the problem on the board:
    Solution:
    $$\begin{aligned} 2^{4x} &= 2^{3x-3+2} \qquad \text{Simplify} \\ 2^{4x} &= 2^{3x-1} \\ 4x &= 3x-1 \qquad \text{Set the powers equal} \\ 4x-3x &= -1 \\ x &= -1 \end{aligned}$$
15. Write on the board: Solve each equation. Check your solution.
    a. $2^{3x+5} = 128$ b. $5^{n-3} = \frac{1}{25}$
16. Ask pupils to solve the problems with seatmates.
17. Walk around to check for understanding and clear misconceptions.
18. Invite two volunteers to write their solutions on the board. Other pupils should check their work.

Solutions:

a.

$$\begin{aligned} 2^{3x+5} &= 128 \\ 2^{3x+5} &= 2^7 \\ 3x+5 &= 7 \\ 3x &= 7-5 \\ 3x &= 2 \\ x &= \tfrac{2}{3} \end{aligned}$$

b.

$$\begin{aligned} 5^{n-3} &= \tfrac{1}{25} \\ 5^{n-3} &= \tfrac{1}{5^2} \\ 5^{n-3} &= 5^{-2} \\ n-3 &= -2 \\ n &= -2+3 \\ n &= 1 \end{aligned}$$

Practice *(15 minutes)*

1. Write on the board: Solve each equation and check your solution.
   a. $10^{x-1} = 100^{2x-3}$
   b. $9^{t-1} = \left(\frac{1}{3}\right)^{4\text{t}-1}$
   c. $\left(\frac{1}{9}\right)^{x} - 3 = 24$
2. Ask pupils to solve the problems independently in their exercise books.
3. Allow pupils to discuss their answer with seatmates when they finish.
4. Invite volunteers to come to the board and write the solutions.

   Solutions:

a. $10^{x-1} = 100^{2x-3}$

$10^{x-1} = 10^{2(2x-3)}$

$x - 1 = 4x - 6$

$-1 + 6 = 4x - x$

$5 = 3x$

$x = \frac{3}{5}$

b. $9^{t-1} = \left(\frac{1}{3}\right)^{4\text{t}-1}$

$(3^2)^{\text{t}-1} = (3^{-1})^{4\text{t}-1}$

$3^{2\text{t}-2} = 3^{-4t+1}$

$2t - 2 = -4t + 1$

$2t + 4t = 1 + 2$

$6t = 3$

$t = \frac{3}{6}$

$t = \frac{1}{2}$

c. $\left(\frac{1}{9}\right)^{x} - 3 = 24$

$\left(\frac{1}{9}\right)^{x} = 24 + 3$

$\left(\frac{1}{3^2}\right)^{x} = 27$

$(3^{-2})^{x} = 3^3$

$3^{-2x} = 3^3$

$-2x = 3$

$x = -\frac{3}{2}$

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L039 in the Pupil Handbook.

Lesson Title: Introduction to standard form	**Theme:** Numbers and Numeration	
Lesson Number: M1-L040	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to express and interpret numbers in standard form.	**Preparation** Write the problem in Opening on the board.	

Opening *(4 minutes)*

1. Write on the board: The following numbers are multiples of ten. Express them as powers of 10:

1000	
100	
10	
1	
0.1	
0.01	
0.001	

2. Ask pupils to work with seatmates to solve the problem. If they do not understand, write 2-3 answers on the board and ask them to finish the remainder.
3. Invite volunteers to write the answers on the board.
   Answers:

1000	10^3
100	10^2
10	10^1
1	10^0
0.1	10^{-1}
0.01	10^{-2}
0.001	10^{-3}

4. Explain that today's lesson is how to express and interpret numbers in standard form.

Teaching and Learning *(25 minutes)*

1. Explain:
   - "Standard form" or "standard index form" is a system of working with very large or very small numbers.
2. Write on the board: a. 0.00000024 b. $5{,}400{,}000$
3. Explain:
   - Number a. is very small. Working with numbers this small is difficult because we must write many zeros.

- Number b. is very large. Working with numbers this large is also difficult.
- Standard form gives us a shorter way to write these numbers.
- Standard form is used by many professionals who work with numbers, including scientists and engineers.

4. Write on the board: Standard form: $a \times 10^n$ where $1 \leq a < 10$ and n is an integer.
5. Explain:
    - Standard form is written as a number between 1 and ten, which is multiplied by a power of 10.
    - Often, the number being multiplied is a decimal number.
6. Write the standard form of numbers a. and b. on the board:
    a. $0.00000024 = 2.4 \times 10^{-7}$ b. $5{,}400{,}000 = 5.4 \times 10^6$
7. Explain:
    - When **very small numbers** are changed to standard form, they have a **negative power**. When **very large numbers** are changed to standard form, they have a **positive power**.
    - To change a number to standard form, first write it as a number between 1 and 10.
    - Then, count the number of spaces you need to move the decimal place to get the new decimal number.
    - The number of spaces you move the decimal space tells you what power to use on the 10.
8. Explain: In the case of a., the decimal place moved 7 spaces to the right to get 2.4.
9. Draw arrows on the board to show the 7 spaces the decimal point moves:

$$0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 2\ .\ 4$$

10. Explain: In the case of b., the decimal place moved 6 spaces to the left to get 5.4.
11. Draw arrows on the board to show the 6 spaces the decimal point moves:

$$5\ .\ 4\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0$$

12. Write on the board: 87.2×10^6
13. Discuss: Is this number written in standard form? (Answer: No, because 87.2 is not between 1 and 10.)
14. Write on the board: 0.25×10^{-4}
15. Discuss: Is this number written in standard form? (Answer: No, because 0.25 is not between 1 and 10.)
16. Write a problem on the board: Express 4146 in standard form.
17. Discuss: How many spaces must we move the decimal point to get a number between 1 and 10? (Answer: 3 spaces to the left)
18. Write the answer on the board: $4146 = 4.146 \times 10^3$
19. Remind pupils of the work they did during Opening. Explain:

a. Multiplying a number by 10^3 is the same as multiplying the decimal by 1000.
b. Recall that when multiplying a decimal number by 1000, the decimal point moves 3 places to the right.
c. Standard form follows the same idea.

20. Write another problem on the board: Express 0.0018 in standard form.
21. Discuss: How many spaces must we move the decimal point to get a number between 1 and 10? (Answer: 3 spaces to the right)
22. Write the answer on the board: $0.0018 = 1.8 \times 10^{-3}$
23. Write 2 more problems on the board: Express in standard form:
    a. 0.000034 b. $62{,}900{,}000$
24. Ask pupils to work with seatmates to solve the problems.
25. Invite 2 volunteers to write the answers on the board and explain. (Answers: a. $0.000034 = 3.4 \times 10^{-5}$; b. $62{,}900{,}000 = 6.29 \times 10^{7}$)
26. Explain:
    - You can also convert from standard form to ordinary numbers. (Note: Ordinary form is also called expanded form.)
    - Work in reverse. Move the decimal point the number of places equal to the power on the 10.
    - If the power of 10 is positive, move to the right.
    - If the power of 10 is negative, move to the left.
    - Fill "empty" places with zeros.
27. Write the following problem on the board: Express 4.3×10^{4} in ordinary form.
28. Explain:
    a. The power on the 10 is positive 4. This means we move the decimal space 4 places to the right.
29. Show how to find the place of the decimal on the board. Use 4 arrows to show that it moves 4 spaces to the right:

$$4\ 3\ \ \ \ \ \ \ \ .$$

30. Fill the empty places with zeros:

$$4\ 3\ 0\ 0\ 0\,.$$

31. Write the answer on the board: $4.3 \times 10^{4} = 43{,}000$
32. Write the following problem on the board: Express 4.3×10^{-3} in ordinary form.
33. Explain: The power on the 10 is negative 3. This means we move the decimal space 3 places to the left.

34. Show how to find the place of the decimal on the board. Use 3 arrows to show that it moves 3 spaces to the left:

$$.\quad\quad 4\ 3$$

35. Fill the empty places with zeros:

$$.\ 0\ \ 0\ \ 4\ \ 3$$

36. Write the answer on the board: $4.3 \times 10^{-3} = 0.0043$
37. Write the following two problems on the board, and ask pupils to solve the problems with seatmates:
    a. Express 1.903×10^{6} in ordinary form.
    b. Express 4.9×10^{-2} in ordinary form.
38. Walk around to check for understanding. Explain as needed.
39. Invite 2 groups of seatmates to each give one of their answers and explain. (Answers: a. $1{,}903{,}000$, the decimal is moved 6 places to the right; b. 0.049, the decimal is moved 2 places to the left.)

Practice *(10 minutes)*

1. Write the following four problems on the board:
    a. Write 3201.7 in standard form
    b. Express 0.001 in standard form
    c. Write 9.01×10^{6} in ordinary form
    d. Express 1.54×10^{-4} in ordinary form
2. Ask pupils to work independently.
3. Ask pupils to exchange books and check each other's answers.
4. Ask 4 volunteers to each call out one of the answers.

    Answers:
    a. $3201.7 = 3.2017 \times 10^{3}$
    b. $0.001 = 1.0 \times 10^{-3}$
    c. $9.01 \times 10^{6} = 9{,}010{,}000$
    d. $1.54 \times 10^{-4} = 0.000154$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L040 in the Pupil Handbook.

<table>
<tr><td>Lesson Title: Standard form addition and subtraction</td><td colspan="2">Theme: Numbers and Numeration</td></tr>
<tr><td>Lesson Number: M1-L041</td><td>Class: SSS 1</td><td>Time: 40 minutes</td></tr>
<tr><td>Learning Outcome
By the end of the lesson, pupils will be able to add and subtract numbers in standard form.</td><td colspan="2">Preparation
Write the problem in Opening on the board.</td></tr>
</table>

Opening *(4 minutes)*

1. Write the following two problems on the board:
   a. Express 670000 in standard form.
   b. Express 2.16×10^{-5} in ordinary form.
2. Ask pupils to solve the problems independently in their exercise books.
3. Invite two volunteers each to write their answer on the board.
   Answer:
   a. $670000 = 6.7 \times 10^5$
   b. $2.16 \times 10^{-5} = 0.0000216$
4. Explain that today's lesson is on addition and subtraction of numbers in standard form.

Teaching and Learning *(22 minutes)*

1. Explain:
   - When adding and subtracting standard form numbers with the same power of 10, we simply add or subtract their "number parts" and then multiply by this same power of 10.
   - Make sure the result is a number in valid standard form.
2. Write the following problem on the board: Evaluate $3.4 \times 10^5 + 2.5 \times 10^5$
3. Solve on the board, adding the 2 decimal numbers and keeping the 10^5:

$$\begin{array}{rl} & 3.4 \times 10^5 \\ + & \underline{2.5} \times 10^5 \\ & 5.9 \times 10^5 \end{array}$$

4. Write another problem on the board: Evaluate: $2.9 \times 10^{-4} - 2.2 \times 10^{-4}$
5. Solve the problem on the board:

$$\begin{array}{rl} & 2.9 \times 10^{-4} \\ & \underline{-\ 2.2} \times 10^{-4} \\ & 0.7 \times 10^{-4} \end{array}$$

6. Ask pupils what they notice about the answer.
7. Allow them to share their ideas, then explain:

- The answer is not in standard form. The number 0.7 is not between 1 and 10.
- In this case, we need to change the result to standard form.
- We can get 7 by moving the decimal place 1 place to the right.

8. Change 0.7×10^{-4} to standard form on the board:
   Step 1. Note that $0.7 = 7 \times 10^{-1}$, and substitute this in the answer:
   $$0.7 \times 10^{-4} = (7 \times 10^{-1}) \times 10^{-4}$$
   Step 2. Evaluate: $(7 \times 10^{-1}) \times 10^{-4} = 7 \times 10^{-1-4} = 7 \times 10^{-5}$
9. Write the answer on the board with the problem: $2.9 \times 10^{-4} - 2.2 \times 10^{-4} = 9 \times 10^{-5}$
10. Explain: When the numbers have different powers of 10 in their standard form, first convert into decimal form or ordinary numbers before adding or subtracting. Then convert back into standard form.
11. Write the following problems on the board:
    a. Calculate $4.5 \times 10^{4} + 6.45 \times 10^{6}$
    b. Calculate $8.53 \times 10^{-4} - 1.2 \times 10^{-5}$
12. Solve the problems on the board, explaining each step to pupils:
    Solutions:
    a.
    Step 1. Express each number as an ordinary number.
    $$4.5 \times 10^{4} = 45{,}000$$
    $$6.45 \times 10^{6} = 6{,}450{,}000$$
    Step 2. Add the ordinary numbers.
    Hence $4.5 \times 10^{4} + 6.45 \times 10^{6} =$
    $$\begin{array}{r} 45{,}000 \\ +\ 6{,}450{,}000 \\ \hline 6{,}495{,}000 \end{array}$$
    Step 3. Change the result to standard form.
    The answer in standard form is 6.495×10^{6}
    b.
    Step 1. Express each number as an ordinary number.
    $$8.53 \times 10^{-4} = 0.000853$$
    $$1.2 \times 10^{-5} = 0.000012$$
    Step 2. Add the ordinary numbers.
    Hence $8.53 \times 10^{-4} - 1.2 \times 10^{-5} =$
    $$\begin{array}{r} 0.000853 \\ -\ 0.000012 \\ \hline 0.000841 \end{array}$$
    Step 3. Change the result to standard form.
    The answer in standard form is 8.41×10^{-4}
13. Write on the board: Simplify the following:
    a. $3.42 \times 10^{-2} + 2.58 \times 10^{-2}$
    b. $2.122 \times 10^{-3} - 1.14 \times 10^{-4}$
14. Ask pupils to work with seatmates to find the answers.

15. Invite two volunteers to come to the board to write their answers. The other pupils should check their answers.

Answers:

a.

$$\begin{array}{r} 3.42 \times 10^{-2} \\ + \underline{\;2.58 \times 10^{-2}} \\ 6.00 \times 10^{-2} \end{array}$$

The answer in standard form is 6×10^{-2}

b. Convert each number in ordinary numbers

$2.122 \times 10^{-3} = \; 0.002122$

$1.14 \times 10^{-4} = \; 0.000114$

Hence $2.122 \times 10^{-3} - 1.14 \times 10^{-4} =$

$$\begin{array}{r} 0.002122 \\ - \; 0.000114 \\ \hline 0.002008 \end{array}$$

The answer in standard form is 2.008×10^{-3}

Practice *(13 minutes)*

1. Write the following two problems on the board:
   a. $5.46 \times 10^{7} - 3.46 \times 10^{7}$
   b. $7.48 \times 10^{6} + 2.52 \times 10^{2}$
2. Ask pupils to solve the problem independently in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite 2 volunteers to write the solutions on the board.

Answers:

a. Subtract:

$$\begin{array}{r} 5.46 \times 10^{7} \\ \underline{-\; 3.46 \times 10^{7}} \\ 2.00 \times 10^{7} \end{array}$$

The answer in standard form is 2.0×10^{7}

b. Convert each number to ordinary form before adding:

$7.48 \times 10^{6} = \; 7{,}480{,}000$

$2.52 \times 10^{2} = \; 252$

Hence $7.48 \times 10^{6} + 2.52 \times 10^{2} =$

$$\begin{array}{r} 7{,}480{,}000 \\ + \quad 252 \\ \hline 7{,}480{,}252 \end{array}$$

The answer in standard form is 7.480252×10^{6}

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L041 in the Pupil Handbook.

Lesson Title: Standard form multiplication and division	**Theme:** Numbers and Numeration	
Lesson Number: M1-L042	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to multiply and divide numbers in standard form.	**Preparation** Write the problem in Opening on the board.	

Opening *(4 minutes)*

1. Review the previous lesson. Write the following problem on the board: Simplify $3.62 \times 10^3 + 2.5 \times 10^2$.
2. Ask pupils to solve the problems independently in their exercise books.
3. Invite one volunteer to write the answer on the board.
   Answer:
   $$\begin{aligned} 3.62 \times 10^3 &= 3620 \\ 2.5 \times 10^2 &= 250 \end{aligned}$$
   Hence $3.62 \times 10^3 + 2.5 \times 10^2 =$
   $$\begin{array}{r} 3620 \\ +\ 250 \\ \hline 3870 \end{array}$$
   The answer in standard form is 3.87×10^3
4. Explain that today's lesson is on multiplication and division of numbers in standard form.

Teaching and Learning *(22 minutes)*

1. Explain:
   - To multiply numbers in standard form, multiply the number parts and then multiply the powers of 10.
   - When multiplying powers of 10, apply the laws of indices. Remember to add the powers.
2. Write the following problem on the board: Simplify $(9.1 \times 10^5) \times (2 \times 10^3)$. Leave your answer in standard form.
3. Explain the solution to pupils on the board:
   Solution:
   $$\begin{aligned} (9.1 \times 10^5) \times (2 \times 10^3) &= (9.1 \times 2) \times (10^5 \times 10^3) && \text{Group numbers and powers of 10} \\ &= 18.2 \times 10^{5+3} && \text{Multiply} \\ &= 18.2 \times 10^8 && \text{Apply law of indices} \\ &= (1.82 \times 10^1) \times 10^8 && \text{Change to standard form} \\ &= 1.82 \times 10^9 \end{aligned}$$
4. Write the following problem on the board: Simplify $(5.2 \times 10^{-4}) \times (2 \times 10^{-3})$.

5. Explain: We follow the same rules, although the powers are negative.
6. Ask volunteers to describe each step. As they give the step, work it on the board:
   Solution:

$(5.2 \times 10^{-4}) \times (2 \times 10^{-3})$	$=$	$(5.2 \times 2) \times (10^{-4} \times 10^{-3})$	Group parts
	$=$	$10.4 \times 10^{-4-3}$	Multiply
	$=$	10.4×10^{-7}	Apply law of indices
	$=$	$(1.04 \times 10^{1}) \times 10^{-7}$	Change to standard form
	$=$	$1.04 \times 10^{1-7}$	
	$=$	1.04×10^{-6}	

7. Explain:
   - To divide in standard form, divide the number parts and then divide the powers of 10.
   - Apply the laws of indices. Remember to subtract the powers.
8. Write the following problem on the board: Simplify $(6 \times 10^{-3}) \div (2 \times 10^{3})$
9. Solve the problem on the board:
   Solution:

$(6 \times 10^{-3}) \div (2 \times 10^{3})$	$=$	$(6 \div 2) \times (10^{-3} \div 10^{3})$	Group parts
	$=$	$3 \times 10^{-3-3}$	Divide
	$=$	3.0×10^{-6}	Apply law of indices

10. Write two more problems on the board: Simplify and leave your answer in standard form:
    c. $(3 \times 10^{-4}) \times (5 \times 10^{6})$
    d. $(7 \times 10^{6}) \div (2 \times 10^{2})$
11. Ask pupils to work with seatmates to find the solutions.
12. Invite two volunteers to come to the board to write the solutions. The other pupils should check their answers.
    Solutions:
    a.

$(3 \times 10^{-4}) \times (5 \times 10^{6})$	$=$	$(3 \times 5) \times (10^{-4} \times 10^{6})$	Group parts
	$=$	$15 \times 10^{-4+6}$	Multiply
	$=$	15×10^{2}	Apply law of indices
	$=$	$(1.5 \times 10^{1}) \times 10^{2}$	Change to standard form
	$=$	$1.5 \times 10^{1+2}$	
	$=$	1.5×10^{3}	

    b.

$(7 \times 10^{6}) \div (2 \times 10^{2})$	$=$	$(7 \div 2) \times (10^{6} \div 10^{2})$	Group parts
	$=$	$3.5 \times 10^{6-2}$	Divide
	$=$	3.5×10^{4}	Apply law of indices

Practice *(13 minutes)*

1. Write the following on the board: Simplify and give your answer in standard form:

a. $(6 \times 10^3) \times (3.4 \times 10^2)$
b. $(4.8 \times 10^{-2}) \div (4 \times 10^3)$
c. $(5.25 \times 10^{-9}) \times (6 \times 10^{-5})$

2. Ask pupils to solve the problems independently in their exercise books.
3. Walk around to check for understanding an clear any misconceptions.
4. Invite 3 volunteers to come to the board and write the solutions.
   Solutions:
   a.
   $$\begin{aligned}(6 \times 10^3) \times (3.4 \times 10^2) &= (6 \times 3.4) \times (10^3 \times 10^2) \\ &= 20.4 \times 10^{3+2} \\ &= 20.4 \times 10^5 \\ &= (2.04 \times 10^1) \times 10^5 \\ &= 2.04 \times 10^{1+5} \\ &= 2.04 \times 10^6\end{aligned}$$
   b.
   $$\begin{aligned}(4.8 \times 10^{-2}) \div (4 \times 10^3) &= (4.8 \div 4) \times (10^{-2} \div 10^3) \\ &= 1.2 \times 10^{-2-3} \\ &= 1.2 \times 10^{-5}\end{aligned}$$
   c.
   $$\begin{aligned}(5.25 \times 10^{-9}) \times (6 \times 10^{-5}) &= (5.25 \times 6) \times (10^{-9} \times 10^{-5}) \\ &= 31.5 \times 10^{-9-5} \\ &= 31.5 \times 10^{-14} \\ &= (3.15 \times 10^1) \times 10^{-14} \\ &= 3.15 \times 10^{1-14} \\ &= 3.15 \times 10^{-13}\end{aligned}$$

Closing *(1 minute)*

1. For homework, have pupils to do the practice activity PHM1-L042 in the Pupil Handbook.

Lesson Title: Practice application of standard form	**Theme:** Numbers and Numeration	
Lesson Number: M1-L043	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to apply operations on numbers in standard form to real-life problems.	**Preparation** None	

Opening *(3 minutes)*

1. Review the previous lesson. Write on the board: Simplify $(1.4 \times 10^{-5}) \times (2 \times 10^{7})$
2. Allow pupils 1 minute to solve it in their own.
3. Invite a volunteer to solve the problem on the board.

   Answer:
$$\begin{aligned}(1.4 \times 10^{-5}) \times (2 \times 10^{7}) &= (1.4 \times 2) \times (10^{-5} \times 10^{7}) \\ &= 2.8 \times 10^{-5+7} \\ &= 2.8 \times 10^{2}\end{aligned}$$

4. Share with the pupils that today they are going to learn how to solve real-life problems using standard form.

Teaching and Learning *(20 minutes)*

1. Ask pupils to give instances in which standard forms are used in everyday life. Allow them to brainstorm for 2 minutes.
2. Explain:
   - In science and astronomy, many measurements are given in very small or very large numbers.
   - If you work as a scientist, you may have to deal with particles that are very small, where their size must be described with standard form.
   - If you work in a bank and have to count large bills and accounts it could be 1×10^{6} for every million Leones in the vault.
   - If you work in the medical profession, you may deal with contamination of water. You would need to find the purity of water with so many parts per million. The reduction and use of power of 10 would be convenient.
3. Write on the board: A country has an estimated population of 5.7×10^{6} people and a land area of $3 \times 10^{4}\text{km}^{2}$. Calculate the population density of that country.
4. Explain:
   - Population density describes how many people live in a space compared to its size.
   - In this case, population density is the average number of people per square kilometre.
   - Population density can be found by dividing the population by the area that they live in.

5. Solve the problem on the board:
   Solution:
   Population density = average number of people per km²
   $= (5.7 \times 10^6) \div (3 \times 10^4)$
   $= (5.7 \div 3) \times (10^6 \div 10^4)$
   $= 1.9 \times 10^{6-4}$
   $= 1.9 \times 10^2$ people per km²
6. Write the following problem on the board: The speed of radio waves is 3×10^8 m/s. How long will it take for a radio wave to travel $9{,}000$ km? (Use $Time = \frac{Distance}{speed}$).
7. Ask a volunteer in the class to explain how to solve the problem. (Answer: Express 9000 in standard form. Divide distance by speed to calculate the time.)
8. Invite a volunteer to write 9000 in standard form on the board. (Answer: 9.0×10^3)
9. Ask pupils to work with seatmates to solve the problem.
10. Invite a volunteer to write the solution on the board.
   Solution:
   Time $= \frac{9\times10^3}{3\times10^8}$
   $= (9 \times 10^3) \div (3 \times 10^8)$
   $= (9 \div 3) \times (10^3 \div 10^8)$
   $= 3 \times 10^{3-8}$
   $= 3 \times 10^{-5}$

11. Write another problem on the board: In a provincial budget, the following allocation were made:

Telecommunications	$Le\ 294{,}000{,}000$
Education	$Le\ 301{,}400{,}000$
Health	$Le\ 49{,}500{,}000$

   a. Find the sum of the three amounts.
   b. Express the sum in standard form.
12. Ask pupils to work with seatmates to solve the problem.
13. Invite a volunteer to write the solution on the board.
   Solution:
   a. Calculate the sum:

		Le
Post and Telecommunication		$294{,}000{,}000$
Education		$301{,}400{,}000$
Health	+	$49{,}500{,}000$
		$644{,}900{,}000$

   b. Express the answer in standard form:
   $644{,}900{,}000 = 6.449 \times 10^8$

14. Write on the board: Express 1 hour in seconds. Write the result in standard form.
15. Discuss: How can we solve this problem? What is the first step?
16. Guide pupils and explain:
    a. We first convert 1 hour to seconds. Multiply 1 hour by the number of minutes in an hour. Then, multiply minutes by the number of seconds in a minute.
17. Ask pupils to work with seatmates to find the number of seconds in an hour.
18. Ask a volunteer to share the answer and explain. (Answer: $1 \times 60 = 60$ minutes → $60 \times 60 = 3{,}600$ seconds)
19. Ask pupils to work independently to write $3{,}600$ seconds in standard form.
20. Invite a volunteer to solve the problem on the board. (Answer: $3600 = 3.6 \times 10^3$ seconds)

Practice *(16 minutes)*

1. Write the following three problems on the board:
    a. The population of two cities are 5.77×10^6 and 3.66×10^6. Find the difference between the two populations.
    b. In an election, 1.2×10^5, people voted for Candidate A, and 9.7×10^4 people voted for Candidate B. Who won the election? How many more votes did he/she get?
    c. The diameter of the sun and moon are $1.4 \times 10^6\text{km}$ and $3.5 \times 10^3\text{km}$ respectively. How many times larger is the sun than the moon?
2. Ask pupils to solve the problem in their exercise books.
3. Ask them to check their answer with seatmates if they finish working. Walk around to check for understanding and clear misconceptions.
4. Invite 3 volunteers to write their answers on the board. Ask other pupils to check their answers.

   Solutions:

   a. $(5.77 \times 10^6) - (3.66 \times 10^6)$

$$\begin{array}{r} 5.77 \times 10^6 \\ \underline{-\ 3.66} \times 10^6 \\ 2.11 \times 10^6 \end{array}$$

   The difference is 2.11×10^6.

   b. Candidate A won, because $1.2 \times 10^5 > 9.7 \times 10^4$

   Subtract:

$$1.2 \times 10^5 - 9.7 \times 10^4 = 120{,}000 - 97{,}000$$

$$\begin{array}{r} 120{,}000 \\ -\ 97{,}000 \\ \hline 23{,}000 \end{array}$$

   Candidate A got 23,000 more votes.

c. $1.4 \times 10^6 \div 3.5 \times 10^3 = (1.4 \div 3.5) \times (10^6 \div 10^3)$

$$= (0.4) \times (10^{6-3})$$
$$= 0.4 \times 10^3$$
$$= (4 \times 10^{-1}) \times 10^3$$
$$= 4 \times 10^{-1+3}$$
$$= 4.0 \times 10^2$$

The sun is 4.0×10^2 times larger than the moon.

5. Explain:
   - This means that the sun is 400 times larger than the moon. We can find interesting facts like this using our knowledge of Maths.

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L043 in the Pupil Handbook.

Lesson Title: Relationships between logarithms and indices	**Theme:** Numbers and Numeration	
Lesson Number: M1-L044	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to identify the relationship between logarithms and indices (e.g. $y = 10^k$ implies $\log_{10} y = k$).	**Preparation** Write the problem in Opening and the summary table and problem in Teaching and Learning on the board.	

Opening *(3 minutes)*

1. Review simple equations that involve indices. Write the following problem on the board: Find the values of the unknown:
   a. $3^x = 9$ b. $2^x = 128$
2. Ask pupils to solve the problems independently.
3. Invite volunteers to write the solutions on the board.
   Solutions:

a.		b.	
	$3^x = 9$		$2^x = 128$
	$3^x = 3^2$		$2^x = 2^7$
	$x = 2$		$x = 7$

4. Explain to pupils that today's lesson is on logarithms and their relationship to indices.

Teaching and Learning *(23 minutes)*

1. Explain: Logarithms are the "opposite" of exponentials, just as subtraction is the opposite of addition and division is the opposite of multiplication.
2. Write on the board: $y = b^x$ is equivalent to $\log_b y = x$.
3. Read the statement aloud so that pupils understand how to read logarithms: "'y equals b to the power x' is equivalent to 'log base b of y equals x'."
4. Label the base and index in each statement so the relationship is clear to pupils:

$y = b^x$ ← power; base ↑ b

$\log_b y = x$ ← power; base ↑ b

5. Explain:
   - The value of the subscripted "b" is "the base of logarithm", just as b is the base in the exponential expression b^x.
   - We can rewrite any exponential expression in this form as a logarithm.
6. Write the following problem on the board: Convert $6^3 = 216$ to the equivalent logarithmic expression.
7. Explain to pupils that to convert, the base (i.e. the 6) remains the same, but the 3 and the 216 switch sides.
8. Write on the board: $\log_6(216) = 3$.

9. Write on the board: Convert $\log_4(1024) = 5$ to the equivalent exponential expression.
10. Ask pupils to work with seatmates to rewrite the logarithm as an exponential expression.
11. Invite a volunteer to write the answer on the board and explain. (Answer: $4^5 = 1024$)
12. Draw the summary table below on the board. It shows the relationship between the index and logarithm, and some examples.

Index	Logarithm
$x = a^y$	$\log_a x = y$
$100 = 10^2$	$\log_{10} 100 = 2$
$64 = 4^3$	$\log_4 64 = 3$
$0.001 = 10^{-3}$	$\log_{10} 0.001 = -3$

13. Write the following problem on the board: Fill the table. Convert numbers in index form to logarithmic form and vice-versa.

No.	Index Form	Logarithmic Form
a.	$10^4 = 10{,}000$	
b.		$\log_p M = k$
c.	$2^x = y$	
d.		$\log_3(xy) = 2$
e.	$7^2 = 49$	

14. Ask pupils to work with seatmates to fill in the blank spaces on the table. They should write their answers in their exercise books.
15. Invite volunteers to write their answers in the table on the board.
Answers:

No.	Index Form	Logarithmic Form
a.	$10^4 = 10{,}000$	$\boldsymbol{\log_{10} 10,000 = 4}$
b.	$\boldsymbol{p^k = M}$	$\log_p M = k$
c.	$2^x = y$	$\boldsymbol{\log_2 y = x}$
d.	$\boldsymbol{3^2 = xy}$	$\log_3(xy) = 2$
e.	$7^2 = 49$	$\boldsymbol{\log_7 49 = 2}$

16. Explain:
    - The base of logarithms can be written in any positive number except 1 and the logarithm of a negative number does not exist.
    - When the base of a logarithm is not written it means it is in base 10.
17. Write on the board: $\log 100 = 2$
18. Explain:
    a. Although the base is not written, we can assume it is 10.
    b. This is an equivalent statement to $10^2 = 100$
19. Write on the board: $\log 100 = 2$ is equivalent to $10^2 = 100$.

Practice *(13 minutes)*

1. Write on the board:
   Write the following as logarithms:
   - $10^5 = 100{,}000$
   - $5^{-3} = 0.008$
   - $a^b = -43$

   Write the following as exponential expressions:
   - $\log_5 125 = 3$
   - $\log_9 27 = m.$
   - $\log_2 0.125 = -3$
2. Ask pupils to solve the problem independently in their exercise books.
3. Walk around to check for understanding and clear misconceptions.
4. Invite volunteers simultaneously to write their answers on the board. (Answers: a. $\log_{10} 100{,}000 = 5$ or $\log 100{,}000 = 5$; b. $\log_5 0.008 = -3$; c. $\log_{\mathrm{a}} - 43 = b$; d. $5^3 = 125$; e. $9^m = 27$; f. $2^{-3} = 0.125$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L044 in the Pupil Handbook.

Lesson Title: Solving logarithms using indices	**Theme:** Numbers and Numeration	
Lesson Number: M1-L045	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to solve logarithms using the relationship to indices.	**Preparation** Write the problem in Opening on the board.	

Opening *(3 minutes)*

1. Write on the board:
   Write the following in logarithm form: a. $256 = 4^4$ b. $0.0001 = 10^{-4}$

2. Ask pupils to solve the problems independently.
3. Invite volunteers to write the answers on the board. (Answers: a. $\log_4 256 = 4$; b. $\log_{10} 0.0001 = -4$).
4. Explain to pupils that today's lesson is on solving logarithms using the relationship to indices.

Teaching and Learning *(20 minutes)*

1. Write on the board: Simplify $x = \log_3 9$.
2. Explain:
   - We can solve this logarithm using its relationship to indices.
   - The solution to the logarithm $log_3 9$ is the value of x.
3. Discuss: How can we rewrite this logarithm? (Answer: $9 = 3^x$ or $3^x = 9$)
4. Write the solution on the board and explain to pupils.
   Solution:

x	$=$	$\log_3 9$	
9	$=$	3^x	Change to index form
3^2	$=$	3^x	Substitute $9 = 3^2$
2	$=$	x	

5. Write another problem on the board: Find the value of $\log_3 27$
6. Explain:
   - This logarithm is not equal to anything, but we can still write it in index form.
   - Set it equal to x, then solve for x to find its value.
7. Write on the board: $\log_3 27 = x$
8. Invite a volunteer to write the logarithm in index form on the board. (Answer: $27 = 3^x$ or $3^x = 27$)
9. Ask pupils to work with seatmates to find the value of x.
10. Invite a volunteer to write the solution on the board.

Solution:

$$\begin{aligned} \log_3 27 &= x \\ 27 &= 3^x && \text{Change to index form} \\ 3^3 &= 3^x && \text{Substitute } 27 = 3^3 \\ 3 &= x \end{aligned}$$

11. Write another problem on the board: Find the value of $\log_4 2$
12. Ask a volunteer to express the number in indices form on the board. (Answer: $2 = 4^x$)
13. Solve on the board, explaining each step:

$$\begin{aligned} \log_4 2 &= x \\ 2 &= 4^x && \text{Change to index form} \\ 2 &= 2^{2x} && \text{Substitute } 4 = 2^2 \\ 1 &= 2x && \text{Set the powers equal} \\ \tfrac{1}{2} &= x && \text{Divide throughout by 2} \end{aligned}$$

14. Explain:
    - Recall and apply the rules for solving simple equations involving indices.
    - Make the bases of the indices the same, then solve for x.
15. Write 3 more problems on the board:
    a. Solve for x if $\log_3 81 = x$
    b. Find the value of $\log_{25} 5$
    c. Simplify $\log_8 \frac{1}{64} = y$
16. Ask pupils to solve the problems with seatmates.
17. Walk around to check for understanding. Provide explanations as needed.
18. Invite volunteers to solve the problems on the board.

Solutions:

a.
$$\begin{aligned} \log_3 81 &= x \\ 3^x &= 81 \\ 3^x &= 3^4 \\ x &= 4 \end{aligned}$$

b.
$$\begin{aligned} \log_{25} 5 &= x \\ 25^x &= 5 \\ 5^{2x} &= 5^1 \\ 2x &= 1 \\ x &= \tfrac{1}{2} \end{aligned}$$

c.
$$\begin{aligned} \log_8 \tfrac{1}{64} &= y \\ 8^y &= \tfrac{1}{64} \\ 8^y &= 64^{-1} \\ 8^y &= 8^{2(-1)} \\ 8^y &= 8^{-2} \\ y &= -2 \end{aligned}$$

Practice *(16 minutes)*

1. Write the following four problems on the board:
    - $\log_{10} 10{,}000 = y$
    - $\log_8 2 = m$
    - $\log_3 \left(\frac{1}{27}\right) = p$
    - $\log_2 32 = q$
2. Ask pupils to solve the problem independently in their exercise books.
3. Walk around to check for accuracy and clear any misconceptions.
4. Ask pupils to exchange their exercise books.
5. Invite four volunteers, one at a time, to solve the problems on the board. Other pupils should check their work.

   Solutions:

a.
$$\begin{aligned} \log_{10} 10{,}000 &= y \\ 10^y &= 10{,}000 \\ 10^y &= 10^4 \\ y &= 4 \end{aligned}$$

b.
$$\begin{aligned} \log_8 2 &= m \\ 8^m &= 2 \\ 2^{3m} &= 2^1 \\ 3m &= 1 \\ m &= \tfrac{1}{3} \end{aligned}$$

c.
$$\begin{aligned} \log_3 \left(\tfrac{1}{27}\right) &= p \\ 3^p &= \frac{1}{27} \\ 3^p &= 27^{-1} \\ 3^p &= 3^{-3} \\ p &= -3 \end{aligned}$$

d.
$$\begin{aligned} \log_2 32 &= q \\ 2^q &= 32 \\ 2^q &= 2^5 \\ q &= 5 \end{aligned}$$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L045 in the Pupil Handbook.

Lesson Title: Logarithms – Numbers greater than 1	**Theme:** Numbers and Numeration	
Lesson Number: M1-L046	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to find the logarithms of numbers greater than 1 using logarithm tables.	**Preparation** Bring a logarithm table and have pupils bring them (found at the end of the lesson and in the Pupil Handbook).	

Opening *(3 minutes)*

1. Write on the board: Express in standard form: a. 24.12 b. $51{,}720$
2. Allow pupils to solve the problems in their exercise books.
3. Ask volunteers to call out their answers. (Answers: $24.12 = 2.412 \times 10^1$; $51{,}720 = 5.172 \times 10^4$)
4. Explain to pupils that today's lesson is on finding the logarithms of numbers greater than 1.

Teaching and Learning *(22 minutes)*

1. Write on the board: $\log_{10} 76.83 = 1.8856$
2. Explain:
   - We can write the logarithm of each number as a decimal number.
   - This can be done using a calculator or logarithm tables. Today we will use logarithm tables.
   - We will only be working with logarithms in base 10.
   - In the result of a logarithm of any number there are two parts, an integer (whole number) before the decimal point and a fraction after the point.
   - The whole number part is called the **characteristic** and the decimal part is called the **mantissa**.
3. Draw on the board:

   Characteristic: whole number → 1.8856 ← Mantissa: decimal part

4. Explain how to find the characteristic and mantissa:
   - The mantissa is found using a logarithm table.
   - The characteristic can be found by expressing the number you are finding the logarithm of (in this case 76.83) in standard form. The power on the 10 is the characteristic.
5. Write on the board: Convert to the form $a \times 10^n$, and n is the characteristic.
6. Write it as a problem on the board: Find $\log_{10} 76.83$
7. Ask a volunteer to express the number 76.83 in standard form. **(**Answer: 7.683×10^1)
8. Explain:

- The whole number part (characteristic) is 1, because the power on 10 is 1.
- As a general rule, if the number is greater than 1, then the characteristic is the number of digits before the decimal point **minus one**. (For example, the characteristic of 104.6 is 2 since the whole number part has 3 digits.)

9. Explain: We will now find the mantissa of $\log_{10} 76.83$ from the logarithm table.
10. Hold up the logarithm table. Explain the steps for finding the mantissa. As you explain, move your fingers and point at the part of the chart you are referring to:
    - $\log 76.83 = 1."something"$. We are looking for the decimal part.
    - To find the decimal part, go along the row beginning with 76 and under 8, which gives 8854.
    - Now find the number in the differences column headed 3. This number is 2.
    - Add 2 to 8854 to get 8856. Therefore $\log 76.83 = 1.8856$.
11. Write the answer on the board: $\log 76.83 = 1.8856$
12. Explain: When using tables, always make sure that the number taken from the differences column is in the same row as the rest of the figures.
13. Ask pupils to open their Pupil Handbook to the logarithm table. Ask them to work with seatmates to find the same mantissa as you have just demonstrated.
14. Walk around to check for understanding and clear any misconceptions.
15. Write the following problem on the board: Find $\log 37$.
16. Solve on the board. Explain the solution to pupils:
    Step 1. Find the characteristic: Change 37 to standard form. The characteristic is the power on 10, which is 1: $37 = 3.7 \times 10^1$
    Step 2. Find the mantissa in the logarithm table: $37 \rightarrow 0.5682$
    Step 3. Rewrite $\log 37$ using the characteristic and mantissa: 1.5682
17. Write the solution to the same problem on the board in powers of 10, and explain each step to pupils:

37	$=$	3.7×10^1	Write in standard form
	$=$	$10^{0.5682} \times 10^1$	From log table; $3.7 = 10^{0.5682}$
	$=$	$10^{0.5682+1}$	Apply law of indices
	$=$	$10^{1.5682}$	

Hence $\log 37 = 1.5682$

18. Write the following problem on the board: Find the logarithm of 513.6.
19. Solve on the board and using the log table, explaining each step to pupils. Ask them to follow along in their own log table.
    Solution:

513.6	$=$	5.136×10^2	Write in standard form
	$=$	$10^{0.7106} \times 10^2$	From table; look for 51.36, which gives 0.7106
	$=$	$10^{0.7106+2}$	Apply the law of indices
	$=$	$10^{2.7106}$	

Hence $\log 513.6 = 2.7106$

20. Write on the board: Find the logarithms of: a. 4137 b. 8.403
21. Ask pupils to solve the problem with seatmates and write the answers in their exercise books.
22. Walk around to check for understanding. Explain as needed.
23. Invite two volunteers to give their answers on the board, and explain how they used the log table. Ask other pupils to check their work.

a.
$$\begin{aligned} 4137 &= 4.137 \times 10^3 \\ &= 10^{0.6167} \times 10^3 \\ &= 10^{0.6167+3} \\ &= 10^{3.6167} \end{aligned}$$

Therefore $\log 4137 = 3.6167$

b.
$$\begin{aligned} 8.403 &= 8.403 \times 10^0 \\ &= 10^{0.9245} \times 10^0 \\ &= 10^{0.9245} \times 1 \\ &= 10^{0.9245} \end{aligned}$$

Therefore $\log 8.403 = 0.9245$

Practice *(14 minutes)*

1. Write on the board: Find the logarithm of the following numbers:
   - 208.5 b. 40.02 c. 1.903 d. 2709
2. Ask pupils to solve the problem independently in their exercise books.
3. Walk around to check for understanding and clear misconceptions.
4. Invite four volunteers, one at a time, to write their solutions on the board and explain how they used the table.

Solutions:

a.
$$\begin{aligned} 208.5 &= 2.085 \times 10^2 \\ &= 10^{0.3192} \times 10^2 \\ &= 10^{0.3192+2} \\ &= 10^{2.3192} \end{aligned}$$

$\log 208.5 = 2.3192$

b.
$$\begin{aligned} 40.02 &= 4.002 \times 10^1 \\ &= 10^{0.6023} \times 10^1 \\ &= 10^{0.6023+1} \\ &= 10^{1.6023} \end{aligned}$$

$\log 40.02 = 1.6023$

c.
$$\begin{aligned} 1.903 &= 1.903 \times 10^0 \\ &= 10^{0.2795} \times 1 \\ &= 10^{0.2795} \end{aligned}$$

$\log 1.903 = 0.2795$

d.

c.
$$\begin{aligned} 2709 &= 2.709 \times 10^3 \\ &= 10^{0.4328} \times 10^3 \\ &= 10^{0.4328+3} \\ &= 10^{3.4328} \end{aligned}$$

$\log 2709 = 3.4328$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L046 in the Pupil Handbook.

<table>
<tr><td>Lesson Title: Antilogarithms - Numbers greater than 0</td><td colspan="2">Theme: Numbers and Numeration</td></tr>
<tr><td>Lesson Number: M1-L047</td><td>Class: SSS 1</td><td>Time: 40 minutes</td></tr>
<tr><td>Learning Outcome
By the end of the lesson, pupils will be able to find the antilogarithms of numbers greater than 0 using antilogarithm tables.</td><td colspan="2">Preparation
Bring an antilogarithm table and have pupils bring them (found in the Appendix in both the lesson and in the Pupil Handbook).</td></tr>
</table>

Opening *(3 minutes)*

1. Write on the board: Use the log table to find the logarithms of the following numbers: a. 8403 b. 45.8
2. Ask pupils to solve the problems independently in their exercise books.
3. Ask volunteers to call out their answers. Write them on the board. (Answers: 3.9245; b. 1.6609)
4. Explain to the pupils that today's lesson is on finding antilogarithms of numbers greater than 0.

Teaching and Learning *(22 minutes)*

1. Explain:
   - Antilogarithms are the opposite of logarithms. They "undo" logarithms.
   - They are called "antilogs" for short.
2. Write on the board: If $\log 673.4 = 2.8283$, then $\text{antilog } 2.8283 = 673.4$.
3. Explain:
   - We use tables of antilogarithms to solve antilog problems.
   - We look for antilogs in a table the same way as logarithms. However, we must use a different table. Antilogarithms and logarithms each have their own table.
   - When finding the antilog, look up the fractional part only. Using the example on the board, we would drop the 2 and look for 0.8283.
4. Write on the board: Find the antilog of 0.5768.
5. Hold up the antilog table. Explain the steps for finding the antilog. As you explain, move your fingers and point at the part of the chart you are referring to:
   - Put the finger under .57, run it along to the column headed 6. Here the number is 3767.
   - Run your finger to the number under 8 in the differences (it is 7).
   - Add the number under the columns for 6 and difference 8: $3767 + 7 = 3774$.
   - We know that there is 1 integer digit in the antilog, because the integer in the problem (the characteristic) is 0. We get 3.774.
6. Explain **how to determine the decimal's placement**:

- We moved the decimal point based on the characteristic in the problem (the integer digit). Move the decimal point one more space than the value of the characteristic.
- In the example, the characteristic was 0. Therefore, we moved 1 space from the left side, and changed 3774 to 3.774
- Recall that when we calculated logs, we gave the characteristic the number of digits before the decimal place minus 1. Therefore, when finding antilogs, we do the opposite. We give the result **one more** integer digit than the characteristic given in the problem.

7. Write on the board: if $\log n = 2.3572$, find n.
8. Find the antilog of both sides of the equation: $\text{antilog}(\log n) = \text{antilog}(2.3572)$
9. Remind pupils that antilog "undoes" log because they are opposites.
10. Write on the board: $n = \text{antilog}\,(2.3572)$
    Explain the solution to pupils. Hold up the antilog tables to show how to find the answer, and write the answer on the board.
    Solution:
    - To find n means we have to use the antilog table. As we know, $\log n$ consists of two parts, the characteristic and mantissa.
    - In this case, the characteristic is 2, and the mantissa is 0.3572. Use the antilog table to find the antilog of 0.3572.
    - The antilog of 0.3572 is 2276 (demonstrate this).
    - Since the characteristic is 2, put the decimal 3 places from the left side.
    - Therefore $n = 227.6$
11. Write on the board: Find the antilog of 2.7547
12. Explain the solution to pupils. Hold up the antilog tables to show how to find the answer, and write the answer on the board.
    Solution:
    - The fractional part of 2.7547 is 0.7547. 0.7547 in the antilog tables gives 5684 (demonstrate this).
    - The integer part of 2.7547 is 2. This shows that there are three digits before the decimal point.
    - Therefore $\text{antilog}\, 2.7547 = 568.4$
13. Write on the board: Find the number whose logarithm is 5.3914.
14. Write this on the board as both a logarithm and antilog: $\log x = 5.3914$, $x = \text{antilog}\, 5.3914$
15. Explain the solution to pupils. Hold up the antilog tables to show how to find the answer, and write the answer on the board.
    Solution:
    - The fractional part of 5.3914 is 0.3914. 0.3914 in the antilog tables gives 2462.
    - The integer 5 shows that there are six digits before the decimal point.
    - Therefore, the number whose logarithm is 5.3914 is $246{,}200$.

16. Write on the board: Find the antilogarithms of the following numbers: a. 1.5752 b. 4.5724
17. Ask pupils to work with seatmates to solve the problems.
18. Walk around to check for understanding and clear any misconceptions.
19. Invite two volunteers to write their answers on the board and explain using the antilog tables. (Answers: a. $\text{antilog } 1.5752 = 37.60$; b. $\text{antilog } 4.5724 = 37{,}360$)

Practice *(14 minutes)*

1. Write on the board: Use antilog tables to find the numbers whose logarithms are:
   a. 2.1814 b. 4.2105 c. 5.0813 d. 2.0088
2. Ask pupils to solve the problem independently in their exercise books.
3. Walk around to check for understanding and clear any misconceptions.
4. Invite volunteers to write their answers on the board. All other pupils should check their work. (Answers: a. $2.1814 = 151.8$ b. $4.2105 = 16{,}240$ c. $5.0813 = 120{,}600$ d. $2.0088 = 102.1$).

Closing *(1 minute)*

1. For home work, have pupils to do the practice activity PHM1-L047 in the Pupil Handbook

Lesson Title: Multiplication and Division of Logarithms – Numbers greater than 1	**Theme:** Numbers and Numeration	
Lesson Number: M1-L048	**Class:** SSS 1	**Time:** 40 minutes
Learning Outcome By the end of the lesson, pupils will be able to multiply and divide numbers greater than 1 using logarithms.	**Preparation** Write the problems in Opening on the board.	

Opening *(3 minutes)*

1. Review logarithms and antilogarithms. Write on the board:
    a. Find $\log 387.5$
    b. Find $\text{antilog } 0.3119$
2. Ask pupils to solve the problems independently.
3. Ask volunteers to call out their answers. Write them on the board. (Answers: a. 2.5883; b. 2.050)
4. Revise log and antilog tables briefly if needed.
5. Explain to pupils that today's lesson is on multiplication and division of numbers greater than 1 using logarithms.

Teaching and Learning *(22 minutes)*

1. Write on the board: Evaluate 34.83×5.427
2. Explain the **product rule**:
    - We can multiply 2 numbers using logarithms.
    - There are 3 steps:
        - Find the logarithms of the numbers.
        - Add the logarithms.
        - Find the antilogarithm of the result.
3. Solve the problem on the board. Explain each step to pupils.
   Solution:
   Step 1. Find the logarithms of the numbers (use the table).
   $$\log 34.83 = 1.5420$$
   $$\log 5.427 = 0.7346$$
   Step 2. Add the logarithms.
   $$\begin{array}{r} 1.5420 \\ +\ 0.7346 \\ \hline 2.2766 \end{array}$$
   Step 3. Find the antilog of 2.2766.
   From the table, we have 1891. The integer part should be 3 digits, since the characteristic is 2. Therefore, the solution is 189.1.
4. Write another problem on the board: Evaluate $85.73 \div 39.63$
5. Explain the **division rule:**

a. We can also divide 2 numbers using logarithms.
b. There are 3 steps:
   - Find the logarithms of the numbers.
   - Subtract the logarithm of the denominator from the numerator.
   - Find the antilogarithm of the result.

6. Explain: Note that for multiplication, the second step is to add the logarithms. For division, the second step is to subtract the logarithms.
7. Solve the problem on the board. Explain each steps to pupils.
   Solution:
   Step 1. and **Step 2.** Find the logarithms and subtract. Use the table as shown.

Numbers	Logarithms
85.73 39.63	1.9332 $-\ 1.5980$
Subtract the logs for division	0.3352

   Step 3. Find the antilog of 0.3352.

   From the table, we have 2164. The integer part should be 1 digit, since the characteristic is 0. Therefore, the solution is 2.164.

8. Explain:
   - Calculations using logarithms follows the laws of indices.
   - Recall that the logarithms we are handling are based on powers of 10, although there is no need to write out the base 10 every time.
   - Thus, when we add logarithms for multiplication and subtract for division, this is similar to applying the multiplication and division rules for indices.
9. Write the following problem on the board: Evaluate $42.87 \times 23.82 \times 1.127$
10. Explain: When you multiply more numbers, follow the same 3 steps.
11. Ask volunteers to give the 3 steps needed to solve the problem. (Answer: Find the logarithms, add, and find the antilogarithm.)
12. Ask pupils to solve the problem with seatmates.
13. Invite a volunteer to write the solution on the board and explain.
    Solution:

Numbers	Logarithms
42.87 23.82 1.127	1.6321 1.3770 $+\ 0.0518$
Add the logs for multiplication	3.0609

    Antilog of $3.0609 = 1150$. The solution is 1150.
14. Write another problem on the board: Evaluate $\frac{675.2}{35.81}$
15. Ask pupils to work with seatmates to solve the problem.

16. Invite a volunteer to write the solution on the board.
Solution:

Number	Logarithm
675.2 35.81	2.8294 $-\ 1.5540$
Subtract the logs for division	1.2754

The antilog of $1.2754 = 1{,}886$. The solution is 18.86.

Practice *(14 minutes)*

1. Write on the board:
   - Evaluate $5.932 \times 8.164 \times 18.51$
   - Evaluate $\frac{17.83 \times 246.9}{256.2 \times 3.28}$
2. Ask pupils to solve the problems independently in their exercise books.
3. Explain to pupils about question b. above. Apply the normal order of operations. Find a single logarithm representing the numerator and a single logarithm representing the denominator. Then apply division (subtract).
4. Walk around to check for understanding and clear any misconceptions.
5. Invite two volunteers, one at a time, to write their answers on the board. Other pupils should check their work.
   Answers:
   a.

Number	Logarithm
5.932 8.164 18.51	0.7732 0.9119 $+\ 1.2674$
Add the logs for multiplication	2.9525

Antilog of $2.9525 = 8964$
Answer= 896.4

b.
Multiply the numerator:

Number	Logarithm
17.83 246.9	1.2511 $+\ 2.3925$
Numerator	3.6436

Multiply the denominator:

Number	Logarithm
256.2 3.28	2.4085 $+\ 0.5159$
Denominator	2.9244

Divide the numerator by denominator:

Number	Logarithm
-- --	3.6436 $-\ 2.9244$
Result	0.7192

Antilog of $0.7192 = 5{,}238$
Answer $= 5.238$

Closing *(1 minute)*

1. For homework, have pupils do the practice activity PHM1-L048 in the Pupil Handbook.

Appendix I: Logarithm Table

COMMON LOGARITHM TABLE

	0	1	2	3	4	5	6	7	8	9	Mean Difference								
											1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4

Appendix II: Anti-Logarithm Table

FRITHLOGARTAIM ANTI-LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
·01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
·02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
·03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
·04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
·05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
·06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	1	2	2	2
·07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
·08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
·09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
·10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
·11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
·12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
·13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
·14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
·15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
·16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
·17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
·18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
·19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
·20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
·21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1696	0	1	1	2	2	2	3	3	3
·22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
·23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
·24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
·25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
·26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
·27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
·28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
·29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
·30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
·31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
·32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
·33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
·34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
·35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
·36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
·37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
·38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
·39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
·40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
·41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
·42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
·43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
·44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
·45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
·46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
·47	2951	2958	2965	2972	2970	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
·48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	4	4	5	6	6
·49	3050	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	4	4	5	6	6

FRITHLOGARTAIM ANTI-LOGARITHMS

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
·50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
·51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
·52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
·53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
·54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
·55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
·56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
·57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
·58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
·59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
·60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
·61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
·62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
·63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
·64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
·65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
·66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
·67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
·68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
·69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
·70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
·71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
·72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
·73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
·74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
·75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
·76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
·77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
·78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
·79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
·80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
·81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
·82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
·83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
·84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
·85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
·86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
·87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
·88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
·89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
·90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
·91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
·92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
·93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
·94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
·95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
·96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
·97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
·98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
·99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20

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