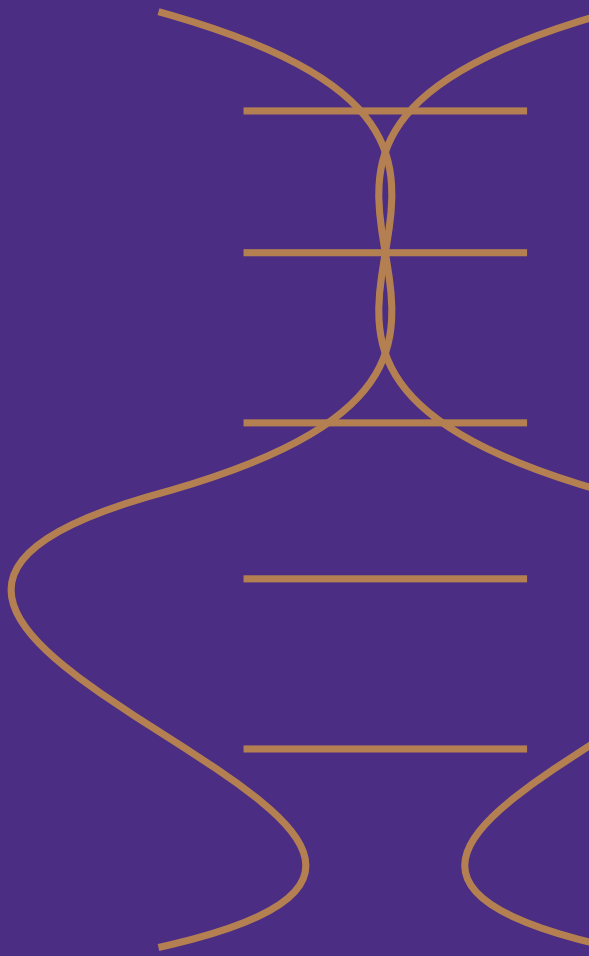
EXAM READY MATHEMATICS

# Exam Ready Mathematics

## GRADE 9

Study Guide, Worked Examples and Practice Tests for the Grade 9 Examination



- ✓ 9 units with clear key ideas, worked examples and “Watch out!” boxes
- ✓ 180 worked examples and 288+ practice questions at three levels
- ✓ 180 unit-quiz questions and 3 full mock exams (60 MCQ each)
- ✓ Diagnostic test · Key Facts Sheet · Top 20 Mistakes · teacher notes

Follows the units and order of the Ethiopian Grade 9 Mathematics textbook

ERMIAS WEDAJE TEGBARU

# Exam Ready Mathematics

## Grade 9 · Study Guide, Worked Examples and Practice Tests

**By Ermias Wedaje Tegbaru**
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First edition, 2026

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This is an independent study guide. It follows the units and order of the Ethiopian Grade 9 Mathematics student textbook, but it is not published or endorsed by the Ministry of Education. All explanations, examples and questions are original. Keep your textbook and your teacher's notes beside this book.

The answers were calculated and checked before printing, but no book is free of errors. If you find a mistake or disagree with an answer, please tell the author on Telegram (@Ermias_Wedaje) and it will be reviewed for the next edition.

# How to Use This Book

Each unit follows the same pattern, so you always know where to look.

**Key ideas**
The rules and facts of the section, short and clear.

**Worked examples**
Step-by-step solutions. Cover the solution and try first.

**⚠ Watch out!**
The mistakes students make most often, and the right way.

**Practice**
Level 1 Basic · Level 2 Standard · Level 3 Challenge.

**Unit quiz**
20 multiple-choice questions in the style of the national examination.

**For the Teacher**
Timing, starters, misconceptions, activities and assessment.

## For students

- Begin with the Diagnostic Test. It shows which units need the most work.
- Read the key ideas, then study each example with the solution covered.
- Do Level 1 and Level 2 practice for every section; try Level 3 when you are ready.
- Take each quiz in 30 minutes, mark it, and redo every question you got wrong.
- In the last weeks, learn the Key Facts Sheet and the Top 20 Mistakes page, and sit the three mock exams. Their answer keys show which unit each question comes from.

## For teachers

- Each unit follows the textbook sections, so the book can sit beside your lessons.
- The “For the Teacher” page gives timing, starters, misconceptions and activities.
- The quizzes and mock exams can be used as class tests; every answer has a short reason.

## For parents

- Ask your child to explain one worked example to you each day. Teaching is the best way to learn.
- Look at the quiz score after each unit, and celebrate progress, not only high marks.

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# Diagnostic Test · Where Should I Start?

20 questions · 15 minutes. Take this test before you start the book. There are two questions on each unit. Your score only shows you where to spend your time.

**1.** A set with no elements is called the

A. empty set  B. universal set  C. finite set  D. power set

**2.** A set with 3 elements has how many subsets?

A. 6  B. 3  C. 8  D. 9

**3.** 125 divided by 7 leaves remainder

A. 5  B. 6  C. 7  D. 4

**4.** A number is divisible by 9 if its digit sum is divisible by

A. 6  B. 11  C. 3 only  D. 9

**5.** Solution of $3x - 7 = 2x + 5$ is

A. $x = -2$  B. $x = 12$  C. $x = 2$  D. $x = 1$

**6.** From $v = u + at$, $t =$

A. $(v + u)/a$  B. $v - u - a$  C. $a(v - u)$  D. $(v - u)/a$

**7.** Solution of $3x - 5 > 7$ is

A. $x > 12$  B. $x > 4$  C. $x > 2$  D. $x < 4$

**8.** Solution of $-3 < 2x + 1 \leq 7$ is

A. $(-4, 6]$  B. $(-2, 3)$  C. $(-2, 3]$  D. $[-2, 3)$

**9.** Legs 6 and 8 give hypotenuse

A. 100  B. 12  C. 10  D. 14

**10.** Two acute angles of a right triangle add to

A. 60°  B. 90°  C. 180°  D. 45°

**11.** A polygon with 8 sides is a

A. nonagon  B. hexagon  C. decagon  D. octagon

**12.** A polygon whose angles sum to 1 440° has

A. 10 sides  B. 8 sides  C. 12 sides  D. 9 sides

**13.** Congruent figures have

A. same shape only  B. same colour
C. same shape and size  D. same size only

**14.** $\triangle ABC \cong \triangle PQR$, $AB = 6$. Then $PQ =$

A. 6  B. cannot tell  C. 12  D. 3

**15.** Which is a vector?

A. velocity  B. speed  C. mass  D. temperature

**16.** After 3 km east then 3 km west the distance is

A. 3 km  B. 0 km  C. 12 km  D. 6 km

# Unit 1 · Further on Sets

**By the end of this unit you will be able to:**

- describe sets by listing and by rule and use set notation
- identify subsets, power sets, equal, equivalent, disjoint, universal and complement sets
- perform union, intersection, difference and complement operations
- solve problems on sets using Venn diagrams and $n(A \cup B) = n(A) + n(B) - n(A \cap B)$

**Before you start — check yourself.** (a) List the elements of $A = \{x : x \text{ is a natural number}, x < 5\}$. (b) Find $n(A)$. (c) Is $3 \in A$?
*Answers: (a) {1, 2, 3, 4} (b) 4 (c) yes*

**Key words:** set · element · subset · power set · universal set · complement · union · intersection · disjoint sets · Venn diagram

**How this unit is examined**

*Question types that appear again and again in Ethiopian model examinations:*

- Sets, Elements and Description
- Subsets and Types of Sets
- Operations on Sets
- Applications of Sets

## 1.1 Sets, Elements and Description

**Key ideas**

- A **set** is a well-defined collection of objects called **elements**. We write $a \in A$ ($a$ belongs to $A$) and $a \notin A$ ($a$ does not belong). **n(A)** is the number of elements. The set with no element is the **empty set** $\varnothing$ or $\{\ \}$.
- **Roster (listing) method:** $A = \{2, 4, 6, 8\}$. **Set-builder (rule) method:** $A = \{x : x \text{ is an even number}, 2 \le x \le 8\}$. Read "x such that".
- **Number sets:** $N = \{1, 2, 3, \ldots\}$, $W = \{0, 1, 2, \ldots\}$, $Z = \{\ldots, -2, -1, 0, 1, 2, \ldots\}$, $Q$ = rational numbers, $Q'$ = irrational numbers, $R$ = real numbers.
- A set is **finite** if its elements can be counted to an end and **infinite** otherwise. Repeated elements are written once and the order does not matter.

**Example 1.1 — List**

List the elements of $A = \{x : x \in N, 2 < x \le 6\}$.

**Solution.** $A = \{3, 4, 5, 6\}$.

**Example 1.2 — Rule**

Describe B = {1, 4, 9, 16, 25} by a rule.

**Solution.** B = $\{x^2 : x \in N, x \leq 5\}$.

**Example 1.3 — Count**

Find n(C) for C = $\{x : x \in Z, -2 \leq x \leq 3\}$.

**Solution.** C = {−2, −1, 0, 1, 2, 3}, so n(C) = 6.

**Example 1.4 — Exam Booster · Empty**

Is $\{x : x \in N, 3 < x < 4\}$ empty?

**Solution.** Yes, no natural number lies between 3 and 4, so it is ø and n = 0.

**Example 1.5 — Exam Booster · Count**

Find n(D) for D = {a, b, a, c, b}.

**Solution.** D = {a, b, c}, so n(D) = 3.

**⚠ Watch out!**

| × Wrong | ✓ Right |
|---|---|
| The set {0} is empty. | It has one element, 0; n = 1. |
| {1, 2, 2, 3} has 4 elements. | Repeats are written once: 3 elements. |
| ø and {ø} are the same. | ø has 0 elements; {ø} has 1. |

## Practice 1.1

**Level 1 — Basic**

1. List $\{x : x \in N, x < 4\}$.
2. n({a, b, c, d})?
3. Is $5 \in \{1, 3, 5\}$?

**Level 2 — Standard**

4. Write {2, 4, 6} by rule.
5. n(ø)?
6. List $\{x \in W : x < 3\}$.

**Level 3 — Challenge**

7. List $\{x \in Z : -1 \leq x \leq 2\}$.
8. Is $\{x \in N : x < 1\}$ empty?

## 1.2 Subsets and Types of Sets

**Key ideas**

- A is a **subset** of B ($A \subseteq B$) if every element of A is in B. A is a **proper subset** ($A \subset B$) if $A \subseteq B$ and $A \neq B$. $\varnothing$ is a subset of every set and every set is a subset of itself.
- A set with n elements has $\mathbf{2^n}$ **subsets**, $\mathbf{2^n - 1}$ **proper subsets**; the **power set** P(A) is the set of all subsets, so $n(P(A)) = 2^n$.
- **Equal sets** have exactly the same elements. **Equivalent sets** have the same number of elements. **Disjoint sets** have no common element.
- The **universal set** U contains all elements under discussion. The **complement** $A' = \{x \in U : x \notin A\}$.

**Example 1.6 — Subsets**

List all subsets of A = {a, b}.

**Solution.** $\varnothing$, {a}, {b}, {a, b}: $4 = 2^2$ subsets.

**Example 1.7 — Count**

How many subsets and proper subsets has a set of 5 elements?

**Solution.** $2^5 = 32$ subsets and 31 proper subsets.

**Example 1.8 — Type**

Are A = {1, 2, 3} and B = {a, b, c} equal or equivalent?

**Solution.** Equivalent (both have 3 elements) but not equal.

**Example 1.9 — Exam Booster · Compl**

U = {1, 2, ..., 10}, A = {2, 4, 6, 8, 10}. Find A′.

**Solution.** A′ = {1, 3, 5, 7, 9}.

**Example 1.10 — Exam Booster · Power**

A set has 64 subsets. How many elements has it?

**Solution.** $2^n = 64 = 2^6$, so n = 6.

# Unit 2 · The Number System

**By the end of this unit you will be able to:**

- use Euclid's lemma, primes, divisibility tests, HCF and LCM
- distinguish rational and irrational numbers and convert recurring decimals to fractions
- work with intervals, absolute value and limits of accuracy
- apply the laws of exponents and radicals, scientific notation and rationalisation

**Before you start — check yourself.** (a) Is 0.25 rational? (b) Is √2 rational? (c) Find $|-6|$.
*Answers: (a) yes (b) no, it is irrational (c) 6*

**Key words:** rational number · irrational number · real number · prime number · HCF · LCM · interval · absolute value · radical · rationalisation

**How this unit is examined**

*Question types that appear again and again in Ethiopian model examinations:*

- Natural Numbers and Integers
- Rational and Irrational Numbers
- Intervals, Absolute Value and Accuracy
- Exponents, Radicals and Rationalisation

## 2.1 Natural Numbers and Integers

**Key ideas**

- **Euclid's division lemma:** for integers a and b > 0, a = bq + r with 0 ≤ r < b. A **prime** has exactly two factors (1 and itself); a **composite** has more than two. 1 is neither.
- **Divisibility:** by 2 – last digit even; 3 – digit sum divisible by 3; 4 – last two digits divisible by 4; 5 – ends 0 or 5; 6 – by 2 and 3; 9 – digit sum divisible by 9; 10 – ends 0; 11 – alternating digit sum divisible by 11.
- **HCF** (greatest common factor) and **LCM** (least common multiple) from prime factorisation: HCF takes the **smallest** powers of common primes, LCM the **largest** powers of all primes. HCF × LCM = a × b for two numbers.
- **Euclidean algorithm:** repeat division until the remainder is 0; the last divisor is the HCF.

**Example 2.1 — Euclid**

Write 125 in the form 7q + r.

**Solution.** 125 = 7 × 17 + 6.

# Unit 5 · Introduction to Trigonometry

**By the end of this unit you will be able to:**

- use the Pythagorean theorem in right-angled triangles
- define sine, cosine and tangent of an acute angle
- use the values of the ratios for 30°, 45° and 60° and complementary angles
- solve right-angled triangles and problems on angles of elevation and depression

**Before you start — check yourself.** (a) In a right triangle with legs 3 and 4, find the hypotenuse. (b) Name the longest side.
*Answers: (a) 5 (b) the hypotenuse*

**Key words:** hypotenuse · opposite · adjacent · sine · cosine · tangent · complementary angles · angle of elevation · angle of depression · Pythagorean theorem

**How this unit is examined**

*Question types that appear again and again in Ethiopian model examinations:*

- Right-angled Triangles
- Trigonometric Ratios
- Special Angles and Identities
- Solving Right Triangles and Applications

## 5.1 Right-angled Triangles

**Key ideas**

- In a right triangle the side opposite the right angle is the **hypotenuse** (longest). **Pythagorean theorem:** $a^2 + b^2 = c^2$, where c is the hypotenuse.
- **Converse:** if $a^2 + b^2 = c^2$ the triangle is right-angled. **Triples:** (3, 4, 5), (5, 12, 13), (8, 15, 17), (7, 24, 25).
- For an acute angle θ: the **opposite** side faces θ, the **adjacent** side touches θ (not the hypotenuse).
- The acute angles of a right triangle are **complementary**: they add to 90°.

**Example 5.1 — Find**

Legs 6 and 8. Find the hypotenuse.

**Solution.** $c^2 = 36 + 64 = 100$, so $c = 10$.

# Unit 8 · Vectors in Two Dimensions

**By the end of this unit you will be able to:**

- distinguish vector and scalar quantities
- represent vectors by arrows and by components and find magnitude
- add and subtract vectors and multiply a vector by a scalar
- use position vectors, midpoints and simple applications

**Before you start — check yourself.** (a) Is mass a vector or a scalar? (b) Is velocity a vector or a scalar?
*Answers: (a) scalar (b) vector*

**Key words:** scalar · vector · magnitude · direction · component · position vector · resultant · parallel vectors · unit vector · midpoint

**How this unit is examined**

*Question types that appear again and again in Ethiopian model examinations:*

- Vector and Scalar Quantities
- Representing Vectors and Magnitude
- Operations on Vectors
- Position Vectors and Applications

## 8.1 Vector and Scalar Quantities

**Key ideas**

- A **scalar** has magnitude (size) only: mass, time, distance, speed, temperature, area. A **vector** has **magnitude and direction**: displacement, velocity, acceleration, force, weight.
- A vector is drawn as an arrow: the **length** shows magnitude and the **arrowhead** shows direction. It is written AB (from A to B) or in bold/with an arrow, e.g. a.
- **Equal vectors** have the same magnitude and direction (position does not matter). The **negative** of a, written −a, has the same magnitude and opposite direction.
- The **zero vector** has magnitude 0. **Displacement** (change of position) is a vector, but **distance** is a scalar.

**Example 8.1 — Class**

Classify: speed, velocity, force, temperature.

**Solution.** Scalars: speed, temperature. Vectors: velocity, force.

# Key Facts Sheet

Learn these by heart. Cover the right-hand side and say each fact from memory.

### Unit 1 · Sets

$n(A \cup B) = n(A) + n(B) - n(A \cap B)$

A set with n elements has $2^n$ subsets

De Morgan: $(A \cup B)' = A' \cap B'$

Neither = $n(U) - n(A \cup B)$

Fill the intersection first in a Venn diagram

Disjoint: $A \cap B = \varnothing$

### Unit 2 · Number system

$a = bq + r$, $0 \le r < b$

HCF × LCM = product of the two numbers

Repeating decimal: multiply by $10^k$, subtract

$a^m \cdot a^n = a^{m+n}$ ; $a^{-n} = 1/a^n$

Rationalise with the conjugate

Limits of accuracy: ± half the unit

### Unit 3 · Equations

Quadratic formula $x = (-b \pm \sqrt{(b^2 - 4ac)}) / 2a$

$D > 0$ two roots ; $D = 0$ one ; $D < 0$ none

$|A| = k$ gives $A = k$ or $A = -k$

Check radical equations for extraneous roots

Elimination or substitution for systems

Parallel lines: no solution

### Unit 4 · Inequalities

Reverse the sign when multiplying by a negative

$|x| < a$ gives $-a < x < a$

$|x| > a$ gives $x < -a$ or $x > a$

$(x - a)(x - b) > 0$ is outside the roots

Dashed line for < and > ; solid for ≤ and ≥

Test (0, 0) to choose the side

### Unit 5 · Trigonometry

sin = opp/hyp ; cos = adj/hyp ; tan = opp/adj

$\sin 30° = 1/2$ ; $\cos 60° = 1/2$ ; $\tan 45° = 1$

$\sin 60° = \cos 30° = \sqrt{3}/2$ ; $\tan 60° = \sqrt{3}$

$\sin(90° - \theta) = \cos \theta$

$\sin^2\theta + \cos^2\theta = 1$

Pythagoras: $a^2 + b^2 = c^2$

### Unit 6 · Polygons

Interior sum = $(n - 2) \times 180°$

Exterior sum = 360°

Each exterior angle = $360°/n$

Each interior angle = $180° - 360°/n$

Diagonals = $n(n - 3)/2$

Central angle = $360°/n$

### Unit 7 · Similarity

Congruence: SSS, SAS, ASA, AAS, RHS

Similarity: AA, SSS, SAS

Perimeter ratio k ; area ratio $k^2$

Area ratio → sides: take the square root

Basic proportionality: AD/DB = AE/EC

Map scale 1 : 50 000: 1 cm = 0.5 km

### Unit 8 · Vectors

AB = B − A (end minus start)

$|[x, y]| = \sqrt{(x^2 + y^2)}$

Add and subtract components

$k[a, b] = [ka, kb]$ ; $k < 0$ reverses direction

Parallel: $a = kb$

Midpoint = $(A + B)/2$

# Mock Examination 1

60 multiple-choice questions · 90 minutes · one mark each. Circle one answer. Mark with the answer key at the back and use the unit number to see where to revise.

**1.** A set with no elements is called the

A. empty set B. universal set C. finite set D. power set

**2.** n({a, b, c, a, b}) =

A. 4 B. 5 C. 2 D. 3

**3.** {x : x ∈ N, 2 < x ≤ 5} =

A. {3, 4} B. {3, 4, 5} C. {2, 3, 4} D. {2, 3, 4, 5}

**4.** A set with 3 elements has how many subsets?

A. 6 B. 3 C. 8 D. 9

**5.** A set with 4 elements has how many proper subsets?

A. 16 B. 14 C. 8 D. 15

**6.** Sets with the same number of elements are

A. always equal B. equivalent C. disjoint D. complements

**7.** Sets with no common element are

A. universal B. equal C. equivalent D. disjoint

**8.** 125 divided by 7 leaves remainder

A. 5 B. 6 C. 7 D. 4

**9.** The smallest prime is

A. 3 B. 0 C. 2 D. 1

**10.** Which is composite?

A. 51 B. 59 C. 47 D. 53

**11.** A number is divisible by 9 if its digit sum is divisible by

A. 6 B. 11 C. 3 only D. 9

**12.** HCF of 12 and 18 is

A. 3 B. 36 C. 6 D. 2

**13.** LCM of 4 and 6 is

A. 12 B. 2 C. 6 D. 24

**14.** HCF(252, 105) =

A. 21 B. 42 C. 7 D. 3

**15.** Solution of 3x − 7 = 2x + 5 is

A. x = −2 B. x = 12 C. x = 2 D. x = 1

**16.** Solution of 2(x − 3) = 4x + 2 is

A. x = −4 B. x = −2 C. x = 4 D. x = 2

**17.** Solution of x/2 + x/3 = 10 is

A. x = 6 B. x = 10 C. x = 12 D. x = 5