EXAM READY MATHEMATICS

Exam Ready Mathematics

GRADE 10

Study Guide, Worked Examples and Practice Tests for the Grade 10 Examination



- ✓ 7 units with clear key ideas, worked examples and “Watch out!” boxes
- ✓ 193 worked examples and 312+ practice questions at three levels
- ✓ 140 unit-quiz questions and 3 full mock exams (60 MCQ each)
- ✓ Diagnostic test · Formula Sheet · Top 20 Mistakes · teacher notes

Follows the units and order of the Ethiopian Grade 10 Mathematics textbook

ERMIAS WEDAJE TEGBARU

Exam Ready Mathematics

Grade 10 · Study Guide, Worked Examples and Practice Tests

By Ermias Wedaje Tegbaru
Civil engineer and author, Addis Ababa
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This is an independent study guide. It follows the units and order of the Ethiopian Grade 10 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?

10 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. If $f(x) = x^2 - 3x + 2$, then $f(3) =$
   A. 2 B. 20 C. 3 D. 0
2. If $f(x) = 3x + 2$, then $f^{-1}(8) =$
   A. 6 B. 2 C. 4 D. 26
3. The degree of $(x^4 + 1)(x^6 - 2)$ is
   A. 10 B. 6 C. 24 D. 9
4. The y-intercept of $p(x) = x^3 + 3x^2 + 5x - 3$ is
   A. −3 B. −2 C. 3 D. 5
5. $\log_2(8) + \log_2(16) =$
   A. 128 B. 8 C. 12 D. 7
6. If $\log_{10} x = 2$, then $x =$
   A. 1024 B. 12 C. 20 D. 100
7. From a point 30 m from the base of a tower, the angle of elevation of its top is 45°. The tower is ____ m high.
   A. 30 B. 75 C. 60 D. 15
8. For $0° \le x \le 90°$, if $\sin x = 1$, then $x =$
   A. 0 B. 105 C. 180 D. 90
9. The area of a sector of 180° in a circle of radius 14 cm ($\pi = 22/7$) is ____ cm^2.
   A. 154 B. 308 C. 616 D. 44
10. Two secants meet outside a circle and cut off arcs of 200° and 30°. The angle between them is
    A. 115 B. 85 C. 230 D. 170

Unit 1 · Relations and Functions

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

- find the domain and range of a relation and represent it by a table, arrow diagram or graph
- decide whether a relation is a function and use function notation
- add, subtract, multiply, divide and compose functions
- identify one-to-one and onto functions and find inverse functions
- draw and read the graphs of linear, quadratic, absolute-value and piecewise functions
- model real situations with functions

Before you start — check yourself. (a) Evaluate $2x^2 - 3x + 1$ for $x = 2$. (b) Solve $3x - 7 = 11$. (c) Find the gradient of the line through (1, 2) and (3, 8). (d) Factorise $x^2 - 5x + 6$.
Answers: (a) 3 (b) x = 6 (c) 3 (d) (x − 2)(x − 3)

Key words: relation · domain · range · function · composite function · inverse function · one-to-one · onto · piecewise function · vertical line test

How this unit is examined

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

- Relations: ordered pairs, domain and range
- The notion of a function
- Combination of functions
- Types of functions and inverse functions
- Graphs of functions
- Applications of relations and functions

1.1 Relations: Ordered Pairs, Domain and Range

Key ideas

- The **Cartesian product** $A \times B$ is the set of all ordered pairs (a, b) with $a \in A$ and $b \in B$. If A has m elements and B has n elements, $A \times B$ has **mn** elements.
- A **relation** from A to B is any subset of $A \times B$. The set of first components is the **domain**; the set of second components is the **range**.
- A relation can be shown as a **set of ordered pairs**, a **table**, an **arrow diagram**, a **graph** on the Cartesian plane, or a **rule** such as $y = 2x + 1$.
- The **inverse** of a relation R is found by interchanging the components: $R^{-1} = \{(b, a) : (a, b) \in R\}$. Domain and range are swapped.
- A relation on a set can be **reflexive**, **symmetric** or **transitive**; one that is all three is an **equivalence relation**.

Example 1.1 — Cartesian product

Let A = {1, 2} and B = {a, b, c}. Find A × B and the number of its elements.

Solution. A × B = {(1, a), (1, b), (1, c), (2, a), (2, b), (2, c)}. It has 2 × 3 = **6** elements.

Example 1.2 — Domain and range

Find the domain and range of R = {(1, 2), (2, 4), (3, 6), (4, 8)}.

Solution. Domain = **{1, 2, 3, 4}**; range = **{2, 4, 6, 8}**.

Example 1.3 — Relation from a rule

Let A = {1, 2, 3, 4} and R = {(x, y) : y = x + 2, x ∈ A}. List R and find the range.

Solution. R = {(1, 3), (2, 4), (3, 5), (4, 6)}. Range = **{3, 4, 5, 6}**.

Example 1.4 — Exam Booster · Inverse relation

Find the inverse of R = {(1, 3), (2, 5), (4, 9)}.

Solution. Interchange the components: R^{-1} = **{(3, 1), (5, 2), (9, 4)}**.

Example 1.5 — Exam Booster · Equivalence

Is "has the same remainder as, when divided by 3" on the integers reflexive, symmetric and transitive?

Solution. Reflexive (a has the same remainder as itself), symmetric and transitive. It is an **equivalence relation**.

⚠ Watch out!

× Wrong	✓ Right
(a, b) and (b, a) are the same ordered pair.	Order matters: (1, 2) ≠ (2, 1).
The range is the set of all the first components.	The first components form the domain; the second components form the range.
A × B = B × A.	In general they are different sets.

Practice 1.1

Level 1 — Basic

1. Find A × B for A = {1, 2}, B = {3}.
2. State the domain of {(1, 5), (2, 6), (3, 7)}.
3. How many elements are in A × B if |A| = 4 and |B| = 5?

Level 2 — Standard

4. Write R = {(x, y) : y = 2x, x ∈ {1, 2, 3}} as a set of ordered pairs.

5. Find the range of the relation in the previous question.
6. Find the inverse of {(1, 4), (2, 5)}.

Level 3 — Challenge

7. A = {1, 2, 3} and R = {(a, b) : a < b}. List R and find its domain and range.
8. Is "is a factor of" on the natural numbers reflexive, symmetric and transitive?

1.2 The Notion of a Function

Key ideas

- A **function** from A to B is a relation in which **every element of A is paired with exactly one element of B**. We write $y = f(x)$ and read it "f of x".
- **Vertical line test:** a graph is a function if no vertical line meets it more than once.
- The **domain** is the set of allowed inputs; the **range** is the set of outputs. For a rule given by a formula the natural domain excludes values that give division by zero or the square root of a negative number.
- **Evaluating:** to find f(a), replace x by a. Example: if $f(x) = 2x^2 - 3x + 1$, then $f(2) = 8 - 6 + 1 = 3$.
- **Linear function** $f(x) = mx + b$; **quadratic function** $f(x) = ax^2 + bx + c$ $(a \neq 0)$.

Example 1.6 — Is it a function?

Which of these relations is a function? $R_1 = \{(1, 2), (2, 3), (3, 4)\}$; $R_2 = \{(1, 2), (1, 3), (2, 4)\}$.

Solution. R_1 is a function (each input has one output). R_2 is **not** a function: 1 is paired with both 2 and 3.

Example 1.7 — Evaluate

If $f(x) = 2x^2 - 3x + 1$, find f(0), f(2) and f(−1).

Solution. $f(0) = \mathbf{1}$; $f(2) = 8 - 6 + 1 = \mathbf{3}$; $f(-1) = 2 + 3 + 1 = \mathbf{6}$.

Example 1.8 — Natural domain

Find the domain of $f(x) = 1/(x - 3)$ and of $g(x) = \sqrt{(x - 2)}$.

Solution. f: $x - 3 \neq 0$, so the domain is **all real numbers except 3**. g: $x - 2 \geq 0$, so the domain is $\mathbf{x \geq 2}$.

Example 1.9 — Exam Booster · Find f(a + h)

If $f(x) = x^2 + 1$, find $f(a + 1)$.

Solution. $f(a + 1) = (a + 1)^2 + 1 = \mathbf{a^2 + 2a + 2}$.

Example 1.10 — Exam Booster · Range

Find the range of $f(x) = x^2 + 3$ on the real numbers.

Solution. $x^2 \geq 0$, so $f(x) \geq 3$. The range is $\mathbf{y \geq 3}$.

Unit 3 · Exponential and Logarithmic Functions

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

- use the laws of exponents including rational exponents
- define logarithms and use their laws, including change of base
- draw and interpret exponential and logarithmic graphs, including $y = e^x$ and $y = \ln x$
- solve exponential and logarithmic equations
- use the inverse relation between exponential and logarithmic functions
- solve problems on compound interest, population growth and the pH scale

Before you start — check yourself. (a) Simplify $2^3 \times 2^4$. (b) Evaluate 9^(1/2). (c) Write 1/8 as a power of 2. (d) Solve $2x + 3 = 11$.
Answers: (a) $2^7 = 128$ (b) 3 (c) 2^{-3} (d) $x = 4$

Key words: exponent · base · logarithm · natural logarithm · exponential function · asymptote · compound interest · growth · decay · pH

How this unit is examined

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

- Exponents
- Logarithms
- Exponential functions and their graphs
- Logarithmic functions and their graphs
- Solving exponential and logarithmic equations
- Relation between exponential and logarithmic functions
- Applications

3.1 Exponents

Key ideas

- **Laws (a, b > 0):** $a^m \cdot a^n = a^{m+n}$; $a^m / a^n = a^{m-n}$; $(a^m)^n = a^{mn}$; $(ab)^n = a^n b^n$; $(a/b)^n = a^n / b^n$.
- **Zero and negative exponents:** $a^0 = 1$ ($a \neq 0$); $a^{-n} = 1/a^n$.
- **Rational exponents:** a^(1/n) = $\sqrt[n]{a}$; a^(m/n) = $(\sqrt[n]{a})^m = \sqrt[n]{(a^m)}$.
- **Scientific notation:** $a \times 10^n$ with $1 \leq a < 10$.
- Compare numbers by writing them with the **same base**: if $a^x = a^y$ ($a > 0$, $a \neq 1$) then $x = y$.

Unit 5 · Circles

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

- use the symmetrical properties of chords, radii and tangents
- use the angle properties of circles: central, inscribed, cyclic quadrilateral and alternate segment
- calculate arc length, sector area and segment area
- use the theorems on angles and arcs formed by chords, secants and tangents
- use the intersecting chords, secant and tangent length theorems

Before you start — check yourself. (a) Find the circumference of a circle of radius 7 cm (π = 22/7). (b) Find the area of a circle of radius 5 cm. (c) What is the angle sum of a quadrilateral? (d) What is the angle between a radius and a tangent at the point of contact?
Answers: (a) 44 cm (b) 25π ≈ 78.5 cm² (c) 360° (d) 90°

Key words: chord · arc · sector · segment · tangent · secant · central angle · inscribed angle · cyclic quadrilateral · semicircle

How this unit is examined

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

- Symmetrical properties of circles
- Angle properties of circles
- Arc length, sectors and segments
- Angles and arcs formed by chords, secants and tangents
- Lengths of intersecting chords, secants and tangents

5.1 Symmetrical Properties of Circles

Key ideas

- A **chord** joins two points of a circle; a **diameter** is the longest chord. A **tangent** touches the circle at one point; a **secant** cuts it at two.
- **The perpendicular from the centre to a chord bisects the chord**, and the line from the centre to the midpoint of a chord is perpendicular to the chord.
- **Equal chords** are equally distant from the centre, and chords equidistant from the centre are equal.
- **A tangent is perpendicular to the radius** at the point of contact. **Two tangents from an external point are equal in length.**
- A circle has infinitely many lines of symmetry (every diameter). Chord length: $\mathbf{2\sqrt{(r^2 - d^2)}}$, where d is the distance of the chord from the centre.

Unit 7 · Coordinate Geometry

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

- find the distance between two points and the midpoint of a segment
- divide a line segment in a given ratio
- find the equation of a line in different forms
- use slopes to decide whether lines are parallel or perpendicular
- write and use the equation of a circle

Before you start — check yourself. (a) Find the slope of the line through (1, 2) and (3, 6). (b) Find the midpoint of (2, 4) and (8, 10). (c) Evaluate $\sqrt{(3^2 + 4^2)}$. (d) Solve $2x + 3 = 11$.
Answers: (a) 2 (b) (5, 7) (c) 5 (d) $x = 4$

Key words: distance formula · midpoint · section formula · slope · intercept · parallel lines · perpendicular lines · equation of a line · centre · radius

How this unit is examined

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

- Distance between two points
- Division of a line segment
- Equation of a line
- Parallel and perpendicular lines
- Equation of a circle

7.1 Distance between Two Points

Key ideas

- **Distance formula:** $d = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2]}$.
- **Midpoint** of (x_1, y_1) and (x_2, y_2): $((x_1 + x_2)/2, (y_1 + y_2)/2)$.
- Use the distance formula to show that a triangle is **isosceles, equilateral or right-angled** (check Pythagoras), and to prove a quadrilateral is a parallelogram, rhombus or square.
- Points are **collinear** if the sum of two distances equals the third.

Example 7.1 — Distance

Find the distance between A(1, 2) and B(7, 10).

Solution. $d = \sqrt{(36 + 64)} = \mathbf{10}$.

Key Formula Sheet

Learn these by heart. Cover the right-hand side and write the formula from memory.

Unit 1 · Relations and Functions

Domain = inputs, range = outputs

$(f \circ g)(x) = f(g(x))$

f^{-1}: swap x and y, solve for y

$(f + g)(x) = f(x) + g(x)$

Unit 2 · Polynomials

Remainder theorem: $p(x) \div (x - c)$ leaves $p(c)$

Factor theorem: $p(c) = 0 \Leftrightarrow (x - c)$ is a factor

Sum of zeros $= -b/a$; product $= c/a$

$\deg(fg) = \deg f + \deg g$

Unit 3 · Exponents and Logs

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

$\log(xy) = \log x + \log y$

$\log(x/y) = \log x - \log y$; $\log x^n = n \log x$

$\log_a x = n \Leftrightarrow a^n = x$

$A = P(1 + r)^n$

Unit 4 · Trigonometry

π rad $= 180°$

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

$a/\sin A = b/\sin B = c/\sin C$

$c^2 = a^2 + b^2 - 2ab \cos C$

Area $= \frac{1}{2}ab \sin C$

Unit 5 · Circles

Central angle $= 2 \times$ inscribed angle

Cyclic quadrilateral: opposite angles add to 180°

Arc $l = (\theta/360°) \cdot 2\pi r$; sector $A = (\theta/360°) \cdot \pi r^2$

$PA \cdot PB = PC \cdot PD$; $PT^2 = PA \cdot PB$

Unit 6 · Solid Figures

Prism/cylinder: $V = Bh$

Pyramid/cone: $V = \frac{1}{3}Bh$

Cone: $l = \sqrt{(r^2 + h^2)}$; curved area $= \pi rl$

Sphere: $V = (4/3)\pi r^3$; $A = 4\pi r^2$

Similar solids: area k^2, volume k^3

Unit 7 · Coordinate Geometry

$d = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2]}$

Midpoint $= ((x_1 + x_2)/2, (y_1 + y_2)/2)$

Slope $m = (y_2 - y_1)/(x_2 - x_1)$

$y - y_1 = m(x - x_1)$

Parallel: $m_1 = m_2$; perpendicular: $m_1 m_2 = -1$

$(x - h)^2 + (y - k)^2 = r^2$

Mock Examination 1

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

1. If $f(x) = 2x - 2$, then $f(2) =$

A. 2 B. 6 C. 0 D. 3

2. If $f(x) = x^2 - 4x - 3$, then $f(-1) =$

A. 2 B. 3 C. 0 D. −6

3. If $f(x) = 4x + 4$ and $g(x) = x^2$, then $(f \cdot g)(4) =$

A. 36 B. 320 C. 68 D. 400

4. $f(x) = 2x + 4$ and $g(x) = x^2 + 1$. $(f \circ g)(1) =$

A. 37 B. 9 C. 6 D. 8

5. If $f(x) = 5x + 2$, then $f^{-1}(17) =$

A. 3 B. 13 C. 87 D. 15

6. The domain of $f(x) = 1/(x - 1)$ is

A. $x \geq 1$ B. all real numbers

C. all real numbers except $x = 1$ D. $x > 1$

7. If A has 2 elements and B has 7 elements, then $A \times B$ has ____ elements.

A. 9 B. 128 C. 14 D. 49

8. The range of $f(x) = x^2 - 3$ is

A. $y \geq -3$ B. $y \leq -3$

C. all real numbers D. $y \geq 3$

9. The inverse of $f(x) = 2x - 2$ is

A. $f^{-1}(x) = 2x + 2$ B. $f^{-1}(x) = (x - 2)/2$

C. $f^{-1}(x) = 1/(2x - 2)$ D. $f^{-1}(x) = (x + 2)/2$

10. The remainder when $x^2 + 3x + 5$ is divided by $x - 3$ is

A. 25 B. −23 C. 5 D. 23

11. If $x - 2$ is a factor of $x^2 + kx + 6$, then $k =$

A. 5 B. −5 C. −6 D. −1

12. The degree of $(x^4 + 1)(x^6 - 2)$ is

A. 10 B. 6 C. 24 D. 9

13. The sum of the zeros of $x^2 - 3x + 6$ is

A. 4 B. −3 C. 6 D. 3

14. The sum of the zeros of $(x - 4)(x - 5)(x - 1)$ is

A. −10 B. 10 C. 29 D. 20

15. The y-intercept of $p(x) = x^3 + 1x^2 - 4x - 7$ is

A. 1 B. −7 C. −4 D. 7

16. The remainder when $x^3 - 2x^2 + x + 5$ is divided by $x + 1$ is

A. 5 B. 9 C. 2 D. 1