EXAM READY PHYSICS

Exam Ready Physics

GRADE 9

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



- ✓ 7 units with clear key ideas, worked examples and “Watch out!” boxes
- ✓ 140 worked examples and 224+ practice questions at three levels
- ✓ 140 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 Physics textbook

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Exam Ready Physics

Grade 9 · Study Guide, Worked Examples and Practice Tests

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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 Physics 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.

Contents

Start	Diagnostic Test · Where Should I Start?	5
Unit 1	Physics and Human Society	7
Unit 2	Physical Quantities	18
Unit 3	Motion in a Straight Line	29
Unit 4	Force, Work, Energy and Power	40
Unit 5	Simple Machines	51
Unit 6	Mechanical Oscillation and Sound Wave	62
Unit 7	Temperature and Thermometry	73
Reference	Key Facts Sheet	84
Reference	Top 20 Mistakes to Avoid	85
Reference	Exam Strategy	86
	Mock Examination 1	87
	Mock Examination 2	91
	Mock Examination 3	95
	Answers to the Mock Examinations	99

Page numbers are the numbers shown at the foot of each page (and in the online reader).

Diagnostic Test · Where Should I Start?

14 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. Physics is the study of
   A. living cells only
   B. plants only
   C. matter, energy and their interactions
   D. rocks only

2. The first step of the scientific method is
   A. observation
   B. communication
   C. conclusion
   D. experiment

3. The SI unit of length is
   A. second
   B. metre
   C. kelvin
   D. kilogram

4. The SI unit of temperature is
   A. celsius
   B. kelvin
   C. joule
   D. fahrenheit

5. Distance is a
   A. force
   B. unit
   C. scalar
   D. vector

6. 150 km in 2.5 h gives average speed
   A. 375 km/h
   B. 60 km/h
   C. 6 km/h
   D. 15 km/h

7. The SI unit of force is the
   A. pascal
   B. joule
   C. newton
   D. watt

8. Weight of 60 kg (g = 10) is
   A. 600 N
   B. 6 N
   C. 60 N
   D. 6000 N

9. A machine makes work easier by
   A. adding mass
   B. removing friction fully
   C. creating energy
   D. changing the size or direction of a force

10. A seesaw is a
    A. pulley
    B. second-class lever
    C. third-class lever
    D. first-class lever

11. A wave transfers
    A. mass only
    B. matter only
    C. energy
    D. volume

12. The wave equation is
    A. $v = f\lambda$
    B. $v = f/\lambda$
    C. $v = f + \lambda$
    D. $v = \lambda/f$

13. Temperature measures how
    A. hot or cold a body is
    B. fast a body is
    C. big a body is
    D. heavy a body is

14. Normal body temperature is about
    A. 0°C
    B. 37°C
    C. 100°C
    D. 20°C

Unit 1 · Physics and Human Society

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

- define physics and describe its nature
- name the branches of physics
- relate physics to other fields
- describe the contributions of great physicists

Before you start — check yourself. (a) What is physics? (b) Name one branch of physics. (c) Name a device based on physics.
Answers: (a) the study of matter, energy and their interactions (b) mechanics (c) a radio or a bulb

Key words: physics · mechanics · optics · thermodynamics · electromagnetism · nuclear physics · astrophysics · biophysics · Newton · Einstein

How this unit is examined

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

- Definition and Nature of Physics
- Branches of Physics
- Physics and Related Fields
- Historical Contributors

1.1 Definition and Nature of Physics

Key ideas

- **Physics** is the **natural science that studies matter, energy and their interactions**. It explains how the universe works, from atoms to galaxies, using observation, experiment, mathematics and models.
- **Nature of physics:** it is **experimental** (tested by experiments), **mathematical** (laws written as equations), **predictive** (theories predict results) and **cumulative** (new ideas build on older ones). Physics uses the **scientific method**: observe, ask, hypothesise, experiment, conclude.
- **Importance in society:** physics gave us electricity, machines, vehicles, radio, television, mobile phones, computers, medical X-rays and ultrasound, and renewable energy such as hydropower (GERD) and solar.
- **Law, theory, hypothesis:** a **hypothesis** is a testable guess; a **theory** is a well-tested explanation; a **law** describes a regular pattern, often in an equation.

Example 1.1 — Define

What is physics?

Solution. The study of matter, energy and their interactions.

Example 1.2 — Link

Name two technologies that depend on physics.

Solution. Mobile phones and X-ray machines.

Example 1.3 — Method

Put in order: experiment, hypothesis, observation, conclusion.

Solution. Observation, hypothesis, experiment, conclusion.

Example 1.4 — Exam Booster · Terms

Distinguish a hypothesis from a law.

Solution. A hypothesis is a testable guess; a law describes a regular pattern.

Example 1.5 — Exam Booster · Nature

Why is physics called experimental?

Solution. Its ideas are tested by experiments.

⚠ Watch out!

× Wrong	✓ Right
Physics studies only living things.	It studies matter and energy.
A hypothesis is a proven law.	It is a testable guess.
Physics has no use in daily life.	It underlies electricity, machines and phones.

Practice 1.1

Level 1 — Basic

1. What is physics?
2. Name a use.
3. First step of method?

Level 2 — Standard

4. What is a theory?
5. What is a law?
6. Is physics experimental?

Level 3 — Challenge

7. Explain the nature of physics.
8. Discuss the importance of physics.

1.2 Branches of Physics

Key ideas

- **Classical physics: mechanics** (motion and forces), **thermodynamics/heat** (temperature and heat), **optics** (light), **acoustics** (sound and waves), **electricity and magnetism** (electromagnetism).
- **Modern physics: atomic and nuclear physics** (atoms, radioactivity), **quantum mechanics** (very small particles), **relativity** (high speeds, gravity) and **particle physics**.
- **Examples:** a falling stone (mechanics), why a hot drink cools (thermodynamics), a rainbow (optics), thunder (acoustics), a magnet (electromagnetism), a nuclear power plant (nuclear physics).
- **Applied branches:** astrophysics (stars), geophysics (earth), biophysics (living systems), medical physics (X-ray, MRI), and engineering physics.

Example 1.6 — Match

Branch for: (a) a rainbow, (b) a falling stone, (c) heat flow.

Solution. (a) optics; (b) mechanics; (c) thermodynamics.

Example 1.7 — Class

Classical or modern: relativity, optics, quantum mechanics, mechanics.

Solution. Classical: optics, mechanics. Modern: relativity, quantum mechanics.

Example 1.8 — Study

What does acoustics study?

Solution. Sound and waves.

Example 1.9 — Exam Booster · Applied

Which branch studies stars?

Solution. Astrophysics.

Example 1.10 — Exam Booster · Medical

Name one medical use of physics.

Solution. X-ray imaging.

Unit 2 · Physical Quantities

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

- state the SI base quantities and units
- use prefixes and convert units
- classify quantities as base or derived and scalar or vector
- use measuring instruments and follow safety rules

Before you start — check yourself. (a) What is the SI unit of length? (b) Which instrument measures mass? (c) Is time a scalar or a vector?
Answers: (a) metre (b) balance (c) scalar

Key words: physical quantity · SI unit · base quantity · derived quantity · scalar · vector · prefix · kilo · milli · conversion

How this unit is examined

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

- Standards, Units and Prefixes
- Measurement and Safety
- Classification of Quantities
- Unit Conversion

2.1 Standards, Units and Prefixes

Key ideas

- A **physical quantity** is something that can be measured: it has a number and a **unit**. The **SI (International System of Units)** has seven base quantities; Grade 9 uses: **length (metre, m)**, **mass (kilogram, kg)**, **time (second, s)**, **temperature (kelvin, K)**, **electric current (ampere, A)**, **amount of substance (mole, mol)** and **luminous intensity (candela, cd)**.
- **Prefixes: kilo (k) = 10^{3}, hecto (h) = 10^{2}, deca (da) = 10^{1}, deci (d) = 10^{-1}, centi (c) = 10^{-2}, milli (m) = 10^{-3}, micro (μ) = 10^{-6}, nano (n) = 10^{-9}, mega (M) = 10^{6}, giga (G) = 10^{9}.**
- **Examples:** 1 km = 1000 m; 1 m = 100 cm = 1000 mm; 1 kg = 1000 g; 1 MB = 10^{6} B.
- **Standards:** a unit needs a standard that is accurate, reproducible and accepted everywhere; the metre and second are defined using light and atomic clocks.

Example 2.1 — Unit

Give the SI units of length, mass and time.

Solution. Metre, kilogram and second.

Unit 4 · Force, Work, Energy and Power

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

- define force and state Newton's laws
- explain friction
- calculate work, kinetic and potential energy
- calculate power

Before you start — check yourself. (a) What is the SI unit of force? (b) What is the unit of energy? (c) What is friction?
Answers: (a) newton (b) joule (c) a force that opposes motion

Key words: force · inertia · Newton's laws · friction · work · joule · kinetic energy · potential energy · power · watt

How this unit is examined

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

- Force and Newton's Laws of Motion
- Friction
- Work, Kinetic and Potential Energy
- Power

4.1 Force and Newton's Laws of Motion

Key ideas

- A **force** is a push or a pull; it can change the **speed, direction or shape** of a body. It is a **vector**, measured in **newtons (N)** (1 N = 1 kg·m/s²). **Weight** = the force of gravity on a mass: **W = mg**.
- **Newton's first law (inertia):** a body stays at rest or moves with constant velocity unless acted on by an **unbalanced (net) force**. **Inertia** is the tendency to resist changes in motion; more mass means more inertia.
- **Second law: F = ma** (acceleration is proportional to net force and inversely to mass). **Third law:** to every action there is an equal and opposite reaction (the two forces act on different bodies).
- **Examples:** A 5 kg trolley with a net force of 20 N has a = 20 ÷ 5 = **4 m/s²**; a 60 kg student has weight 60 × 10 = **600 N**; a rocket pushes gas down and the gas pushes the rocket up.

Example 4.1 — Calc

A net force of 20 N acts on a 5 kg trolley. Find its acceleration.

Solution. 20 ÷ 5 = 4 m/s².

Unit 6 · Mechanical Oscillation and Sound Wave

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

- describe oscillations of a pendulum and a spring
- use wave quantities and the wave equation
- explain the production and propagation of sound
- describe the characteristics of sound

Before you start — check yourself. (a) What is a wave? (b) What carries sound? (c) What is frequency?
Answers: (a) a disturbance that transfers energy (b) a medium such as air (c) number of waves per second

Key words: oscillation · amplitude · wavelength · frequency · period · wave speed · longitudinal · transverse · pitch · echo

How this unit is examined

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

- Characteristics of Waves
- Oscillations: Pendulum and Spring
- Sound Waves
- Characteristics of Sound and Echo

6.1 Characteristics of Waves

Key ideas

- A **wave** is a disturbance that transfers **energy** from one place to another without moving the medium permanently. **Transverse waves:** particles vibrate **perpendicular** to the direction of travel (water ripples, light, waves on a rope). **Longitudinal waves:** particles vibrate **parallel** to travel direction, forming compressions and rarefactions (sound, spring waves).
- **Quantities: amplitude (A)** – maximum displacement from rest position; **wavelength (λ)** – distance between two successive crests (or compressions); **frequency (f)** – number of waves per second, in **hertz (Hz)**; **period (T)** – time for one wave, **T = 1 ÷ f**; **wave speed v = f × λ**.
- **Example:** f = 50 Hz and λ = 6.8 m gives v = 50 × 6.8 = **340 m/s**. A wave with f = 4 Hz has period T = 1 ÷ 4 = **0.25 s**.
- **Mechanical waves** need a medium; electromagnetic waves (light) do not.

Key Facts Sheet

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

Unit 1 · Physics and society

Physics: matter, energy and interactions

Branches: mechanics, optics, acoustics, thermodynamics, electromagnetism, nuclear

Newton: laws of motion ; Einstein: relativity ; Faraday: induction ; Curie: radioactivity

Unit 2 · Physical quantities

SI: m, kg, s, K

kilo 10^3 ; centi 10^{-2} ; milli 10^{-3}

Scalar: magnitude ; vector: magnitude and direction

km/h ÷ 3.6 = m/s

1 m² = 10,000 cm²

Unit 3 · Motion

speed = distance ÷ time

a = (v − u) ÷ t

v = u + at ; s = ut + ½at² ; v² = u² + 2as

g = 10 m/s²

d–t gradient = speed ; v–t gradient = acceleration ; area = distance

Unit 4 · Force and energy

F = ma ; W = mg

f = μN

W = Fd ; KE = ½mv² ; PE = mgh

P = W ÷ t (watt)

Efficiency = useful ÷ total × 100%

Unit 5 · Simple machines

MA = load ÷ effort

VR = effort distance ÷ load distance

Efficiency = MA ÷ VR × 100%

Lever classes: fulcrum, load, effort in the middle

Ramp VR = length ÷ height

Unit 6 · Waves and sound

v = fλ ; T = 1 ÷ f

Sound: longitudinal, needs a medium, 340 m/s in air

Pitch: frequency ; loudness: amplitude

Audible 20–20,000 Hz

Echo distance = vt ÷ 2 ; Hooke: F = kx

Unit 7 · Temperature

K = °C + 273

°F = 9/5 °C + 32

Fixed points: 0°C and 100°C

$\Delta L = \alpha L_0 \Delta T$

Heat flows from hot to cold ; body 37°C

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. Physics is the study of
   A. living cells only
   B. plants only
   C. matter, energy and their interactions
   D. rocks only

2. Physics is mainly
   A. a sport
   B. an experimental science
   C. a religion
   D. a language

3. A testable guess is a
   A. theory
   B. conclusion
   C. law
   D. hypothesis

4. The first step of the scientific method is
   A. observation
   B. communication
   C. conclusion
   D. experiment

5. The study of motion and forces is
   A. mechanics
   B. acoustics
   C. optics
   D. thermodynamics

6. The study of light is
   A. acoustics
   B. mechanics
   C. optics
   D. thermodynamics

7. The study of sound is
   A. optics
   B. astronomy
   C. mechanics
   D. acoustics

8. The study of heat is
   A. thermodynamics
   B. acoustics
   C. mechanics
   D. optics

9. A rainbow belongs to
   A. nuclear physics
   B. optics
   C. acoustics
   D. mechanics

10. The SI unit of length is
    A. second
    B. metre
    C. kelvin
    D. kilogram

11. The SI unit of mass is
    A. newton
    B. gram
    C. kilogram
    D. metre

12. The SI unit of time is
    A. second
    B. metre
    C. minute
    D. hour

13. The SI unit of temperature is
    A. celsius
    B. kelvin
    C. joule
    D. fahrenheit

14. Kilo means
    A. 0.01
    B. 1000
    C. 100
    D. 0.001

15. Milli means
    A. one million
    B. one-thousandth
    C. one thousand
    D. one-hundredth

16. Centi means
    A. one-thousandth
    B. one hundred
    C. one million
    D. one-hundredth