FULL REVIEW

Full Review: Units and Measurements — Calculus-Based

Review the essential ideas, relationships, and problem-solving tools for units, measurement, dimensional reasoning, precision, and estimation.

◷ TIME	◎ BEST FOR	✓ FINISH WITH
45–60 minutes	A complete topic review	A readiness check

After this full review, you'll be able to…
apply measurement and dimensional reasoning to algebraic and calculus-based models, including derivatives, integrals, scaling, and uncertainty.

HOW TO USE THIS GUIDE

Work through the stages in order. Write directly in the spaces provided, check your work in the Solutions section, and finish by choosing the next resource that matches your confidence.

Choose how you want to review: work through this guide, follow the online review, or watch the video review.

Start the Review Online →
Watch the Video Review →

YOU WILL NEED

Pencil or pen • Calculator if needed • Approximately 45–60 minutes

FR-02 • COURSE ALIGNMENT

Course Alignment

This Physics Sensei Unit Review is an independent learning resource. Use it to reinforce key concepts, prepare for homework, or review before a quiz or exam.

RESOURCE: Physics Sensei Unit Review **UNIT ID: MEC-U01** **TOPIC: Units and Measurements** **COURSE LEVEL: Calculus-based introductory university physics**	**BEST USED** ✓ After learning the unit ✓ Before starting homework ✓ Before a quiz or exam

Start the Unit Review Online →

Physics Sensei organizes this material as an independent learning unit rather than following an external textbook chapter sequence.

FR-03 • YOUR REVIEW PLAN

Your Review Plan

Complete these six stages in order. Each stage builds on the previous one and prepares you for the final readiness check.

6 stages • Approximately 45–60 minutes

PRINTING TIP

For student copies, print double-sided and keep the Solutions section after the student activities so learners attempt each activity before checking their work.

FR-04 • STAGE 1 OF 6

Warm-Up Check

Before you begin, take a moment to see what you already remember. Do not worry about getting everything right. This is only a starting point.

ACTIVITY 1

Recall Activity 1

Track units through differentiation.

If $x(t) = At^2 + Bt + C$ is a position in meters, determine the units of A, B, and C.

ACTIVITY 2

Recall Activity 2

Track units through integration.

If acceleration a is measured in m/s^2, what are the units of $\int a\,dt$?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Use dimensions to reject impossible forms.

Could kinetic energy be $\propto mv$? Explain dimensionally.

Ready to strengthen your understanding?

You've refreshed what you already know. Next, reinforce the essential concepts that will help you solve problems with confidence.

Continue to Core Concepts — page 6 →

FR-05 • STAGE 2 OF 6

Core Concepts

Let's rebuild the key ideas one step at a time. Focus on understanding the relationships before worrying about solving problems.

KEY CONCEPT 1

Measurement Units in Mathematical Models

A physical model is meaningful only when every term has compatible dimensions. Constants and coefficients carry whatever units are required to make each term consistent. Scientific notation and SI prefixes change numerical scale but never the underlying physical dimensions.

$$x = At^2 + Bt + C \;\Rightarrow\; [A] = L\,T^{-2},\; [B] = L\,T^{-1},\; [C] = L.$$

EXAMPLE In $x = At^2 + Bt + C$, A must have units m/s^2, B units m/s, and C units m.

SENSEI NOTE Never assume a symbol is dimensionless merely because it is called a constant.

KEY CONCEPT 2

Dimensions of Derivatives, Integrals, and Scaling

Differentiation with respect to a variable divides by that variable's units; integration multiplies by them. Dimensional analysis can constrain scaling laws by matching powers of base dimensions.

$$[dx/dt] = L\,T^{-1};\; [d^2x/dt^2] = L\,T^{-2};\; [\int v\,dt] = L.$$

EXAMPLE dE/dt has units J/s = W, $\int F\,dx$ has units N m = J, and dimensional matching gives pendulum scaling $T \propto \sqrt{(L/g)}$.

SENSEI NOTE Dimensional analysis cannot recover a purely dimensionless numerical coefficient such as 2π.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Uncertainty, Significant Figures, and Continuous Models

Calculus does not remove measurement uncertainty. Experimental parameters, fitted coefficients, derivatives estimated from data, and integrals of measured functions all inherit finite precision. Final reporting should reflect the quality of the underlying measurements.

$$[dE/dt] = M\,L^2\,T^{-3} = W;\; [\int F\,dx] = M\,L^2\,T^{-2} = J.$$

EXAMPLE A fitted value 9.81736 ± 0.03 m/s^2 should be reported consistently with the uncertainty, such as 9.82 ± 0.03 m/s^2.

SENSEI NOTE More computational digits can improve intermediate numerical stability without justifying more reported experimental digits.

Ready to apply these ideas?

You've reinforced the essential concepts. Now put them into practice by working through guided examples and building your problem-solving confidence.

Continue to Guided Practice — page 8 →

FR-06 • STAGE 3 OF 6

Guided Practice

Now it's time to apply what you've reviewed. Work through each activity in order. The examples become gradually more challenging, and each prepares you for the final readiness check.

PRACTICE 1

Worked Example

Determine coefficient units from term-by-term consistency.

For $x(t) = At^3 + Bt^2 + Ct + D$, determine the SI units of A, B, C, and D.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Use integral units to identify a physical quantity.

Evaluate the unit structure of $\int_0^t F(t')\,dt'$. What physical quantity has these units?

PRACTICE 3

Independent Problem

Derive a scaling law from dimensions.

Assume the period T of a simple pendulum depends only on length L and gravitational acceleration g. Determine the powers of L and g.

Ready to check your understanding?

You've practiced the essential skills with guidance. Now solve a few short problems on your own and confirm you're ready to move forward.

Continue to Confidence Check — page 10 →

FR-07 • STAGE 4 OF 6

Confidence Check

You've rebuilt the key ideas and practiced them with guidance. Now try these short questions on your own to check your understanding before moving on.

QUICK CHECK 1

Derivative Units

Differentiate the unit structure.

If momentum p has units kg m/s, what are the units of dp/dt?

QUICK CHECK 2

Integral Units

Include the differential.

If pressure is in Pa and volume in m^3, what are the units of integral P dV?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Model Consistency

Check both dimensions and reporting precision.

A model produces y = 4.372819 m from inputs measured to about 1%. What two checks should you make before reporting the result?

HOW DID IT GO?

I answered ____ of 3 questions correctly.

Use the Solutions section to check your reasoning, then take one final look at the essential ideas.

You've checked your understanding.

Take one final look at the essential ideas before deciding what to do next.

Continue to Summary — page 12 →

FR-08 • STAGE 5 OF 6

Summary

Before moving on, take one final look at the most important ideas from this review.

KEY TAKEAWAY 1

Every Coefficient Has Dimensional Responsibilities

Each term in a physical equation must independently match the dimensions of the quantity represented.

KEY TAKEAWAY 2

Derivatives and Integrals Transform Units Systematically

Use the independent-variable or differential unit to predict the resulting dimensions.

KEY TAKEAWAY 3

Mathematical Sophistication Does Not Create Measurement Precision

Uncertainty and significant figures remain constraints on continuous and fitted models.

MY ONE-SENTENCE SUMMARY

In my own words, the most important idea is:

Ready for your next step?

You've reviewed the essential ideas one last time. Now choose the resource that best matches how confident you feel.

Continue to Next Step — page 16 →

ANSWER KEY • CHECK AFTER ATTEMPTING

Solutions and Explanations

Use these solutions to check your reasoning—not only your final answer. Use each answer and explanation to identify the step that supports the result.

WARM-UP • ACTIVITY 1

Recall Activity 1

A: m/s^2; B: m/s; C: m.

WHY IT WORKS At^2, Bt, and C must each have units of position.

WARM-UP • ACTIVITY 2

Recall Activity 2

Integral a dt has units m/s.

WHY IT WORKS $(m/s^2)(s) = m/s$, the units of velocity change.

WARM-UP • ACTIVITY 3

Recall Activity 3

No. mv has momentum dimensions ML/T, not energy dimensions ML^2/T^2.

WHY IT WORKS Dimensional mismatch rules out the proposed proportionality.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

A: m/s^3; B: m/s^2; C: m/s; D: m.

WHY IT WORKS Every polynomial term must have units of meters.

PRACTICE 2

Guided Problem

Integral F dt has units N s = kg m/s, the units of impulse or momentum change.

WHY IT WORKS Force times time gives momentum dimensions.

PRACTICE 3

Independent Problem

$T \propto \sqrt{(L/g)}$.

WHY IT WORKS Let $T \propto L^a g^b$. Matching L and T powers gives b = -1/2 and a = 1/2.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Derivative Units

dp/dt has units kg m/s^2 = N.

WHY IT WORKS Dividing momentum units by time gives force units.

QUICK CHECK 2

Integral Units

Pa m^3 = (N/m^2)m^3 = N m = J.

WHY IT WORKS Pressure-volume work has energy dimensions.

QUICK CHECK 3

Model Consistency

Check dimensional consistency and report precision consistent with the roughly 1% inputs.

WHY IT WORKS A mathematically computed value must still have the correct units and cannot claim precision unsupported by the measurements.

READINESS GUIDE

3 correct: You're ready to continue. • 2 correct: Review the missed idea, then continue. • 0–1 correct: Revisit Core Concepts or choose more practice.

FR-09 • STAGE 6 OF 6

Next Step: Continue Learning

Great work! You've completed this review. Choose the next resource that best matches how confident you feel.

? I'm Still Unsure	◎ I Need More Practice	✓ I'm Ready
Review the key ideas and examples again.	Continue with additional practice for this topic.	Continue to the next recommended resource.
Review again: return to Warm-Up Check on page 4.	Go to Practice →	Continue →

RECOMMENDED LINKS

Review again: return to Warm-Up Check on page 4.

Find additional practice →

Choose another type of physics help →

Continue reviewing with these companion resources.

Start the Review Online →
Watch the Video Review →

PHYSICS HELP THAT MAKES SENSE

A Physics Sensei review never ends at the last question. It always guides you toward the next useful step.

PhysicsSensei.com