

FULL REVIEW

Full Review — Significant Figures and Measurement Uncertainty — Calculus-Based

Review the essential ideas, relationships, and problem-solving tools for Significant Figures and Measurement Uncertainty.

 TIME 45–60 minutes	 BEST FOR A complete topic review	 FINISH WITH A readiness check
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After this full review, you'll be able to...

recall the essential ideas, apply them to representative problems, and determine what to study next.

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

Related Unit Review: If you need to review the complete unit material, review [Units and Measurements here →](#)

RESOURCE: Physics Sensei Topic Review TOPIC ID: MEC-U01-T02 TOPIC: Significant Figures and Measurement Uncertainty PARENT UNIT: MEC-U01 — Units and Measurements COURSE LEVEL: Calculus-Based College Physics	BEST USED ✓ After learning the topic ✓ Before starting homework ✓ Before a quiz or exam
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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

1 Warm-Up Check Activate prior knowledge.	2 Core Concepts Review the essential ideas.	3 Guided Practice Apply what you learned.
4 Confidence Check Confirm your understanding.	5 Summary Review the key ideas.	6 Next Step Continue your learning.

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**

Answer before revealing the response.

For $y = x^2$, does a fixed Δx create a larger or smaller Δy as x increases? Explain using the graph or slope.

ACTIVITY 2**Recall Activity 2**

Answer before revealing the response.

$A = \pi r^2$. Which mathematical quantity tells you how sensitive A is to a small change in r ?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Answer before revealing the response.

Why should a final numerical answer not display many more digits than its propagated uncertainty supports?

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 →

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

First-Order Propagation with a Derivative

For a derived quantity depending on one measured variable, the derivative estimates how a small input uncertainty maps into an output uncertainty. This is a local linear approximation and is most appropriate when the uncertainty is small compared with the scale over which the function changes strongly.

$$\text{For } y = f(x), \Delta y \approx |dy/dx| \Delta x$$

EXAMPLE For $A = \pi r^2$ at $r = 2.00 \pm 0.01$ m, the radius uncertainty produces an area uncertainty controlled by the local slope of $A(r)$.

SENSEI NOTE The derivative determines sensitivity; the number of calculator digits does not.

KEY CONCEPT 2

Independent Uncertainties in Several Variables

When a result depends on several independently measured variables, each variable contributes through its own sensitivity. Independent random contributions are commonly combined in quadrature rather than simply added.

$$\Delta f \approx \sqrt{[(\partial f / \partial x) \Delta x]^2 + (\partial f / \partial y) \Delta y]^2}$$

EXAMPLE For $f = xy$, uncertainty contributions come from uncertainty in x and uncertainty in y , weighted by the corresponding partial derivatives.

SENSEI NOTE Use linear addition only when the stated model or worst-case analysis calls for it; independent random uncertainties are usually combined differently.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

From Propagated Uncertainty to Significant Digits

After estimating uncertainty, the central value should be rounded to the same decimal place as the uncertainty. Often the uncertainty itself is reported with one or two significant digits, depending on context and convention.

Report x and Δx to matching decimal places

EXAMPLE If $x = 7.4382$ and $\Delta x \approx 0.06$, a consistent report is $x \approx 7.44 \pm 0.06$.

SENSEI NOTE Do not use the number of significant figures in the inputs as a substitute for an explicit uncertainty calculation when propagation data are available.

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 →](#)

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**

Propagate through a Square

For $y = x^2$ with $x = 4.00 \pm 0.03$, estimate y and its uncertainty.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Two-Variable Estimate

For $f = xy$ with $x = 2.00 \pm 0.02$ and $y = 5.00 \pm 0.05$, estimate the independent combined uncertainty using partial-derivative contributions.

PRACTICE 3

Independent Problem

Propagate through a Reciprocal

For $y = 1/x$ with $x = 2.00 \pm 0.02$, estimate y and its uncertainty using a first-order derivative.

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 →

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**Sensitivity Direction**

Interpret the derivative.

If $|df/dx|$ doubles while Δx is unchanged, what happens to the first-order contribution to Δf ?

QUICK CHECK 2**Report Consistently**

Match digits to uncertainty.

If a computed value is 3.141592 with uncertainty about 0.03, which report is more sensible: 3.141592 ± 0.03 or 3.14 ± 0.03 ?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Approximation Condition

Check the method.

Why is first-order derivative propagation most reliable for relatively small input uncertainties?

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 →

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**Derivatives Measure Sensitivity**

Use derivatives or partial derivatives to determine how input uncertainty influences a derived quantity.

KEY TAKEAWAY 2**Uncertainty Controls Reporting**

After propagation, round the uncertainty sensibly and report the central value to a matching decimal place.

KEY TAKEAWAY 3**Linearization Has a Domain**

First-order propagation is a local approximation. If uncertainty is large or the function is strongly nonlinear, a more complete analysis may be needed.

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 →

ANSWER KEY • CHECK AFTER ATTEMPTING

Solutions and Explanations

Use these solutions to check your reasoning—not only your final answer. Replace each placeholder with a concise answer and the essential explanation.

WARM-UP • ACTIVITY 1

Recall Activity 1

Larger, because the slope magnitude of x^2 grows as x increases.

WHY IT WORKS The same horizontal uncertainty spans a larger vertical interval where the function is steeper.

WARM-UP • ACTIVITY 2

Recall Activity 2

The derivative dA/dr .

WHY IT WORKS It gives the local change in area per unit change in radius.

WARM-UP • ACTIVITY 3

Recall Activity 3

Because those digits suggest precision that the measurement model does not support.

WHY IT WORKS Propagated uncertainty sets the meaningful reporting scale.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Worked Example**

$y = 16.00$. The local sensitivity magnitude is 8.00, giving $\Delta y \approx 0.24$, so report about 16.00 ± 0.24 .

WHY IT WORKS The solution applies the stated precision or uncertainty method while keeping the final report consistent with the data.

PRACTICE 2**Guided Problem**

The contributions are $5.00(0.02)=0.10$ and $2.00(0.05)=0.10$; quadrature gives about 0.14, so $f \approx 10.00 \pm 0.14$.

WHY IT WORKS The solution applies the stated precision or uncertainty method while keeping the final report consistent with the data.

PRACTICE 3**Independent Problem**

$y = 0.500$. The sensitivity magnitude at $x = 2.00$ is 0.25, so $\Delta y \approx 0.005$; report approximately 0.500 ± 0.005 .

WHY IT WORKS The solution applies the stated precision or uncertainty method while keeping the final report consistent with the data.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Sensitivity Direction

It doubles.

WHY IT WORKS The answer follows directly from the measurement-precision or propagation principle tested by the question.

QUICK CHECK 2

Report Consistently

3.14 ± 0.03 is consistent; the extra digits are not supported by the uncertainty.

WHY IT WORKS The answer follows directly from the measurement-precision or propagation principle tested by the question.

QUICK CHECK 3

Approximation Condition

Because it uses a local linear approximation; large intervals may sample significant curvature.

WHY IT WORKS The answer follows directly from the measurement-precision or propagation principle tested by the question.

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 Review the key ideas and examples again. Review Again →	 I Need More Practice Continue with additional practice for this topic. Go to Practice →	 I'm Ready Continue to the next recommended resource. Continue →
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RECOMMENDED LINKS

[Review this topic again →](#)[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