

FULL REVIEW

Full Review: Stress, Strain, and Elasticity

Review the essential ideas, relationships, and problem-solving tools for stress, strain, and elasticity.

 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...

explain the key elastic relationships, solve representative deformation problems, and interpret what the results mean physically.

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-U24
TOPIC: Stress, Strain, and Elasticity
COURSE LEVEL: Calculus-Based

BEST USED

- ✓ After learning the unit
- ✓ Before starting homework
- ✓ Before a quiz or exam

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**Local Relations**

Connect stress, strain, and displacement.

Write $\sigma = F/A$, $\varepsilon = du/dx$ for small axial strain, and $\sigma = Y\varepsilon$ for linear elasticity.

ACTIVITY 2**Uniform vs. Nonuniform**

Choose the correct model.

When can $\Delta L = FL/(AY)$ be used directly, and when is an integral required?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Quick Application

Inspect the integrand.

For constant F and Y , what geometric change increases the local extension rate $F/[YA(x)]$?

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

Local Axial Elasticity

For small deformation, $\epsilon = du/dx$ and $\sigma = Y\epsilon$. Force equilibrium gives $\sigma = F/A$, so $du/dx = F(x)/[Y A(x)]$.

$$\epsilon = du/dx \quad \sigma = Y\epsilon$$

EXAMPLE Uniform quantities integrate to $\Delta L = FL/(AY)$.

SENSEI NOTE Keep the sign convention consistent for tension and compression.

KEY CONCEPT 2

Accumulated Extension

For a nonuniform member, total extension is $\Delta L = \int F(x)/[Y(x)A(x)] dx$ over the length.

$$\Delta L = \int F(x)/[Y(x)A(x)] dx$$

EXAMPLE A tapered rod extends more strongly where its area is smaller.

SENSEI NOTE Do not replace $A(x)$ by an average area unless an approximation is explicitly intended.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Elastic Energy

The work stored elastically per unit volume is $u = \int \sigma \, d\epsilon$. For linear elasticity, $u = \frac{1}{2}\sigma\epsilon = \frac{1}{2}Y\epsilon^2 = \sigma^2/(2Y)$.

$$u = \int \sigma \, d\epsilon = \frac{1}{2}\sigma\epsilon \text{ (linear)}$$

EXAMPLE The stress-strain curve gives energy density as the area under the loading path.

SENSEI NOTE Energy formulas based on $\frac{1}{2}\sigma\epsilon$ assume linear elastic loading from zero.

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**Guided Example**

Integrate a variable-force case.

A uniform rod has constant A and Y , length L , and axial force $F(x)=F_0x/L$. Find ΔL .

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2**Independent Check**

Integrate a tapered rod.

For constant F and Y with $A(x)=A_0(1+x/L)$, set up and evaluate ΔL from $x=0$ to L .

PRACTICE 3**Independent Problem**

Find elastic energy in a uniform rod.

A uniform rod of volume V is held at axial stress σ in the linear elastic regime. Express its stored elastic energy in terms of σ , Y , and V .

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

Energy Density

Recall a useful elastic result.

For linear elasticity, what area under a σ -versus- ϵ graph gives the elastic energy density?

QUICK CHECK 2

Stiffness Distribution

Reason from the integral.

If Y is smaller in one segment, how does that segment affect total extension?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Variational Check

Connect field quantities.

If displacement $u(x)$ is known, how do you obtain small axial strain and stress for a linear elastic rod?

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**Local-to-global deformation**

Local strain integrates over length to produce total extension.

KEY TAKEAWAY 2**Variable properties**

Use $\Delta L = \int F/[YA] dx$ when force, modulus, or area changes with position.

KEY TAKEAWAY 3**Energy and fields**

Stress, strain, displacement gradients, and elastic energy provide complementary descriptions of the same deformation.

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.

WARM-UP • ACTIVITY 1

Local Relations

$$\sigma = F/A; \epsilon = du/dx; \sigma = Y\epsilon.$$

WHY IT WORKS Together they give $du/dx = F/(YA)$.

WARM-UP • ACTIVITY 2

Uniform vs. Nonuniform

Use $FL/(AY)$ only for uniform F , A , and Y ; otherwise integrate.

WHY IT WORKS The uniform formula is the constant-integrand special case.

WARM-UP • ACTIVITY 3

Quick Application

A smaller area increases the local extension rate.

WHY IT WORKS The integrand varies as $1/A(x)$.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Guided Example**

$$\Delta L = F_0 L / (2AY).$$

WHY IT WORKS Integrate $F_0 x / (LAY)$ from 0 to L .

PRACTICE 2**Independent Check**

$$\Delta L = (FL / (YA_0)) \ln 2.$$

WHY IT WORKS Integrate $1 / (1 + x/L)$ over 0 to L .

PRACTICE 3**Independent Problem**

$$U = [\sigma^2 / (2Y)]V.$$

WHY IT WORKS Multiply the linear elastic energy density by volume.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Energy Density

$$u = \int_0^\epsilon \sigma \, d\epsilon = \frac{1}{2} Y \epsilon^2 = \frac{\sigma^2}{2Y}.$$

WHY IT WORKS The area under the stress-strain curve is work per unit volume.

QUICK CHECK 2

Stiffness Distribution

It contributes more extension for the same F and A .

WHY IT WORKS The integrand is inversely proportional to $Y(x)$.

QUICK CHECK 3

Variational Check

$$\epsilon = du/dx \text{ and } \sigma = Y \, du/dx.$$

WHY IT WORKS Strain is the displacement gradient; the constitutive law converts strain to stress.

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