

## FOCUSED REVIEW

# Focused Review: Stress, Strain, and Elasticity

Review the most important ideas, reinforce the essential skills, and confirm you're ready to move on.

|                                                                                                                   |                                                                                                                        |                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <br><b>TIME</b><br>15–20 minutes | <br><b>BEST FOR</b><br>Focused review | <br><b>FINISH WITH</b><br>Greater confidence |
|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|

**After this focused 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 15–20 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 focused stages in order. Each stage reinforces your understanding and prepares you for a final confidence check.

6 stages • Approximately 15–20 minutes

|                                                                    |                                                               |                                                              |
|--------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------|
| <b>1</b><br><b>Warm-Up Check</b><br>Refresh key ideas.             | <b>2</b><br><b>Core Concepts</b><br>Reinforce the essentials. | <b>3</b><br><b>Guided Practice</b><br>Strengthen key skills. |
| <b>4</b><br><b>Confidence Check</b><br>Confirm your understanding. | <b>5</b><br><b>Summary</b><br>Remember the essentials.        | <b>6</b><br><b>Next Step</b><br>Choose your next step.       |

**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 minute to reactivate what you already know. This quick warm-up will help you focus on the most important ideas before moving on.

**WARM-UP 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.

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**WARM-UP 2****Uniform vs. Nonuniform**

Choose the correct model.

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

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## FR-04 • WARM-UP CHECK CONTINUED

## WARM-UP 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 the most important ideas. Now reinforce the concepts you'll use most often.

**Continue to Core Concepts →**

## FR-05 • STAGE 2 OF 6

# Core Concepts

Let's reinforce the most important concepts you'll need to solve problems with confidence. Focus on the ideas that appear most often in homework, quizzes, and exams.

## 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.

### Ready to apply these ideas?

You've reinforced the essential concepts. Now strengthen your problem-solving skills by working through a few guided examples.

[Continue to Guided Practice →](#)

## FR-06 • STAGE 3 OF 6

## Guided Practice

Now apply the key concepts you've just reviewed. Work through these focused practice activities to reinforce your problem-solving skills before the final confidence 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  $\Delta L$ .*

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### 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  $\Delta L$  from  $x=0$  to  $L$ .*

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### Ready for a confidence check?

You've reinforced the essential skills through focused practice. Now confirm your understanding with two short questions.

**Continue to Confidence Check →**

FR-07 • STAGE 4 OF 6

# Confidence Check

You've reinforced the key concepts and practiced the essential skills. Now confirm you're ready to move forward by completing these short confidence checks.

## CONFIDENCE CHECK 1

### Energy Density

Recall a useful elastic result.

*For linear elasticity, what area under a  $\sigma$ -versus- $\epsilon$  graph gives the elastic energy density?*

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## CONFIDENCE CHECK 2

### Stiffness Distribution

Reason from the integral.

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

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## HOW DID IT GO?

**I answered \_\_\_\_ of 2 questions correctly.**

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

**You've confirmed your understanding.**

Take one final look at the essential ideas before choosing your next step.

**Continue to Summary →**



## FR-08 • STAGE 5 OF 6

# Summary

Before moving on, take one final look at the essential ideas you'll want to remember.

**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.

**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  $L$ .

## SOLUTIONS • CONFIDENCE CHECK

## CONFIDENCE 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.

## CONFIDENCE CHECK 2

**Stiffness Distribution**

It contributes more extension for the same  $F$  and  $A$ .

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

## READINESS GUIDE

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

FR-09 • STAGE 6 OF 6

## Next Step: Continue Learning

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

|                                                                                                                                                          |                                                                                                                                              |                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <p><b>?</b></p> <p><b>I'm Still Unsure</b></p> <p>Review the focused review again to strengthen the essential concepts.</p> <p><b>Review Again →</b></p> | <p><b>🎯</b></p> <p><b>I Need More Practice</b></p> <p>Build confidence with additional practice problems.</p> <p><b>Go to Practice →</b></p> | <p><b>✓</b></p> <p><b>I'm Ready</b></p> <p>Continue to the next topic or learning resource.</p> <p><b>Continue →</b></p> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|

### 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**