

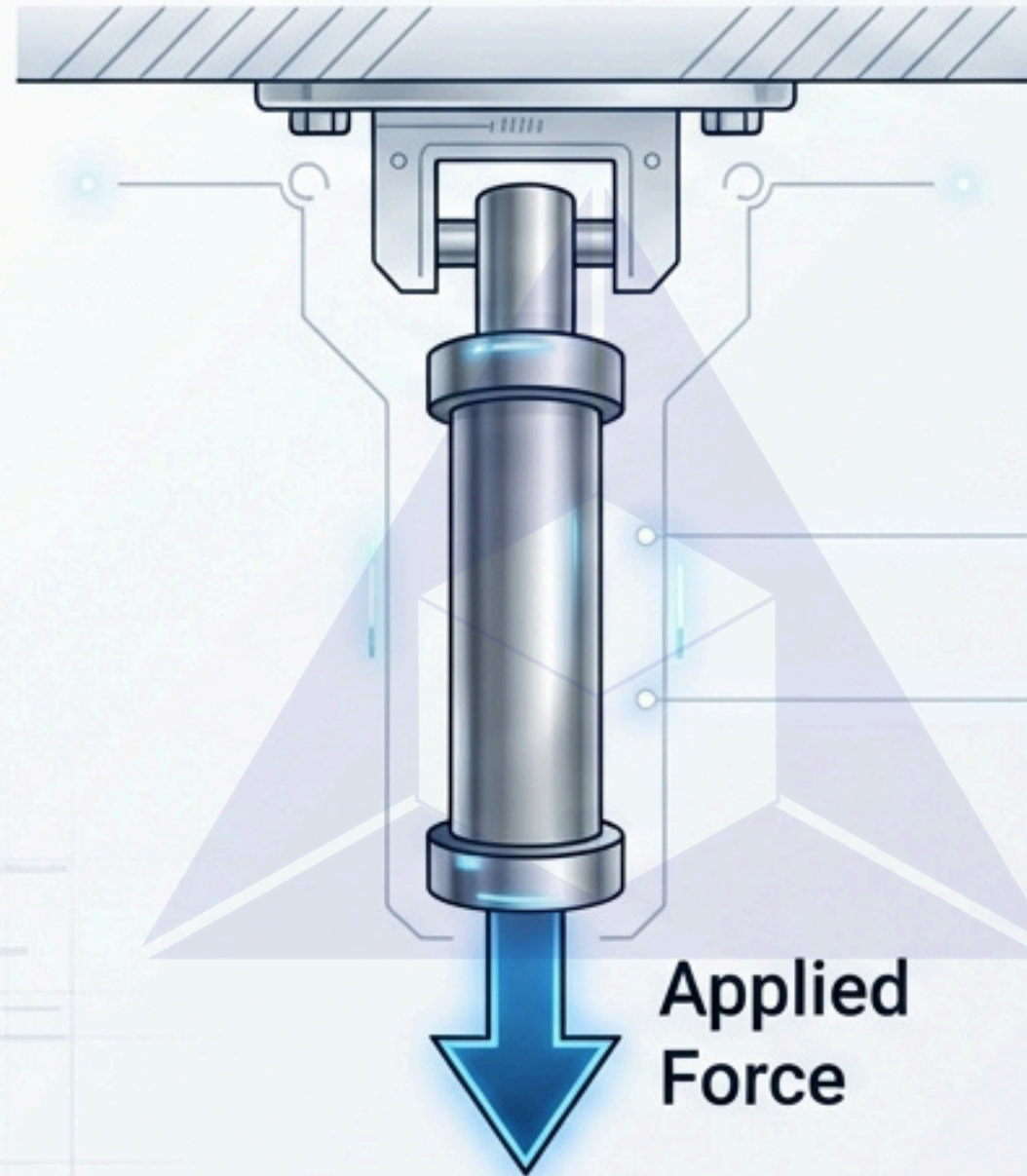
8.4 Stress-Strain Curve

The Story of a Material as it Stretches



Every material has a breaking point. This map shows exactly how it gets there.

The Tensile Test Experiment

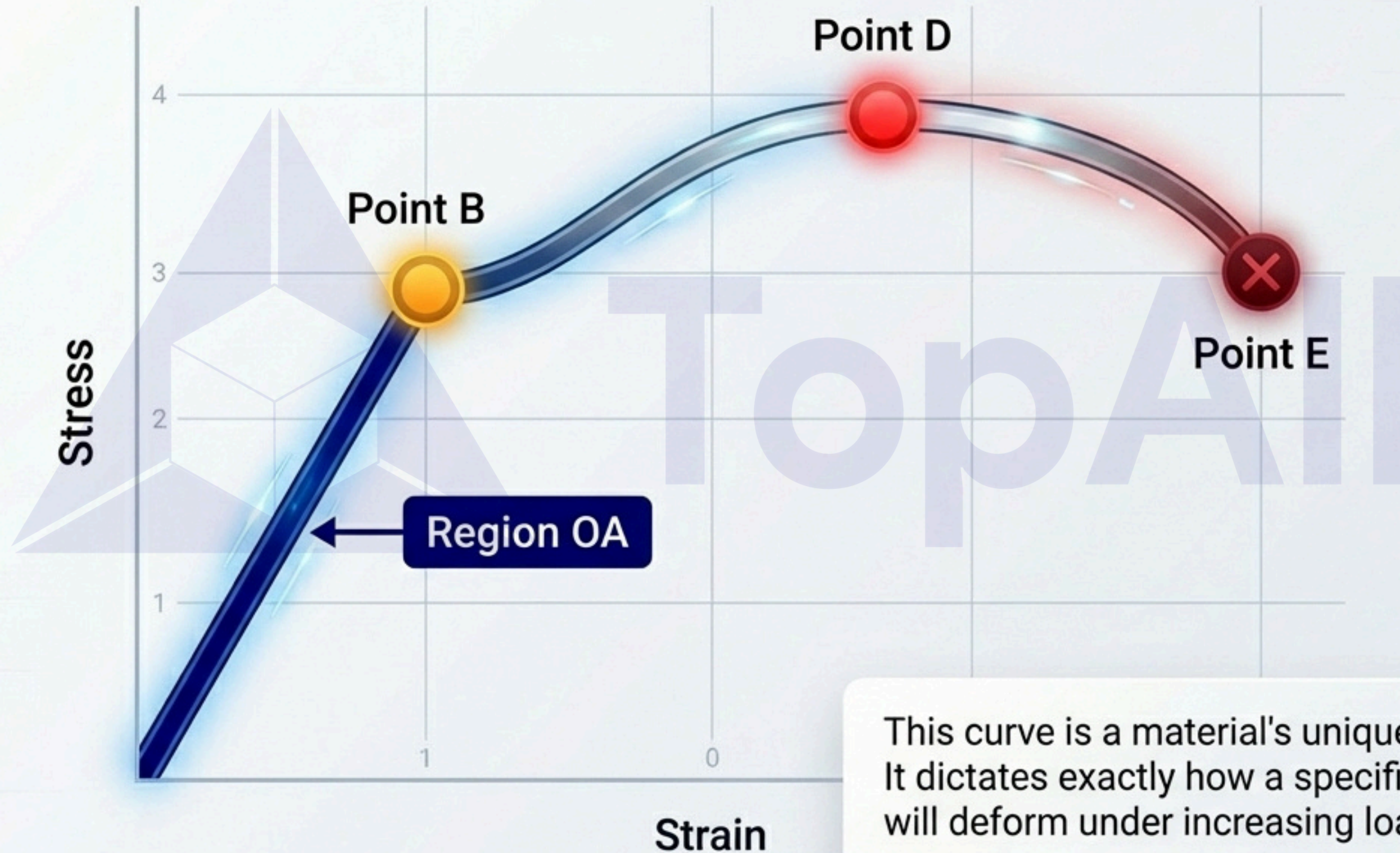


- $$\text{Stress} = \frac{\text{Applied Force}}{\text{Area}}$$

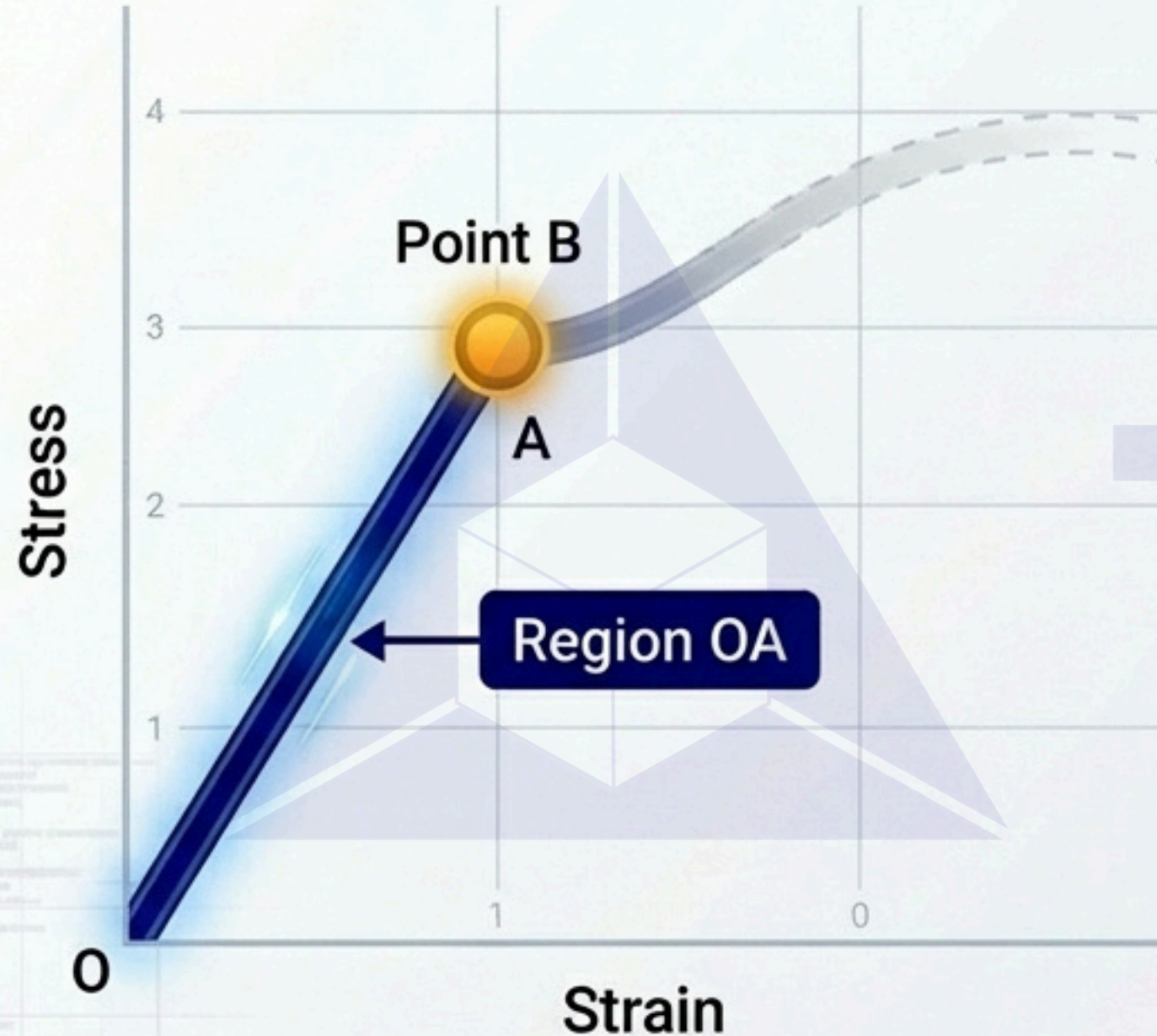
- $$\text{Strain} = \frac{\text{Fractional Change in Length}}{\text{Original Length}}$$

Exam Takeaway: The load is increased gradually in steps, and the resulting strain is continuously mapped against the applied stress.

Anatomy of the Stress-Strain Curve



The Elastic Region: Bouncing Back



Region OA (Linear)

Hooke's Law is strictly obeyed (Stress $\propto$ Strain). The solid behaves as a perfectly elastic body.

Region AB (Non-proportional)

Stress and strain are no longer perfectly proportional, but the material is still elastic. It will return to its original dimensions when the load is removed.

Caution: Hooke's law is ONLY valid in the linear part (OA), not the entire elastic region.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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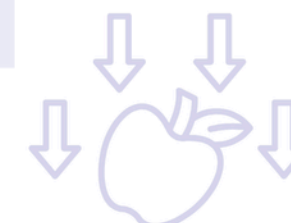
Practice Now



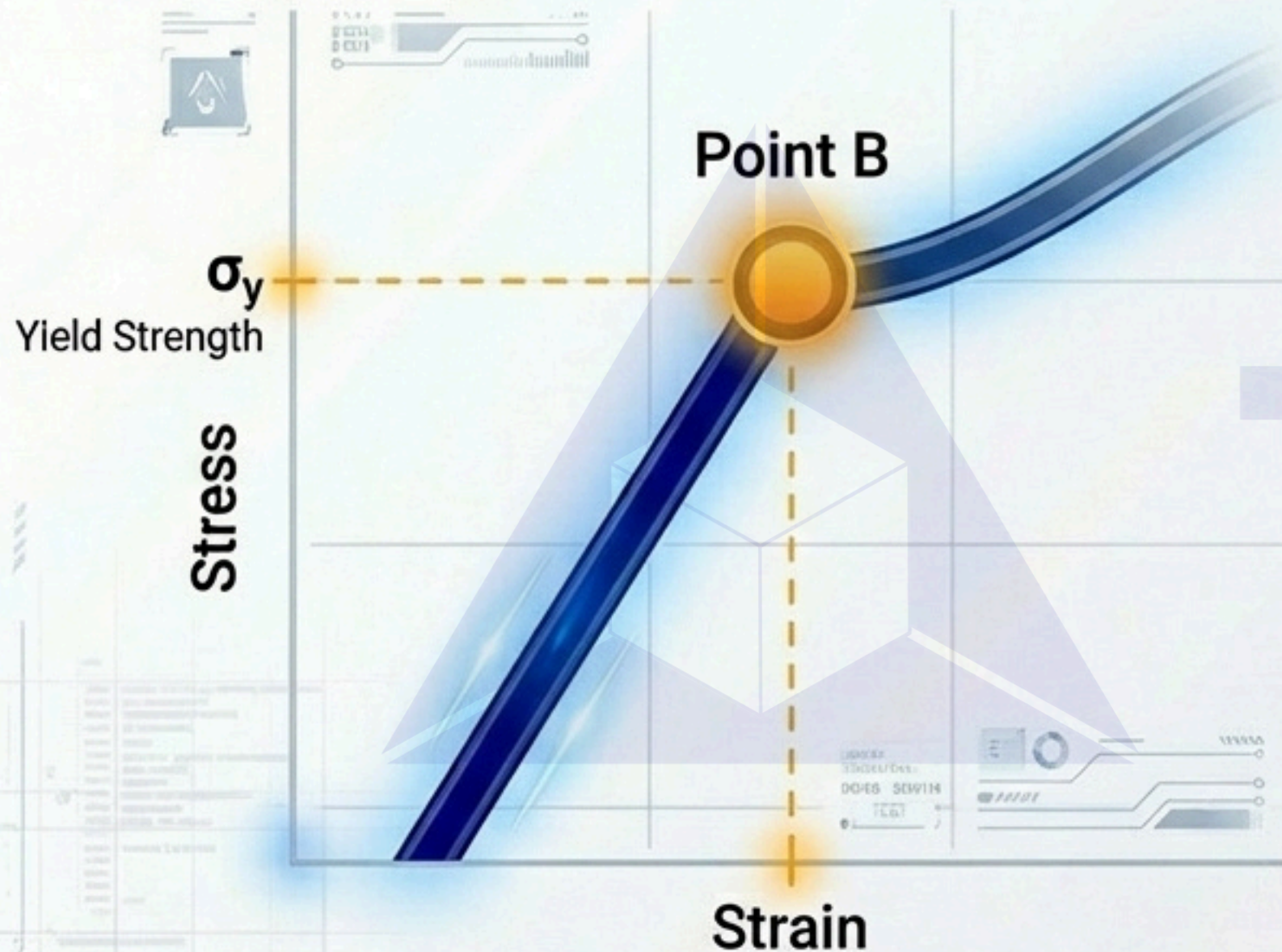
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Point B: The Limit of Elasticity



Yield Point (Elastic Limit)

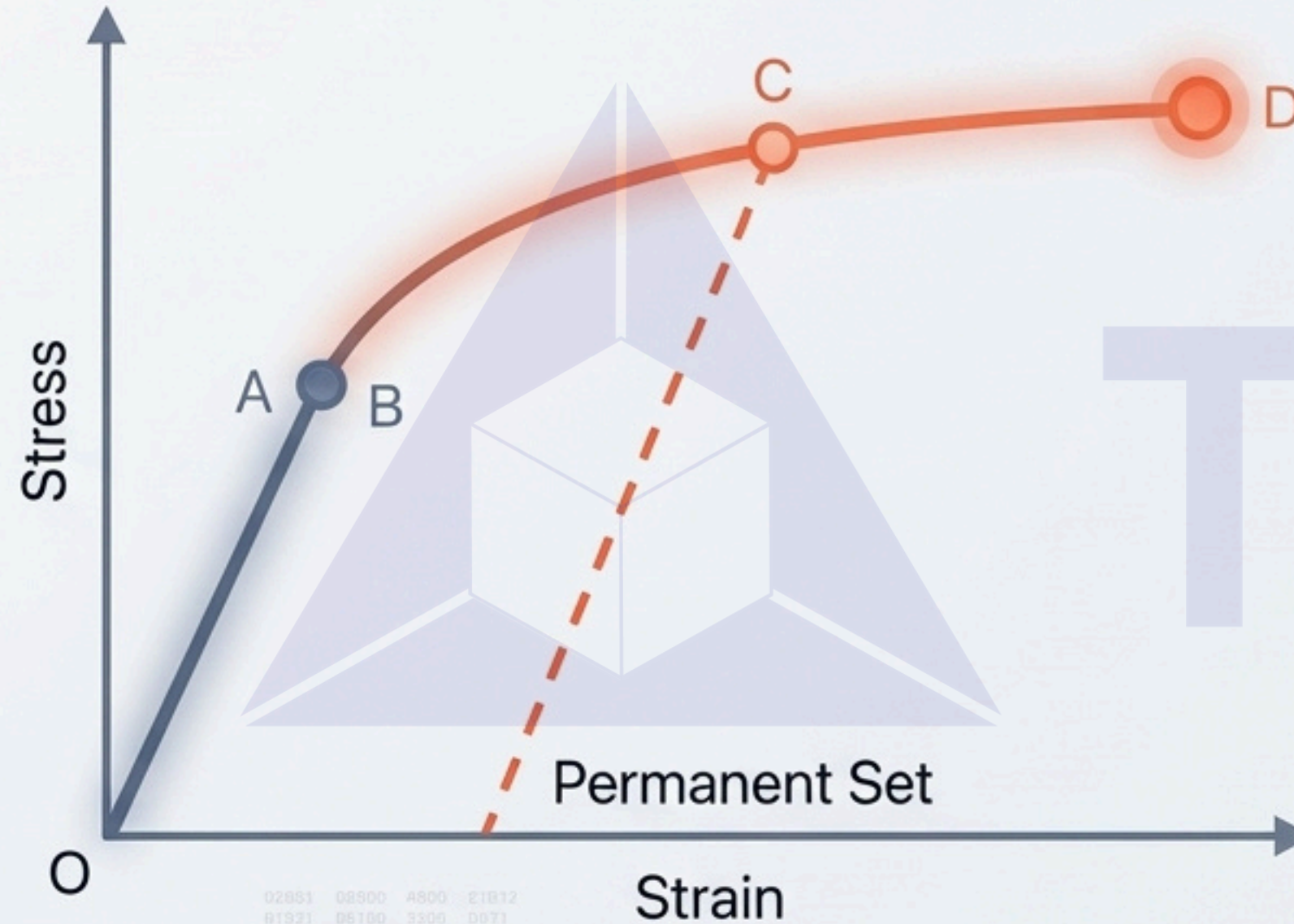
The exact coordinate on the curve where the material loses its perfect elasticity.

Yield Strength (σ_y)

The corresponding stress value on the Y-axis.

Key Idea: Pushing beyond this exact stress value means the material will never return to its original shape.

Region B to D: Plastic Deformation



The Overload

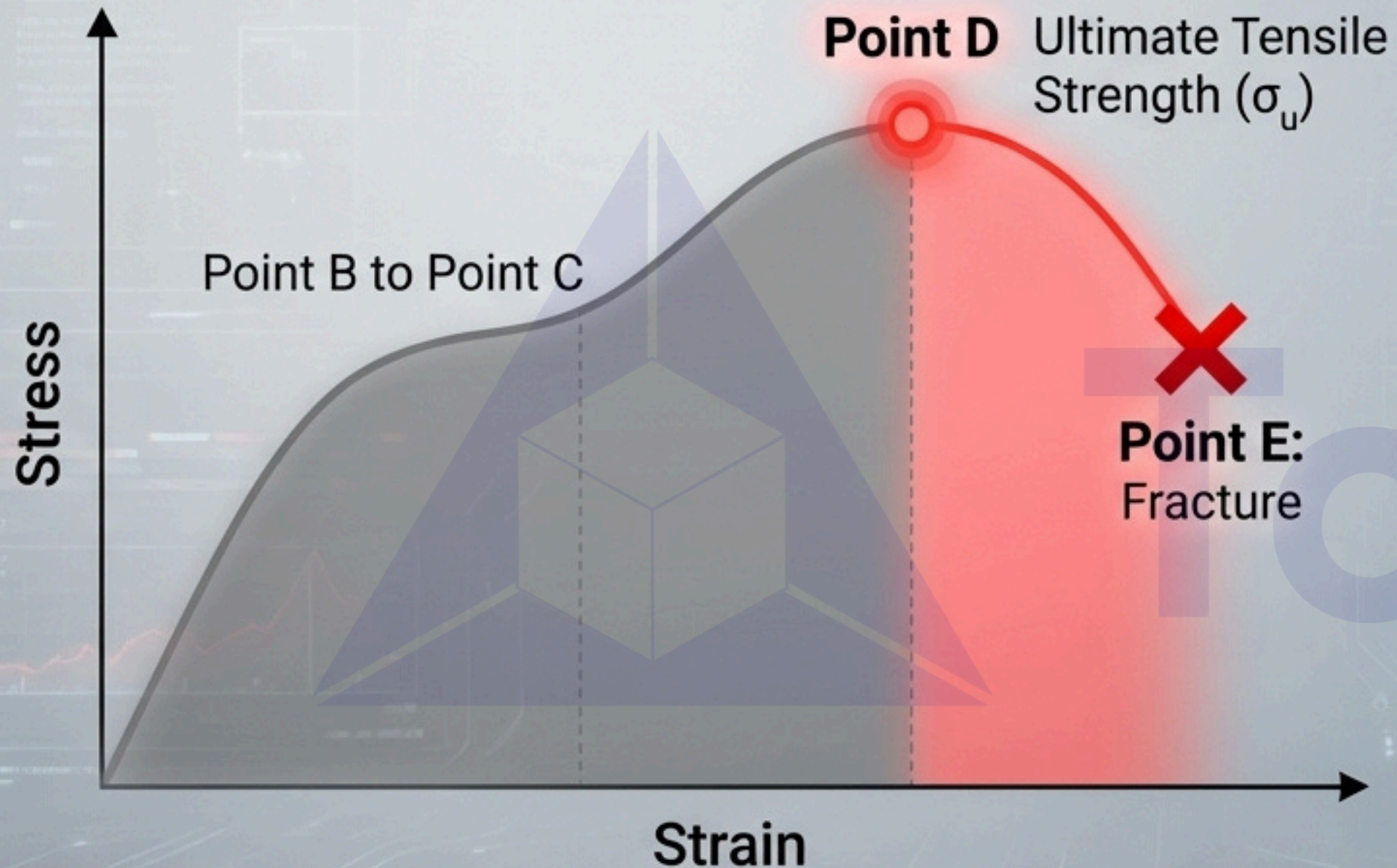
Strain increases rapidly even for tiny changes in stress.

Permanent Unloading

If the load is removed at Point C, the stress drops to zero, but the strain does not. The material has suffered permanent plastic deformation.

Exam Takeaway: A permanent set means the material is permanently stretched, even when all external force is removed.

Points D & E: The Breaking Point



Point D: Ultimate Tensile Strength (σ_u)

The absolute maximum stress the material can mathematically handle.

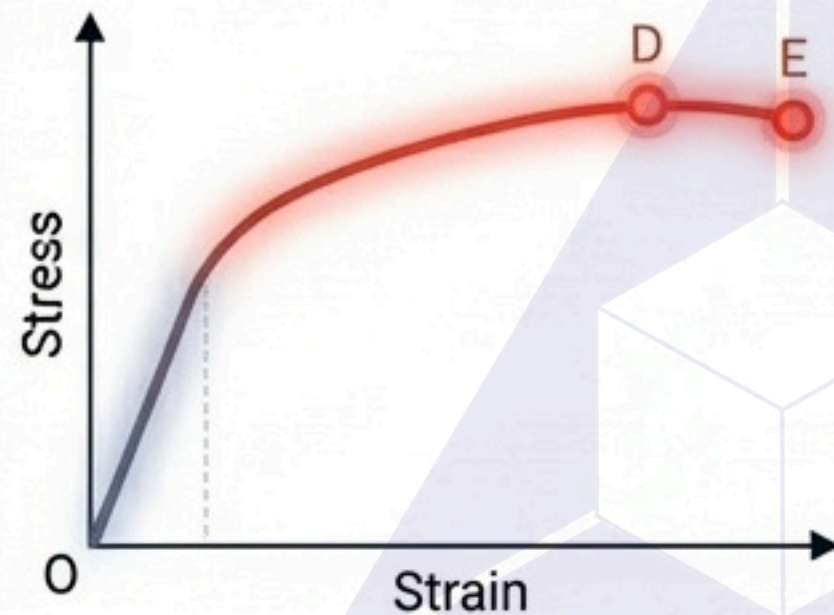
Point E: Fracture Point

Beyond point D, additional strain happens even if applied force is reduced, ending in structural failure (fracture).

Exam Takeaway: Once Ultimate Tensile Strength (Point D) is crossed, fracture (Point E) is inevitable even with less force.

Material Behaviors: A Side-by-Side Comparison

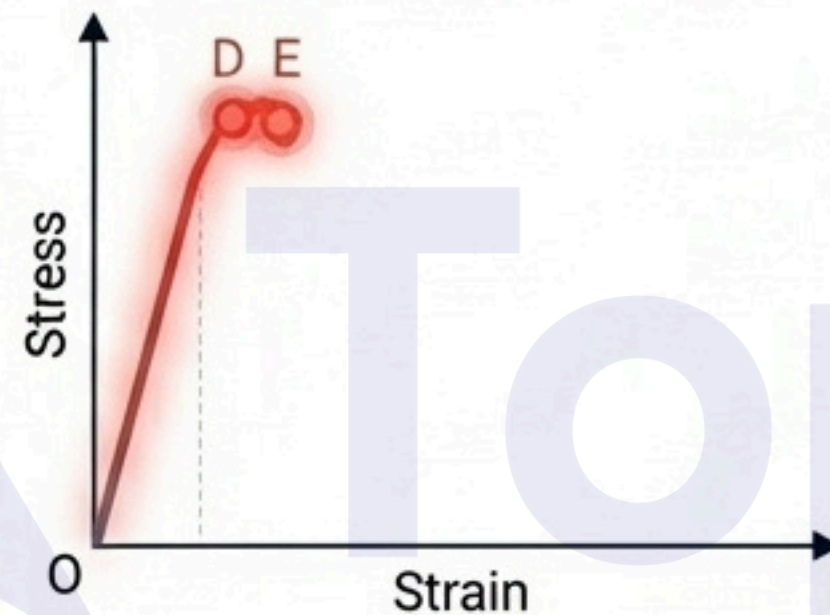
Ductile Materials



Can undergo massive plastic deformation. Points D and E are far apart.

Example: Copper drawn into wires.

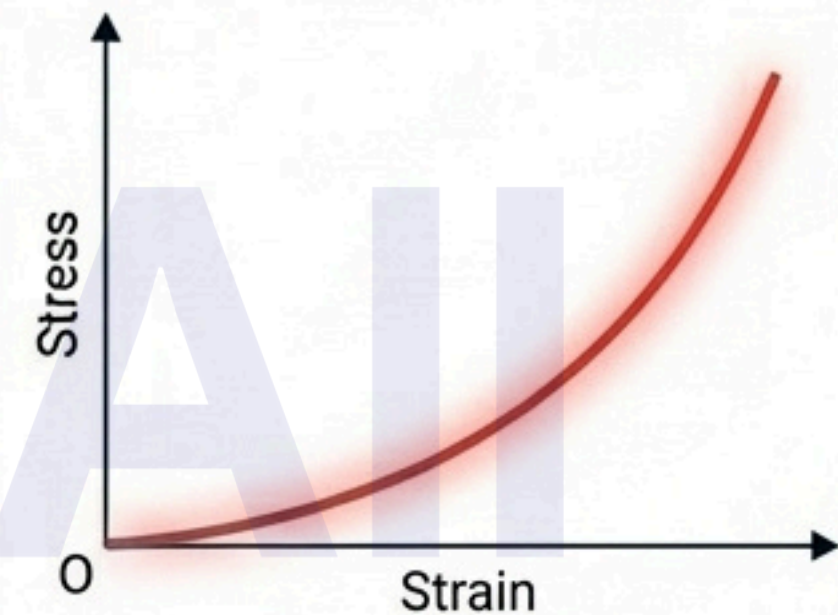
Brittle Materials



Breaks shortly after its elastic limit. Points D and E are very close together.

Example: Glass.

Elastomers



Massive elastic region, stretches several times. Does not obey Hooke's Law. No clear plastic region.

Example: Rubber, tissue of aorta.

Exam Takeaways: 8.4 Stress-Strain

Region OA = Linear (Hooke's Law active)

Point B = Yield Point / Elastic Limit

Point D = Ultimate Tensile Strength (σ_u)

Point E = Fracture Point

Permanent Set = Strain left over when stress is removed past Point B

Elastomers = Large strain, no Hooke's Law, no clear plastic region

$$Y = \text{Stress} / \text{Strain}$$

(Valid only in Region OA)



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