

## Bike Frames Day 2 Learning objectives

- Describe the evolution of bike materials from a materials properties perspective (strength, weight).
- Explain stress and strain conceptually and relate these to strength of bike tubes, tire pressure etc.
- Interpret stress–strain curves (elastic region, yield, UTS, fracture).
- Calculate engineering stress and engineering strain from experimental data.

## History of bike frames

1817:

- The "Draisine" or "laufmaschine" (precursor to the modern bike) was made of wood.



<https://wide.piaggiogroup.com/articles/products/ducento-anni-in-bicicletta-dalla-draisine-alla-wi-bike/foto1-small.jpg>

1820s-1850s:

- 3 and 4 wheelers.
- Less balance required.
- Introduction of pedals, treadles, hand-crank.
- First pedal crank appears in 1853.
- "Penny farthing" design with solid rubber tires and high speeds



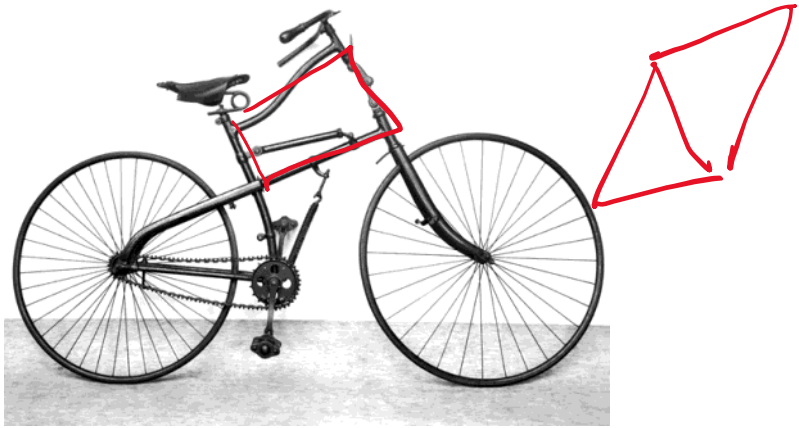
[https://upload.wikimedia.org/wikipedia/commons/7/70/Bicycle\\_two\\_1886.jpg](https://upload.wikimedia.org/wikipedia/commons/7/70/Bicycle_two_1886.jpg)

Late 1800s:

- Steel tubing introduced.
- Wire spoke tension wheels.



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- Wire spoke tension wheels.
- Shift from expensive toy to utilitarian transportation "Safety bicycle."
- Diamond frame invented by Isaac R. Johnson.
- Step through frames.



[https://upload.wikimedia.org/wikipedia/commons/4/48/Whippet\\_Safety\\_Bicycle.jpg](https://upload.wikimedia.org/wikipedia/commons/4/48/Whippet_Safety_Bicycle.jpg)

1900 - 1940s:

- Aluminum frames become popular.
- Single tube with no lugs.
- "Lu-Min-Num" bike model out of St. Louis Refrigerator and Gutter Co.



<https://jeffreyrubel.substack.com/p/the-aluminum-bike-frame>

1970s:

- plastic bikes "Itera"
- Plastic everything! Chains, hubs, spokes etc
- Claim: "17 lbs and stronger than steel..."
- Not a commercial success



[https://upload.wikimedia.org/wikipedia/commons/a/a0/Itera\\_plastic\\_bicycle.jpg](https://upload.wikimedia.org/wikipedia/commons/a/a0/Itera_plastic_bicycle.jpg)

1990s:

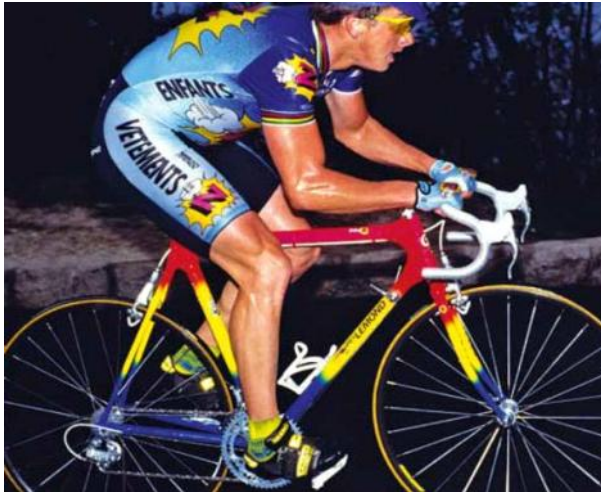
- Titanium frames
- Full suspension 1992 Gary Fischer RS-1



<https://www.unicorncycles.com/titanium-road-gravel-bike-frames>

Modern era:

- Carbon fiber dominates high-performance bikes.
- 1991 first appears on the Tour de France.



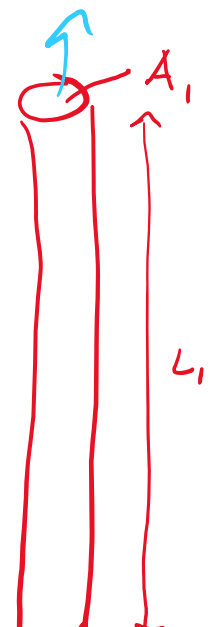
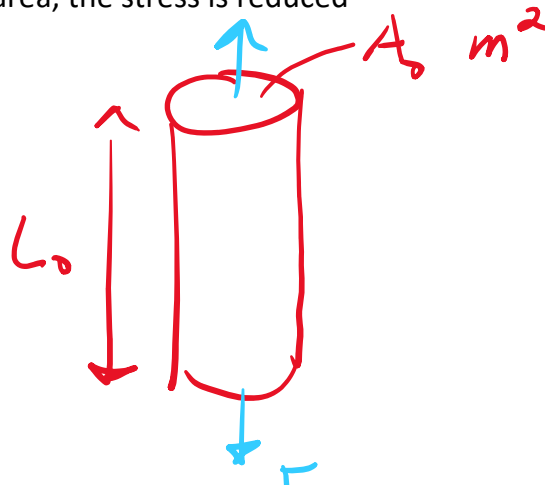
## Stress and strain

This allows us to connect the concepts of force to material strength

Stress is an internal pressure caused by forces

When a force is distributed over a larger area, the stress is reduced

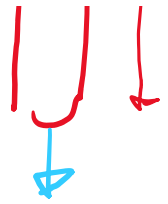
$$\sigma = \frac{F}{A}$$



Pressure has the same units!

Let's convert a bike tire at 25psi to Pa.

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What would be the stress of our 160 lb biker on the ground below?

$$75 \text{ kg} \cdot 9.8 \frac{\text{m}}{\text{s}^2} = \frac{735 \text{ N}}{40 \text{ cm}^2}$$

**Group activity! Let's calculate the stress on the ground as a function of tire pressure**  
Nice article from University of Wisconsin-Milwaukee and Harley Davidson [here](#).

**How much will a material deform under a stress?**

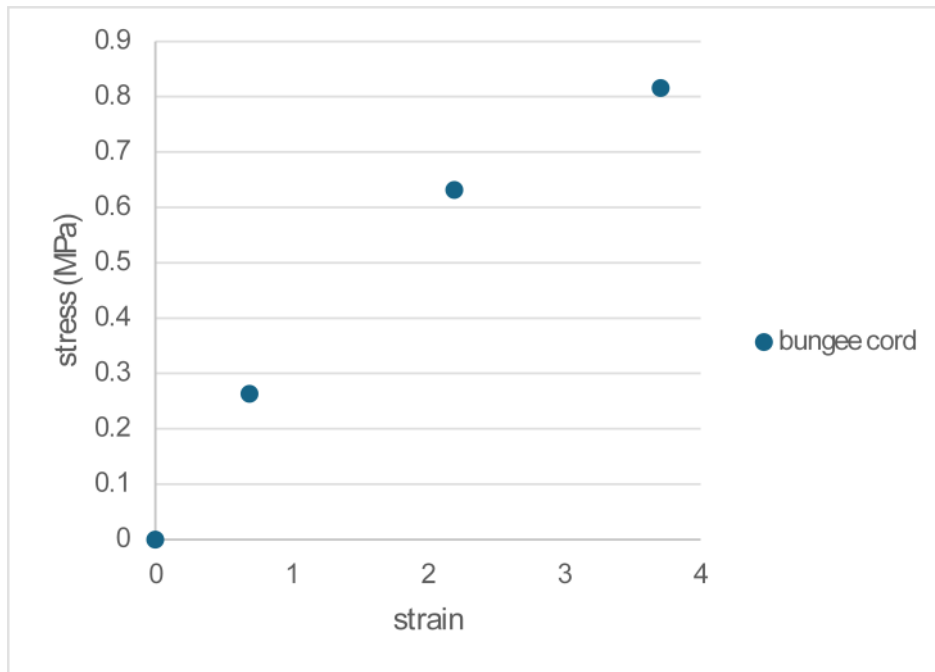
Strain ( $\epsilon$ ) is the percent change in physical dimensions when stress is applied

$$\epsilon = \frac{\Delta L}{L_{\text{initial}}}$$

The change in length is  $L_{\text{final}} - L_{\text{initial}} = \Delta L$ .

What units does strain have??

**Group activity:** Let's test the stress and strain of some real materials!!



Let's see some curves for real materials

