Solids

Crystalline vs. Amorphous

Crystalline solid:

The atoms are arranged in a regular periodic array.

Amorphous solid:

The atoms have a more or less random arrangement.

Density

Conceptually, *density* describes the "compactness" of matter.

(For example, a dense forest has many trees in a given region and a sparse forest has few trees in a given region.)

$$\text{Mass density} = \frac{\text{Mass}}{\text{Volume}} = \frac{m}{V}$$

For example, the density of water is $= 1.0 \ \frac{\text{grams}}{\text{cm}^3} = 1000 \ \frac{\text{kg}}{\text{m}^3}$.

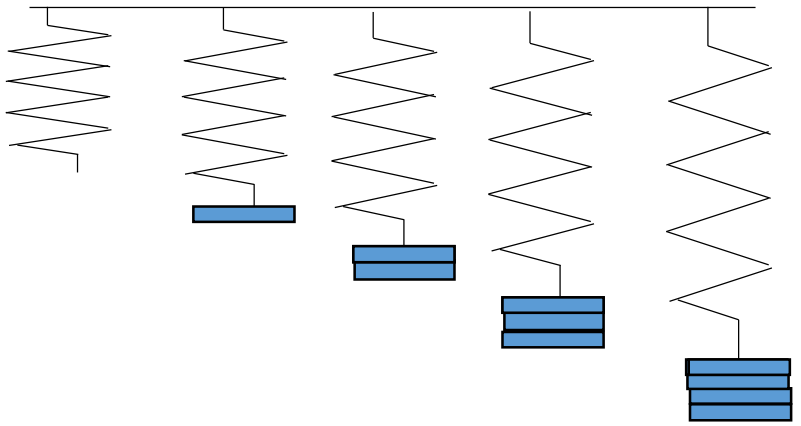
$$\text{Weight density} = \frac{\text{Weight}}{\text{Volume}} = \frac{mg}{V} \ (= 10000 \ \frac{\text{N}}{\text{m}^3} \text{ for water}).$$

Elasticity

The amount of deformation of an object experiencing a force is directly proportional to the applied force. That is, $F_{app} \propto \Delta x$.

Hooke's law: $F_{app} = k\Delta x$.

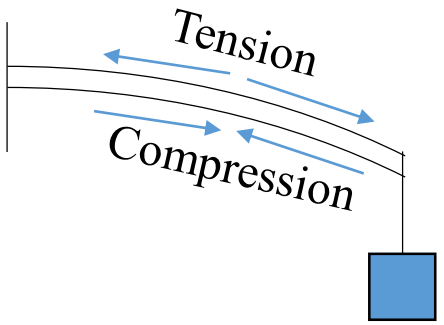
Each additional increment n weight caused the spring to stretch by the same amount.



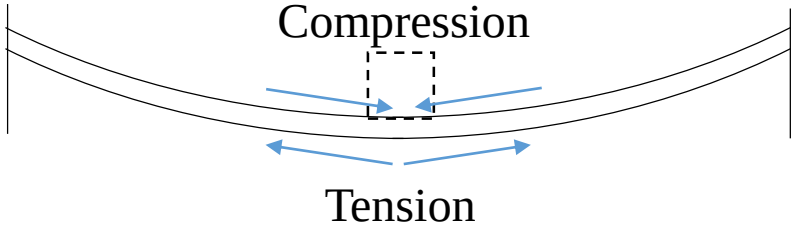
Tension & Compression

Where a object is stretched, that part of the object is said to be under *tension*. Where it is squashed, the object is under *compression*.

For the cantilever beam with the weight hanging from the end, the top surface is under tension and the bottom is under compression.



For the beam supported at both ends with the weight in the middle, the top of the beam is under compression and top is under tension.



Scaling

When an object is “scaled up,” the surface area increases as the square of the length and the volume increases as the cube of the length. However, the “surface area to volume ratio” decreases as the inverse of the length.

For example, consider a cube of edge length 1cm being scaled up:

Length (cm)	Face Area (cm^2)	Surface Area (cm^2)	Volume (cm^3)	S.A./Vol. Ratio (cm^{-1})
1	1	6	1	6
2	4	24	8	3
3	9	54	27	2
…	…	…	…	…
10	100	600	1000	0.6

Questions

Why do elephants have such large ears?

Answer: Their large bodies have a relatively small surface area to volume ratio. Without the extra surface area of the ears to dissipate excess body heat, elephants would otherwise die of heat stroke.

Why are penguins and walruses shaped the way they are?

Answer: Their round compact bodies minimize their S.A./Vol. ratio to help retain body heat.

If you baked a set of cupcakes as though you were baking a birthday cake, what will you get when you open the oven door?

Answer: Burnt cupcakes! The small S.A./Vol. ratio lets then cook faster.

Exotic Forms of Matter

Antimatter:

Matter that that has the same mass as “ordinary” matter, but has opposite electrical charge. For example, an atom of “anti-hydrogen” consists of a *negatively* charged proton surrounded by a *positively* charged electron.

Dark Matter:

Unseen and unidentified matter whose existence is evidenced by the gravitational effect it has on matter we can see. For example, the rotational rates of galaxies is too fast to be consistent with the amount of matter visible. There must be more “stuff” out there to account for the observations.