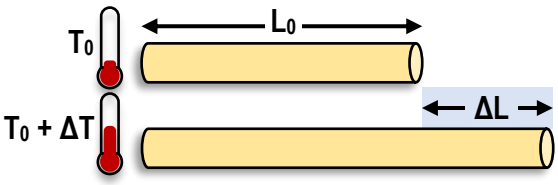
## CONCEPT: VOLUME THERMAL EXPANSION

● When you increase the temperature of a **3D object** (e.g a sphere or cube) their _____ also increases.

### LINEAR Thermal Expansion (1D)

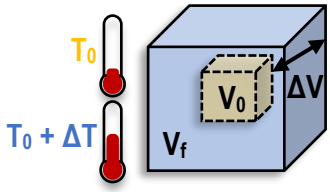



$$\Delta L = \alpha L_0 \Delta T$$

$$L_f = L_0(1 + \alpha \Delta T)$$

● $\alpha$ = *linear* expansion coefficient

### VOLUMETRIC Thermal Expansion (3D)




$$\Delta V = \_\_\_\_\_$$

$$V_f = \_\_\_\_\_$$

| | $\alpha$ | $\beta=3\alpha$ |
|---|---|---|
| Aluminum | $2.4\times10^{-5}$ | $7.2\times10^{-5}$ |
| Copper | $1.7\times10^{-5}$ | $5.1\times10^{-5}$ |
| Steel | $1.1\times10^{-5}$ | $3.3\times10^{-5}$ |

● $\beta$ = *volume* expansion coefficient

- For the same material, β = ____

EXAMPLE: A ball of lead at a temperature 333K has a volume of 50.000cm$^3$. By how much does the ball shrink when you decrease the temperature to 303K? The coefficient of linear expansion for lead is $2.9\times10^{-5}$.

PROBLEM: A geodesic, hemispherical dome made of aluminum has a diameter of exactly 50m on a winter day at a temperature of –10°C. How much more interior space does the dome have on a summer day at a temperature of 30°C? The volume expansion coefficient for aluminum is $7.2\times10^{-5}$.

| VOLUME THERMAL EXPANSION |
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| $\Delta V = \beta V_0 \Delta T$ |
| $V_f = V_0(1 + \beta \Delta T)$ |

PROBLEM: A 250cm$^3$ flask is completely filled with mercury (Hg) at 0°C. If you increase the temperature of the flask and mercury to 100°C, how much mercury (in cm$^3$) overflows and spills out of the flask?

| VOLUME THERMAL EXPANSION |
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| $\Delta V = \beta V_0 \Delta T$ |
| $V_f = V_0(1 + \beta \Delta T)$ |
| $\beta_{Hg} = 1.8\times10^{-4}$ |
| $\beta_{glass} = 1.2\times10^{-5}$ |