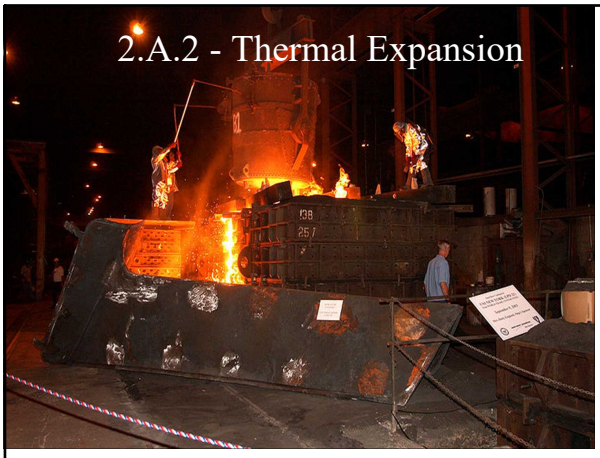
2.A.2 - Thermal Expansion



What?

Warming molecules require more space around them as they move faster.
Methylene chloride glassware demo.

Solids and liquids also expand when heated, but not to the extent that gases do.

Linear Expansion Math

The following equation(s) do not require that you be in meters, only that the units are the same:

$\Delta L = \alpha \cdot L_o \cdot \Delta T$	ΔL = change in length α = coefficient of linear expansion (Table 2.A in Booklet) L_o = original length ΔT = K or °C
$L = L_o(1 + \alpha \cdot \Delta T)$	L = final length

Area Expansion

Change in two dimensions of an object:

$\Delta A = 2\alpha \cdot A_o \cdot \Delta T$	ΔA = change in area α = coefficient of linear expansion (Table 2.A in Booklet) A_o = original area ΔT = K or °C
$A = A_o(1 + 2\alpha \cdot \Delta T)$	A = final area

Volume Expansion of a Solid

Change in three dimensions of a <u>solid</u> object:

$\Delta V = 3\alpha \cdot V_o \cdot \Delta T$	ΔV = change in volume α = coefficient of linear expansion (Table 2.A in Booklet) V_o = original volume ΔT = K or °C
$V = V_o(1 + 3\alpha \cdot \Delta T)$	V = final volume

Demo/Example Time

Watch this!
- Heated object demo: brass ring around sphere.

1. At what temperature will the sphere get stuck? Assume it starts at zero degrees Celsius.
   Ring inner diameter: 2.48 cm.
   Sphere outer diameter: 2.46 cm.

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

$$\frac{\Delta L}{\alpha \cdot L_0} = \Delta T = \frac{2.48\,cm - 2.46\,cm}{19E-6 \cdot 2.46\,cm} = 427.9^\circ C$$

Fluid Volume Expansion

Fluids (liquids or gases) normally expand withincreasec temperature too.
Only volume expansion is meaningful (notarea).

$\Delta V = \beta \cdot V_0 \cdot \Delta T$	ΔV = change in volume β = coefficient of liquid volume expansion (Table 2.A in Booklet) V_o = original volume ΔT = K or °C
$V = V_0(1 + \beta \cdot \Delta T)$	V = final volume

Demo: Nitinol Metal

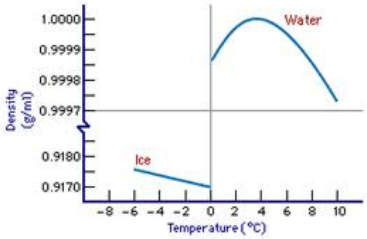
Watch this!!

A Note On Water

As water cools, it contracts like other liquids.

Below 4°C, water behaves anomalously: it expands until it freezes at 0°C.

Why is that??



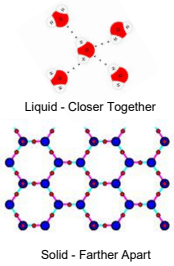
Answer:

Water contains hexagonal sub-microscopic crystal moieties which get larger as it cools.

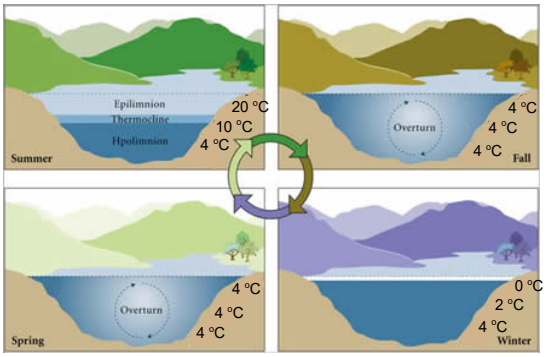
At 4°C these grow big enough so that its density starts diminishing.

At 0°C ice begins to form as these moieties combine.

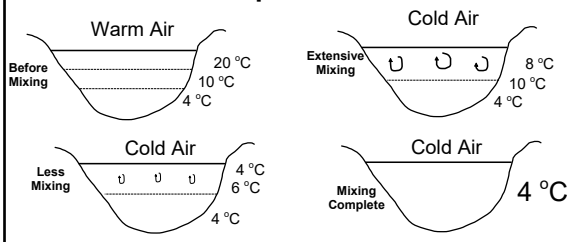
This leads to water bodies mixing in the spring and fall, moving nutrients/gases.



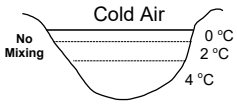
Lake Temperature Profile Overview



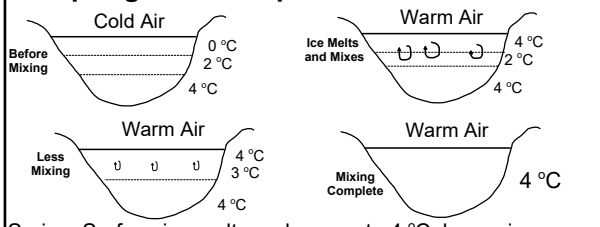
Fall Lake Temperature Profile Detailed



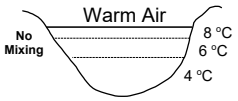
Fall: Surface water cools, becoming more dense, and sinking. As surface water approaches 4 °C, mixing slows, stopping when all water is 4 °C.
The surface cools more, and density decreases until water freezes.



Spring Lake Temperature Profile Detailed



Spring: Surface ice melts and warms to 4 °C, becoming more dense, and sinking.
As surface layer approaches 4 °C, mixing slows, stopping when all water is 4 °C.
The surface warms more; density decreases as summer goes by.



Homework

2.A.2 Problems
Due: next class.