PREPARING FOR YOUR
MEDICAL SCHOOL INTERVIEW
Workshop

November 24, 2009 or January 11, 2010

TIME: 6:00 – 7:30 pm
LOCATION: Room 200 Armes Building
FACILITATORS: David Ness & Angela Bohonos

For more information, call Career Services at 474-9456

WileyPLUS Assignment 4

Chapters 8, 9, 10
Due: Friday, November 27 at 11 pm

Next Week: Tutorial & Test 4

Bernoulli's Equation

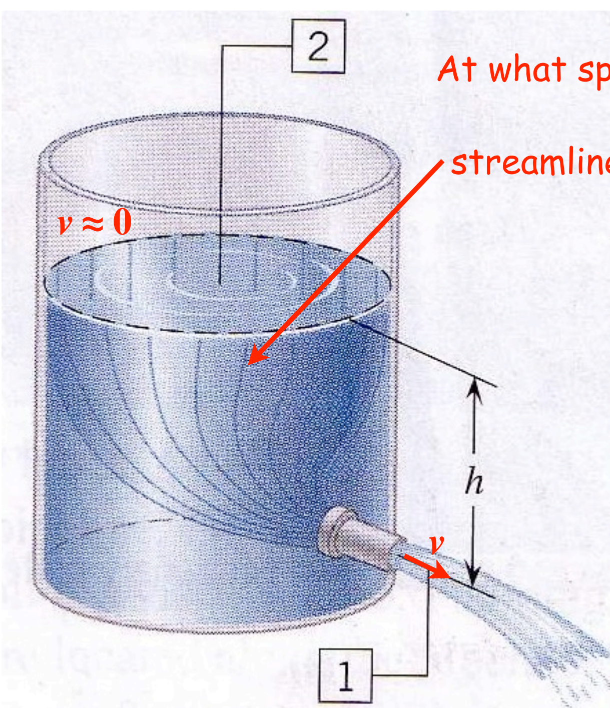
For streamline flow of an incompressible fluid (or close to incompressible in some situations such as airflow over an airplane wing)

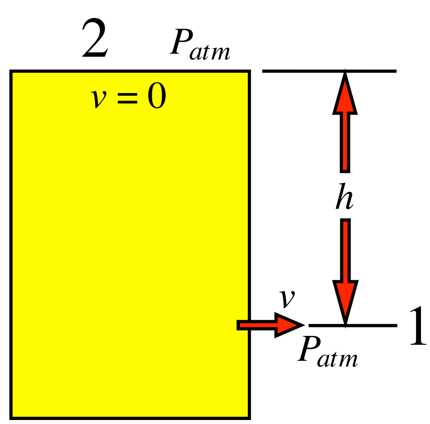
$$P + \rho g y + \frac{1}{2}\rho v^2 = \text{ constant}$$

Equation of continuity for fluid of constant density:

$$vA = \text{constant}$$

At what speed does the water leave the hole?





Bernoulli: at 2 and 1

$$\cancel{P_{atm}} + \rho g h = \cancel{P_{atm}} + \frac{1}{2}\rho v^2 \rightarrow \; v^2 = 2gh, \text{ as if the water had fallen a distance } h$$

What the water loses in potential energy, it gains in kinetic energy

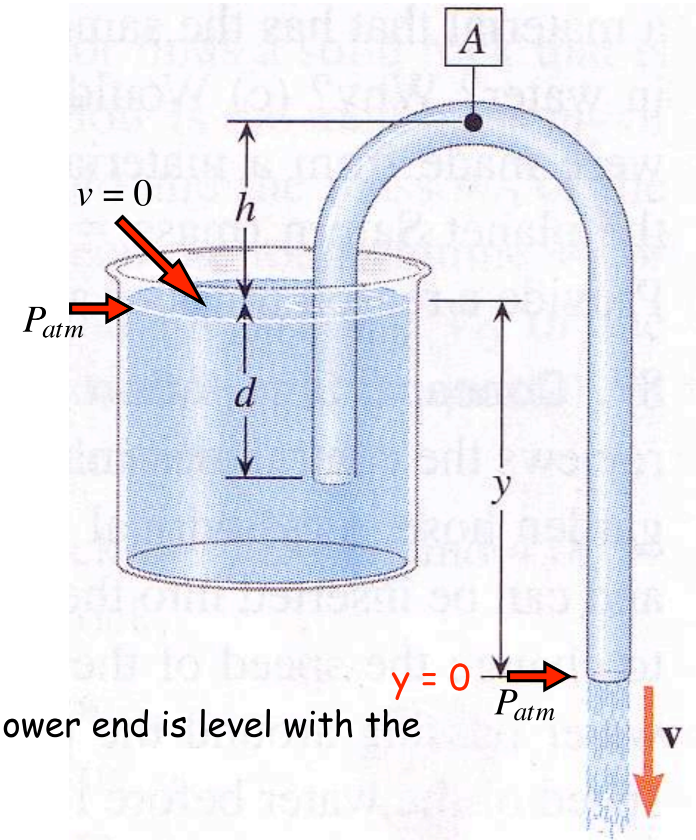
11.76/96: (a) Find v

Bernoulli:

$$P_{atm} + \rho g y = P_{atm} + \frac{1}{2}\rho v^2$$

At surface of water | At exit of tube

So, $v = \sqrt{2gy}$



(b) At what value of y will the syphon stop working?

v = 0 when y = 0, i.e. when the lower end is level with the water surface.

(c) Find the absolute pressure at A.

Bernoulli, at surface of water and at A:

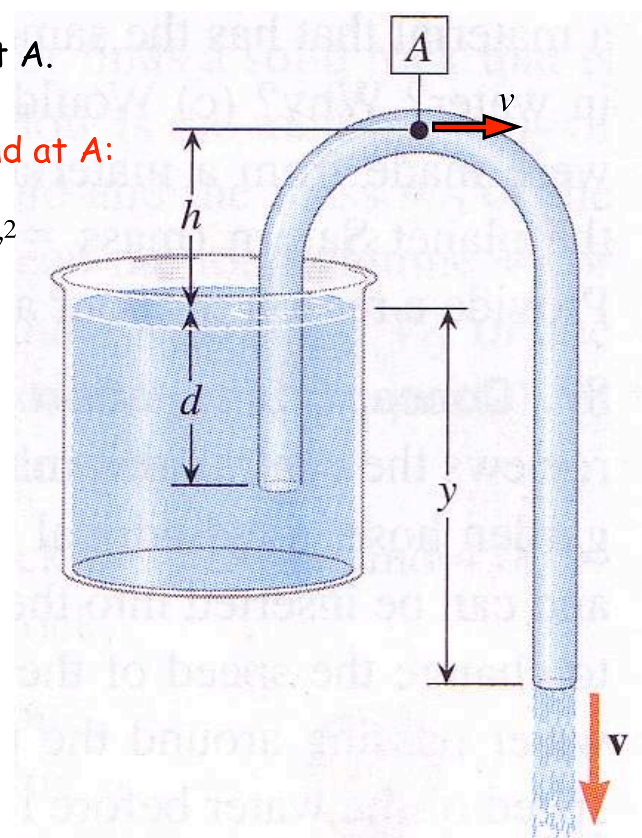
$$P_{atm} + \rho g y = P_A + \rho g(y+h) + \frac{1}{2}\rho v^2$$

$$P_A = P_{atm} - \rho g h - \frac{1}{2}\rho v^2$$

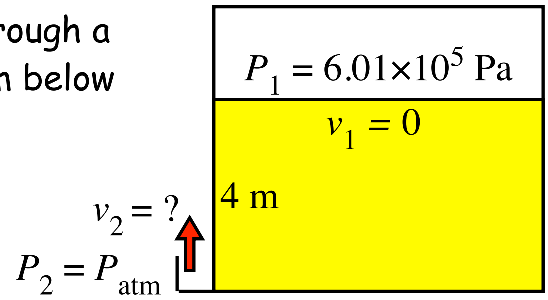
Since, $v = \sqrt{2gy}$,

$$P_A = P_{atm} - \rho g h - \frac{1}{2}\rho \times 2gy$$

$$= \underline{P_{atm} - \rho g(h+y)}$$



11.71/93: Water leaves the tank through a nozzle that points upward and is 4 m below the surface of the water.



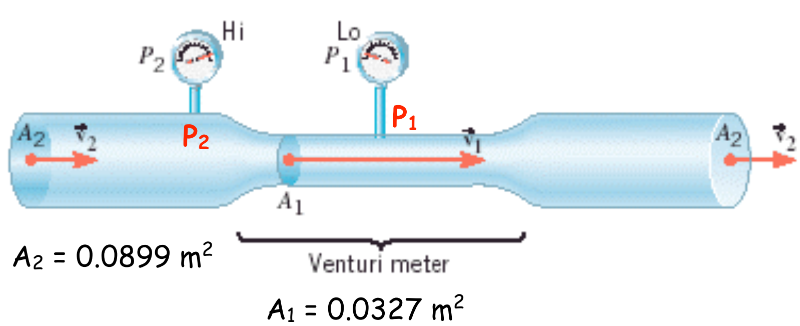
a) What is the speed of the water as it leaves the nozzle?

b) To what height does the water rise?

Chapter 11, Problem 69

A Venturi meter is a device for measuring the speed of a fluid within a pipe. The drawing shows a gas flowing at speed v_2 through a horizontal section of pipe whose cross-sectional area is $A_2 = 0.0899\ m^2$. The gas has a density of $\rho = 1.30\ kg/m^3$. The Venturi meter has a cross-sectional area of $A_1 = 0.0327\ m^2$ and has been substituted for a section of the larger pipe. The pressure difference between the two sections is $P_2 - P_1 = 54.5$ Pa.

Find (a) the speed v_2 of the gas in the larger original pipe and (b) the volume flow rate Q of the gas.



Chapter 11, Problem 66 GO

A ship is floating on a lake. Its hold is the interior space beneath its deck; the hold is empty and is open to the atmosphere. The hull has a hole in it, which is below the water line, so water leaks into the hold. The effective area of the hole is 6.5×10^{-3} m^2 and is located 1.6 m beneath the surface of the lake. What volume of water per second leaks into the ship?

Summary of Motion of Fluids

Equation of continuity:

$$\rho_1 v_1 A_1 = \rho_2 v_2 A_2 = \text{mass flowing per second}$$

If the density does not change:

$$v_1 A_1 = v_2 A_2 = \text{volume flowing per second}$$

Bernoulli's Equation:

$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2 = \text{constant}$$

– based on work-energy theorem, assumes streamline flow

Chapter 12: Temperature and Heat

- Temperature scales, thermometers
- Linear and volume expansion
- Internal energy
- Specific heat
- Change of phase, latent heat

Leave out sections 9, 10: equilibrium between phases of matter, humidity

Temperature Scales

Common temperature scales are based on the freezing and boiling points of water:

0° C, or 32° F = freezing point
100° C, or 212° F = boiling point

and are measured conveniently by thermal expansion of mercury in a thermometer.

Fahrenheit's scale: 0°F = coldest temperature in Danzig in winter of 1708-09, 100°F = body temperature?? Origin of scale very uncertain.

The Kelvin, or absolute, scale is of greater scientific significance.

Temperature differences have the same magnitude in Celsius and Kelvin.

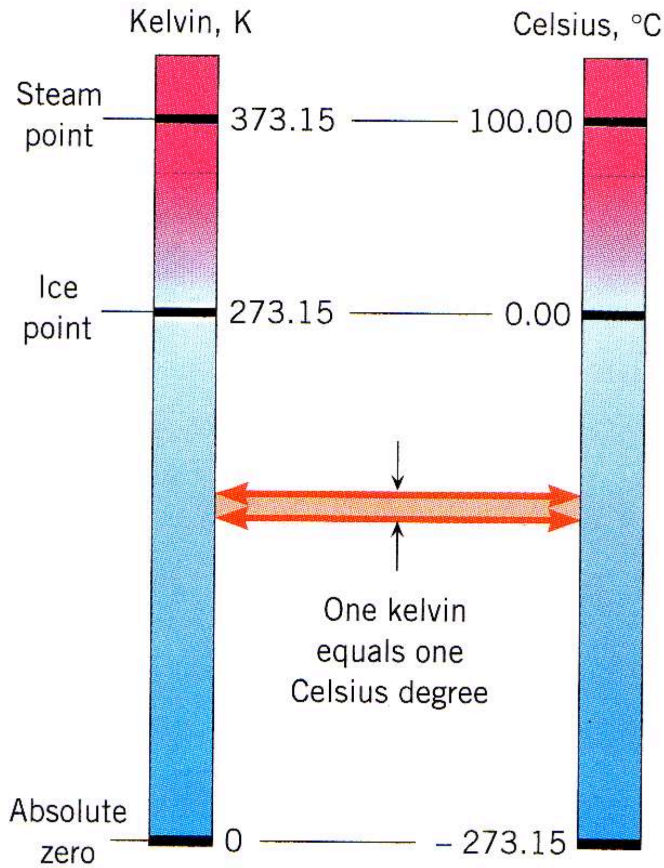
Kelvin and Celsius

0° C = 273.15 K (no degree symbol for K)

Absolute zero, the lowest temperature attainable (or, more accurately, not quite attainable) is:

0 K = –273.15° C

So, T (°C) = T (K) – 273.15

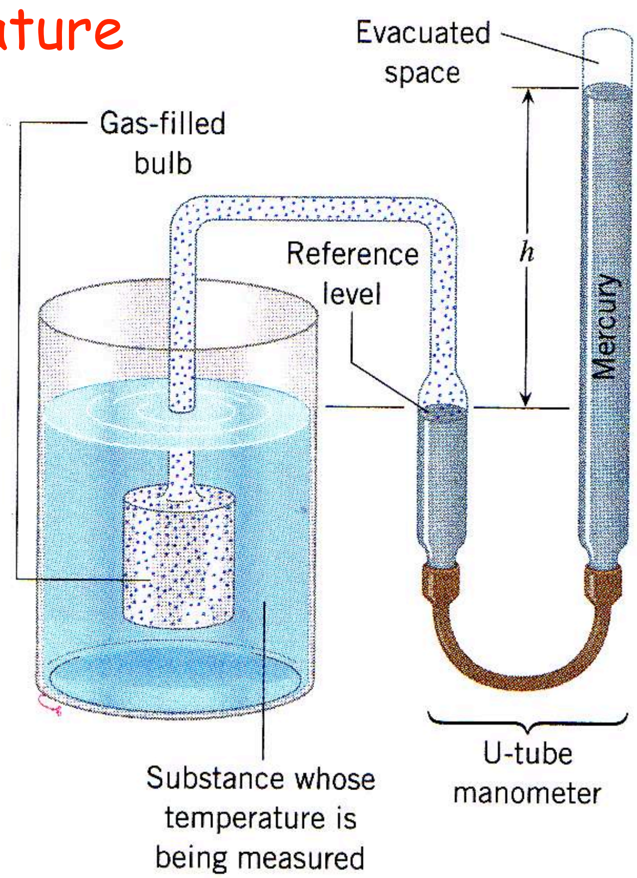


Measuring Temperature

Constant volume gas thermometer

Bulb contains low density hydrogen or helium gas – they liquefy at very low temperature. The right arm of the manometer is raised to keep the level of mercury in the left arm at constant height, so the gas has constant volume.

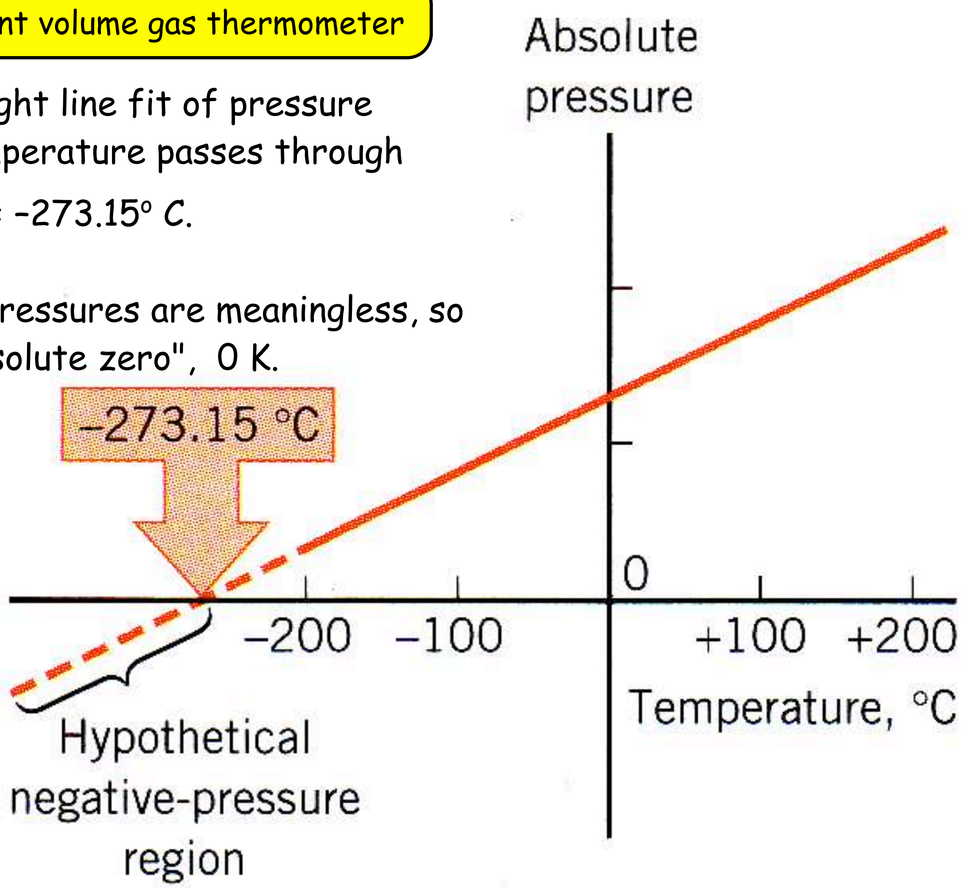
Measure the pressure of the gas as a function of temperature. Find that...



Constant volume gas thermometer

...the straight line fit of pressure versus temperature passes through zero at T = –273.15° C.

Negative pressures are meaningless, so this is "absolute zero", 0 K.



12.7/7: A constant-volume thermometer has a pressure of 5000 Pa when the gas temperature is 0° C. What is the temperature when the pressure is 2000 Pa?

Pressure is proportional to absolute (Kelvin) temperature. So –

$$\frac{T_2}{T_1} = \frac{P_2}{P_1}$$

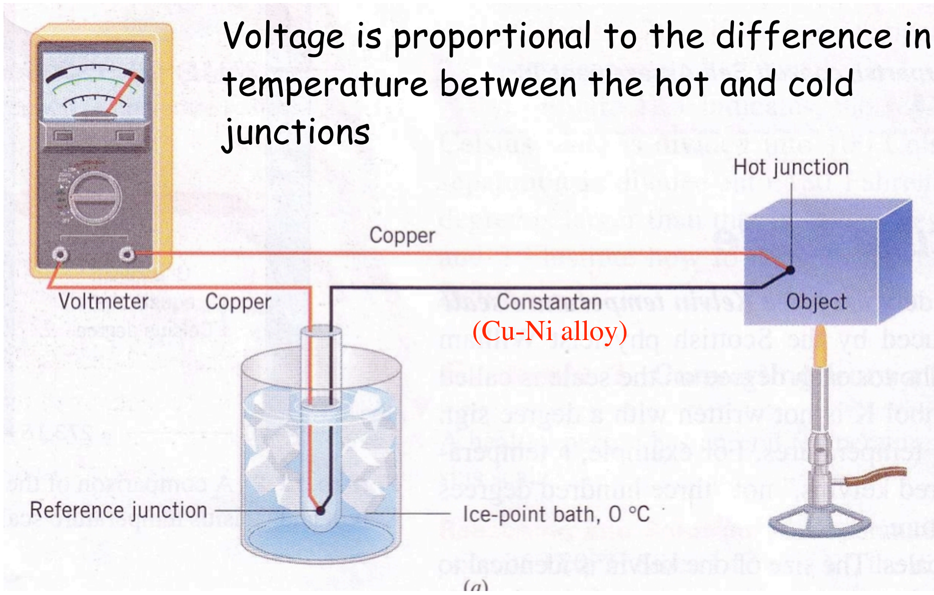
$$\frac{T_2}{273.15} = \frac{2000}{5000}$$

$$T_2 = 109.26\text{ K} = -163.9^\circ\text{ C}$$

Types of Thermometers

- Expansion as a function of temperature – eg mercury thermometers.

- Thermocouple – current induced by metals at different temperatures.

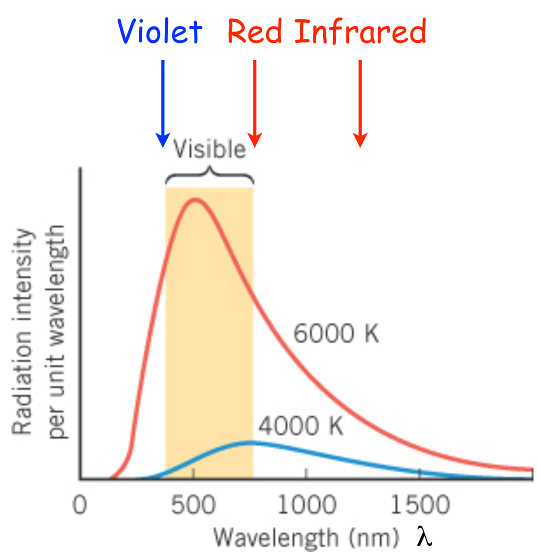


Types of Thermometers

- Resistance thermometers – use fact that electrical resistance varies with temperature.

- Spectrum of light from heated objects – the colour varies with temperature. Infrared at lower temperatures, shifting to blue at high temperature.

  Deduce the temperature of the surface of the sun from the spectrum of sunlight. Or of distant stars, or the filament of a light bulb.



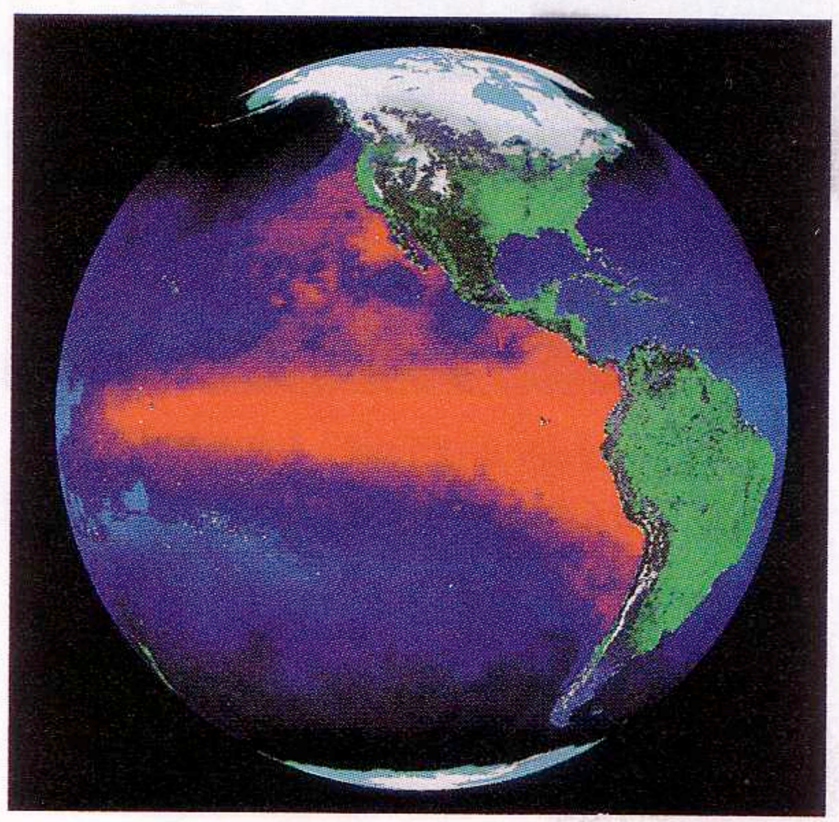
$$\lambda_{max} T = \text{constant}, T \text{ in Kelvin}$$

Wavelength at peak of spectrum

Thermograms of smoker's hands before and after smoking a cigarette. Vasoconstriction reduces blood flow and temperature.

These are "false colours" – the pictures are taken with infrared-sensitive film. White: 34° C, blue: 28° C

Infrared picture taken from space showing the warm El Niño ocean current



Thermal Expansion

Linear expansion – the increase in length, width or thickness when an object is heated.

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

α = coefficient of linear expansion

Typical values for metals ≈15×10^{-6} per C°.

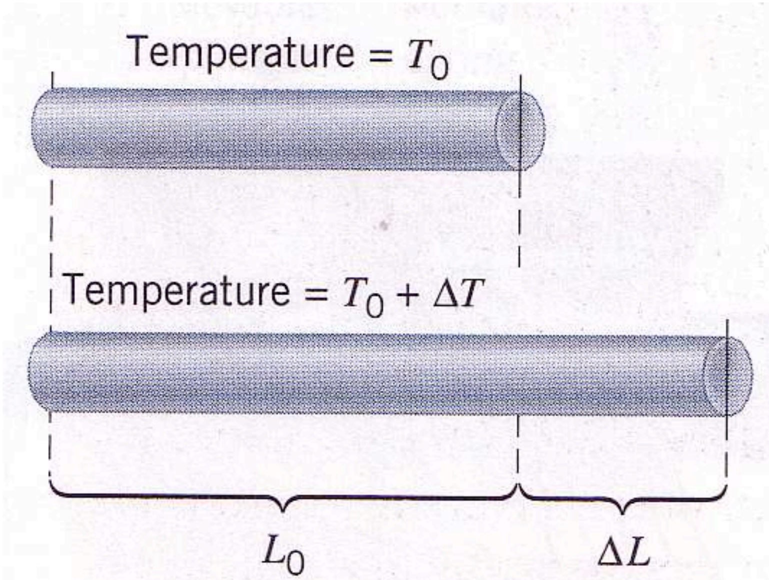
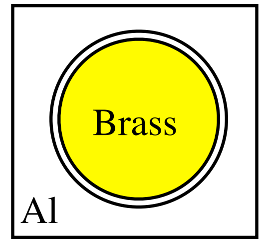


Table 12.1 Coefficients of Thermal Expansion for Solids

Substance	Coefficient of Thermal Expansion $(C°)^{-1}$ Linear (α)
Solids	
Aluminum	23×10^{-6}
Brass	19×10^{-6}
Concrete	12×10^{-6}
Copper	17×10^{-6}
Glass (common)	8.5×10^{-6}
Glass (Pyrex)	3.3×10^{-6}
Gold	14×10^{-6}
Iron or steel	12×10^{-6}
Lead	29×10^{-6}
Nickel	13×10^{-6}
Quartz (fused)	0.50×10^{-6}
Silver	19×10^{-6}

A circular hole is cut through a flat aluminum plate. A spherical brass ball has a diameter that is slightly smaller than the diameter of the hole. If the ball and plate have equal temperature at all times, should the ball and plate be heated or cooled to prevent the ball from falling through the hole?



Linear expansion coefficients:
Aluminum: 23×10^{-6} $(C^{o})^{-1}$ $\qquad \alpha_{Al} > \alpha_{brass}$
Brass: 19×10^{-6} $(C^{o})^{-1}$

The aluminum expands more than the brass as the temperature is increased, so the diameter of the hole increases more than the diameter of the ball.

As they are cooled, the diameter of the hole in the aluminum decreases more than does the diameter of the ball.

The Concorde aircraft is 62 m long when its temperature is 23°C. In flight, the outer skin can reach 105°C due to air friction. Find the amount Concorde expands.

The coefficient of linear expansion of the skin is α = $2\text{x}10^{-5}$ per C°.

The increase in length is: $\Delta L = \alpha L_0 \Delta T$

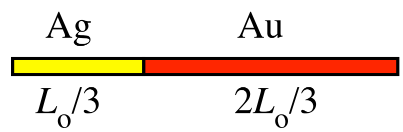
$$\Delta L = (2\times10^{-5}\text{ per C}^{\circ})\times(62\text{ m})\times(105-23\ ^{\circ}\text{C})$$

$$\Delta L = 0.102\text{ m}$$

12.90/82: A thin rod consists of two parts joined together. One third is silver, the rest is gold. The temperature increases by 26°C. Find the fractional increase in the rod's length.

α_{Ag} = 19×19^{-6} per C°.

α_{Au} = 14×10^{-6} per C°.



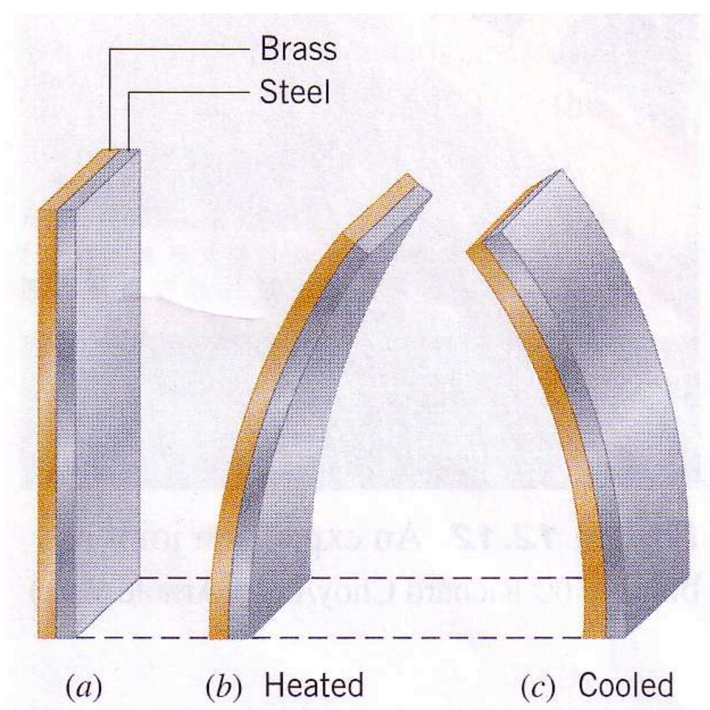
$$\text{The silver increases in length by } \Delta L_{Ag} = \alpha_{Ag}(L_0/3) \times 26$$
$$= 1.647 \times 10^{-4} L_0$$
$$\text{The gold increases in length by } \Delta L_{Au} = \alpha_{Au}(2L_0/3) \times 26$$
$$= 2.427 \times 10^{-4} L_0$$
$$\text{The total increase in length } = (1.647 + 2.427) \times 10^{-4} L_0$$
$$= 4.07 \times 10^{-4} L_0$$

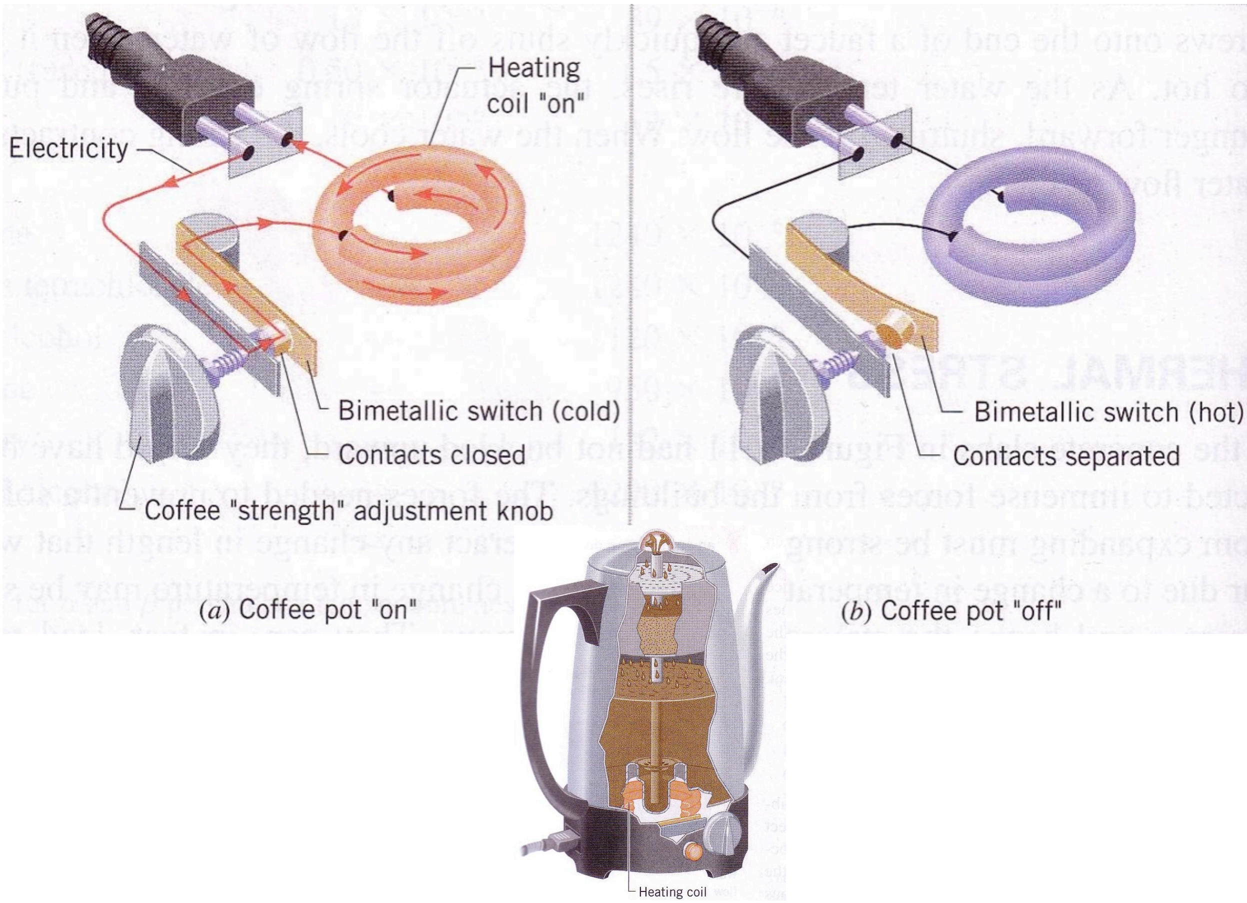
The Bimetallic Strip

Two thin strips of metals of different temperature coefficient of expansion, welded or riveted together.

The strip bends when it is heated or cooled.

Used as switches for heating elements, thermostats.





Volume Expansion

When heated, objects expand in all three dimensions:

$$L_x = L_{x0}(1+\alpha\Delta T)$$
$$L_y = L_{y0}(1+\alpha\Delta T)$$
$$L_z = L_{z0}(1+\alpha\Delta T)$$

The same coefficient of expansion in all dimensions

The volume increases to:

$$V = L_x \times L_y \times L_z$$
$$= L_{x0}L_{y0}L_{z0}(1+\alpha\Delta T)(1+\alpha\Delta T)(1+\alpha\Delta T)$$
$$\simeq V_0(1+3\alpha\Delta T)$$

The volume coefficient of temperature expansion is defined by:

$$\boxed{V = V_0(1+\beta\Delta T)}$$

So, $\beta \simeq 3\alpha$

Table 12.1 **Coefficients of Thermal Expansion for Solids and Liquids**[a]

Substance	Coefficient of Thermal Expansion $(\mathrm{C}°)^{-1}$	
	Linear (α)	Volume (β)
Solids	$\beta \simeq 3\alpha$	
Aluminum	23×10^{-6}	69×10^{-6}
Brass	19×10^{-6}	57×10^{-6}
Concrete	12×10^{-6}	36×10^{-6}
Copper	17×10^{-6}	51×10^{-6}
Glass (common)	8.5×10^{-6}	26×10^{-6}
Glass (Pyrex)	3.3×10^{-6}	9.9×10^{-6}
Gold	14×10^{-6}	42×10^{-6}
Iron or steel	12×10^{-6}	36×10^{-6}
Lead	29×10^{-6}	87×10^{-6}
Nickel	13×10^{-6}	39×10^{-6}
Quartz (fused)	0.50×10^{-6}	1.5×10^{-6}
Silver	19×10^{-6}	57×10^{-6}
Liquids[b]		
Benzene	—	1240×10^{-6}
Carbon tetrachloride	—	1240×10^{-6}
Ethyl alcohol	—	1120×10^{-6}
Gasoline	—	950×10^{-6}
Mercury	—	182×10^{-6}
Methyl alcohol	—	1200×10^{-6}
Water	—	207×10^{-6}

[a]The values for α and β pertain to a temperature near 20 °C.

[b]Since liquids do not have fixed shapes, the coefficient of linear expansion is not defined for them.