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

This Week

Tutorial & Test 4

Next Week

Experiment 5: Thermal conductivity of an insulator

Temperature and Thermal Expansion

Temperature: T (°C) = T (K) – 273.15

Thermal expansion:

Linear expansion: $\Delta L = \alpha L_0 \Delta T$

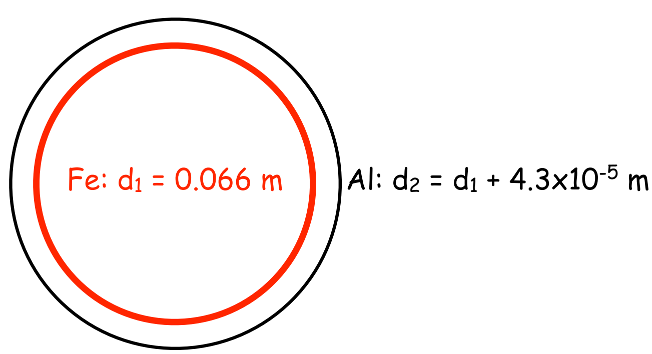
Volume expansion: $\Delta V = \beta V_0 \Delta T$

$\beta \approx 3\alpha$

12.14/-

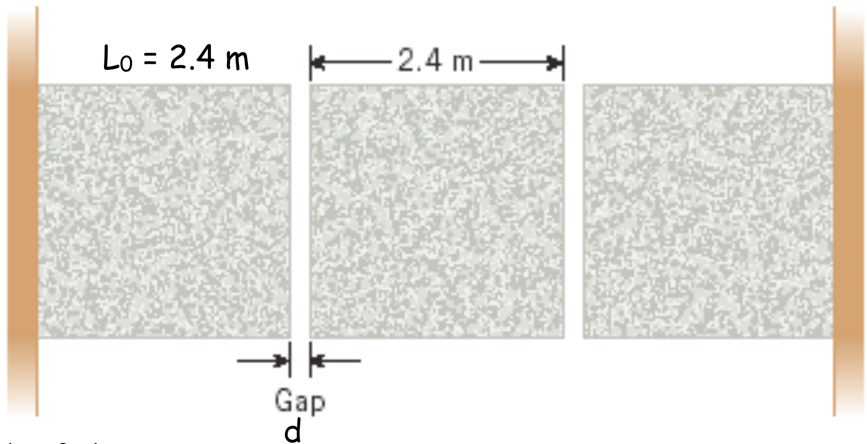
A thick, vertical iron pipe has an inner diameter of 0.066 m. A thin aluminum ($\alpha = 23 \times 10^{-6}\ (C°)^{-1}$) disk, heated to a temperature of 88°C, has a diameter that is 4.3×10^{-5} m greater than the pipe's inner diameter. The disk is laid on top of the open upper end of the pipe, perfectly centred on it, and allowed to cool.

What is the temperature of the aluminum disk when the disk falls into the pipe? Ignore the temperature change of the pipe.



12.18/59

Concrete sidewalks are always laid in sections, with gaps between each section. For example, the drawing shows three identical 2.4-m sections, the outer two of which are against immovable walls. The two identical gaps between the sections are provided so that thermal expansion will not create the thermal stress that could lead to cracks. What is the minimum gap width necessary to account for an increase in temperature of 29 C°?



Concrete: $\alpha = 12\times10^{-6}\ (C^0)^{-1}$

12.21/17

A simple pendulum consists of a ball connected to one end of a thin brass wire. The period of the pendulum is 1.90 s. The temperature rises by 146 C°, and the length of the wire increases. Determine the change in the period of the heated pendulum.

Brass: $\alpha = 19\times10^{-6}\ (C^0)^{-1}$

The coolant reservoir catches the radiator fluid that overflows when an engine becomes hot. The radiator is made of copper.

$\beta_{coolant} = 4.10\times10^{-4}$ per C°.
$\beta_{Cu} \quad = 51\times10^{-6}$ per C°.

The radiator is filled to its 15 litre capacity at 6° C. How much fluid overflows when the temperature reaches 92° C?

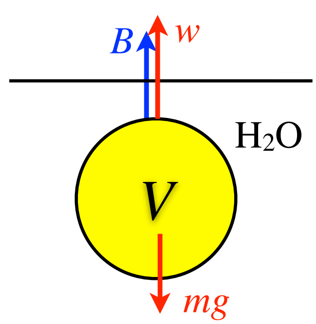
Both the coolant and the copper radiator expand.

The coolant expands by: $\Delta V_{coolant} = \beta_{coolant} V_0 \Delta T = (4.10\times10^{-4})(15)(86)$
$\Delta V_{coolant} = 0.53$ litres.

The radiator expands by: $\Delta V_{Cu} = \beta_{Cu} V_o \Delta T = (51\times10^{-6})(15)(86) = 0.07$ l.

So, amount of overflow is (0.53 – 0.07) = 0.46 litres.

12.37/34: A solid Al sphere has a radius of 0.5 m and a temperature of 75°C. The sphere is completely immersed by suspending it in a large pool of water at 25°C. The sphere cools, the temperature of the water remains the same. The sphere is weighed in the water while it is still at 75°C and when it has cooled to 25°C (think Archimedes). Which weight is larger? What is the difference in the weights?



The buoyancy force is equal to the weight of displaced water.

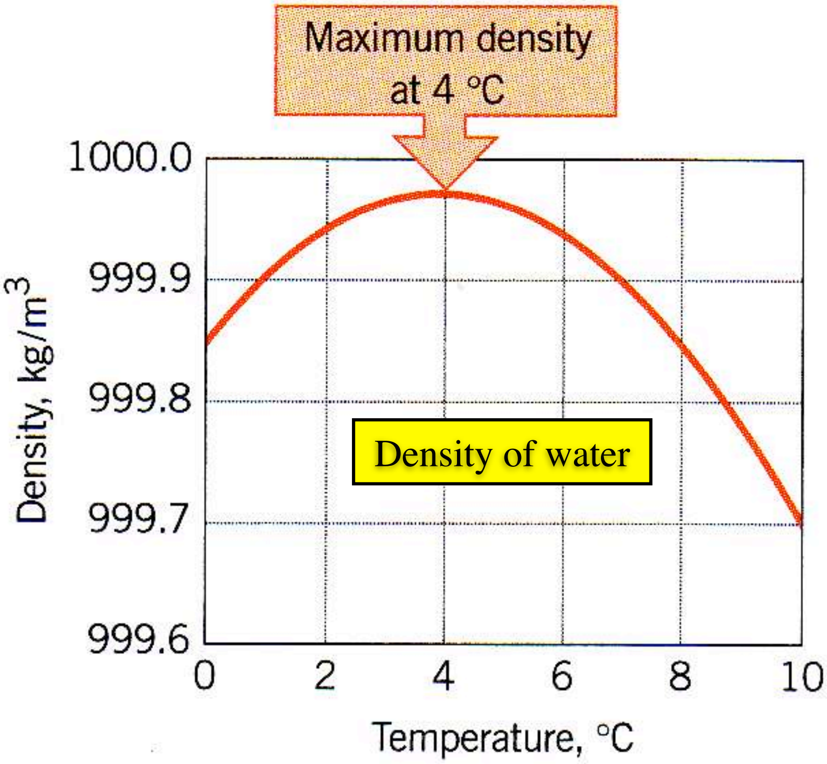
The sphere has a larger volume and displaces more water when it is at the higher temperature, so the buoyancy force is greater and the weight is less.

The difference in buoyancy force, and therefore the difference in weight, is equal to the difference in the weight of displaced water:

$$\Delta W = \Delta V \times g\rho_{H_2O}$$

Water is different from most liquids – it expands as it freezes, from 4°C to 0°C.

Water at 4°C is more dense than freezing water, so freezing water rises to the surface, forming an insulating ice layer, while life can continue below in the liquid water.



Heat and Internal Energy

- Heat is a flow of energy from one object to another.
- Thermal energy is an "internal energy" – the random motion and the potential energy of molecules making up a substance.
- Temperature is a measure of internal energy. The greater the internal energy, the greater the temperature.
- The flow of energy (heat) is from higher temperature to lower temperature.
- The SI unit of heat is the Joule.
- Also used, the calorie (cal). 1 cal = 4.186 J.
- **NB the food calorie is 1000 cal.**
  Melting ice cubes in your mouth is not an effective way of burning calories!

Heat and Temperature Change

The amount of heat, Q, to raise the temperature of a mass m of a substance by ΔT C^{o} is:

$$Q = mc\Delta T$$

c = specific heat capacity (or specific heat) in J/(kg.C°).

Water: c = 4186 J/(kg.C°), that is, 1000 cal/(kg.C°)

In 30 minutes, a 65 kg jogger generates 800 kJ of heat. If the heat were not dissipated, how much would the jogger warm up?

Average specific heat of the body = 3500 J/(kg.C°)

$$\Delta T = \frac{Q}{mc} = \frac{8 \times 10^5 \text{ J}}{65 \times 3500} = 3.5°\text{C}$$

Table 12.2 **Specific Heat Capacities[a] of Some Solids and Liquids**

Substance	Specific Heat Capacity, c J/(kg · C°)
Solids	
Aluminum	9.00×10^2
Copper	387
Glass	840
Human body (37 °C, average)	3500
Ice (−15 °C)	2.00×10^3
Iron or steel	452
Lead	128
Silver	235
Liquids	
Benzene	1740
Ethyl alcohol	2450
Glycerin	2410
Mercury	139
Water (15 °C)	4186

[a]Except as noted, the values are for 25 °C and 1 atm of pressure.

12.-/41: Blood carries excess energy from the interior to the surface, where energy is dispersed. While exercising, 0.6 kg of blood flows to the surface at 37°C and releases 2000 J of energy. Find the temperature at which blood leaves the surface.

Specific heat of blood = 4186 J/(kg.C°)

The blood loses 2000 J of energy and cools, Q = –2000 J:

$$\Delta T = \frac{Q}{mc} = \frac{-2000 \text{ J}}{0.6 \times 4186} = -0.8°\text{C}$$

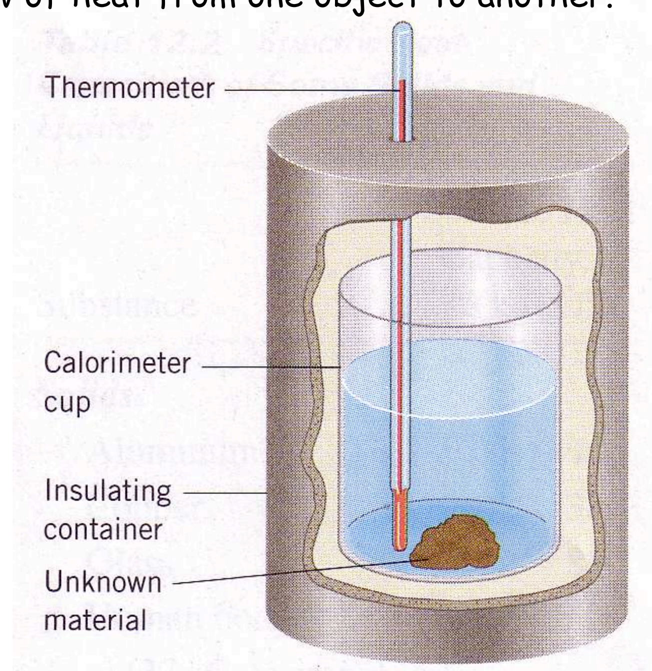
So, blood returns at 37 – 0.8 = 36.2°C

Calorimetry

Heat is a flow of energy, so should be included in the conservation of energy equation. Energy is conserved, no matter what its form. **Calorimetry**: studies the flow of heat from one object to another.

Calorimeter – a thermally insulated container – no flow of heat to or from outside.

Measure specific heat of an unknown material by heating or cooling to a known temperature, putting it into the calorimeter full of liquid of known specific heat, and measuring the equilibrium temperature.



Q12, Final Exam 2005: A 0.2 kg lead shot is heated to 90°C and dropped into an ideal calorimeter containing 0.5 kg of water initially at 20°C. What is the final temperature of the lead shot?

Specific heat capacities:
Pb: c_1 = 128 J/(kg.C°)
H_2O: c_2 = 4186 J/(kg.C°)

The thermal energy is not lost or gained, it just moves around:

$$Q_{Pb} + Q_{H_2O} = 0$$

Final temperature is T

$$\text{That is, } m_1 c_1 \Delta T_1 + m_2 c_2 \Delta T_2 = 0$$

$$0.2 \times 128(T - 90) + 0.5 \times 4186(T - 20) = 0$$

T = 20.8°C

A calorimeter is made from 0.15 kg of aluminum and contains 0.2 kg of water. Initially, the calorimeter and water are at 18^{0}C. A 0.04 kg mass of unknown material is heated to 97^{0}C and added to the water. At equilibrium, everything is at 22^{0}C. What is the specific heat of the mass?

Calculate the heat flow into each object, set the sum to zero:

$$Q_{Al} \quad + \quad Q_{H20} \quad + \quad Q_x \quad = 0$$

$$m_{Al}\, c_{Al}\, \Delta T_{Al} + m_{H2O}\, c_{H2O}\, \Delta T_{H2O} + m\, c\, \Delta T = 0$$

Al water unknown

$$\text{So, } c = \frac{-m_{Al}\, c_{Al}\, \Delta T_{Al} - m_{H2O}\, c_{H2O}\, \Delta T_{H2O}}{m\, \Delta T}$$

$$c = \frac{-0.15 \times 900 \times (22-18) - 0.2 \times 4186 \times (22-18)}{0.04 \times (22-97)} = 1296 \text{ J/(kg.C}^\circ)$$

12.50/44: A piece of glass is at 83°C. An equal mass of liquid at 43°C is poured over the glass. An equilibrium temperature of 53°C is reached. Assuming negligible heat loss, find the specific heat of the liquid.

Specific heat of glass = 840 J/(kg.C°)

12.43/84

Ideally, when a thermometer is used to measure the temperature of an object, the temperature of the object itself should not change. However, if a significant amount of heat flows from the object to the thermometer, the temperature will change.

A thermometer has a mass of 34.4 g, a specific heat capacity of c = 850 J/(kg C°), and a temperature of 11.8 °C. It is immersed in 125 g of water, and the final temperature of the water and thermometer is 67.0 °C.

What was the temperature of the water in degrees Celsius before the insertion of the thermometer?