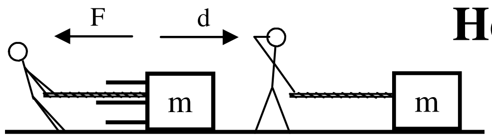
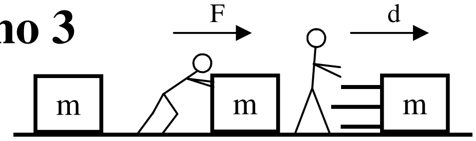
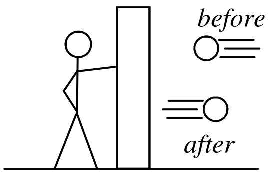
Heat and Thermo 3





Remember that W is − when F and d oppose each other or when energy is removed.

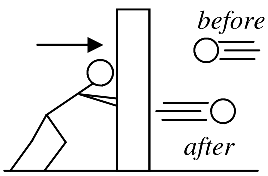
Remember that W is + when F and d are in the same direction or when energy is added.



1. A moving ball hits a wall and bounces back. Let's imagine that the wall is on a friction-less surface, so it can slide, and that the ball is heavy enough that it can move the wall. Slim Jim keeps the wall from falling over.

   A. * Since the ball moves to the right after hitting the wall, the direction of the wall's normal force on the ball is:

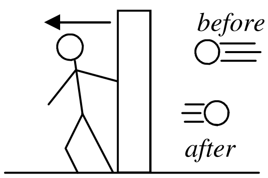
   B. * The direction of the ball's force on the wall is:
   (*And the ball is going the same speed as before, assuming an elastic collision. 0 W on the ball.)*



2. Then Slim Jim pushes the wall toward the ball. The ball still ricochets off the wall.

   A. The direction of the wall's normal force on the ball is:

   B. The direction of the ball's force on the wall is:
   (*And the ball picks up speed, like a ball hit by a racket or bat. +W done on the ball.)*



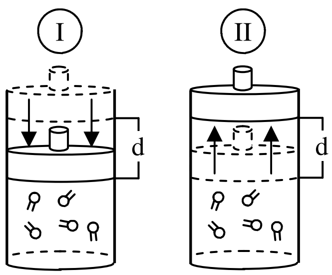
3. Now Jim pulls the wall away from the ball. Of course, the ball still ricochets back off the wall.

   A. The direction of the wall's normal force on the ball is:

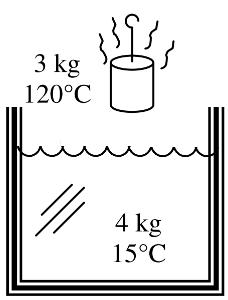
   B. The direction of the ball's force on the wall is:
   (*And the ball loses speed. This is how a tennis player catches a tennis ball: they move their racket backwards with the ball, slowing the ball down. −W done on the ball.)*

Now we change from a wall to a piston and gas molecules instead of a ball. And the forces work exactly the same: the molecules bounce off the piston, so **THE PISTON ALWAYS PUSHES DOWN** *(or in). And* **THE GAS MOLECULES ALWAYS PUSH UP** *against the piston, since their pressure is what keeps the piston from falling without an outside force.*

4. In diagram I the piston is moving down. In diagram II the piston is moving up. Diagram I or II (or both)?



A. ___ * The force of the piston is down.
B. ___ The force of the gas is up.
C. ___ * F and d for the piston are in the same direction.
D. ___ F and d for the gas are in opposite directions.
E. ___ * + W is done by the gas (*by the system—the gas is the system*).
F. ___ * −W done by the piston (*on the system, on the gas*).
G. ___ * + W is done on the system.
H. ___ * The gas's temperature increases.
I. ___ The gas's temperature decreases.



5. A 3 kg copper mass (c_p = 387) is heated to 120°C. It is then placed into a well insulated container with 4 kg of water at 15°C.

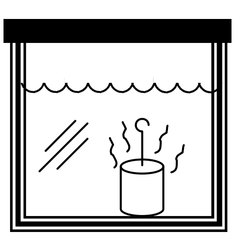
   A. Heat always travels from ______ to ______.

   B. Which object will lose energy?

   C. Which object's temperature will go up?

   D. Will the final temperature of the water be above, below, or at 15°C?

   E. Since the copper loses heat, where does the heat go?



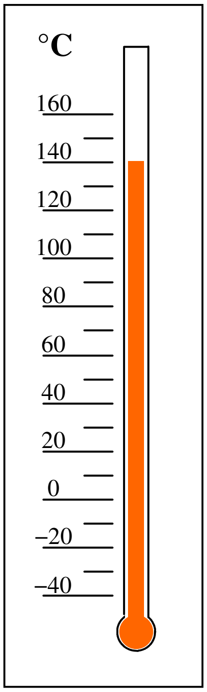
   F. Since the container is well insulated, the amount of energy lost to the outside of the container is:
   After a while the two objects come to thermal equilibrium at 21.8°C.

   G. What is the change of temperature for the copper?

   H. Calculate the amount of heat gained or lost by the copper.

A. Hot to cold.
B. Copper
C. Water
D. Above (it gains Q)
E.
F. 0J
G. −98.2°C (Tf−Ti)

6. The Celsius thermometer below is used to measure the temperature of 2 kg of water. We will assume that the water is at normal atmospheric pressure.



A. Label the boiling point and freezing point of water.

A.

B. Label the phases of water on the thermometer.

B.

C. Label the Cp's for the different phases of water.

C. See "Heat" notes

D. Label the present reading as T_1.

D.

E. In what phase is water at this temperature?

E. Steam (over 100°C)

We want to lower the 2 kg of water to −10° C.

F. Mark the desired temperature as T_2.

F.

G. What is the lowest temperature water will stay steam?

G. 100°C

H. What will be the change of temperature during its gaseous phase (ΔT_{steam})?

H. Tf−Ti = (100−140) =−40°C

I. Calculate the heat change for the water to lower it to 100°C.

I. $Q = mc_{p\ steam}\Delta T$ = 2(2010)(−40) = −1.61E5 J

Now the 2 kg of water is at 100°C. At this point heat must be removed to UNvaporize it into liquid water. $Q = mL_{vaporization}$ *and* $L_{vapor\ for\ water} = \pm 2.26\times10^{6}$ *J/kg.*

J. How much heat must be removed to UNvaporize (condensate) the 2kg of water to liquid water?

J. 2(−2.26E6) = −4.52E6 J (− since condensating)

K. What will be the initial temperature of this water when it has turned to liquid?

K. 100°C

Now this liquid water needs to be cooled to −10° C.

L. But what is the lowest temperature for liquid water?

L. 0°C

M. What will be the change of temperature of this water during its liquid phase (ΔT_{liquid})?

M. Tf−Ti = 0−100 = −100°C

N. Calculate the heat added or removed from the liquid water to lower it to 0°C.

N. $Q = mc_{p\ liquid}\Delta T$ = 2(4186)(− 100) = − 8.37E5J

Of course, now you have to convert it to ice. The equation is $Q = mL_{fusion}$ *and* $L_{fusion\ for\ ice} = \pm 3.33\times10^{5}$ *J/kg. It is + when melting and −when freezing.*

O. Calculate the total heat added or removed to freeze the water at 0°C.

O. 2(-3.33E5) = −6.66E5 J (− since freezing)

P. Now how much heat is added or removed to lower the water from 0°C to −10°C?

P. $Q = mc_{p\ ice}\Delta T$ = 2(2090)(−10) = − 4.18E4J

Q. Now calculate the total heat added or removed to change 2 kg of ice from 140°C to −10°C

Q. $Q_{steam} + Q_{condensation} + Q_{liquid} + Q_{freeze} + Q_{ice}$ =
−1.61E5 J
− 4.52E6 J
− 8.37E5J
− 6.66E5 J
− 4.18E4 J =
Q_{total} = −6.23E6 J

1A) → 1B) ←
4A) both 4C) I 4E) II (gas pushes up and moves up) 4F) II (piston pushes down, but moves up)
4G) I 4H) I (gas is compressed)