

AOS 100/101  
Spring 2019  
HMWK #2  
Solutions

**1)** The water at the lake surface is the only water in contact with the cold overlying air. Consequently, it is cooled by conduction by that contact. As the surface layer of water cools by conduction, it becomes more dense and sinks to lower depth in the lake and is replaced by warmer water that had resided just below the surface. This water is then in position to be cooled by conduction, become denser and sink. The sinking is part of a convection process that mixes large volumes of water. This cycle continues so long as the air above is colder than the water *and* the water is not yet as cold as 34°F. Once it gets to that temperature any further cooling of the surface layer of water will NOT result in sinking as all the water below it (at 34°F) will be denser than the colder overlying water. Just a bit more cooling below 34° will initiate the formation of ice. Since this combination of conduction and convection takes time, the lake with less water in it (the shallow lake) will freeze first.

**2)** Snow is an excellent absorber and emitter of infrared (IR) radiation. Snow cover has two sides, an underside (that makes contact with the Earth's surface) and a top side (that faces the sky). Overnight the underside absorbs the IR emitted by the surface of the Earth. Since snow is so good at absorbing that energy, only the thinnest layer of snow on the underside really benefits from that absorption. Very little IR energy is transmitted through the snow. On the top side of the snow, there is a lot of emission of IR energy to space and, depending on the depth of the snow layer, sometimes little absorption of IR from the underlying surface. When the snow is deep, there is NO absorption of energy from the surface and so the top surface of the snow loses energy all night long without any replenishment. Consequently, the surface of a deep snow layer gets VERY cold and air in contact with it gets very cold as well.

**3)** Since Object A experiences a steady decrease in temperature, you have to conclude that it is emitting more energy than it is absorbing. Since we do not know how rapidly the temperature is decreasing all we can safely say is that Object A must be emitting more than 100 units of energy. Thus, it is NOT in radiative equilibrium.

**4)** Set 2 has to be the initial condition because heat cannot be transferred between objects at all if there is no temperature difference between them. Set 1 indicates there is a hot reservoir and a cold one. In such a case, the Second Law asserts that the transfer will go from the hot fluid to the cold fluid. The result would be that the originally hot fluid would cool off and the originally cold fluid would heat up, rendering both of them cool.