AOS 100/101
Spring 2017
SOLUTIONS
HOMEWORK #2

1) In order to get the surface of a lake to freeze, a substantial amount of heat has to be removed from the lake. Since water is most dense at 34F, once a parcel of water is cooled to 34F it will sink to the bottom of the lake. When cold air moves over the top of the lake, the surface water is cooled by conduction. As that water is made colder and more dense, it sinks and is replaced at the surface by new water. This is convection in action. The new water then cools by conduction and the cycle of cooling by conduction, followed by convection continues until the surface water on the lake is cooled below 32F at which point it freezes. Before this happens, all of the water in the lake has to have been cooled to 34F in order that the top layer of water can finally cool to 32F and freeze. Naturally, the lake with more water in it will take longer to cool to this point than the shallow lake.

2) Another way to interpret the statement that "Snow behaves like a black-body with respect to infra-red radiation" is to say that snow is able to absorb and emit infra-red radiation extremely well. If a person inhabits an igloo or a snowcave, the infra-red radiation emitted by that person is readily absorbed by the snow on the inside wall of the igloo or cave. This absorption warms the snow and the snow begins to re-radiate infra-red back into the inside of the igloo. Since humans are able to keep body temperature constant, there is a constant source of infra-red radiation inside the igloo. The snow, with its excellent absorbing and emitting characteristics acts like a "trap" for this infra-red radiation, allowing it to collect inside and gradually warm the igloo. Thus, the igloo with the dozen dogs will be much warmer than the igloo with the supplies. The sled-dog racer's igloo would be warmer than the supplies but not as warm as the dog's igloo.

3) If the object is absorbing 100 units of radiant energy every second AND is cooling down, then it must emitting more than 100 units of radiant energy. Recall that radiative equilibrium is the condition in which the amount of radiation absorbed is equal to the amount emitted. In that case, the temperature of the object does not change. If more radiation is emitted than absorbed, the temperature of an object will increase. That is the case in this example.

4) The Second Law of Thermodynamics asserts that heat is transferred in only one direction; namely from warmer objects to cooler objects. Since heat transfer takes time, one could say that as time moves forward, heat is transferred from warm objects to cooler objects. The set of observations called SET 1 in Fig. 1 exhibits fluids of nearly the same temperature. SET 2 in Fig. 1 exhibits a cold fluid placed within a hot fluid. The Second Law asserts that heat would be transferred from this hot fluid to the cold fluid and the final result would be two fluids with roughly the same temperature. Therefore, SET 2 has to have been the initial condition of this experiment.