1. Suppose a clothed person can be represented as a cylinder 170 cm tall with a radius of 15 cm, with a skin temperature of 30 **°**C. Assume the person radiates as a blackbody.  
   1. Calculate the radiative power of the person in Watts.
   2. Imagine that this person is standing alone in the middle of a room in which all the walls, ceiling, and floor have a constant temperature of 22 **°**C.  
        
      Calculate the net rate of energy gain or loss by the person in Watts.
   3. Using your answer from part (b), calculate the number of *dietary calories* the person must consumer each day to stay “warm” (alive!). [**HINT: 1 dietary calorie (kcal) = 1000 calories; 1 calorie = 4.186 Joules]**

1. Surface temperature at sunset in Fort Collins in May is about 15 **°**C.
   1. Using this temperature and assuming the surface emits thermal radiation as a blackbody, calculate the rate of radiative cooling of the surface in Watts per square meter.
   2. The volumetric heat capacity soil is about 1.5 x 106 J K-1 m-3. This means it take 1.5 million Joules of heat to heat or cool a cubic meter of soil by 1 degree Kelvin (same as Centigrade).   
        
      Assuming that the rate of cooling of the surface you found in (a) is the only energy transfer, and that the top 10 cm (0.1 m) of soil cools at night, calculate how many degrees would the soil cool during a 10-hour May night in Fort Collins. Using this value, estimate the surface temperature at sunrise.
   3. In reality, the average morning low temperature in Fort Collins is about 44 **°**F (7 **°**C), so there has to be another source of energy besides the one we calculated in part (a). A tiny amount comes from the air and from deep underground, but not even close to enough to keep the surface warm. Where does the extra energy come from?
2. Use the toy model called “Two-layer graybody atmosphere” found on the web at <http://bit.ly/1KAK3pa> to answer the following questions. The model lets you vary the absorptivity (also called emissivity) of the layers of air, and also the amount of convective mixing of heat from the surface into the atmosphere. You will probably need the “Diagram” tab for this problem.
   1. Increase the emissivity of the lower layer to 0.75 and the upper layer to 0.65. What are the temperatures of the surface, lower atmosphere, and upper atmosphere? How does the simulated surface temperature compare to the actual global mean surface temperature of the Earth?
   2. Is it reasonable that the emissivity (absorptivity) of the lower atmosphere is greater than the upper atmosphere? Why or why not?
   3. Add convective mixing of heat: 100 W m-2 from the surface to the lower atmosphere and 50 W m-2 from the lower to upper atmosphere. What is the effect on the temperature of each layer? Is this arrangement more or less realistic than the situation you simulated in part (a)?
   4. Turn down the brightness of the Sun by 10%. Can you bring the surface temperature back up to the Earth’s average surface temperature by adjusting the emissivity of the atmospheric layers? What values for the emissivity did you use?