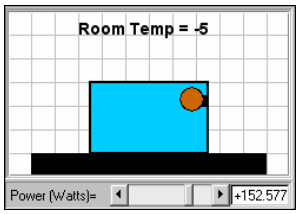
Worksheet for Exploration 19.4: Heat Balance



The animation depicts an incubator for chicks. Inside the box is a heat lamp with varying power. The incubator is made of material with a thermal conductivity of 0.15 W/m*K and of thickness 2 cm. The dimension of the box you cannot see (the depth of the box going into the screen) is 0.3 m (**position is given in tenths of meters and temperature is given in degrees Celsius**). As you change the power of the heat lamp, notice how the inside equilibrium temperature changes, as does the energy/time (power) lost by conduction through the walls to the outside. Restart.

The box must also be coated in a shiny reflective material (foil) so that there are no significant contributions through radiative heat exchange processes. The only significant energy exchange process is conductive.

a. The animation shows an instantaneous change in temperature as you change the heater power. Explain why this is nonphysical (the temperature does not change instantly as shown). What determines how long it will actually take for the system to reach equilibrium?
   i. In other words, the animation calculates and then shows the final equilibrium condition and makes no attempt to show the approach to equilibrium. It jumps right to the end result.

b. When the heater runs at 50 W, calculate the energy lost through conduction using $P = (kA/x)\,\Delta T$, where k is the thermal conductivity (0.15 W/m*K in this case), A is the surface area of the box, x is the thickness of the box material, and ΔT is the temperature difference between the inside of the incubator and the outside environment. This should be equal to the power delivered by the heater (50 W).
   i. Show that you get this result.

c. By equating the energy/time into the box (from the heat lamp) to the energy lost from the box (by conduction out through the walls), predict the power required from the heat lamp to keep the box at $27^{\circ}C$.

$P_{prediction}$=_____

d. Check your prediction by varying the heat lamp power. Note that if there are chicks in the incubator, they will radiate heat as well, and so the heat required from the heat lamp will be reduced.

$P_{measured}$=_____