Newton's Law of Cooling

Newton's Law of Cooling deals with the rate at which an object will change temperature when brought into a new environment of constant temperature. The law is:

Newton's Law of Cooling
$T = T_s + \left(t_0 - T_s\right)e^{-kt}$ T is the temperature of the object at time t, T_s is the surrounding temperature of the environment, t_0 is the initial temperature of the object.

Notice that, **just like in previous equations, the sub 0 always designates initial conditions.** Also, you will not have to memorize this formula. If you need it, I will give it to you.

These problems are not bad but they usually do take a bit of algebra to get to the answer. Let's do a problem using this formula.

In this problem a pan of warm (46^{o} C) water is put into a refrigerator to cool down. At t = 10, T = 39^{o} C and 10 minutes later (at t = 20), T = 33^{o} C. We need to find how cold the refrigerator is, T_s .

$39 = T_s + \left(46 - T_s\right)e^{-10k}$ $33 = T_s + \left(46 - T_s\right)e^{-20k}$	First we will use the data given to set up two equations, using the given information about time and temperature.
$e^{-10k} = \dfrac{39 - T_s}{46 - T_s}$ $33 = T_s + \left(46 - T\right)\left(\dfrac{39 - T_s}{46 - T_s}\right)^2$ $33 = T_s + \dfrac{\left(39 - T_s\right)^2}{46 - T_s}$	I am going to solve for e^{-10k} in the first equation. Now I am going to put this in the second equation since the square of e^{-10k} is e^{-20k}. Simplify.
$1518 - 33T_s = 46T_s - \left(T_s\right)^2$ $+1521 - 78T_s + \left(T_s\right)^2$	Multiply through by the 46 - T_s. Square the binomial on the right side.
-3^{o} C = T_s	Simplify. Notice how that horrible-looking algebra problem turned out nicely! We just had to keep plodding along carefully.