1. The following equation for the temperature $T = T(t)$ represents a spherical thermocouple with convective conditions and includes radiation exchange with its surrounding walls

$$c_2 \frac{dT}{dt} = -(T - T_\infty + c_1(T^4 - T_{sur}^4)).$$

In this equation, $c_1 = 1.27575 \times 10^{-10} K^{-3}$ and $c_2 = 0.991667s$. If it is assumed that $T_\infty = 473.15$, $T_{sur} = 673.15K$, and $T(0) = 298.15K$, determine the time t_s at which $T(t_s) = 490.85K$.

We can start by expressing our derivative in a discreet form. This gives the equation

$$c_2 \left(\frac{T(n+1) - T(n)}{\Delta t} \right) = -(T - T_\infty + c_1(T^4 - T_{sur}^4)).$$

Solving this for $T(n+1)$ gives

$$T(n+1) = -\frac{\Delta t}{c_2}(T - T_\infty + c_1(T^4 - T_{sur}^4)) + T.$$

We can model this simply in C:

```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <unistd.h>

int main(int argc, const char* argv[]){
    float temps [10000];
    temps[0] = 298.15;
    float starttime = 0;
    float deltat;
    if(argc > 1)
        deltat = atof(argv[1]);
    else
        deltat = 0.001;
    float c2 = 0.991667;
    float c1 = 1.27575 * powf(10,-10);
    float tinf = 473.15;
    float tsur = powf(673.15,4);
    FILE* fp = fopen("data.txt","w+");
    int i = 0;
    for(i = 0; i < 10000 && temps[i] < 490.85; i++){
        if(i % 10 == 0){
            fprintf(fp, "%f\n", temps[i]);
        }
        temps[i + 1] = (-1) * (deltat/c2) * (temps[i] - tinf + c1 * (pow(temps[i],4) - tsur)) + temps[i];
        starttime += deltat;
    }
    fclose(fp);
}
```