Assignment 9 - Interim Project Deliverable #2

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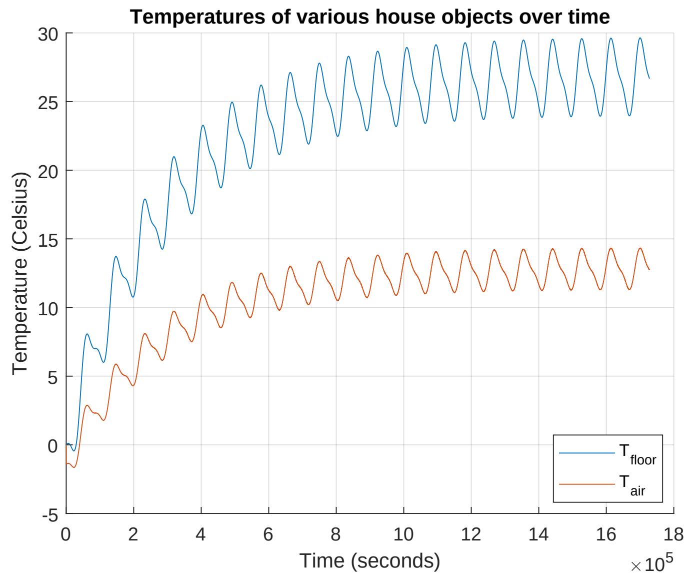

Figure 1: Our initial plot of T_{floor} and T_{air} over 20 days

The model seems pretty good! We're getting a good heat cycle as the heat flux of the sun changes over time, but we reach a pretty stable 13 degrees celcius after a week or so, with nominal high and low temps at 11.3 and 14.3 degrees Celcius respectively. My (Aydin's) only concern is that the floor seems much to hot to live comfortably in. This can probably be tuned with several parameters, though. If we make the floor store a little less heat, then it might be more comfortable while not making the house appreciably colder. Note that we're defining the start of the simulation as if the house merely started existing in space; this could represent the completion of the house or the sealing of it as a closed thermal space. Next steps are probably expanding

the model to include the roof of the house as a thermal capacitance directly heated by the sun. This was in our original scoping, but we pared it down a little for the MVP. Our MATLAB script is shown below. We

define our constant variables, our input parameters, and do some basic math and solve our system of thermal equations to find the resultant temperatures of the floor and air with respect to time.

```
clc, clear all

% todo:
% find thermal resistance(s) for each heat flow
% find actual thermal properties of each object


% heat flows:
%    sun -> floor
%        just qA, with A as window area
%    floor -> air
%        just convection im pretty sure
%    air -> outside
%        parallel convection through the walls/roof/window

num_days = 20
tspan = [0 86400*num_days]; % s

% house dimension parameters
h_length = 6; % m
h_width = 2; % m
h_height = 3; % m

g_height = 2; % m
g_area = h_length * g_height; % m ^ 2
% g_thick = 0.005; % m

r_height = sqrt(h_width^2 + (h_height - g_height)^2); % m
r_area = h_length * r_height; % m ^ 2
% r_thick = 0.1; % m

bwa_area = h_length * h_height; % m ^ 2
swa_area = (g_height * h_width) + .5 * (h_width * (h_height -
    g_height)); % m ^ 2
wa_thick = 0.1; % m

f_area = h_width * h_length; % m ^ 2
f_thick = 0.5; % m

ins_net_area = bwa_area + 2 * swa_area + r_area + f_area;

% house material properties
f_density = 0; % kg / m ^ 2

% material thermal properties
h_glass = .7; % W/m^2-K
```

```
h_in = 15; % W/m^2-K
h_out = 30; % W/m^2-K

k_wall = .4; % W/m-K

v_air = swa_area * h_width; % m^3
d_air = 1.225; %kg/m^3
m_air = d_air * v_air; %kg
c_air = 1012; %J/kg-K

v_abs = f_area * f_thick; % m^3
d_abs = 3000; % kg/m^3
m_abs = d_abs * v_air; % kg
c_abs = 800; % J/kg-K

C_abs = 800 * m_abs % J/K
C_a = c_air * m_air; % J/K

% partial resistances
R_abs_air = 1/(h_in * f_area);

R_air_wall = 1/(h_in * ins_net_area);
R_wall_wall = wa_thick/(k_wall * ins_net_area);

R_air_glass = 1/(h_in * g_area);
R_glass_glass = 1/(h_glass * g_area);

R_outer_air = 1/(h_out * ins_net_area);

% equivalent resistances
R_fa = R_abs_air; % total thermal resistance from floor to air
R_ao = + 1/(1/(R_air_wall + R_wall_wall)+1/(R_air_glass + R_glass_glass)) + R_outer_air; % total thermal resistance from air to outside

% f = @(t,T) [(1/C_abs)*(g_area*(-361*cos(pi*t/43200) + 224*cos(pi*t/21600) + 210) - ((T(1)-T(2))/R_fa)); ...
%             (1/C_a)*((T(1)-T(2))/R_fa) - (T(2)-(6*sin((2*pi*t/86400)+3*pi/4)-3)/R_ao)];

f = @(t,T) [(1/C_abs)*(g_area*(-361*cos(pi*t/43200) + 224*cos(pi*t/21600) + 210) - ((T(1)-T(2))/R_fa)); ...
            (1/C_a)*(((T(1)-T(2))/R_fa) - (T(2) - -3)/R_ao)];

[t,dT] = ode45(f, tspan, [0 0]);

```

```
hold on;
grid on;
plot(t,dT,'-')
legend("T_{floor}", "T_{air}");
title("Temperatures of various house objects over time");
xlabel("Time (seconds)");
ylabel("Temperature (Celsius)");
hold off
```