

Simple Model

%define constants

k_wall = .04; %W/m-K

%sa_wall = total surface area of wall in contact with internal air

sa_wall = (.2*5) + (5.1*5) + (3*5) + (5.1*5) + (.4*5); %m^2

L_wall = .05; %m

d_floor = 3000; %kg/m^3, based on d for recycled ceramic tile

c_floor = 800; %J/kg-K, based on c for recycled ceramic tile

v_floor = 5.1 * .05 * 5; %m^3

C_floor = d_floor * v_floor * c_floor; %J/K

sa_floor = 5.1*5; %m^2

sa_window = 2.6*5; %m^2

h_eq_window = .7; %W/m^2-K

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

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

%start with constant air temp, confirm model works, then switch to sinusoidal

T_out = -3; %degC

%Calculate Resistances, these Rs are defined in doc named

%updatedSimpleModel

R0 = 1/(h_in * sa_floor);

R1 = 1/(h_in * sa_wall);

R2 = L_wall/(k_wall * sa_wall);

R3 = 1/(h_out * sa_wall);

R4 = 1/(h_in * sa_window);

R5 = 1/(h_eq_window * sa_window);

R6 = 1/(h_out * sa_window);

RA = R1 + R2 + R3;

RB = R4 + R5 + R6;

%Equations

t_span = [0 60*60*24*20];

Q_in = @(t) ((-361*cos(pi * t/(12*3600)) + 224*cos(pi * t/(6*3600)) + 210)*sa_window);

dFloordt = @(t, T_floor) ((Q_in(t) - ((T_floor - T_out)/(R0 + (1/RA + 1/RB)^-1)))/C_floor);

[t, Temp_floor] = ode45(dFloordt, t_span, T_out);

T_air = Temp_floor - R0*((Temp_floor - T_out)./(1/RA + 1/RB)^-1);

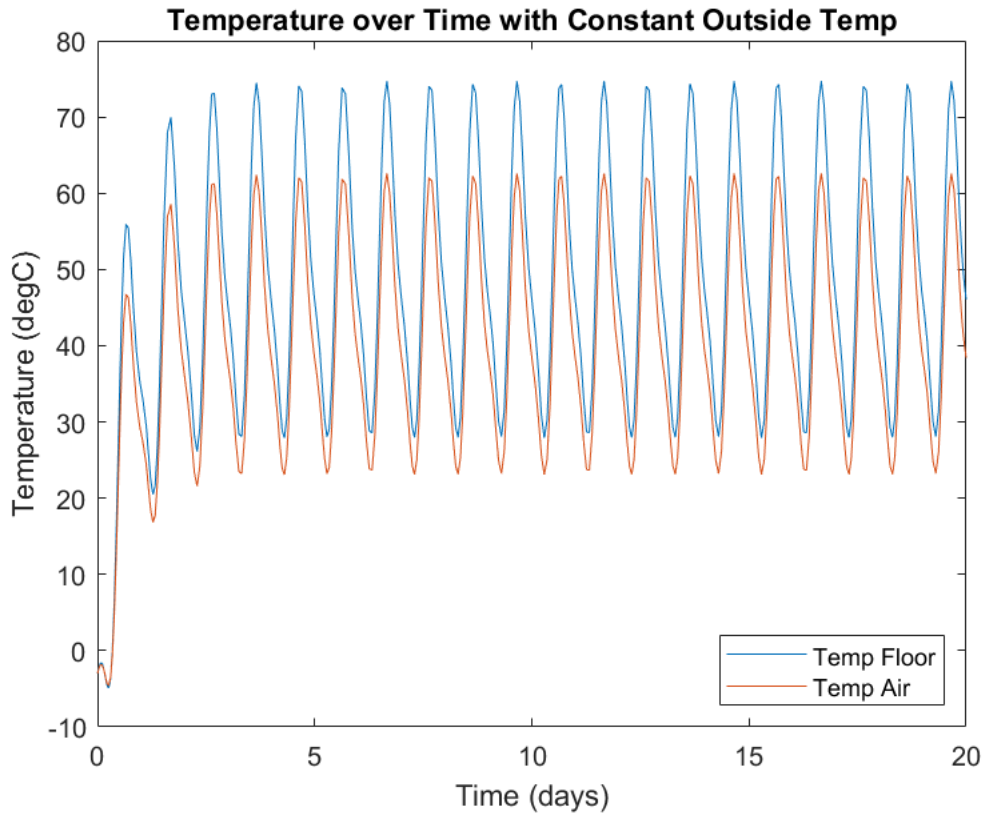
T_out_sin = @(t) (-3 + 6*sin((2*pi*t)/(24*60*60)) + (3*pi)/4);

dFloordt_sin = @(t, T_floor_sin) ((Q_in(t) - ((T_floor_sin - T_out_sin(t))/(R0 + (1/RA + 1/RB)^-1)))/C_floor);

[t1, Temp_floor_sin] = ode45(dFloordt_sin, t_span, T_out_sin(0));

T_air_sin = Temp_floor_sin - R0*((Temp_floor_sin - T_out_sin(t1))./(1/RA + 1/RB)^-1);

```
clf,
figure();
plot(t./(60*60*24), Temp_floor, t./(60*60*24), T_air);
legend('Temp Floor', 'Temp Air', 'Location', 'southeast')
title('Temperature over Time with Constant Outside Temp')
xlabel('Time (days)')
ylabel('Temperature (degC)')
```



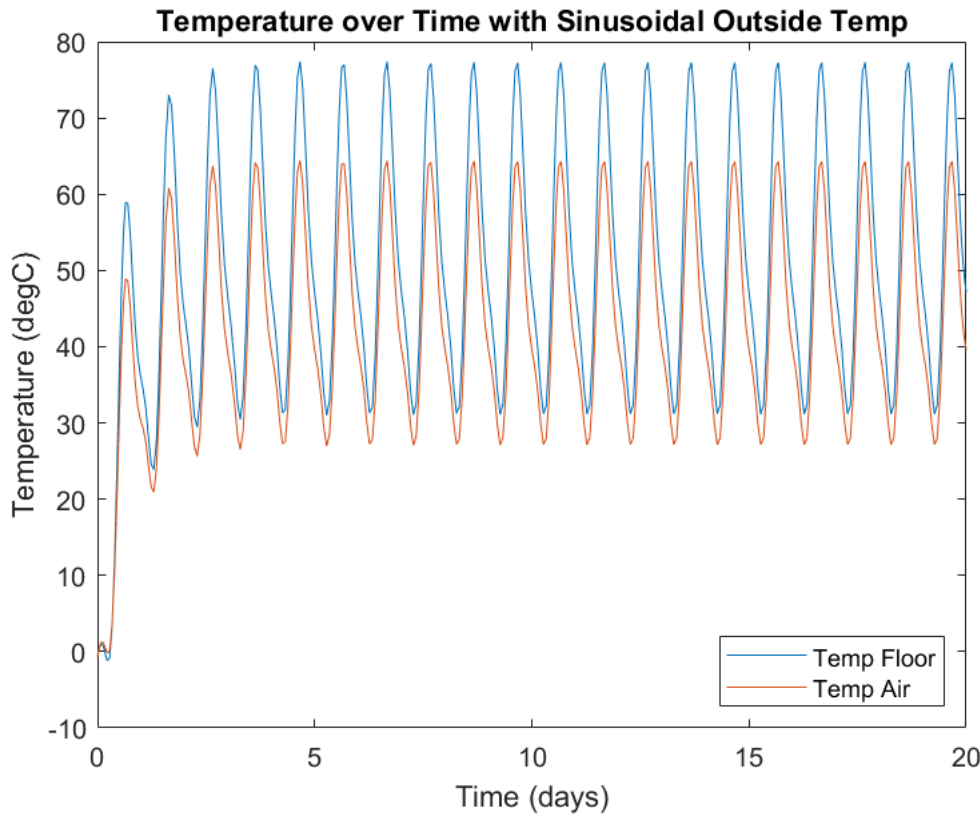
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minTempAir = min(T_air)
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```
minTempAir = -4.5990
```

```
maxTempAir = max(T_air)
```

```
maxTempAir = 62.6101
```

```
figure();
plot(t1./(60*60*24), Temp_floor_sin, t1./(60*60*24), T_air_sin);
legend('Temp Floor', 'Temp Air', 'Location', 'southeast')
title('Temperature over Time with Sinusoidal Outside Temp')
xlabel('Time (days)')
ylabel('Temperature (degC)')
```



```
minTempAirSin = min(T_air_sin)
```

```
minTempAirSin = -0.6438
```

```
maxTempAirSin = max(T_air_sin)
```

```
maxTempAirSin = 64.4410
```

Kindly note that we began exploring the variance in the floor temperature by attempting to use the sinusoidal equation for the external temperature. We noticed that the floor temperature is slightly higher with this equation as compared to that of constant external temperature.

Results

Based on the resultant plot, we can conclude that our passive solar house model, even though uncomfortably hot during peak solar hours with the floor temperature of about 75 degrees Celsius and inside air temperature around 65 degrees Celsius, is working reasonably well. At night the floor temperature decreases to almost 30 degrees Celsius, a significant change that leads the air temperature to go below 30 degrees Celsius. While this temperature is still quite warm, the temperature change is something to address in future iterations.

It was expected that the floor temperature would turn out to be higher than that seen in the previous QEA assignments due to the fact that the Sun in our model is exuding significantly more watts of energy compared to the heated floor in other examples. It is also worth noting that the plot of this model can be seen oscillating in a wave like form between each day over the given period of time as a result of the cos function in the equation for heat flux from the sun. This behaviour exhibits the increase of the air temperature in the house as the Sun

rises during the daytime and decreases as the Sun sets in the evening. The presence of heat from sunlight as a source of heat allows the house temperature to increase in the day. We also witness the temperature of the floor and the air in the house steadily increasing in the span of one month starting at the same temperature as the outside temperature (an assumption we made) and increasing until it reaches a plateau at 75 degrees Celsius.

The temperature of the air in the house also seems to steadily increase until about the 3rd day, and then plateaus at above 65 degrees celsius. Given that the heat from the sun goes directly into the absorber (a given assumption), which we have defined as the floor, and then heat leaves the floor and heats the air in the room through convection, the resulting temperature trends are logical. The air in the house should be a lower temperature than the floor because air has a lower heat capacity and is thus not as effective at storing heat as ceramic tile.

Considering that our model is reasonable but yields an uncomfortable internal temperature, we will focus on adjusting the absorbers, insulators, and perhaps the thickness of the wall in the next phase of this project.