QEA

Quantitative Engineering Analysis
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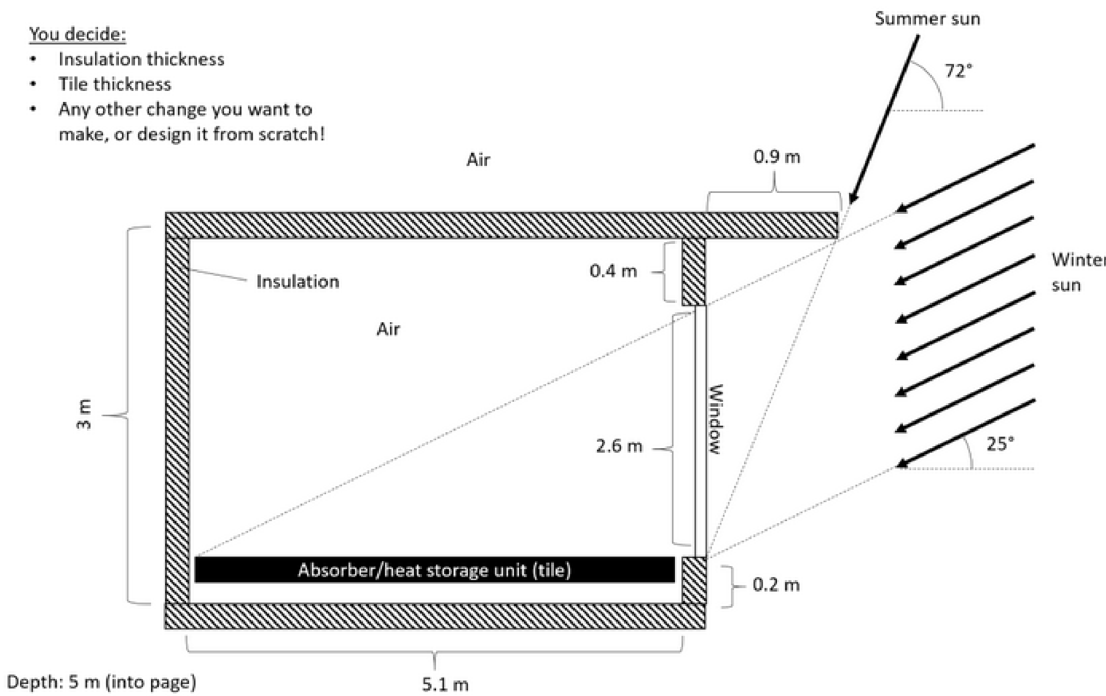
Background

Background: In a paragraph or two, introduce your project. What is a passive solar house, and why would someone build one? What are the basic working principles of passive solar houses? What is your team's approach to designing/optimizing a passive solar house for Massachusetts? You should reference at least two sources in this section.

What is a passive solar house?
What is our approach to designing a passive solar house for a winter in mass?
This is a project where we'll be modeling a passive solar house. A passive solar house is a house that heats solely from radiation from the sun. The radiation passes through south facing windows and hits a thermal mass inside the house. The thermal mass stores energy and slowly releases it as heat to keep the house warm. ___explain why building one would be good___. We're going to start with a 256 sq ft house with one big south facing window and a floor thermal mass that absorbs all the radiation that hits the window. Our house needs to stay at a reasonable temperature for living (17-25 degrees C) in Massachusetts winters (which average a daily low of 0 C in January, 2020)

Modeling:



Our House Design as Taken from The QEA Document***

Material	Heat transfer coefficient (W/m^2 K)	Conductivity (W/m K)	Heat capacity (J/kg K)	density (kg/m^3)	Our Area (m^2)	Our thickness (m)
Fiberglass	inside: 15 Outside: 30	0.04			143.24	.8
Tile (heat storage unit)	Inside: 15		800	3000	25	.1
Window	0.7	0.78 (found online)			6.76	.05

We can model the energy flux of the air inside the house as:

$Qnet = Qin - Qout$

Where $Qnet$ is the energy of the floor. So $Qnet = mc\frac{dT}{dt}$

Where Qin is radiation from the sun through the window and absorbed by the tile floor. We're assuming that all the sun energy that hits the window is being absorbed by the floor.
$Qin = qsun * Awin = -361cos(\pi t/(12 * 3600)) + 224cos(\pi t/(6 * 3600)) + 210$
Where $qsun$ is the normal component of solar flux through south-facing window in the winter, and $Awin$ is the area of the window.

We are modeling $Qout$ as energy from the floor to the outside air:
$Qout = (Tf - Ta)/Rtot$

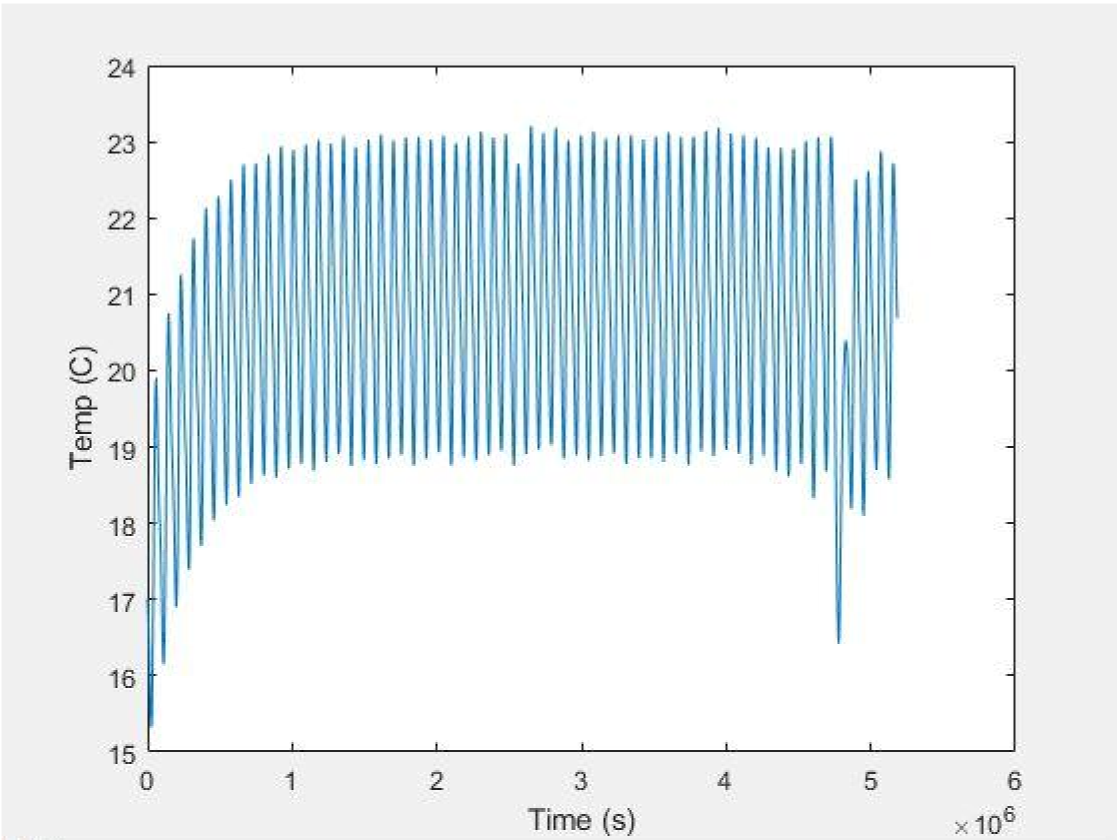
• Modeling: clearly explain the model using at least one graphic as well as equations and words. (Note: Screenshots of code may not substitute for explaining your model.) List major assumptions you made in modeling and why they are reasonable. Include the complete system of equations that comprises the model as well as any key material properties (e.g., if you use a unique insulation material, list its thermal conductivity); a table may be well-suited to listing material properties.
• Design and optimization: Using a diagram and words, describe the design of the house. Include
key dimensions and materials. If you use the default house design, you have our permission to include the diagram from this project description and cite this assignment as a reference. Choose values for exible parameters in your house design (at the minimum: thickness of insulation and heat storage unit) that lead to reasonable comfort (within about 17-25 ◦C air temperature indoors). Describe how these parameter values were chosen. These questions must be answered:
– How does the storage unit thickness affect the house's thermal behavior, and why?
– How does the insulation thickness affect the house's thermal behavior, and why?
You may (but do not have to) use plots or gures to help answer the questions above.
If you changed anything else about the design (besides thickness of insulation and heat storage unit), explain what you did, why, and how it affected the performance of the house.

Results and Discussion

• Results and discussion:
– Plot the solution for house temperature with your chosen parameters over a long enough time period that the solution approaches a periodic solution and with hourly (or ner) time resolution. Discuss the plot in the text.
– Plot the temperature over a single 24 hr period after the house has reached a consistent (periodic) temperature pattern. Annotate this plot with the minimum and maximum temperature the house reaches during the (winter) day. Discuss the plot in the text. How does your house

compare to typical dwelling temperatures?

Temperature of the house in the winter over 24 weeks



Discuss

A house that is fully passively heated is difficult to achieve in the northeast without major compromises in the design that impact comfort and function. After doing our analysis and changing some of the parameters, it is clear that each parameter is quite sensitive to changes that impact the comfort of the house as a whole. The best method for new construction would be to use some of the principles of passive solar design incorporated in the design, but not the main method for indoor air temperature regulation. Furthermore, as the ambient temperatures continue to rise in Massachusetts, it is projected that the heating degree-days will be 11-24% lower, but cooling degree-days will be 57-150% higher by the middle of the century****, the need for passive cooling will far exceed the need for passive heating. Thus using a relatively high thermal mass is a poor design choice as cooling

Considering your experiences with different temperatures, how would a person living in this house feel? What future improvements would be necessary or desirable to make this house comfortable?

References

Include a list of three or more references in any common formal style, such as IEEE or MLA. Cite references where used in the text by reference number or author/year, depending on your
chosen reference style.

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Source Code