# Heat Loss Lab: Designing and Insulating a Home Using the Engineering Design Process

Members of Team: _____

Step #1: Design Constraints

1. The home must have two stories
   a. Story #1 must be between 15 and 20 cm high
   b. Story #2 is the attic and must be between 5 and 10 cm high
2. The base of the home must have dimensions that are between 22–25 cm long (see below). Note: If you make a circular home the diameter must also be between 25-28 cm.
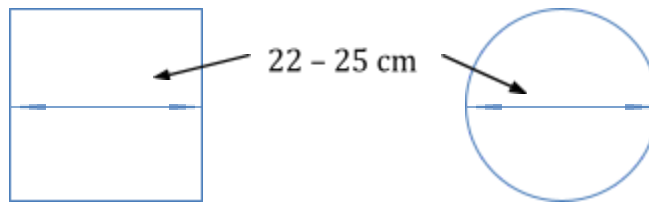
3. The home must have 2 doors that together have a total surface area of 80-100 cm^2 and 4 windows that together have a total surface area of $100 - 200$ cm^2
4. Sample homes are shown below

In the space below, draw a blueprint (front, side and top view) of your model home. Label the doors and windows and provide the basic dimensions of the home.

Front View   Back View   Top View

Side 1 View   Side 2 View

Step #2: Build a House
Using cardstock/thick paper and small sticks of wood, build your home. Hot glue the wood pieces together to make a frame for the house and then cover the sides and roof with paper. Packing tape will be used for the windows. Note: At this point, you do not need to make the home airtight!!! The purpose of this activity is to **improve** the thermal efficiency of the home.

Note: Once your house is built, show it to the teacher for a completion signature and prepare for initial data collection. Teacher: _____

Step #3: Pre-Test/Data Collections and Asking Design Questions
Problem: The home we have just built is not thermally efficient. We need to determine how to best insulate the home to eliminate excess heat loss. First, however, we need to conduct some science experiments on your house to collect data related to the heat loss problem.

Test #1 - Data Sheet: Before Insulation
1. Make a small hole in the roof of the house about 3 centimeters from the very top. Place an oven thermometer into the roof and conduct test #1 by turning on the furnace (light) and recording the temperature at the various time increments.
2. Record your data on the **Temperature Data Sheet/Graph Page**

Test #2: Thermal Images – Before Insulation
With your home placed over the testing station:
1. Turn on the furnace (light) and,
2. Use the Thermal Cam App on your iPad/iPhone to take thermal images from each of the sides and the top of the house.
3. Save these images to compare to the thermal images you will take **after** you insulate the home.

Test #3: Temperature Probe – Before Insulation
1. Pick and label 8 different locations in which you can measure the thermal energy escaping from your house.
2. Use the digital temperature probe to determine the temperature of these locations with the furnace (light) on. To do this, turn on the light (furnace) for 60 seconds and then begin recording temperature data.
3. Record your data on the **Temperature Data Sheet/Graph Page – Page 4.**

Step #4: Insulate the Home

Budget Sheet: Thermal Insulating Materials

Now that you have collected the data for the home (before insulation), it is time to insulate your home. In this activity, you will be given a budget of $1000 to insulate your house. **You must use at least three types of materials.** The cost of each material is given below. Use your money wisely!!!!!!!!

Material	Price	Units Purchased	Total Cost
Recycled Foam Strips (3cm x 3cm x 10cm)	$50 each		
Cotton Balls	$15 each		
Sheet of Fabric 30 cm x 30 cm	$100 each		
Packing Peanuts	$15 each		
Napkins	$15 each		
Sheet of Bubble Wrap 30 cm x 30 cm	$100 each		
Newspaper	$50 per sheet		
Other? (Negotiate with the teacher)			
Total Cost of Thermal Insulating Materials			

Step #5: Post-Test Data Collection (After insulation)

Test #1 - Data Sheet: House with Insulation
1. Place an oven thermometer into the roof like before and conduct test #1 by turning on the furnace (light) and recording the temperature at the various time increments given (See the **Temperature Data Sheet/Graph Page)**
2. Record your data on the **Temperature Data Sheet/Graph Page**

Test #2: Thermal Images – After Insulation

With your home over the testing station:
1. Turn on the furnace (light) and,
2. Use the Thermal Cam App on your iPad/iPhone to take thermal images from each of the sides and the top of the house.
3. Save these images to compare to the thermal images you took **before** you insulated the home.

Test #3: Temperature Probe
1. Using the same 8 places from your pre-test and with the furnace (light) on, use the digital temperature probe to measure the thermal energy escaping from your house.
2. To do this, turn on the light (furnace) for at least 60 seconds to let the house warm up and then begin recording temperature data.
3. Record your data in the table below**.**

Item #	Location	Temp: Before Insulation	Temp: After Insulation
1			
2			
3			
4			
5			
6			
7			
8			

Temperature Data Sheet

Time Period	Temperature (No Insulation)	Temperature (With Insulation)
Start- Turn Light On		
30 s		
1 min		
1 min 30 s		
2 min		
2 min 30 s		
3 min		
Turn Light Off		
30 s		
1 min		
1 min 30 s		
2 min		
2 min 30 s		
3 min		

Graph:

5
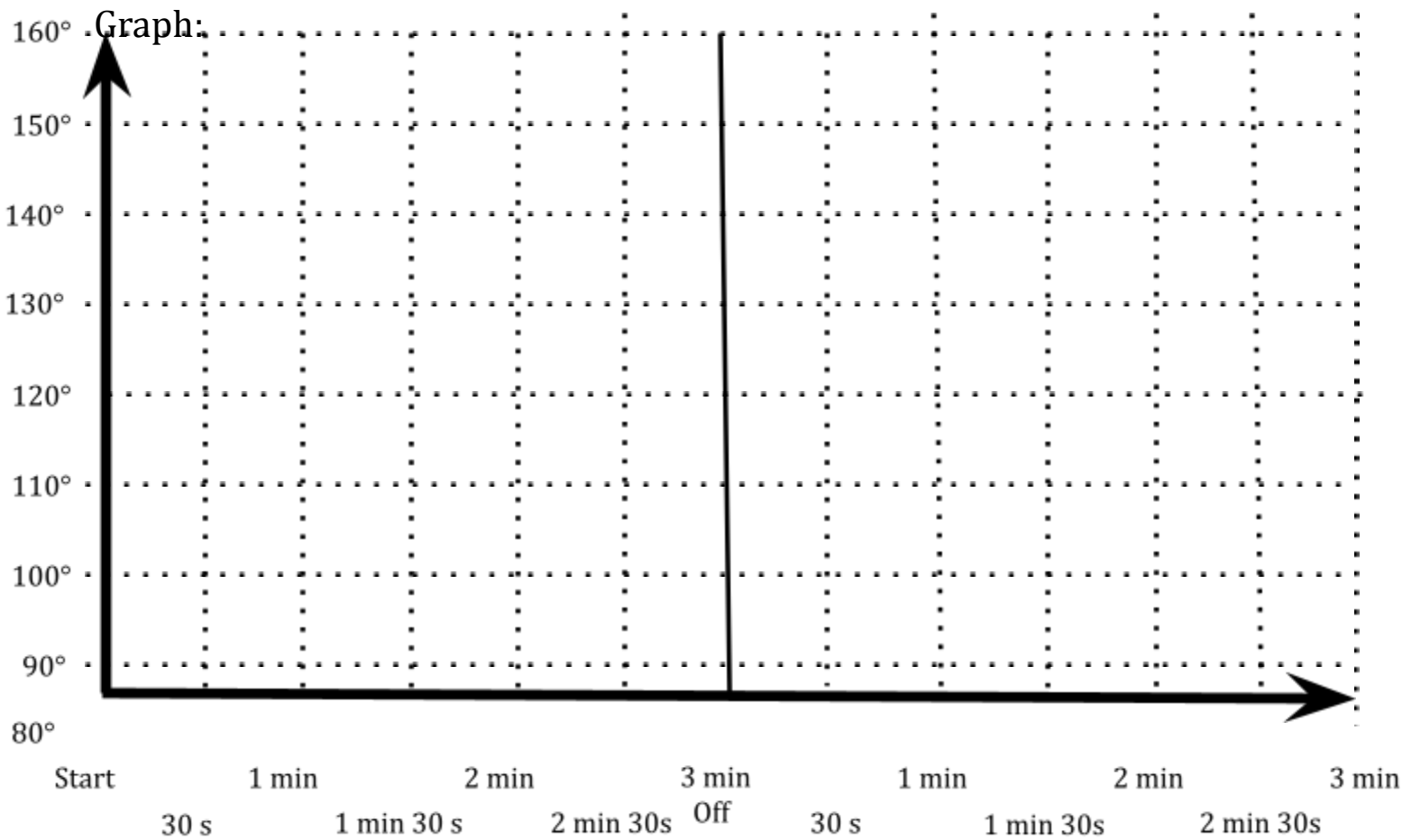
Scoring the Efficiency of Your Home / Calculations

1. **Determine the high temperature score** for the <u>insulated house</u> at the 3 minute mark (see the graph).　　　Your High Temp Score Insulated = _____
2. **Determine the Time score** (Note: the Time Score tells us how well your insulated home retains the heat once the furnace (light bulb) is turned off. To determine the Time Score you need the High Temp Score at the 3 minute mark and the final temperature after the 3 minute cool down time.
   a. Time Score = (Temp (after cool down) / High Temp) * 100
   b. Your Time Score = _____%
3. **Improvement Score:** The improvement score is the percentage of the improvement from the high temp of the non-insulated home to the high temp of the insulated home. To calculate the improvement score, use the following formula: ((High Temp of Insulated – High Temp of non-insulated) / High Temp: non-insulated)) * 100
   a. Your Improvement Score = _____%

Rubric for scoring

	Excellent (50 – 40 points)	Good (39 – 20 points)	Need to redesign (20-0 points)	Score
Documentation and Data	Drawings, costs, data and graphs are all completed and easy to read and understand	Drawings, costs, data and graphs are all completed	Missing drawings, costs data or graphs	
High Temp Score (insulated house)	High Temp Score of 150° = 50 points Minus 1 point for every 5° less than 150° Bonus 1 point for every 5° more than 150°			
Time Score (Insulated house)	Time (efficiency) score of 75% after a 3 minute cool down period = 50 points Minus 1 point for every % point less than 75% Bonus 1 point for every % point greater than 75%			
Improvement Score MTN: Max Temp Non-insulated = _____° MTI: Max Temp Insulated = _____° ((MTI – MTN) / MTN)) * 100	Improvement Score of 25% = 50 points Minus 1 point for every % point less than 25% Bonus 1 point for every % point greater than 25%			
Cost Score	1 point for every $100			

Use the following equation to determine the final score for this activity

　　　　　　High Temp score (from insulated house)
　　　+　　Time score (from insulated house)
　　　+　　Improvement Score
　　　-　　 <u>Cost Score   </u>
　Total Score=_____