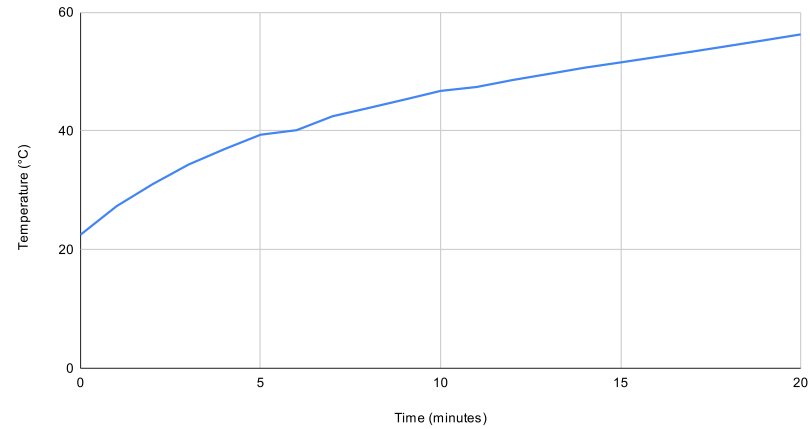


### 1.3.4 Renewable Insulation

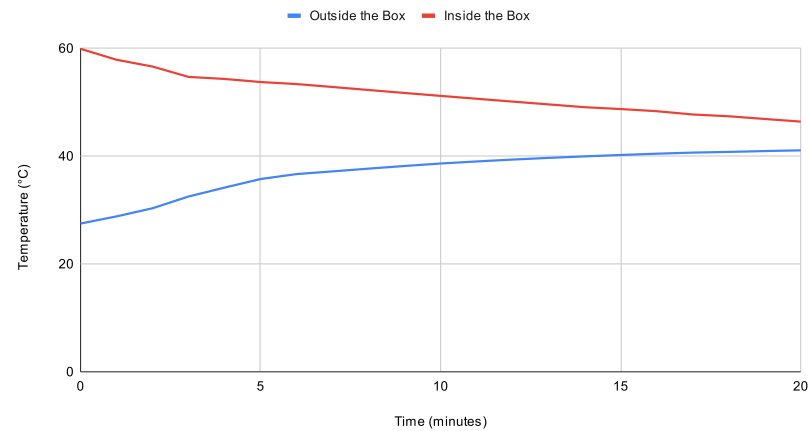
Data Collection and Analysis

Data				
#	Heating Phase			
	Time (min)	Temp (C)		
1	0	22.51		
2	1	27.31		
3	2	31.02		
4	3	34.33		
5	4	36.94		
6	5	39.36		
7	6	40.12		
8	7	42.47		
9	8	43.86		
10	9	45.28		
11	10	46.74		
12	11	47.4		
13	12	48.57		
14	13	49.6		
15	14	50.65		
16	15	51.54		
17	16	52.45		
18	17	53.37		
19	18	54.32		
20	19	55.28		
21	20	56.26		
#	Cooling Phase (out)		Cooling Phase (in)	
	Time (min)	Temp (C)	Time (min)	Temp (C)
1	0	27.5	0	59.91
2	1	28.83	1	57.88
3	2	30.34	2	56.62
4	3	32.52	3	54.7
5	4	34.17	4	54.32
6	5	35.76	5	53.75
7	6	36.68	6	53.37
8	7	37.18	7	52.83
9	8	37.69	8	52.27
10	9	38.18	9	51.72
11	10	38.64	10	51.18
12	11	39.02	11	50.65
13	12	39.37	12	50.12
14	13	39.68	13	49.6
15	14	39.96	14	49.08
16	15	40.22	15	48.74
17	16	40.46	16	48.34
18	17	40.66	17	47.73
19	18	40.79	18	47.4
20	19	40.95	19	46.9
21	20	41.08	20	46.41

Heating Phase



Cooling Phase Inside/Outside Box



**Problems:** Work each problem showing all work. For each problem, select equation(s), list all knowns and unknowns, substitute known values into equation(s), simplify and solve for desired value.

1 Mass of air being heated  $m = 0.004956 \text{ kg}$

Possible materials:  
- Felt  
- Electrical tape  
- cardboard  
- Aluminum Foil

8 in.  
6 in.  
6 in.  
8 in.  
Height = 7 in.

$6 \text{ in} \times 6 \text{ in} \times 7 \text{ in} = 252 \text{ in}^3$   
Convert  $\text{in}^3$  to  $\text{m}^3$   
 $252 \text{ in}^3 = 0.00413 \text{ m}^3$   
volume of air =  $0.00413 \text{ m}^3$

1) Mass of Air being heated (Density, volume needed)  
Mass = density  $\times$  volume  
Density =  $1.20 \text{ kg/m}^3$  } Known values  
Volume =  $0.00413 \text{ m}^3$   
 $1.20 \text{ kg/m}^3 \times 0.00413 \text{ m}^3 = 0.004956 \text{ kg}$  Mass = unknown (m)  
 $m = 0.004956 \text{ kg}$

2 Energy gained by the air in the box during heating - Q (heat) in J (joules)  
 $Q = 167.265 \text{ J}$

2) Energy gained by the air in the box during heating  
 $Q = mc\Delta T$

$(0.004956 \text{ kg})(1000 \text{ J/kg}^\circ\text{C})(33.75^\circ\text{C})$   
 $= 167.265 \text{ J}$   
 $Q = 167.265 \text{ J}$

$m = 0.004956 \text{ kg}$   
 $C = 1000 \text{ J/kg}^\circ\text{C}$   
 $\Delta T = (56.26^\circ\text{C} - 22.51^\circ\text{C}) = 33.75^\circ\text{C}$   
 $Q = \text{unknown}$

3 Energy lost by the air in the box during cooling - Q (heat) in J (joules)  
 $Q = -66.906 \text{ J}$  (Energy is being lost, so answer should be negative)

3) Energy lost by the air in the box during cooling  
 $Q = mc\Delta T$

$(0.004956 \text{ kg})(1000 \text{ J/kg}^\circ\text{C})(-13.5^\circ\text{C})$   
 $= -66.906 \text{ J}$   
 $Q = -66.906 \text{ J}$

$m = 0.004956 \text{ kg}$   
 $C = 1000 \text{ J/kg}^\circ\text{C}$   
 $\Delta T = (46.41^\circ\text{C} - 59.91^\circ\text{C}) = -13.5^\circ\text{C}$   
 $Q = \text{unknown}$

1.3.4 Renewable Insulation

Possible materials:  
- Felt  
- Electrical tape  
- cardboard  
- Aluminum Foil

8 in.  
6 in.  
6 in.  
8 in.  
Height = 7 in.

$6 \text{ in} \times 6 \text{ in} \times 7 \text{ in} = 252 \text{ in}^3$   
Convert  $\text{in}^3$  to  $\text{m}^3$   
 $252 \text{ in}^3 = 0.00413 \text{ m}^3$   
volume of air =  $0.00413 \text{ m}^3$

1) Mass of Air being heated (Density, volume needed)  
Mass = density  $\times$  volume  
Density =  $1.20 \text{ kg/m}^3$  } Known values  
Volume =  $0.00413 \text{ m}^3$   
 $1.20 \text{ kg/m}^3 \times 0.00413 \text{ m}^3 = 0.004956 \text{ kg}$  Mass = unknown (m)  
 $m = 0.004956 \text{ kg}$

2) Energy gained by the air in the box during heating  
 $Q = mc\Delta T$

$(0.004956 \text{ kg})(1000 \text{ J/kg}^\circ\text{C})(33.75^\circ\text{C})$   
 $= 167.265 \text{ J}$   
 $Q = 167.265 \text{ J}$

$m = 0.004956 \text{ kg}$   
 $C = 1000 \text{ J/kg}^\circ\text{C}$   
 $\Delta T = (56.26^\circ\text{C} - 22.51^\circ\text{C}) = 33.75^\circ\text{C}$   
 $Q = \text{unknown}$

3) Energy lost by the air in the box during cooling  
 $Q = mc\Delta T$

$(0.004956 \text{ kg})(1000 \text{ J/kg}^\circ\text{C})(-13.5^\circ\text{C})$   
 $= -66.906 \text{ J}$   
 $Q = -66.906 \text{ J}$

$m = 0.004956 \text{ kg}$   
 $C = 1000 \text{ J/kg}^\circ\text{C}$   
 $\Delta T = (46.41^\circ\text{C} - 59.91^\circ\text{C}) = -13.5^\circ\text{C}$   
 $Q = \text{unknown}$

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Date: 10/17/22

1.3.4 Renewable Insulation

1) Net energy retained within the box (2 net)  
Gained - Lost = Retained  
 $167.265 \text{ J} - 66.906 \text{ J} = 100.359 \text{ J}$   
 $Q(\text{net})/\text{Gained} = 167.265 \text{ J}$   
 $Q(\text{net})/\text{Lost} = -66.906 \text{ J}$   
 $Q(\text{net}) = 100.359 \text{ J}$

5) Qualitative Measure of Insulating Ability

$T_{\text{in}}(\text{max}) = 59.91^\circ\text{C}$   
 $T_{\text{in}}(\text{min}) = 41.09^\circ\text{C}$   
 $\Delta T(\text{max}) = 19.82^\circ\text{C}$

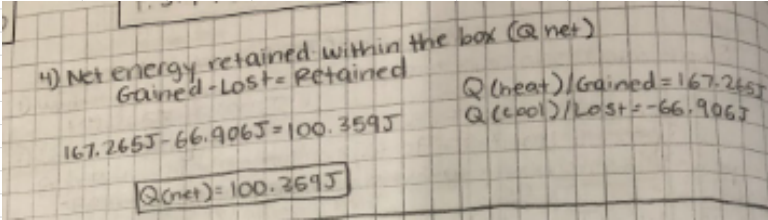
$\Delta T(\text{max}) = T_{\text{in}}(\text{max}) - T_{\text{out}}(\text{max})$   
 $\Delta T(\text{max}) = 59.91^\circ\text{C} - 41.09^\circ\text{C}$   
 $\Delta T = 18.82^\circ\text{C}$

Unit Cost of Panel

Material	Bulk/Industrial Cost	Amount per panel	Cost per panel
Natural Cotton	\$15.99 / 1,729 $\text{m}^2$	$256 \text{ in}^2 = 0.166 \text{ m}^2$	\$1.48
Battling	\$5.94 per $\text{m}^2$	$256 \text{ in}^2 = 0.166 \text{ m}^2$	\$0.98
Packing Tape	\$15.00 / 5,101 $\text{m}^2$	$67 \text{ in}^2 = 0.043 \text{ m}^2$	\$0.30
Tape	\$14.91 per $\text{m}^2$	$256 \text{ in}^2 = 0.166 \text{ m}^2$	\$1.68
Total Cost	\$13.93		\$1.68

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Date: 10/17/22

Complete Pages from Engineering Notebook

4	Net energy retained within the box - Q (heat) in J (joules) $Q(\text{net}) = 100.369 \text{ J}$		
			
5	A qualitative measure of your insulating ability is the difference between the maximum inside temperature and the maximum outside temperature (larger is better)		
	Tin (max)	=	59.91°C
	Tout (max)	=	41.08°C
	Change in T (max)	=	18.83°C
	