



Phase Change Engineering Internship

The E in STEM: Meaningful Content for Engineering





ASK

How can premature babies be kept at optimal temperature without an electrical sources?

-ask students to determine problems, info needed, and questions they might encounter in the process

Identify Problems/Questions

- What is optimal temp?
- Cost?
- What materials are safe to use?
- Allergies?

Imagine

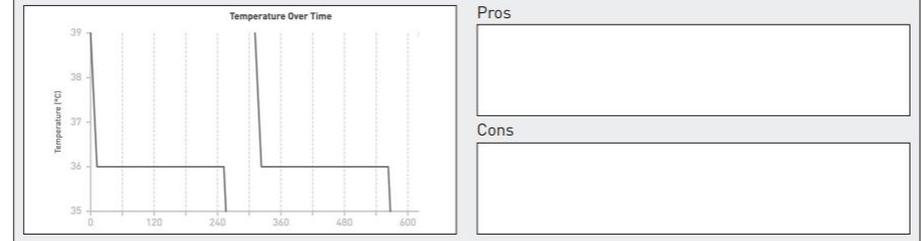
Investigate possible PCM (Phase Change Materials) to be used to make a portable baby incubator.

- Conduct a PCM Analysis of three different PCM
- Conduct an insulating materials test
 - material test
 - number of layers test

Isolating PCM A

 BUILD Design Details	 TEST Test Results		
PCMs Used: 4 × PCM A Insulating Material: None	Baby's Average Temperature [°C] <input type="text"/>	Time Outside Healthy Range (min) <input type="text"/>	Total Cost (\$) <input type="text"/>

plateau temperature: 36.0°C plateau time: long reheat time: 55 minutes cost: \$15



Circle which variable you are isolating for all your tests: **number of layers** OR **insulating material type**

 BUILD Design Details	 TEST Test Results		
PCMs Used: None Insulating Material: <input type="text"/> <input type="text"/>	Baby's Average Temperature [°C] <input type="text"/>	Time Outside Healthy Range (min) <input type="text"/>	Total Cost (\$) <input type="text"/>
layers	material		

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

 BUILD Design Details	 TEST Test Results		
PCMs Used: None Insulating Material: <input type="text"/> <input type="text"/>	Baby's Average Temperature [°C] <input type="text"/>	Time Outside Healthy Range (min) <input type="text"/>	Total Cost (\$) <input type="text"/>
layers	material		

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

Design Details:

PCMs Used: Insulating Material

PCM A PCM B PCM C LAYERS MATERIAL

0 0 4

PCM C PCM C

PCM C PCM C

FUTURA

EDIT



Design Details:

PCMs Used: Insulating Material

PCM A PCM B PCM C LAYERS MATERIAL

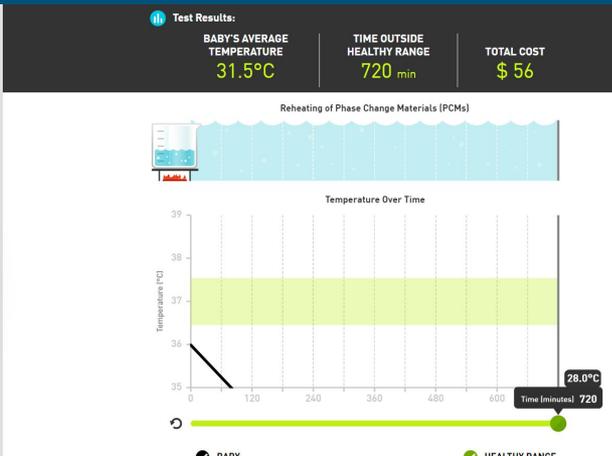
0 0 0 3 Wool

EMPTY EMPTY

EMPTY EMPTY

FUTURA

EDIT



Name: E. R. STEM Date: _____

Run each test and annotate the graph. After completing all three tests, summarize the pros and cons of each PCM.

Isolating PCM A

BUILD Design Details

PCMs Used: 4 × PCM A
Insulating Material: None

TEST Test Results

Baby's Average Temperature [°C] 35.8°C	Time Outside Healthy Range [min] 720 min	Total Cost [\$] \$80
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plateau temperature: 36.0°C plateau time: long reheat time: 55 minutes cost: \$15

Temperature Over Time

Pros
-highly basic for design
-only 1 reheat

Cons
-long reheat time
-temp too low

Isolating PCM B

BUILD Design Details

PCMs Used: 4 × PCM B
Insulating Material: None

TEST Test Results

Baby's Average Temperature [°C] 38.2°C	Time Outside Healthy Range [min] 628 min	Total Cost [\$] \$52
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plateau temperature: 38.6°C plateau time: short reheat time: 10 minutes cost: \$8

Temperature Over Time

Pros
-short reheat

Cons
-temp above healthy range

Phase Change Engineering Internship - Day 4
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Isolating PCM C

BUILD Design Details

PCMs Used: 4 × PCM C
Insulating Material: None

TEST Test Results

Baby's Average Temperature [°C] 36.4°C	Time Outside Healthy Range [min] 187 min	Total Cost [\$] \$108
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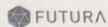
plateau temperature: 36.5°C plateau time: medium reheat time: 25 minutes cost: \$22

Temperature Over Time

Pros
-Least amount of time out of healthy range
-long plateau

Cons
Expensive

Insulating Materials Analysis



Name _____ Date _____

Circle which variable you are isolating for all your tests: number of layers OR insulating material type

BUILD Design Details	TEST Test Results			
PCMs Used: None	Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)	
Insulating Material:				
1 layers	Wool material	36.7°C	720min	\$32

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

BUILD Design Details	TEST Test Results			
PCMs Used: None	Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)	
Insulating Material:				
2 layers	Wool material	31.1°C	720min	\$44

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

BUILD Design Details	TEST Test Results			
PCMs Used: None	Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)	
Insulating Material:				
3 layers	Wool material	31.5°C	720	\$56

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

Conclusions

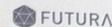
1. How do different insulating materials affect the baby's average temperature?

Wool is optimal material/

2. How does the number of layers affect the baby's average temperature?

more layers maintains temperature longer

Insulating Materials Analysis



Name _____ Date _____

Circle which variable you are isolating for all your tests: number of layers OR insulating material type

BUILD Design Details	TEST Test Results			
PCMs Used: None	Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)	
Insulating Material:				
2 layers	Cotton material	36.4°C	720°C	\$30

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

BUILD Design Details	TEST Test Results			
PCMs Used: None	Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)	
Insulating Material:				
2 layers	Fleece material	30.6°C	720°C	\$30

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

BUILD Design Details	TEST Test Results			
PCMs Used: None	Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)	
Insulating Material:				
2 layers	Wool material	31.1°C	720min	\$44

- Cost per layer of insulating material (\$):
- Time for baby's temperature to decrease from 36.0°C to 35.0°C (minutes):

Conclusions

1. How do different insulating materials affect the baby's average temperature?

2. How does the number of layers affect the baby's average temperature?

PLAN

Use the results of the insulation and PCM analysis to design a optimal Portable Baby Incubator.

Students will need to consider the following

-cost

-time in healthy temp range

Plan: Include ideas for Portable Baby Incubator.

BabyWarmer Data FUTURA

Design Team _____ Date _____

1 **PLAN**
VERSION Use long lasting insulating material with best performing PCM.

BUILD Design Details		TEST Test Results		
PCMs Used:		Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)
A	B	36.4°C	130min	\$132
Insulating Material:		Additional Notes		
2	Wood	keep out of		
layers	material			

ANALYZE - Only out of Range for 130min.
- Since plateau temp is baby in range, at least one higher temp PCM is needed

2 **PLAN**
VERSION Use less of the cheaper PCM(B) that has a higher plateau temperature with PCM(C)

BUILD Design Details		TEST Test Results		
PCMs Used:		Baby's Average Temperature (°C)	Time Outside Healthy Range (min)	Total Cost (\$)
A	B	36.8°C	106min	132 \$130
Insulating Material:		Additional Notes		
3	Wood			
layers	material			

ANALYZE - Baby is outside healthy range less and at very small time spans due to PCM reactivity/head.

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CREATE

Include a prototype of the Baby Incubator and the materials that would be optimal for keeping a premature baby at a healthy temperature.

Prototype to be Tested



VERSION 1

TEST

Conduct a test of the proposed prototype.

Prototype Analysis

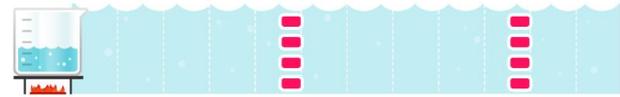
Test Results:

BABY'S AVERAGE
TEMPERATURE
36.4°C

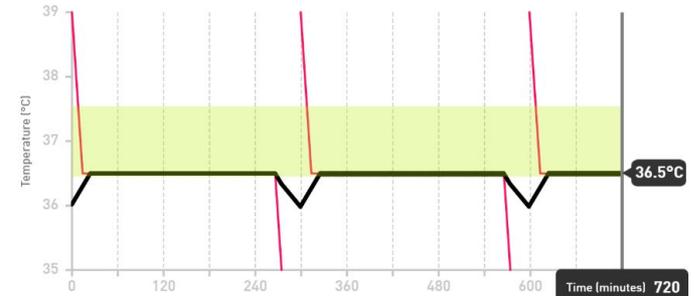
TIME OUTSIDE
HEALTHY RANGE
130 min

TOTAL COST
\$ 132

Reheating of Phase Change Materials (PCMs)



Temperature Over Time



BABY

PCM C

HEALTHY RANGE

VERSION 1

IMPROVE or SHARE

Based on the analysis of the prototype determine what improvements need to be made.

A plan and new prototype can be developed if needed or to see the possibility of lowering the cost.

Regardless, results need to be shared.

IMPROVEMENTS or SHARE

