Information Gathering:
Phase Change Incubator Example

Its often helpful to keep track of all the questions you want to answer about your project so that you can determine the best method for answering them and make sure that you get all the information that you need. This may be through internet and library research, interviews, patent searches, benchmarking, observational research, or physical testing.

Questions
What is the cost of currently available incubators?
What types of tests are done in an incubator?
What is the temperature required for these tests?
How long do the tests take?
What size should the incubator be?
What power sources are available at the clinics?
What should the capacity of the incubator be?

Currently Available Incubators

<table>
<thead>
<tr>
<th>Benchtop Incubators</th>
<th>Chamber Size</th>
<th>Range/Accuracy</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab-Line L-C</td>
<td>13&quot; x 13&quot; x 13&quot;</td>
<td>ambient-65</td>
<td>$770</td>
</tr>
<tr>
<td>Lab-Line</td>
<td>7&quot; x 10&quot; x 8&quot;</td>
<td>ambient-40</td>
<td>$335</td>
</tr>
<tr>
<td>Thermolyne</td>
<td>11&quot; x 11&quot;</td>
<td>ambient-60</td>
<td>$440</td>
</tr>
<tr>
<td>Boekel</td>
<td>13&quot; x 16&quot; x 15&quot;</td>
<td>ambient-45</td>
<td>$410</td>
</tr>
<tr>
<td>Precision</td>
<td>8&quot; x 10&quot; x 6.75&quot;</td>
<td>30-60 +/-0.6</td>
<td>$440</td>
</tr>
<tr>
<td>Precision Economy</td>
<td>12&quot; x 14&quot; x 10&quot;</td>
<td>ambient-60</td>
<td>$392</td>
</tr>
<tr>
<td></td>
<td>13&quot; x 14&quot; x 13&quot;</td>
<td>ambient-65 +/-0.3</td>
<td>$1295</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ambient-65 +/-0.5</td>
<td>$595</td>
</tr>
</tbody>
</table>

Features of Incubators:
Temperature Control  Gravity Flow Convection or Forced Convection
Carbon Dioxide Control Water Jacketed (to maintain humidity)
Power Indicator, Heat Indicator, Back-up Indicator Capacity

Interview with Janet Bertolini of the MIT Medical Department:
What tests require incubation?
Bacterial cultures such as salmonella, shagella and eurocinea STD
tests such as ghonnorea (which also require carbon dioxide) Elisa
tests and Western blots for AIDS diagnosis antibody tests
What should the internal chamber be?
petri dish-sized diameter, height depends on lab
What temperatures are required?
mostly human temperatures (36 - 38)
Problem Framing:
Phase Change Incubator Example

A good way to communicate different problem framings is to make simple, annotated sketches that show the general approach rather than emphasizing specific details. This can help provide additional perspectives on the problem and its potential solutions.

Problem Framing 1:
Providing Alternative Energy For Existing Incubators

1. Draw the main diagram
2. Add labels, arrows and detailed information
3. Write brief explanation notes
Problem Framing 2:
Develop Tests That Don’t Require Constant Temperatures

Outdoor Setting
Variable Temperatures

Problem Framing 3:
Keep the Samples Warm Using Other Means

Safety Goggles = adherence to strict guidelines of proper of science

Biodegradable

Pouch Incubator
Problem Statement:
Phase Change Incubator Example

We will build a device to allow nurses, doctors and/or technicians in rural medical clinics in developing countries to grow bacterial samples for the purpose of analysis or diagnostics. The device should be inexpensive, easy to use and be compatible with the existing testing equipment.
## Design Specifications: Phase Change Incubator Example

<table>
<thead>
<tr>
<th>User Need</th>
<th>Design Specification</th>
<th>Acceptable Value</th>
<th>Ideal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portable</td>
<td>weight</td>
<td>&lt; 3 Kg</td>
<td>&lt; 2 Kg</td>
</tr>
<tr>
<td></td>
<td>size</td>
<td>&lt; 18 x 15 x 15</td>
<td>&lt; 14 x 12 x 10</td>
</tr>
<tr>
<td>Provides a constant temperature</td>
<td>internal temperature</td>
<td>37°C +/- 1°C</td>
<td>37°C +/- 0.5°C</td>
</tr>
<tr>
<td>Safety</td>
<td>non-toxic materials</td>
<td>&lt; irritant</td>
<td>restorative</td>
</tr>
<tr>
<td></td>
<td>fire resistance</td>
<td>fire resistant</td>
<td>fire retardant</td>
</tr>
<tr>
<td></td>
<td>materials</td>
<td>materials</td>
<td>materials</td>
</tr>
<tr>
<td>Affordable</td>
<td>cost</td>
<td>&lt; $500</td>
<td>&lt; $100</td>
</tr>
<tr>
<td>Easy to Use</td>
<td>time to prepare incubator for use</td>
<td>&lt; 30 minutes</td>
<td>&lt; 10 minutes</td>
</tr>
<tr>
<td></td>
<td>Frequency of monitoring</td>
<td>&lt; 3 times a day</td>
<td>&lt; 1 time a day</td>
</tr>
<tr>
<td>Flexibility</td>
<td>ability to accommodate different sample form factors</td>
<td>test tubes &amp; petri dishes</td>
<td>test tubes, petri dishes &amp; 100ml bottles</td>
</tr>
</tbody>
</table>
Idea Generation: Phase Change Incubator Example

Sketches/Sticky Notes (group brainstorm)
Writing down ideas in words and images to capture them and share with others.

Mobile Healthcare, eliminate the need for an incubator

Fire Powered fridge

TIMING

FRICTION GENERATOR

Change the System
Idea Generation:
Phase Change Incubator Example

Bisociation
Incubators and Butterflies

Prints out results 12 hours later

Butterflies:
Cocoon
Nectar
Flight
...

Slow then fast
- Caterpillar then butterfly
- Slow prep, fast test

Genetic alteration to flowers, their reaction is the test.
Analysis & Experimentation
Phase Change Incubator Example
# Concept Evaluation: Phase Change Incubator Example

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Datum</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Battery-operated</td>
<td>Solar</td>
<td>Phase-change</td>
<td>Water Bath</td>
</tr>
<tr>
<td>cost</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>reliability</td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>accuracy (x2)</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
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<td>maintenance</td>
<td>0</td>
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<td>+</td>
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<tr>
<td>safety</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ease of use</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>-3</td>
<td>+2</td>
<td>-1</td>
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</tbody>
</table>
Detailed Design:
Phase Change Incubator Example
Testing & Evaluation: Phase Change Incubator Example

Results of comparative testing with conventional incubators