Unit Performance Expectations

- Design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- Develop and revise the design of the device.
- Conduct an investigation to test how thermal energy transfers in the device.

Evaluation and Feedback
Your work will be evaluated using the:

- Science and Engineering Practices Rubric
- Energy Unit Content Rubric
- Oral Presentation Rubric

Group Culminating Project

As a group:

- Choose a client.
- Draw a model of the device.
- Design a device to fit the client’s needs.
- Build your device.
- Test your device.
- Revise your device.
- Draw a model of your final device.
- Present your device to the class.

Vocabulary

- kinetic energy
- maximizes
- minimizes
- thermal energy

Individual Culminating Project

- Write a draft of your Patent Application for your device.
- Get feedback from your teacher and peers.
- Finalize your Patent Application for your device.
Overview • Letter from TET

To: Students of [School Name]
From: Marie Watt, President of TET
CC: [Teacher Name]
Date: July 17, 2016
Re: Call for Innovative Design

As the president of Thermal Energy Transfer (TET), I am pleased to hear that your team of young scientists and engineers is interested in helping our company design solutions for some real-world problems.

Several clients have come to TET asking us to help them design special devices in the area of thermal energy. Now we are asking for your help to make this possible! Both we at TET and our clients are interested in seeing what innovative and groundbreaking ideas your team will come up with in the area of thermal energy. We are asking you to choose from one of the clients listed on the following page. The goal of your group will be to create a device that will either maximize or minimize thermal energy transfer. You will work collaboratively to design, build, test, and revise your model to make your device as thermally efficient as possible.

As part of this work, your team will need to design and construct a device for the client. You will need to test the device, collect data, and analyze how well your device works. You will also need to make changes to improve the original design.

At TET we want to protect all new ideas we receive from our skilled engineers. In order to do this, we require you to write a Patent Application to accompany your device. In addition, your team will be required to give an oral presentation to share your design with your client. The presentation should include:

• Demonstration of the device
• Description of thermal energy transfer in your device
• Analysis of the data from your investigation

We look forward to being impressed by your design and presentation.
The project deadline is _______________ [Insert Date].

Sincerely,

Marie Watt
Marie Watt, President of TET
Overview • Client List

TET Thermal Energy Transfer, Inc. Client List

1. Cocina del Sol: A Latin American, eco-friendly food truck company
   Needs: A device to bake their specialty cookies (Spicy Mayan Chocolate Chip) using the power from the sun.

2. Salmon Conservation Foundation: A company that researches Alaskan salmon
   Needs: A design for gloves for their researchers in Alaska who work with salmon in very cold streams and rivers. The stream temperatures range from 8–14°C. The temperature of the human body is 37°C.

3. Only Have Ice for You: An ice delivery company specializing in ice for ice-carving competitions
   Needs: A device that will keep a large block of ice the size of a refrigerator from melting. (Note: Given the large size of their ice blocks, the prototype must be a scaled-down model of the actual device.)

4. Homemade Hot Tubs, Inc.: A company that provides the materials and instructions for people to make their own hot tubs
   Needs: An engineering model that is similar to the homemade hot tub shown below. The company wants a model that is much smaller than the real version, and they do not want you to use fire as a thermal energy source due to safety considerations. Your goal is to maximize the temperature increase inside the “tub.”
**Overview • Patent Application**

The Patent Application must include:

- The title of the invented device

- **Context**
  *(One paragraph introducing your client, what the client needs, and requirements for the device)*

- **Science background about the device**
  *(An explanation of how thermal energy, thermal energy transfer, temperature, and kinetic energy relate to your device)*

- A **Portfolio** of the design process of your device:
  
  - A model of your initial device before testing, including materials and dimensions
  
  - Detailed steps you took to test the device, resulting in revision of the device, including:
    
    - Detailed replicable procedures
    
    - List of tools/equipment
    
    - Organized data gathered during the test
    
    - Tools/equipment used to gather data
    
    - Number of test trials included in data
  
  - A model of your revised device after testing, including materials and dimensions

- **Conclusion**
  
  - Explain how well your final device meets the needs of your client.
  
  - Use your data to explain what revisions you made to produce your final device.
## Overview • Individual Project Organizer—Lift-Off Task

**Lift-Off Task: Build a Working System**

Use this Project Organizer to organize your information and visuals for your Patent Application. Write in full sentences.

<table>
<thead>
<tr>
<th>□ EXPLAIN who your client is and why they need this device.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>□ DESCRIBE the challenges of designing and building the device (e.g., cost, mobility, temperature, budget, etc.).</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>□ IDENTIFY at least four “need-to-knows” that are necessary for designing and building your device.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>□ DESCRIBE how the device you chose to build is a system.</td>
</tr>
</tbody>
</table>
Overview • Individual Project Organizer—Task 1

Task 1: Compare Thermal Energy and Temperature

Your job is to help your client understand thermal energy and temperature. You may use examples or evidence from the task in your models below. You may also choose to use everyday examples in your models to help your client understand the energy concepts.

<table>
<thead>
<tr>
<th>DRAW A MODEL to help your client understand:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>❑ How to distinguish between thermal energy and temperature</td>
<td>❑ How particles move in ice and water</td>
</tr>
</tbody>
</table>

- Sketch a very simple model of your device.
- Color red where you will find the highest temperature in your device.
- Color blue where you will find the lowest temperature in your device.
**Overview • Individual Project Organizer—Task 2**

**Task 2: Thermal Energy Transfer**

Continue to revise your model of your device. Consider your model to be a work in progress.

<table>
<thead>
<tr>
<th>Who is your client?</th>
<th>What is your device?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Sketch a model of your device.
  (You will be able to revise your design as you discover more about energy.)
- Label dimensions and materials used.

- Is your device increasing thermal energy transfer (making a substance hotter) or decreasing thermal energy transfer (keeping the substance the same temperature)?
- Re-sketch the model of your device and include energy particles with arrows to show movement of thermal energy.
Overview • Individual Project Organizer—Task 3

Task 3: Insulators and Conductors

In the device that you are building for your client, you will either be maximizing or minimizing the amount of thermal energy transferred through a system. Put another way, you will either be heating your product or keeping your product at the same temperature. One way to maximize or minimize thermal energy is by using materials that are either insulators or conductors.

<table>
<thead>
<tr>
<th>Who is your client?</th>
<th>What is your device?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Make a list of what material(s) might be helpful for insulating or conducting thermal energy in your device.

- Use evidence from the results of the ice pop experiment to explain your choice of materials.

- Explain your choice of material(s) using the key terms thermal energy, temperature, particle(s), and thermal energy transfer.
Overview • Individual Project Organizer—Task 4

Task 4: Mass and Thermal Energy

You need to think about the way mass affects thermal energy transfer in your device. At the end of Task 4, you are given a choice about the possible sizes of the device you are designing. Your job is to choose the size that will be most effective for your design.

Who is your client?  
What is your device?

- Look at end of the Task 4 for possible sizes for your device.
- Decide which size/mass option would be best for your design and for your client.

- Make an argument why your choice is best for your design. Use the Claim, Evidence, and Reasoning format.

Claim

Evidence
Reasoning

☐ Explain your choice of size/mass using the key terms mass, thermal energy, kinetic energy, thermal energy transfer, insulator(s), and conductor(s).

☐ On a separate piece of paper, sketch a final model of your device.
☐ Label any parts, materials, and dimensions on your model.
☐ Make any design notes necessary for building your device on/near your sketch.
☐ This sketch will go into your Patent Application.

Evaluation • Science and Engineering Practices Rubric

The Energy Unit will be assessed using the highlighted rows.

<table>
<thead>
<tr>
<th>SCIENCE AND ENGINEERING PRACTICES RUBRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCORING DOMAIN</td>
</tr>
<tr>
<td>ASKING QUESTIONS AND DEFINING PROBLEMS</td>
</tr>
<tr>
<td>☐ No Evidence*</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>DEVELOPING AND USING MODELS</td>
</tr>
<tr>
<td>☐ No Evidence*</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>PLANNING THE INVESTIGATION OR DESIGN</td>
</tr>
<tr>
<td>-------------------------------------</td>
</tr>
<tr>
<td>CONDUCTING INVESTIGATION OR TESTING DESIGN</td>
</tr>
</tbody>
</table>

* If there is no student response then check the No Evidence box.

The Energy Unit will be assessed using the highlighted rows.

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### SCIENCE AND ENGINEERING PRACTICES RUBRIC

<table>
<thead>
<tr>
<th>SCORING DOMAIN</th>
<th>EMERGING</th>
<th>DEVELOPING</th>
<th>PROFICIENT</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANALYZING AND INTERPRETING DATA</strong></td>
<td>Makes spreadsheets, data tables, charts, or graphs that are not accurately labeled or do not display all the data</td>
<td>Makes accurate and labeled spreadsheets, data tables, charts, or graphs to summarize and display data but does not arrange the data to examine the relationships between variables</td>
<td>Makes accurate and labeled spreadsheets, data tables, charts, and/or graphs to summarize and display data and arranges the data to examine relationships between variables</td>
<td>Makes accurate and labeled spreadsheets, data tables, charts, and/or graphs and uses more than one of these methods to summarize and display data; arranges the data to examine relationships between variables</td>
</tr>
<tr>
<td>Accurately labeled means inclusion of title, column titles, description of units, proper intervals.</td>
<td>Uses inappropriate methods or makes major errors analyzing the data</td>
<td>Uses appropriate methods but makes minor errors analyzing the data</td>
<td>Uses appropriate methods to accurately and carefully identify patterns or explains possible error or limitations of analyzing the data</td>
<td>Uses appropriate methods to accurately and carefully identify patterns and explains possible error or limitations of analyzing the data</td>
</tr>
<tr>
<td><strong>CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS</strong></td>
<td>Constructs an explanation that includes an inappropriate claim, inaccurate evidence, and/or unclear reasoning</td>
<td>Constructs or evaluates an explanation consisting of minimal claim(s), limited sources of accurate evidence, and/or minimal reasoning</td>
<td>Constructs or evaluates an explanation that includes a claim, multiple sources of accurate evidence, and reasoning using accurate and adequate scientific ideas or principles</td>
<td>Constructs, evaluates, or revises an explanation that includes a claim, multiple sources of accurate evidence, and reasoning using accurate and adequate scientific ideas or principles</td>
</tr>
</tbody>
</table>
### Project Specifications

| No Evidence* | Uses no data to evaluate how well the design answers the problem and the redesign of the original model or prototype is inappropriate or incomplete | Uses minimal data to evaluate how well the design answers the problem and describes an appropriate redesign of the original model or prototype with minor errors | Uses adequate data to evaluate how well the design answers the problem and accurately explains an appropriate redesign of the original model or prototype | Uses adequate data to evaluate how well the design answers the problem and accurately provides a detailed rationale for the appropriate redesign of the original model or prototype |
| --- | --- | --- | --- |
| ENGAGING IN ARGUMENTS FROM EVIDENCE | Constructs an argument that includes an inappropriate claim, inaccurate evidence, and/or unclear reasoning | Constructs or evaluates an argument consisting of minimal claim(s), limited sources of evidence, or minimal reasoning | Constructs and/or evaluates an argument consisting of appropriate claim(s), multiple sources of evidence, and reasoning using accurate and adequate scientific ideas or principles | Constructs, evaluates, or revises an argument consisting of appropriate claim(s), multiple sources of evidence, and reasoning using accurate and adequate scientific ideas or principles |
| COMMUNICATING INFORMATION | Communicates information that is inaccurate and/or inconsistent with the evidence | Communicates accurate and minimal information consistent with the evidence but does not explain the implications or limitations of the investigation or design | Communicates accurate, clear, and adequate information consistent with the evidence and explains the implications and/or limitations of the investigation or design | Communicates accurate, clear, and complete information consistent with the evidence and provides a rationale for the implications and limitations of the investigation or design |

* If there is no student response then check the No Evidence box.

### Evaluation • Science Content Rubric

<table>
<thead>
<tr>
<th>THE STUDENT DEMONSTRATES THEIR SCIENTIFIC KNOWLEDGE OF THE FOLLOWING CONTENT STANDARD</th>
<th>EMERGING</th>
<th>DEVELOPING</th>
<th>PROFICIENT</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (ETS1.B)</td>
<td>Constructs an explanation about how the device was modified based on no investigation data and/or with major errors</td>
<td>Constructs an explanation about how the device was modified based on limited investigation data and/or with minor errors</td>
<td>Constructs an accurate explanation about how the device was modified based on investigation data</td>
<td>Constructs an accurate and detailed explanation about how the device was modified based on investigation data</td>
</tr>
<tr>
<td>Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3.B)</td>
<td>Constructs an explanation about energy transfer with no evidence and/or major errors</td>
<td>Constructs an explanation about energy transfer with limited evidence and/or minor errors</td>
<td>Constructs an accurate explanation about energy transfer with evidence</td>
<td>Constructs a detailed accurate explanation about energy transfer with evidence</td>
</tr>
</tbody>
</table>
## Evaluation • Oral Presentation Rubric

### ORAL PRESENTATION RUBRIC

<table>
<thead>
<tr>
<th>SCORING DOMAIN</th>
<th>EMERGING</th>
<th>E/D</th>
<th>DEVELOPING</th>
<th>D/P</th>
<th>PROFICIENT</th>
<th>P/A</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CLARITY</strong></td>
<td>Presents an unclear perspective</td>
<td>Presents a general perspective</td>
<td>Presents a clear perspective</td>
<td>Line of reasoning can be followed</td>
<td>Line of reasoning is clear and easy to follow</td>
<td>Addresses alternative or opposing perspectives when appropriate</td>
<td></td>
</tr>
<tr>
<td>What is the evidence that the student can present a clear perspective and line of reasoning?</td>
<td>Line of reasoning is absent, unclear, or difficult to follow</td>
<td>Line of reasoning can be followed</td>
<td>Line of reasoning is clear and easy to follow</td>
<td>Addresses alternative or opposing perspectives when appropriate</td>
<td>Addresses alternative or opposing perspectives in a way that sharpens one’s own perspective</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EVIDENCE</strong></td>
<td>Draws on facts, experience, or research in a minimal way</td>
<td>Demonstrates limited understanding of the topic</td>
<td>Draws on facts, experiences, and/or research inconsistently</td>
<td>Demonstrates an incomplete or uneven understanding of the topic</td>
<td>Demonstrates an understanding of the topic</td>
<td>Synthesizes facts, experience, and research to support a perspective</td>
<td></td>
</tr>
<tr>
<td>What is the evidence that the student can present a perspective with supportive evidence?</td>
<td>Demonstrates limited understanding of the topic</td>
<td>Demonstrates an incomplete or uneven understanding of the topic</td>
<td>Demonstrates an understanding of the topic</td>
<td>Synthesizes facts, experience, and research to support a perspective</td>
<td>Demonstrates an in-depth understanding of the topic</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ORGANIZATION</strong></td>
<td>Lack of organization makes it difficult to follow the presenter’s ideas and line of reasoning</td>
<td>Inconsistencies in organization and limited use of transitions detract from audience understanding of line of reasoning</td>
<td>Organization is appropriate to the purpose, audience, and task and reveals the line of reasoning; transitions guide audience understanding</td>
<td>Organization is appropriate to the purpose and audience and supports the line of reasoning; effectively hooks and sustains audience engagement, while providing a convincing conclusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is the evidence that the student can use language appropriately and fluidly to support audience understanding?</td>
<td>Uses language and style that are unsuited to the purpose, audience, and task</td>
<td>Uses language and style that are at times unsuited to the purpose, audience, and task</td>
<td>Uses appropriate language and style that are suited to the purpose, audience, and task</td>
<td>Uses sophisticated and varied language that is suited to the purpose, audience, and task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LANGUAGE USE</strong></td>
<td>Uses language and style that are unsuited to the purpose, audience, and task</td>
<td>Speaking is fluid with minor lapses of awkward or incorrect language use that detracts from audience understanding</td>
<td>Speaking is fluid and easy to follow</td>
<td>Speaking is consistently fluid and easy to follow</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## ORAL PRESENTATION RUBRIC

<table>
<thead>
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<th>PROFICIENT</th>
<th>P/A</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USE OF DIGITAL MEDIA / VISUAL DISPLAYS</strong></td>
<td>Digital media or visual displays are confusing, extraneous, or distracting</td>
<td></td>
<td>Digital media or visual displays are informative and relevant</td>
<td></td>
<td>Digital media or visual displays are appealing, informative, and support audience engagement and understanding</td>
<td></td>
<td>Digital media or visual displays are polished, informative, and support audience engagement and understanding</td>
</tr>
<tr>
<td><strong>PRESENTATION SKILLS</strong></td>
<td>Makes minimal use of presentation skills: lacks control of body posture; does not make eye contact; voice is unclear and/or inaudible; and pace of presentation is too slow or too rushed</td>
<td></td>
<td>Demonstrates a command of some aspects of presentation skills, including control of body posture and gestures, language fluency, eye contact, clear and audible voice, and appropriate pacing</td>
<td></td>
<td>Demonstrates a command of presentation skills, including control of body posture and gestures, eye contact, clear and audible voice, and appropriate pacing</td>
<td></td>
<td>Demonstrates consistent command of presentation skills, including control of body posture and gestures, eye contact, clear and audible voice, and appropriate pacing, in a way that keeps the audience engaged</td>
</tr>
<tr>
<td><strong>INTERACTION WITH AUDIENCE</strong></td>
<td>Provides a vague response to questions; demonstrates a minimal command of the facts or understanding of the topic</td>
<td></td>
<td>Provides an indirect or partial response to questions; demonstrates a partial command of the facts or understanding of the topic</td>
<td></td>
<td>Provides an indirect or partial response to questions; demonstrates a partial command of the facts or understanding of the topic</td>
<td></td>
<td>Provides a precise and persuasive response to questions; demonstrates an in-depth understanding of the facts and topic</td>
</tr>
</tbody>
</table>
## Evaluation • Peer Feedback for Patent Application

<table>
<thead>
<tr>
<th>Name of the Person Who Owns the Patent Application</th>
<th>Name of the Peer Reviewer</th>
</tr>
</thead>
</table>

1. Pair up with a partner from another group and exchange your Patent Application and this Peer Feedback form.

2. Review your peer’s Patent Application and give positive feedback or constructive feedback as instructed by your teacher.

- **The title of the invented device**
  
  Comment:

- **Context**
  
  *(One paragraph introducing your client, what the client needs, and requirements for the device)*
  
  Comment:

- **Science background about the invented device**
  
  *(An explanation of how thermal energy, thermal energy transfer, temperature, and kinetic energy relate to your device)*
  
  Comment:
A labeled drawing of your final design before testing, including materials and dimensions
Comment:

Detailed replicable procedures
Comment:

Organized data gathered during the test
Comment:

Tools/equipment used to gather data
Comment:
Number of test trials included in data
Comment:

Labeled drawing of final revised design after testing, including materials and dimensions
Comment:

Conclusion
Comment:

What are two specific things you think are strong in the Patent Application?
1. 
2.

What are two specific things you think could be changed or improved on in the Patent Application?
1.
2.