



#### **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.



How do we use and control thermal energy in a system?

#### **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



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To:Students of [School Name]From:Marie Watt, President of TETCC:[Teacher Name]Date:July 17, 2016Re: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.
- 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:

- **D** 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

- **u** 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.



#### 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.

<b>EXPLAIN</b> who your client is and why they need this device.
DESCRIBE the challenges of designing and building the device (e.g., cost, mobility, temperature, budget, etc.).
<b>IDENTIFY</b> at least four "need-to-knows" that are necessary for designing and building your device
DESCRIBE how the device you chose to build is a system.



#### 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.

DRA	DRAW A MODEL to help your client understand:						
	How to distinguish between thermal energy and temperature	How particles move in ice and water					
	<ul> <li>Sketch a very simple model of your device.</li> <li>Color red where you will find the highest temperature in your device.</li> <li>Color blue where you will find the lowest temperature in your device.</li> </ul>						



## Task 2: Thermal Energy Transfer

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

Who is your client?	What is your device?
<ul> <li>Sketch a model of your device. (You will be able to revise your design as you discover</li> <li>Label dimensions and materials used.</li> </ul>	more about energy.)
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.



#### **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.

Who is your client?	What is your device?
Make a list of what material(s) might be helpful for ins	ulating or conducting thermal energy in your device.
Use evidence from the results of the ice pop experime	nt 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.	
Bedraw the model of your device using red to show an	v revisions
<ul> <li>Label the parts, materials, and dimensions in the mode</li> </ul>	el of your device.



## 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?			
<ul> <li>Look at end of the Task 4 for possible sizes for your de</li> <li>Decide which size/mass option would be best for your</li> </ul>	vice. design and for your client.			
Make an argument why your choice is best for your de	sign. Use the Claim, Evidence, and Reasoning format.			
Claim				
Evidence				
Reasoning				
Explain your choice of size/mass using the key terms n transfer, insulator(s), and conductor(s).	nass, thermal energy, kinetic energy, thermal energy			
<ul> <li>On a separate piece of paper, sketch a final model of your device.</li> <li>Label any parts, materials, and dimensions on your model.</li> <li>Make any design notes necessary for building your device on/near your sketch.</li> <li>This sketch will go into your Patent Application.</li> </ul>				



# **Evaluation • Science and Engineering Practices Rubric**

The Energy Unit will be assessed using the highlighted rows.

SCIENCE AND ENGINEERING PRACTICES RUBRIC							
SCORING DOMAIN	EMERGING	DEVELOPING	PROFICIENT	ADVANCED			
ASKING QUESTIONS AND DEFINING PROBLEMS No Evidence*		Asks specific questions that can be investigated but do not require empirical evidence	Asks questions that require empirical evidence to answer	Asks questions that require empirical evidence to answer and evaluates the testability of the questions			
	Writes a problem or design statement but it does not match the intent of the problem or the need of the client	Writes a problem or design statement that matches the intent of the problem or the need of the client with minor errors	Writes a problem or design statement that accurately matches the intent of the problem or the needs of the client	Writes a problem or design statement that accurately and completely matches the intent of the problem or the need of the client			
DEVELOPING AND USING MODELS Makes models (drawings, diagrams, or other) with major errors Makes models (drawings, diagrams, or other) to represent the process or system to be investigated with minor errors		Makes models (drawings, diagrams, or other) to represent the process or system to be investigated with minor errors	Makes accurate and labeled models (drawings, diagrams, or other) to represent the process or system to be investigated	Makes accurate and labeled models (drawings, diagrams, or other) to represent the process or system to be investigated and explains the model			
No Evidence*	Explains the limitations of the model with major errors	Explains the limitations of the model with minor errors	Explains the limitations of the model as a representation of the system or process	Explains the limitations of the model as a representation of the system or process			
PLANNING THE INVESTIGATION OR DESIGN	Plans an investigation that will not produce relevant data to answer the empirical question(s)	Plans an investigation that will produce some relevant data to answer the empirical question(s)	Plans an investigation that will produce relevant data to answer the empirical question(s) and identifies the dependent and independent variables when applicable	Plans an investigation that will completely produce relevant and adequate amounts of data to answer the empirical question(s) and identifies the dependent and independent variables when applicable			
No Evidence* Plans a design that does not match the criteria, constraints, and intent of the problem Plans a design an explanation that matches the criteria, constraints, and intent of the problem Plans a design an explanation that matches the criteria and the problem Plans a design an explanation that matches the criteria and the problem Plans a design an explanation that matches the criteria and the problem Plans a design an explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and explanation that matches the criteria and the problem Plans a design and the plans a design and the problem Plans a design and the plans a design and the problem Plans a design and the plans a		Plans a design and writes an explanation that partially matches the criteria, constraints, and intent of the problem	Plans a design and writes an explanation that accurately and adequately matches the criteria, constraints, and intent of the problem	Plans a design and writes a detailed explanation that accurately and completely matches the criteria, constraints, and intent of the problem			
CONDUCTING INVESTIGATION OR TESTING DESIGN	Writes procedures that lack detail so the procedures cannot be duplicated by another person	Writes procedures with enough detail that another person can duplicate (replicable) but does not conduct a sufficient number of trials	Writes detailed replicable procedures with descriptions of the measurements, tools, or instruments and conducts adequate number of trials	Writes detailed replicable procedures with descriptions of the measurements, tools, or instruments and conducts adequate number of trials with an explanation for the proposed data collection			

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

The Energy Unit will be assessed using the highlighted rows.

SCIENCE AND ENGINEERING PRACTICES RUDRIC							
SCORING DOMAIN	EMERGING	DEVELOPING	PROFICIENT	ADVANCED			
ANALYZING AND INTERPRETING DATA Accurately labeled" means inclusion of title, column titles,	Makes spreadsheets, data tables, charts, or graphs that are not accurately labeled or do not display all the data	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	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	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			
proper intervals.	Uses inappropriate methods or makes major errors analyzing the data	Uses appropriate methods but makes minor errors analyzing the data	Uses appropriate methods to accurately and carefully identify patterns <b>or</b> explains possible error or limitations of analyzing the data	Uses appropriate methods to accurately and carefully identify patterns <b>and</b> explains possible error or limitations of analyzing the data			
CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS	Constructs an explanation that includes an inappropriate claim, inaccurate evidence, and/or unclear reasoning	Constructs or evaluates an explanation consisting of minimal claim(s), limited sources of accurate evidence, and/or minimal reasoning	Constructs or evaluates an explanation that includes a claim, multiple sources of accurate evidence, and reasoning using accurate and adequate scientific ideas or principles	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			
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, <b>or</b> 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 <b>or</b> 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			

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

## **Evaluation • Science Content Rubric**

SCIENCE CONTENT RUBRIC							
THE STUDENT DEMONSTRATES THEIR SCIENTIFIC KNOWLEDGE OF THE FOLLOWING CONTENT STANDARD	EMERGING	DEVELOPING	PROFICIENT	ADVANCED			
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)	Constructs an explanation about how the device was modified based on no investigation data and/or with major errors	Constructs an explanation about how the device was modified based on limited investigation data and/or with minor errors	Constructs an accurate explanation about how the device was modified based on investigation data	Constructs an accurate and detailed explanation about how the device was modified based on investigation data			
Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3.B)	Constructs an explanation about energy transfer with no evidence and/or major errors	Constructs an explanation about energy transfer with limited evidence and/or minor errors	Constructs an accurate explanation about energy transfer with evidence	Constructs a detailed accurate explanation about energy transfer with evidence			

CULMINATING PROJECT



# **Evaluation • Oral Presentation Rubric**

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

# Project Specifications

ORAL PRESENTATION RUBRIC							
SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
USE OF DIGITAL MEDIA / VISUAL DISPLAYS What is the evidence that the student can use digital media/visual displays to engage and support audience understanding?	Digital media or visual displays are confusing, extraneous, or distracting		Digital media or visual displays are informative and relevant		Digital media or visual displays are appealing, informative, and support audience engagement and understanding		Digital media or visual displays are polished, informative, and support audience engagement and understanding
PRESENTATION SKILLS What is the evidence that the student can control and use appropriate body language and speaking skills to support audience engagement?	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 Presenter's energy and affect are unsuitable for the audience and purpose of the presentation		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 Presenter's energy and/or affect are usually appropriate for the audience and purpose of the presentation, with minor lapses		Demonstrates a command of presentation skills, including control of body posture and gestures, eye contact, clear and audible voice, and appropriate pacing Presenter's energy and affect are appropriate for the audience and support engagement		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 Presenter maintains a presence and a captivating energy that is appropriate to the audience and purpose of the presentation
INTERACTION WITH AUDIENCE What is the evidence that the student can respond to audience questions effectively?	Provides a vague response to questions; demonstrates a minimal command of the facts or understanding of the topic		Provides an indirect or partial response to questions; demonstrates a partial command of the facts or understanding of the topic		Provides an indirect or partial response to questions; demonstrates a partial command of the facts or understanding of the topic		Provides a precise and persuasive response to questions; demonstrates an in-depth understanding of the facts and topic

CULMINA THIG PROJECT



## **Evaluation • Peer Feedback for Patent Application**

Name of the Person Who Owns the Patent Application	Name of the Peer Reviewer

- 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:

#### **Gamma** 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.