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## **AC 2012-4716: A THERMODYNAMICS SHORT COURSE FOR A SUMMER OUTREACH PROGRAM**

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## **A Thermodynamics Short Course for a Summer Outreach Program**

### **Context**

The Sophomore Academic Boot Camp (SABC) is a program designed to help minority sophomore engineering students adjust from first year engineering to their specific engineering disciplines (MEP, 2011). This program takes place for four weeks during the first summer session at a large Midwestern university. The selected students can take up to four of the following courses offered: Chemical Engineering Calculations, Electrical Circuit Analysis, Modern Mechanics and Thermodynamics I. These courses are considered to be more difficult courses for engineering students at the institute.

### **Minority Engineering Program**

The Minority Engineering Program (MEP) is the sponsoring program and its mission is “to engage in activities designed to increase and improve the enrollment, retention and successful graduation of engineers from African American, Native American, Hispanic and historically under-represented groups.” The web-site does not indicate how long the SABC has been in existence, but MEP was started in 1974. The SABC is one of several programs that the MEP administers during the summer. Some of the other programs are Multiethnic Introduction to Engineering for 11<sup>th</sup> graders, Summer Engineering Workshops for 6<sup>th</sup> through 8<sup>th</sup> graders, and Pre-Freshman and Cooperative Education for 9<sup>th</sup> and 10<sup>th</sup> graders.

### **Intended Learners**

The majority of the learners for this program will be participants of the Academic Boot Camp held during the previous summer to help newly admitted students acclimate to the university. All of the students will be engineering sophomores and most of the students from a minority group. The students will either have no or limited previous exposure to thermodynamics. There will be up to ten students in this course. If the student has already taken thermodynamics, then they will not take this course. The ten students are chosen by the program director and pay a fee of \$500 for participation in the program.

### **Contextual Issues**

This short course does not count for course credit and is meant as a primer for Thermodynamics I. Depending on the classes that students have already taken, they may take up to four courses including this one. All of the students in the program also participate in an industry project led by an engineer from a local corporation. One major limitation is that there will only be about 16 hours of instruction time for this course.

### **Content**

#### **Curricular Priorities**

Wiggins and McTighe (1998) discuss three facets of understanding to help learners grasp material. The first is enduring understanding and these are the big ideas that the learners should be able to understand even if they have forgotten the course details. The second is important to know and this is important knowledge and skills that is considered essential. Finally, the good

to know are ideas that are helpful to know, but do not need as much emphasis placed upon them. Below I list the enduring understandings and the important to know for this course.

*Enduring Understanding-* Students will understand the essential basic terms of thermodynamics such as heat and energy. Students will apply the first and second laws of thermodynamics to the solution of problems. Students will develop learning strategies for the successful completion of Thermodynamics I.

*Important to Know-* Students will understand the relevant thermodynamics concepts from chemistry and physics.

The enduring understandings for this course were determined by reviewing thermodynamics textbooks and study books, including the text used for the thermodynamics course (Kondepudi, 2008; Moran & Shapiro, 2006; Van Ness, 1983) since the American Society of Mechanical Engineers has not created an extensive body of knowledge like the one created by the American Society of Civil Engineers. All of the material reviewed contained substantial references to the first and second laws of thermodynamics. Concepts like heat and energy were also contained in the reviewed material. For these reasons, the first two enduring understandings relate to essential concepts and application of the first and second laws. Finally, this course is meant as a primer, so it is important that the students learn strategies to use for the Thermodynamics I course.

Midkiff et al (2001) indicate that there are key concepts from physics and chemistry that are used in thermodynamics. In addition, Bransford and others (2000) contend that new learning is based upon previous learning; therefore, the important to know was determined to be previously learned physics and chemistry topics that are essential to thermodynamics such as the conservation of energy and the ideal gas law. Finally, the short length of the course does not leave time for good to know material, so no good to know understandings were determined.

### **EU1: Understand the essential concepts of thermodynamics**

The essential concepts that will be focused upon in this course are heat, work, energy, and temperature. I decided upon these concepts because I found several studies that indicate student difficulty with distinguishing between heat and temperature concepts (Jasien & Oberem, 2002; Sözbilir, 2003; Wisler, 1995). Studies like the one conducted by Laburú and Niaz (2002) and Lewis and Linn (1994) further indicate that students have difficulties understanding heat, energy, and temperature. Work was also considered to be a poorly understood concept due to its units being the same as heat and energy (Meltzer, 2004). Streveler et al (2003) show that the concepts of heat versus energy and heat versus temperature were considered to be both poorly understood by students and important concepts by 30 engineering faculty experts during a Delphi study for thermal and transport science disciplines. Finally, Midkiff and others (2001) note that students have difficulty recognizing the difference between work and heat transfer processes.

### **EU2: Apply the first and second laws of thermodynamics to the solution of problems**

The first and second laws of thermodynamics are considered to be the cornerstones of thermodynamics. However, studies have indicated that students have difficulty applying these laws to problems (Cotignola, Bordogna, Punte, & Cappannini, 2002) .

#### *Misconceptions for the First Law of Thermodynamics*

Meltzer contends that students are not able to apply the first law of thermodynamics (2004). In his study, the students were given a pressure-volume diagram that shows an idea gas going

through two processes. For the adiabatic process, the students were asked if the heat,  $Q$ , was greater for process 1. Although the acceptable selection ranged from 40% to 56% percent, only 11% gave an acceptable response based upon the first law of thermodynamics. This implies that although the students could get the correct answer, they could not give an acceptable reason about why it was correct. This could be because they lack conceptual understanding of the first law, but not necessarily procedural understanding. In addition, Loverude and others (2002) show that students did not consider the first law of thermodynamics when given a problem that needed the first law to be answered correctly. Loverude and others questioned 36 thermal physics students during two rounds of interviews about the temperature of the air in a bicycle pump that would have the open end sealed while the handle of the pump was rapidly pushed inward. Although 75% of the students correctly answered that the temperature would increase, most students incorrectly explained the temperature increase by inappropriately applying the ideal gas law or disregarding the first law. Interestingly, the students still did not realize that the first law should be used even after the interviewer mentioned if energy, work, or the first law algebraic statement could be used to solve the problem. The authors state that many physicists would attempt to use the ideal gas law to attempt to solve the bicycle pump problem; however, they believe that the physicists would quickly see that the ideal gas law was not valid for this case and turn to the first law of thermodynamics. These studies indicate that there are student misconceptions associated with applying the first law of thermodynamics.

#### *Misconceptions for the Second Law of Thermodynamics*

Streveler et al (2003) show that the second law of thermodynamics is a difficult concept for students as a result of the Delphi study performed. Kesidou and Duit (1993) found that students were able to come to the same conclusions as physicists about irreversibility, but the student explanations of irreversibility were based on significantly different conceptual frameworks. Cochran and Heron (2006) go further to describe how students were not able to successfully apply the second law to cyclic devices such as heat engines and refrigerators. Cochran and Heron demonstrated that students ( $N=71$ ) enrolled in courses ranging from algebra-based introductory physics to junior level thermodynamics were not able to correctly answer if three different devices would function as shown in a diagram. The responses were considered correct only if the answer as well as the explanation were deemed correct. The students were given a heat engine that satisfies the first law, but not the second law and only 35% of the students were able to answer correctly. The students were also given a refrigerator cycle that satisfies both the first and second law; however, only 30% of the students correctly answered these question. Finally, the students were given a strange device that satisfied the first law, but violated the second law. For this question, 60% of the students were able to correctly answer the question. The authors note that the students mainly relied on the first law to answer the questions and did not realize the relevance of the second law, so it seems students may not understand how the second law imposes limitations on the first law.

#### **EU3: Develop learning strategies for the successful completion of Thermodynamics I**

This mini-course is a primer for the semester long course that the students will eventually take. This means that this course should equip the students with tools and strategies to help the student when taking Thermodynamics I. Bransford et al (2000) suggest that developing metacognitive abilities can help with transfer

Svinicki (2004) states that students often confuse the ability to recognize material in context with the ability to recognize the material out of context. This “illusion of comprehension” may cause the students to not use more effective learning strategies because they believe that familiarity is knowing (Druckman & Bjork, 1994; Glenberg, Wilkinson, & Epstein, 1982). Therefore it is not only important to teach students learning strategies, but it is also important to show them the need for these strategies. One way to accomplish this is through aligned assessments. The two strategies most applicable to this course are elaboration and developing process steps. Svinicki (2004) contends “students who put concepts into their own words are processing them in a much better way than can be had with memorization.” This strategy is called elaboration.

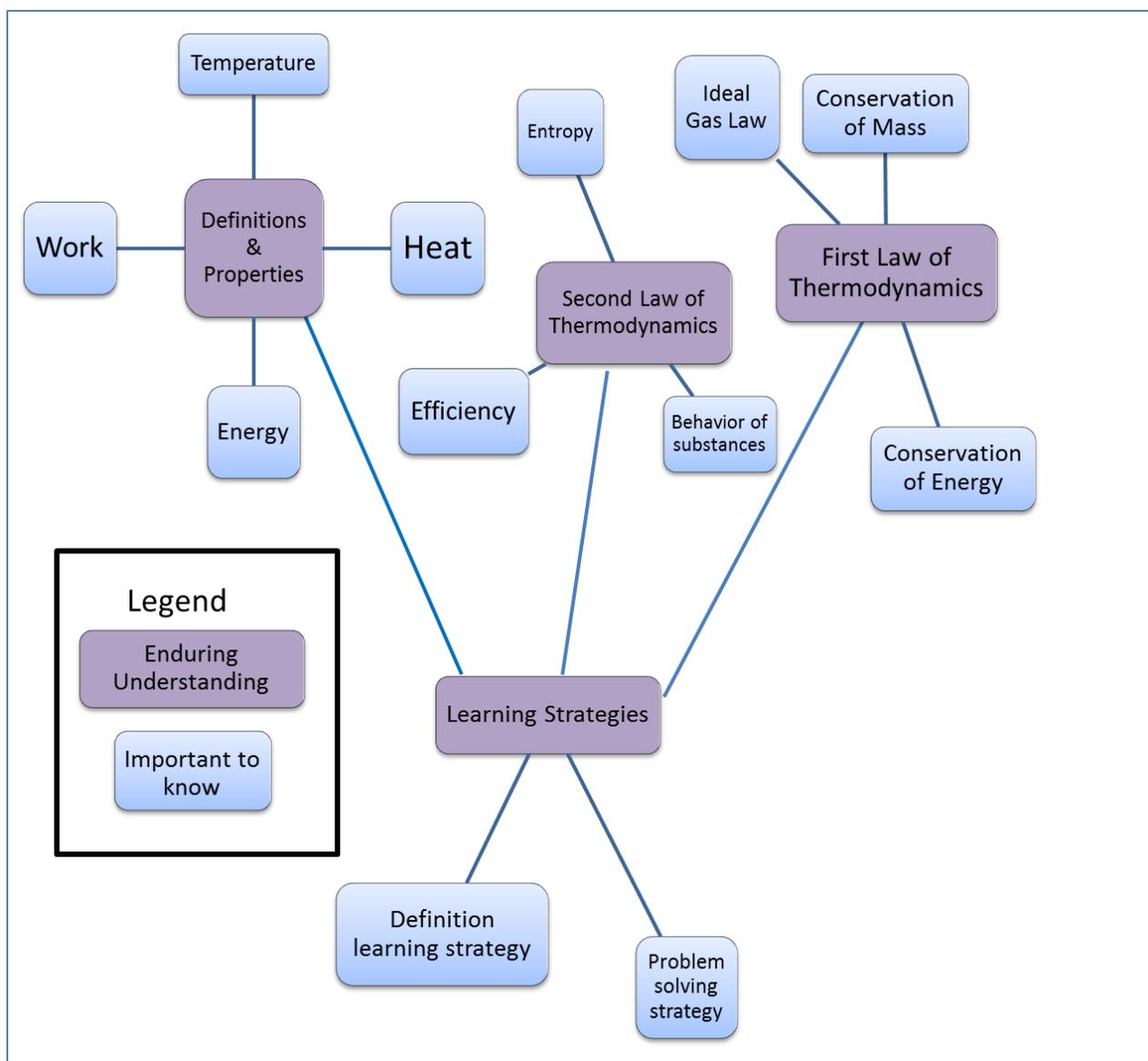
The second strategy involves developing process steps. Problem solving strategies are considered to be important for learning thermodynamics (Mettes, Pilot, Roossink, & Kramers-Pals, 1981; Moran & Shapiro, 2006). For the developing process steps strategy, the students figure out the steps for applying the concepts by analyzing examples that illustrate that concept and look for common characteristics. Students then use these steps with a new example. This helps the student know the steps of the procedure as well as when to use it (Deny, 1990). Once these steps are developed into a process, Svinicki (2004) proposes “chaining” to help students develop links between each step.

### **Learning Theories**

For this course, I draw upon three learning theories that relate to definition design, concept learning, and general learning. Perkins (1986) indicates that students learn best when they refine definitions to clarify, account for counterexamples, and describe differences between similar concepts. Svinicki (2004) notes several aspects of concept learning. She states that students learn concepts best when they encode new information as concepts, clarify the key features of a concept, and interconnect concepts. Bransford et al (2000) insist students construct new knowledge from existing knowledge. Finally, Bransford and others contend students learn best when they can extract the underlying themes and principles from their learning exercises.

### **Concept Map**

The concept map shown in Figure 1 below is divided into four areas that correspond with the enduring understanding. The definitions and properties content area corresponds with the enduring understanding *students will understand the essential basic terms of thermodynamics*. The first law of thermodynamics and second law of thermodynamics content areas correspond to the enduring understanding *students will apply the first and second laws of thermodynamics to the solution of problems*. The concepts that stem from these three content areas are the important to know understanding students will understand the relevant thermodynamics concepts from chemistry and physics. The final content area entitled learning strategies corresponds to the enduring understanding *students will develop learning strategies for the successful completion of Thermodynamics I*. The concepts that stems from this content area are the specific learning strategies. The concepts shown in the map are highly interconnected; however, these connections were not noted in the figure for simplification (i.e. energy is connected to the first law, second law, work, and the conservation of energy).



**Figure 1: Concept Map for Course Content**

**Assessment**

Pellegrino (2006) and Wiggins and McTighe (1998) think assessment should be aligned with content. Wiggins and McTighe (1998) suggest that assessments such as academic prompts and performance tasks and projects be used to assess enduring understanding since these assessments are open-ended and more complex than multiple choice assessments. For this section, I will describe the learning goals for this course, present the assessment matrices and assessment triangles for the three most important learning goals, and show how all of the learning goals fit into a taxonomy.

**Learning Goals**

I have determined four learning goals for this short course and they are all derived from the enduring understandings. These learning goals are:

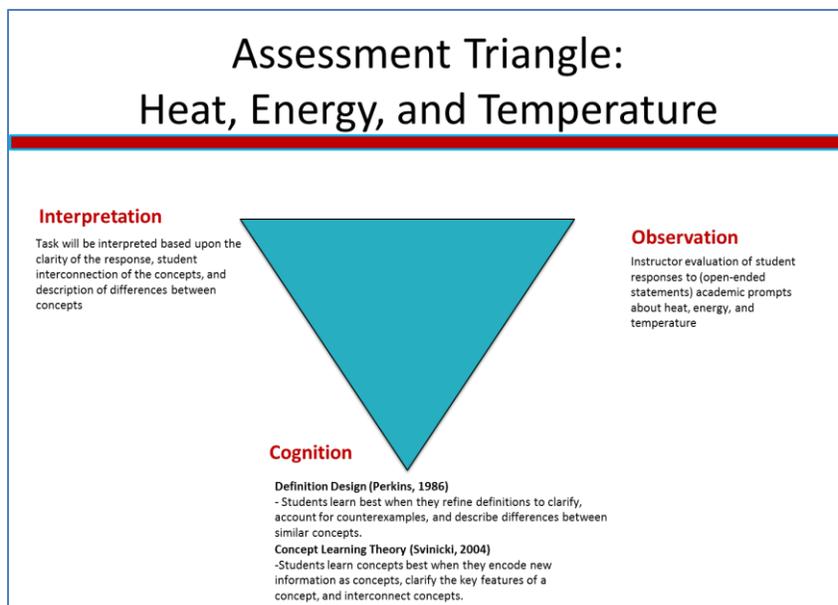
1. The learners should be able to distinguish between heat, temperature, and energy.
2. The learners should be able to apply the first law of thermodynamics.
3. The learners should be able to use the second law of thermodynamics to defend their answers.
4. The learners should be able to create study strategies that will aid them during Thermodynamics I.

**Learners should be able to distinguish between heat, temperature, and energy**

The common misconceptions regarding heat, temperature and energy in thermodynamics coupled with the enduring understanding *students will understand the essential basic terms of thermodynamics* led me to create the learning goal learners should be able to distinguish between heat, temperature, and energy. As shown in Figure 2, the assessment for this learning goal is an open-ended statement regarding these three concepts. The students will be able to describe at least two features of these concepts for an acceptable response. In the book *Knowing what Students Know*, Pellegrino and others (2003) develop an assessment triangle. The assessment triangle has cognition, observation, and interpretation for its corners. The cognition corner is the theory behind the method used in the interpretation corner to interpret the observation noted in the observation corner. The assessment triangle for learning goal 1 can be seen in Figure 3.

Learning Goals and Assessments: Heat, Energy, and Temperature			
Learning Goal	Assessment		
<ul style="list-style-type: none"> <li>Students will be able to distinguish between heat, energy, and temperature.</li> </ul>	<ul style="list-style-type: none"> <li>General: Written Academic Prompt</li> </ul> <p>→ Claim: Students will be able to distinguish between heat, energy, and temperature by relating them to the laws of thermodynamics and molecular activity.</p> <table border="1"> <tr> <td>Task: For each open-ended statement the student will be able to describe the heat, energy, and temperature of the system.</td> <td>Evidence: For each open-ended statement the student will be able to use at least two of the following to describe heat, energy, and temperature: -movement from hot to cold -increased entropy -motion of molecules</td> </tr> </table>	Task: For each open-ended statement the student will be able to describe the heat, energy, and temperature of the system.	Evidence: For each open-ended statement the student will be able to use at least two of the following to describe heat, energy, and temperature: -movement from hot to cold -increased entropy -motion of molecules
Task: For each open-ended statement the student will be able to describe the heat, energy, and temperature of the system.	Evidence: For each open-ended statement the student will be able to use at least two of the following to describe heat, energy, and temperature: -movement from hot to cold -increased entropy -motion of molecules		

**Figure 2: Assessment Matrix for learning goal 1**



**Figure 3: Assessment Triangle for learning goal 1**

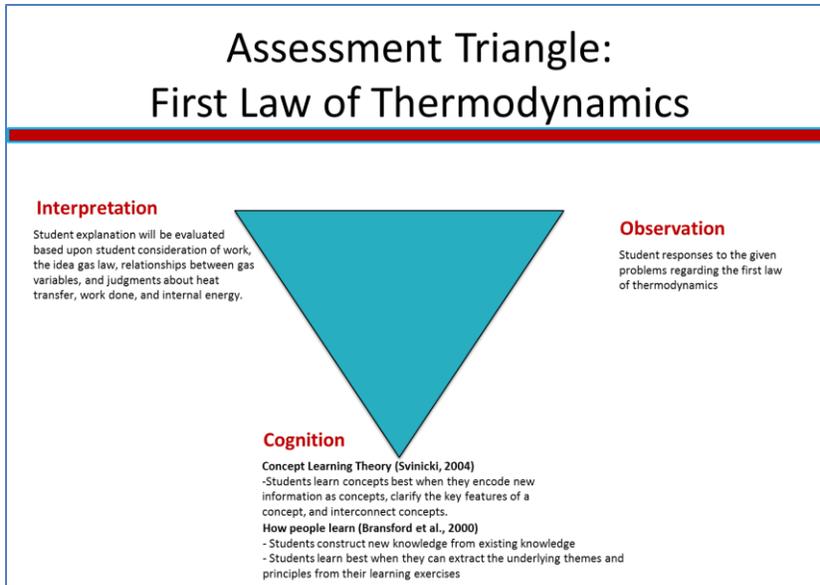
**Learners should be able to apply the first law of thermodynamics**

The second learning goal learners should be able to apply the first law of thermodynamics is derived from the enduring understanding *students will apply the first and second laws of thermodynamics to the solution of problems*. An academic prompt that requires the development of a strategy and evaluation is used as the assessment for this learning goal (Figure 4). The corresponding assessment triangle is shown in Figure 5.

### Learning Goals and Assessments: First Law of Thermodynamics

Learning Goal	Assessment
<ul style="list-style-type: none"> <li>Students will be able to apply the first law of thermodynamics.</li> </ul>	<ul style="list-style-type: none"> <li>General: Written Academic Prompt</li> </ul> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>Claim:</b> Students will be able to apply the first law of the thermodynamics to a problem when given the Pressure-Volume diagram of two processes.</p> </div> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%; border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>Task:</b> Students will respond to set of questions based upon a pressure-volume diagram of two processes. They will be asked if the heat/work for a process is greater than, less than, or equal to the heat/work done for another process.</p> </div> <div style="width: 45%; border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>Evidence:</b> For each question, the student will be able to describe how the first law affect the work and heat for the presented processes. The student will also use one of the following items in the description: the idea gas law or relationships between gas variables.</p> </div> </div>

**Figure 4: Assessment Matrix for learning goal 2**



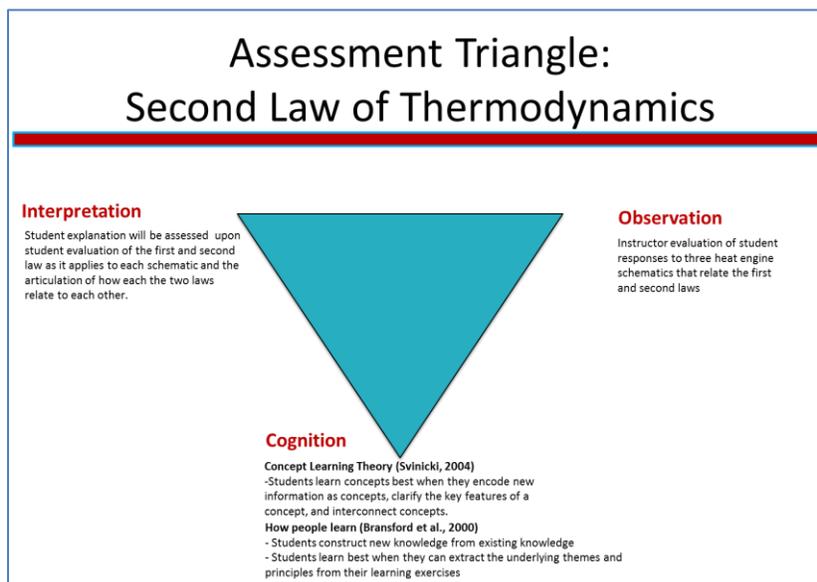
**Figure 5: Assessment Triangle for learning goal 2**

**Learners should be able to use the second law of thermodynamics to defend their answers**  
 Learning goal 3 is based upon students' difficulty with showing how the second law imposes limits upon the first law as discussed in the content section of this paper. Further, this learning goal also stems from enduring understanding *students will apply the first and second laws of thermodynamics to the solution of problems*. The assessment matrix and triangle that corresponds with this learning goal can be seen in Figures 6 and 7, respectively.

### Learning Goals and Assessments: Second Law of Thermodynamics

Learning Goal	Assessment		
<ul style="list-style-type: none"> <li>Students will be able to use the second law to defend their answer.</li> </ul>	<ul style="list-style-type: none"> <li>General: Written Academic Prompt</li> </ul> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>Claim:</b> Students will be able to use the second law to defend their determination about a given heat engine system.</p> </div> <table border="1" style="width: 100%; border-collapse: collapse; margin: 5px 0;"> <tr> <td style="width: 50%; padding: 5px;"> <p><b>Task:</b> Given several schematics of heat engines, the students will be asked if the device could function and to explain their reasoning.</p> </td> <td style="width: 50%; padding: 5px;"> <p><b>Evidence:</b> For each schematic the student will be able to use the first law to determine if it is valid. The student will also evaluate the schematic using the second law to determine whether or not it is satisfied. Both the evaluation of the first and second law are needed for an acceptable response.</p> </td> </tr> </table>	<p><b>Task:</b> Given several schematics of heat engines, the students will be asked if the device could function and to explain their reasoning.</p>	<p><b>Evidence:</b> For each schematic the student will be able to use the first law to determine if it is valid. The student will also evaluate the schematic using the second law to determine whether or not it is satisfied. Both the evaluation of the first and second law are needed for an acceptable response.</p>
<p><b>Task:</b> Given several schematics of heat engines, the students will be asked if the device could function and to explain their reasoning.</p>	<p><b>Evidence:</b> For each schematic the student will be able to use the first law to determine if it is valid. The student will also evaluate the schematic using the second law to determine whether or not it is satisfied. Both the evaluation of the first and second law are needed for an acceptable response.</p>		

**Figure 6: Assessment Matrix for learning goal 3**



**Figure 7: Assessment Triangle for learning goal 3**

### Taxonomy

The revised Bloom’s taxonomy of educational objectives was chosen for this course because of its emphasis on four types of knowledge (Anderson, Krathwohl, & Bloom, 2001). As seen in Figure 8, the first three learning goals correspond to the first three portions of the knowledge dimension. The students will use factual knowledge to solve a problem and analyze a definition. The students will use conceptual knowledge to analyze inter-relationships and evaluate the first and second law. The students will use procedural knowledge to solve problems regarding the first and second laws. The last portion of the knowledge dimension is most related to learning goal 4. Students will use metacognitive knowledge to apply definitions, distinguish between concepts and evaluate problems.

**The learning goals for this course are:** LG1-The learners should be able to distinguish between heat, temperature, and energy, LG2- The learners should be able to apply the first law of thermodynamics, LG3- The learners should be able to use the second law of thermodynamics to defend their answers, and LG4- The learners should be able to create study strategies that will aid them during Thermodynamics I.

### Alignment of Content and Assessment

As noted in this section, the learning goals for the assessment section were derived from the enduring understandings from the content section. Academic prompts as described in Figures 2, 4, and 6 were chosen to assess the enduring understanding through open-ended problems that require students to develop a strategy and think critically (Wiggins & McTighe, 1998) . The cognition corner for each of the assessment triangles shown in figures 3, 5, and 7 were taken from the learning theories described in the content section. These learning theories were also used to determine an interpretation method for each of the assessments.

(Anderson & Krathwohl, 2001).

**The Cognitive Process Dimension** 

	Remember	Understand	Apply	Analyze	Evaluate	Create
<b>The Knowledge Dimension</b> 	<b>Factual Knowledge</b> – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements		LG2: solve problem	LG1: definition		
	<b>Conceptual Knowledge</b> – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures			LG1: classifications and inter-relationships	LG2 & LG3: First law Second law	
	<b>Procedural Knowledge</b> – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures				LG2 & LG3: thermo problem solving skills	
	<b>Metacognitive Knowledge</b> – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge			LG1 & LG4: applying first law definition	LG1 & LG4: distinguishing between concepts	LG2, LG3 & LG4: evaluating using first and second law; problem solving strategies

**Figure 8: Learning Goals using revised Bloom's taxonomy**

**Pedagogy**

The pedagogy to be used in this course will be definition modeling to help students with the first enduring understanding and learning goal. I will also use narrated modeling to help students see the underlying principles in the problems which helps with all of the enduring understandings. Smith and others (2005) note that teachers can uncover material for students by using pedagogies of engagement. To engage my students, I will use collaborative learning where the students will work in small groups during class to solve problems. Finally, I plan to incorporate feedback through class discussions, homework, and team problems.

**Teaching Philosophy**

The teaching philosophy for this course was based upon the book *Making Learning Whole* (Perkins, 2009) . Below I will outline how each of the seven steps impacted the design of this course.

*Play the whole game-* I will help my students see the “whole game” by introducing them to the entire game of the first and second laws of thermodynamics at the beginning of the course. I plan to show the students how the important to know understanding from physics and chemistry build upon each other and relate to the first and second laws. For instance, students will be able to see how the ideal gas law from chemistry is used in thermodynamics as I highlight the

differences in the equations as used in many thermodynamics by transforming the chemistry equation that emphasizes moles to the thermodynamics equation that emphasizes mass.

*Make the game worth playing-* I plan to make the game worth playing by showing the students how their previous knowledge relates to this course and how all of the concepts in the course relate to each other. I will also make connections to their industry project with Caterpillar to help students see how thermodynamics is relevant in engineering. Finally, I intend to create a welcoming climate by setting realistic, high expectations and supporting the students as they navigate through the process of learning.

*Work on the hard parts-* I anticipate the hard parts will be the common thermodynamics misconceptions mentioned in content portion. These misconceptions were used to create the learning goals. For instance, students commonly are unable to distinguish between heat and temperature and the first learning goal is learners should be able to distinguish between heat, temperature, and energy. To prepare for the related assessment, the students will be given problems to practice with for homework. Students will also discuss definition modeling during the course to help them to clarify their definitions and distinguish between the concepts. Students will receive timely and constructive feedback such as notes on homework and peer feedback during problem solving.

*Play out of town-* At the beginning of the course, prior knowledge from physics and chemistry will be "imported" through discussions, in class problems, and homework problems. The students will have an opportunity to be active with the material by presenting a problem as part of a group (see Syllabus). Finally, the students will be given varied problems for low road transfer and they will have opportunity for reflection in their learning portfolio where they will reflect on three problems for high road transfer.

*Uncover the hidden game-* Several strategies will be used to make the implicit explicit. Students will be given authentic tasks like the open-ended problem assessment for the third learning goal. In addition, I will use narrated modeling to help students discover the underlying rules of the problems. Scaffolding will be used to help students to surface previously learned material that is relevant to the problem being worked. Again, students will have a chance to articulate the steps when they present a problem as a group. Finally, students will be able to reflect on their process in their learning portfolio.

*Learning from the team...and other teams-* Students will get an opportunity to learn from the team as they complete in class problems in small teams of two to three. Students will also be able to learn from each other during their group problem presentation. The students will choose a problem as a group to present to the class that relates to one of the first three learning goals. They will work with each other to create a solution. Finally, they will present the problem to their peers using narrated modeling to uncover the hidden aspects of the chosen problem.

*Learn the game of learning-* As noted in other steps, I will give the students an opportunity to reflect on their learning through their learning portfolio. For the learning portfolio, they will choose one problem for each of the following content areas: definitions, first law of thermodynamics, and second law of thermodynamics. They will also note the problem solving process for each selected problem.

## Content, Assessment, and Pedagogy Alignment

Figure 9 below shows the alignment of the most important three learning objectives. The alignment in this course can be demonstrated by taking an example from the middle column. The second enduring understanding of applying the first and second laws to the solution of problems led to the learning goal of students will be able to apply the first law to problems. The learning theories for this goal were students learn best when they encode, clarify, and interconnect concepts; students construct new knowledge from previous knowledge; and students learn best when they extract underlying themes and principles from learning exercises. This understanding is assessed by an academic prompt that is an open-ended problem that requires the proper application of the first law of thermodynamics as acceptable evidence (i.e. how first law affects heat and work processes). This task is interpreted based upon student consideration of work, the idea gas law, relationships between gas variables, and judgments about heat transfer, work done, and internal energy. Several pedagogies are employed to achieve the enduring understanding and learning goal. Narrative modeling is used to highlight the hidden game in classroom problems relating to the first law. Also, students collaborate with each other to assist in understanding of first law problems. Finally, the students are given specific feedback from the instructor and classmates to help students understand how to make judgments about heat transfer, work, and energy in first law problems.

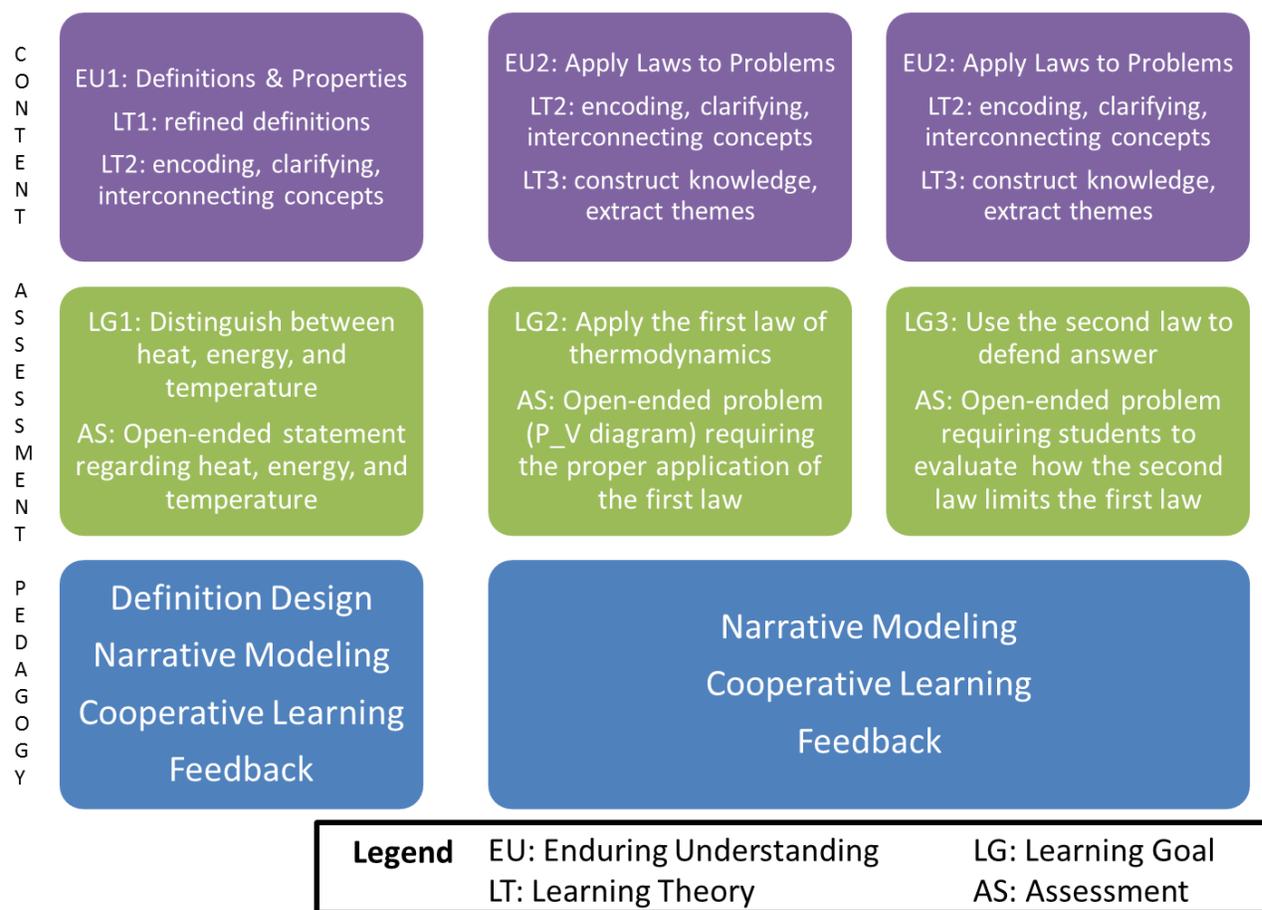


Figure 9: Alignment of content, assessment, and pedagogy

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## Appendix: Syllabus for short course

### Syllabus

## Thermodynamics I

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### Learning Goals

After completion of this course, you will be able to:

1. Understand the essential basic terms of thermodynamics such as heat and energy.
2. Apply the first and second laws of thermodynamics to the solution of problems.
3. Develop learning strategies for the successful completion of Thermodynamics I.

### Course Expectations

#### *What I expect from you?*

I expect you to come to class ready to learn and engage with your classmates in learning thermodynamics. I also expect you to complete your assigned readings before class and complete homework assignments on time. I expect you to respect me and your classmates. I expect you to feel free to ask any relevant course question without ridicule.

#### *What you should expect from me?*

You can expect me to encourage you through this course. You can also expect me to uncover the underlying principles of the problems presented in class. You can expect me to be available for your questions and concerns.

#### *What you should expect from the class?*

You can expect the class to be interactive with discussions about the material and group problems. You can expect to learn from your classmates in addition to your instructor (collaborative learning). You can also expect to be both challenged by the material and be supported by your instructor and classmates through the difficult parts.

### Grading

Your assignments will be graded\* even though you will not receive credit for this course. The percentages are as follows:

Assignment	Percentage
Homework	15%
Participation	15%
Quizzes (3)	30%

Group Problem Presentation	15%
Learning Portfolio	15%
Final Exam	10%

\*There is no guarantee that the grade you earn in this course will be the same grade that you will earn in Thermodynamics I, but I hope that knowing your grades helps you to gauge your progress.

### Grading Scale

A: 90 – 100    C: 70- 79    F: Less than 60  
 B: 80- 89    D: 60 -69

### Assignments

**Homework:** Homework will consist of assigned textbook problems, reading assignments, definition modeling of given terms, and special problems taken from other sources.

**Participation:** Most class sessions will consist of active in class problem solving and discussions. You are expected to participate in these activities, ask questions, and be prepared to respond if called upon.

**Quizzes:** There will be three quizzes that will cover each of the major topics: Essential basic terms, First Law of Thermodynamics, and Second Law of Thermodynamics. These quizzes will either be administered in class or given as a take home quiz.

**Group Problem Presentation:** Each group will select a problem that will be presented in class (group size will depend on class size, but there will be three groups). This problem will be used to help prepare you and your classmates for a quiz, so it is expected to be of the appropriate difficulty and topic. I will meet with your group to help your group choose a problem, approve your group’s final selection, and answer any questions that your group may have. The group will submit a complete solution of the problem with the “hidden game” identified and all steps shown before the presentation. You will sign up for problems during the first week of class. The presentation should be no longer than 15 minutes, it should be interactive, and it should illustrate the “hidden game” to your classmates, and it should be clearly presented to your classmates.

**Learning Portfolio:** You will take a problem from the course (quiz, homework problem, etc.) for each of the major topics and create a solution for the problem with all of the steps shown. You will identify the process that you used to solve each problem (including any “chaining” used). You will also include your definitions for the terms used in the problem (i.e. heat, work, ideal gas law). Finally, you will discuss how the processes for each of the three problems are similar and dissimilar and note any changes you would make to your process if the problem were

reversed (i.e. provided with the solution and asked to find one of the previously given properties instead).

### Preparing for each class session

You can prepare for class by reading the assigned reading before class, completing homework assignments on time, participating in class discussions and group problems, and keeping a good attitude.

### Preparing for quizzes and the final exam

You can prepare for examinations by participating in the group problem presentation, redoing class problems, and redoing homework problems. You can also help prepare for examinations by using the reading strategy described below.

### Class Schedule

Week	Topic	Assessments	Reading	Assignment Due
1	Important concepts from Physics and Chemistry Definitions & Properties	Quiz 1	TBD	homework as assigned Group 1 Presentation
2	Definitions & Properties First Law of Thermodynamics	Quiz 2	TBD	homework as assigned Learning Portfolio draft Group 2 Presentation
3	First Law of Thermodynamics, Second Law of Thermodynamics	Quiz 3	TBD	homework as assigned Learning Portfolio draft Group 3 Presentation
4	Second Law of Thermodynamics Course Review	Final	TBD	homework as assigned Learning Portfolio due