Student Learning Outcomes/Objectives, with Any Associations and Related Measures, Targets, Findings, and Action Plans

SLO 1: Critical Thinking
Students will demonstrate critical thinking skills by applying fundamental physical principles to real world examples.

A quiz consisting of several (4) parts will be given to the students as part of their normal quiz grade. The quiz will require both an understanding of fundamental concepts (C. T.), as well as a calculation requiring a command of the basic mathematics of problems solving (Q. T.). The quiz will then be assessed for each student with a rubric for Critical Thinking.

Some physical properties of Silver and Gold are listed in the table on the next page. You have 10 grams of each metal initially at 0°C.

(a) Which of the quantities on the table are required in order to determine the heat required to melt each metal completely? Explain why each quantity is required.

(b) Which metal will require more heat to raise the temperature to its melting point? Why?

(c) Which metal requires more heat to raise to the melting point (starting from 0°C) and then melt completely? Justify your answer.

(d). Does the metal with the highest melting point or boiling point require the most heat to melt? Explain your answer.

Table of Thermal Properties

<table>
<thead>
<tr>
<th></th>
<th>Silver</th>
<th>Gold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Heat Capacity (J/g°C)</td>
<td>0.0924</td>
<td>0.0560</td>
</tr>
<tr>
<td>Melting Point (°C)</td>
<td>961</td>
<td>1063</td>
</tr>
<tr>
<td>Latent Heat of Fusion (J/g)</td>
<td>21.1</td>
<td>15.4</td>
</tr>
<tr>
<td>Boiling Point (°C)</td>
<td>2193</td>
<td>2660</td>
</tr>
</tbody>
</table>
| Latent Heat of Vapor (J/g) | 557 377 | Rubric: We will use the following AACU rubric for Critical Thinking to assess the quiz problem:

Critical Thinking VALUE Rubric

for more information, please contact value@aacu.org
Relevant Associations:
Standard Associations

New Core Component Areas
2. Life & Physical Science (L & PS)

New Core Objectives
1. Critical Thinking (CT)

Related Measures

M 1: Critical Thinking Measure
Critical Thinking Measure.

Students will demonstrate critical thinking skills by applying fundamental physical principles to real world examples. A quiz consisting of several (4) parts will be given to the students as part of their normal quiz grade. The quiz will require both an understanding of fundamental concepts (C. T.), as well as a calculation requiring a command of the basic mathematics of problems solving (Q. T.). The quiz will then be assessed for each student with a rubric for Critical Thinking. Some physical properties of Silver and Gold are listed in the table on the next page. You have 10 grams of each metal initially at .

(a) Which of the quantities on the table are required in order to determine the heat required to melt each metal completely? Explain why each quantity is required.

(b) Which metal will require more heat to raise the temperature to its melting point? Why?

(c) Which metal requires more heat to raise to the melting point (starting from ) and then melt completely? Justify your answer.

(d). Does the metal with the highest melting point or boiling point require the most heat to melt? Explain your answer.

Table of Thermal Properties

<table>
<thead>
<tr>
<th></th>
<th>Silver</th>
<th>Gold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Heat Capacity (J/g°C)</td>
<td>0.0924</td>
<td>0.0560</td>
</tr>
<tr>
<td>Melting Point (°C)</td>
<td>961</td>
<td>1063</td>
</tr>
<tr>
<td>Latent Heat of Fusion (J/g)</td>
<td>21.1</td>
<td>15.4</td>
</tr>
<tr>
<td>Boiling Point (°C)</td>
<td>2319</td>
<td>2660</td>
</tr>
<tr>
<td>Latent Heat of Vapor (J/g)</td>
<td>557</td>
<td>377</td>
</tr>
</tbody>
</table>

Source of Evidence: Writing exam to assure certain proficiency level
Target:
We expect students to obtain at least 75% of the points obtainable from the Rubric.

SLO 2: Quantitative Thinking
Students will demonstrate quantitative thinking skills by applying basic mathematical principles to the solution of real world examples.

A quiz consisting of several (4) parts will be given to the students as part of their normal quiz grade. The quiz will require both an understanding of fundamental concepts (C. T.), as well as a calculation requiring a command of the basic mathematics of problems solving (Q. T.). The quiz will then be assessed for each student with a rubric for Quantitative Thinking skills.

Some physical properties of Silver and Gold are listed in the table on the next page. You have 10 grams of each metal initially at .

(a) Which of the quantities on the table are required in order to determine the heat required to melt each metal completely? Explain why each quantity is required.

(b) Which metal will require more heat to raise the temperature to its melting point? Why?

(c) Which metal requires more heat to raise to the melting point (starting from ) and then melt completely? Justify your answer.

(d). Does the metal with the highest melting point or boiling point require the most heat to melt? Explain your answer.

Table of Thermal Properties

<table>
<thead>
<tr>
<th></th>
<th>Silver</th>
<th>Gold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Heat Capacity (J/g°C)</td>
<td>0.0924</td>
<td>0.0560</td>
</tr>
</tbody>
</table>
Quantitative Literacy VALUE Rubric
for more information, please contact value@aacu.org

Relevant Associations:
Standard Associations
New Core Component Areas
2 Life & Physical Science (L & PS)
New Core Objectives
3 Empirical & Quantitative Skills (EQS)

Related Measures
M 2: Quantitative Thinking Measure
Quantitative Thinking Measure.

Students will demonstrate critical thinking skills by applying fundamental physical principles to real world examples. A quiz consisting of several (4) parts will be given to the students as part of their normal quiz grade. The quiz will require both an understanding of fundamental concepts (C. T.), as well as a calculation requiring a command of the basic mathematics of problems solving (Q. T.). The quiz will then be assessed for each student with a rubric for Quantitative Thinking. Some physical properties of Silver and Gold are listed in the table on the next page. You have 10 grams of each metal initially at.

(a) Which of the quantities on the table are required in order to determine the heat required to melt each metal completely? Explain why each quantity is required.
(b) Which metal will require more heat to raise the temperature to its melting point? Why?
(c) Which metal requires more heat to raise to the melting point (starting from ) and then melt completely? Justify your answer.
(d) Does the metal with the highest melting point or boiling point require the most heat to melt? Explain your answer.

Table of Thermal Properties
<table>
<thead>
<tr>
<th></th>
<th>Silver</th>
<th>Gold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Heat Capacity</td>
<td>0.0924</td>
<td>0.0560</td>
</tr>
<tr>
<td>Melting Point</td>
<td>961</td>
<td>1063</td>
</tr>
<tr>
<td>Latent Heat of Fusion</td>
<td>21.1</td>
<td>15.4</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>2193</td>
<td>2660</td>
</tr>
<tr>
<td>Latent Heat of Vapor</td>
<td>557</td>
<td>377</td>
</tr>
</tbody>
</table>

Source of Evidence: Writing exam to assure certain proficiency level

Target:
We expect students to obtain at least 75% of the points obtainable from the Rubric.

SLO 3: Teamwork
Students will demonstrate the ability to work with others in a common effort to achieve an outcome through cooperation and teamwork in laboratory exercises. Laboratory Exercise - Thermal Expansion:

PHY 1407 Laboratory 8

Thermal Expansion

I. Design an experiment, with the equipment at your lab station, to measure the thermal expansion of the ~1 m long metal pipes. The length of a metal pipe will increase by some small amount when heated to a higher temperature. We wish to determine by how many mm a 1 m long rod of a given material will increase in length when heated by 1oC. We call this the Expansion Coefficient, called .

In designing the experiment, think about how you can determine the slight change in length of the pipe, and how you will know the change in temperature of the pipe. Once you have the experiment figured out, draw a sketch of the setup below:
II. The tiny increase in the length of the pipe can be measured by measuring the angular change in the pointer position. If \( \ell \) is the circumference of the pointer spindle (\( \ell \)), then the change in the length can also be written

\[
\text{(3)}
\]

The expansion coefficient is then the change in length divided by the change in temperature:

III. Determine the experimental angle for the three metal pipes using the setup. At the end we will combine all the results of the lab groups and compare experimental values with “accepted values” from tables.

DATA

<table>
<thead>
<tr>
<th></th>
<th>Aluminum</th>
<th>Brass</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original temperature</td>
<td>( ___ ) ( ^\circ C )</td>
<td>( ___ ) ( ^\circ C )</td>
<td>( ___ ) ( ^\circ C )</td>
</tr>
<tr>
<td>Final temperature</td>
<td>( ___ ) ( ^\circ C )</td>
<td>( ___ ) ( ^\circ C )</td>
<td>( ___ ) ( ^\circ C )</td>
</tr>
<tr>
<td>Temp. Change (( \ell ))</td>
<td>( ___ ) ( ^\circ C )</td>
<td>( ___ ) ( ^\circ C )</td>
<td>( ___ ) ( ^\circ C )</td>
</tr>
<tr>
<td>Angle turned (( \theta ))</td>
<td>( ___ ) ( ^\circ )</td>
<td>( ___ ) ( ^\circ )</td>
<td>( ___ ) ( ^\circ )</td>
</tr>
</tbody>
</table>

IV. ANALYSIS: CALCULATION OF THE EXPANSION COEFFICIENT

The angle turned indicates the amount of expansion. For example, if the angle turned had been 360\( ^\circ \), this would indicate that the spindle had turned through a complete circle. For that to happen, the rod would have to expand by an amount equal to the circumference of the spindle (which happens to be 7.5 mm), assuming it doesn't slip!

Now the angle turned in the experiment was some fraction of 360\( ^\circ \), and so the amount of increase is a similar fraction of 7.5 mm. Be sure to keep at least 3 significant figures in your calculations!

Fraction of a Aluminum Brass Iron circle turned : = \( ___ \) \( ___ \) \( ___ \)
To calculate the expansion coefficient, divide the expansion length by the temperature change:

Expansion of 1 m Aluminum Brass Iron
for 1°C Temperature Rise _____ _____ _____
(Expansion Coefficient)

Class Average, _____ _____ _____
Std. Dev. ± _____ ± _____ ± _____

Accepted Values _____ _____ _____

Questions

1. How do the class average values compare with the accepted values from tables?

2. Exactly what are the units of the expansion coefficient we have calculated?

3. What would the total expansion of the aluminum have been if the original length of the rod had been 60 m instead of 1 m? (Assume the accepted value for the expansion coefficient of aluminum)

4. Suppose a 200 m long steel pipe is installed in a straight line from one building to the next when the temperature is 20°C. What happens when the pipe comes to equilibrium with a hot fluid at 520°C? By what length will the pipe expand? (Steel has an expansion coefficient of about 0.006 mm/°C for each meter of length).
Draw a Sketch below to show a possible remedy for this situation Rubric: We have developed our own rubric for assessing Teamwork in our laboratory:

TEAMWORK VALUE RUBRIC

The Teamwork Value Rubric developed by the Association of Colleges and Universities (AAC&U) was designed to assess student progress over the course of an extended project did not fit the needs of our particular assessment needs. However the following rubric was developed using the AAC&U project rubric as a guide in conjunction with the work of Larson and LaFasto (Teamwork: What Must Go Right/What Can Go Wrong, Sage Publications 1989).

Relevant Associations:

- Standard Associations
  - New Core Component Areas
    - Life & Physical Science (L & PS)
  - New Core Objectives
    - 4 Teamwork (TW)

Related Measures

M 3: Teamwork Measure

Teamwork Measure.

Laboratory Exercise - Thermal Expansion: PHYS 1407 Laboratory 8 Thermal Expansion I. Design an experiment, with the equipment at your lab station, to measure the thermal expansion of the ~1 m long metal pipes. The length of a metal pipe will increase by some small amount when heated to a higher temperature. We wish to determine by how many mm a 1 m long rod of a given material will increase in length when heated by 1°C. We call this the Expansion Coefficient, called . In designing the experiment, think about how you can determine the slight change in length of the pipe, and how you will know the change in temperature of the pipe. Once you have the experiment figured out, draw a sketch of the setup below. II. The tiny increase in the length of the pipe can be measured by measuring the ANGULAR change in the pointer position. If is the circumference of the pointer spindle ( ), then the change in the length can also be written (3) The expansion coefficient is then the change in length divided by the change in temperature: III. Determine the experimental angle for the three metal pipes using the setup. At the end we will combine all the results of the lab groups and compare experimental values with “accepted values” from tables. DATA Aluminum Brass Iron Original temperature oC oC oC Final temperature oC oC oC Temp. Change ( ) oC oC oC Angle turned ( ) o o o IV. ANALYSIS: CALCULATION OF THE EXPANSION COEFFICIENT The angle turned indicates the amount of expansion. For example, if the angle turned had been 360°, this would indicate that the spindle had turned through a complete circle. For that to happen, the rod would have to expand by an amount equal to the circumference of the spindle (which happens to be 7.5 mm), assuming it doesn’t slip! Now the angle turned in the experiment was some fraction of 360°, and so the amount of increase is a similar fraction of 7.5 mm. Be sure to keep at least 3 significant figures in your calculations! Fraction of a Aluminum Brass Iron circle turned : = Expansion = = mm mm mm To calculate the expansion coefficient, divide the expansion length by the temperature change: Expansion of 1 m Aluminum Brass Iron for 1°C Temperature Rise (Expansion Coefficient) Class Average, ________ ± ± ± Accepted Values ________ ________ ________ Questions 1. How do the class average values compare with the accepted values from tables? 2. Exactly what are the units of the expansion coefficient we have calculated? 3. What would the total expansion of the aluminum have been if the original length of the rod had been 60 m instead of 1 m? (Assume the accepted value for the expansion coefficient of aluminum) 4. Suppose a 200 m long steel pipe is installed in a straight line from one building to the next when the temperature is 20°C. What happens when the pipe comes to equilibrium with a hot fluid at 520°C? By what length will the pipe expand? (Steel has an expansion coefficient of about 0.0066 mm/°C for each meter of length). Draw a Sketch below to show a possible remedy for this situation Rubric: We have developed our own rubric for assessing Teamwork in our laboratory: TEAMWORK VALUE RUBRIC The Teamwork Value Rubric developed by the Association of Colleges and Universities (AAC&U) was designed to assess student progress over the course of an extended project did not fit the needs of our particular assessment needs. However the following rubric was developed using the AAC&U project rubric as a guide in conjunction with the work of Larson and LaFasto (Teamwork: What Must Go Right/What Can Go Wrong, Sage Publications 1989).

Source of Evidence: Project, either individual or group

Target:

We expect students to obtain at least 75% of the points obtainable from the Rubric.

SLO 4: Communication

Students will demonstrate communication skills by reporting the process and results of laboratory exercise in a written laboratory report. Laboratory Exercise - Thermal Expansion:

PHYS 1407 Laboratory 8

Thermal Expansion
I. Design an experiment, with the equipment at your lab station, to measure the thermal expansion of the ~1 m long metal pipes. The length of a metal pipe will increase by some small amount when heated to a higher temperature. We wish to determine by how many mm a 1 m long rod of a given material will increase in length when heated by 1°C. We call this the Expansion Coefficient, called \( \alpha \).

In designing the experiment, think about how you can determine the slight change in length of the pipe, and how you will know the change in temperature of the pipe. Once you have the experiment figured out, draw a sketch of the setup below:

II. The tiny increase in the length of the pipe can be measured by measuring the ANGULAR change in the pointer position. If \( \ell \) is the circumference of the pointer spindle (\( \ell \)), then the change in the length can also be written

\[
(3)
\]

The expansion coefficient is then the change in length divided by the change in temperature:

III. Determine the experimental angle for the three metal pipes using the setup. At the end we will combine all the results of the lab groups and compare experimental values with “accepted values” from tables.

DATA

Aluminum Brass Iron

<table>
<thead>
<tr>
<th>Original temperature</th>
<th>__________°C</th>
<th>__________°C</th>
<th>__________°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final temperature</td>
<td>__________°C</td>
<td>__________°C</td>
<td>__________°C</td>
</tr>
<tr>
<td>Temp. Change ( )</td>
<td>__________°C</td>
<td>__________°C</td>
<td>__________°C</td>
</tr>
<tr>
<td>Angle turned ( )</td>
<td>__________°</td>
<td>__________°</td>
<td>__________°</td>
</tr>
</tbody>
</table>
IV. ANALYSIS: CALCULATION OF THE EXPANSION COEFFICIENT

The angle turned indicates the amount of expansion. For example, if the angle turned had been 360o, this would indicate that the spindle had turned through a complete circle. For that to happen, the rod would have to expand by an amount equal to the circumference of the spindle (which happens to be 7.5 mm), assuming it doesn't slip!

Now the angle turned in the experiment was some fraction of 360o, and so the amount of increase is a similar fraction of 7.5 mm. Be sure to keep at least 3 significant figures in your calculations!

Fraction of a Aluminum Brass Iron

Circle turned : = __________ __________

Expansion = =________mm ________mm ________mm

To calculate the expansion coefficient, divide the expansion length by the temperature change:

Expansion of 1 m Aluminum Brass Iron

For 1°C Temperature Rise ________ ________ ________

(Expansion Coefficient)

Class Average, ________ ________ ________

Std. Dev. ±________ ±________ ±________

Accepted Values ________ ________ ________

Questions

1. How do the class average values compare with the accepted values from tables?

2. Exactly what are the units of the expansion coefficient we have calculated?

3. What would the total expansion of the aluminum have been if the original length of the rod had been 60 m instead of 1
4. Suppose a 200 m long steel pipe is installed in a straight line from one building to the next when the temperature is 20°C. What happens when the pipe comes to equilibrium with a hot fluid at 520°C? By what length will the pipe expand? (Steel has an expansion coefficient of about 0.006 mm/oC for each meter of length).

Draw a Sketch below to show a possible remedy for this situation Rubric: We have developed our own rubric for assessing Teamwork in our laboratory:

Communication VALUE RUBRIC

Relevant Associations:

Standard Associations
New Core Component Areas
2 Life & Physical Science (L & PS)
New Core Objectives
2 Communication (COM)

Related Measures

M 4: Communication Measure
Communication Measure.

Laboratory Exercise - Thermal Expansion: PHYS 1407 Laboratory 8 Thermal Expansion I. Design an experiment, with the equipment at your lab station, to measure the thermal expansion of the ~1 m long metal pipes. The length of a metal pipe will increase by some small amount when heated to a higher temperature. We wish to determine by how many mm a 1 m long rod of a given material will increase in length when heated by 1°C. We call this the Expansion Coefficient, called . In designing the experiment, think about how you can determine the slight change in length of the pipe, and how you will know the change in temperature of the pipe. Once you have the experiment figured out, draw a sketch of the setup below: II. The tiny increase in the length of the pipe can be measured by measuring the ANGULAR change in the pointer position. If is the circumference of the pointer spindle ( ), then the change in the length can also be written (3) The expansion coefficient is then the change in length divided by the change in temperature: III. Determine the experimental angle for the three metal pipes using the setup. At the end we will combine all the results of the lab groups and compare experimental values with “accepted values” from tables. DATA Aluminum Brass Iron Original temperature ___oC ___oC ___oC Final temperature ___oC ___oC ___oC Temp. Change ( ) ___oC ___oC ___oC Angle turned ( ) N. ANALYSIS: CALCULATION OF THE EXPANSION COEFFICIENT The angle turned indicates the amount of expansion. For example, if the angle turned had been 360°, this would indicate that the spindle had turned through a complete circle. For that to happen, the rod would have to expand by an amount equal to the circumference of the spindle (which happens to be 7.5 mm), assuming it doesn’t slip! Now the angle turned in the experiment was some fraction of 360°, and so the amount of increase is a similar fraction of 7.5 mm. Be sure to keep at least 3 significant figures in your calculations! Fraction of a Aluminum Brass Iron circle turned : = Expansion = = mm mm mm To calculate the expansion coefficient, divide the expansion length by the temperature change: Expansion of 1 m Aluminum Brass Iron for 1°C Temperature Rise ___°C ___°C ___°C (Expansion Coefficient) Class Average, ___ abreasi 3. What would the total expansion of the aluminum have been if the original length of the rod had been 60 m instead of 1 m? (Assume the accepted value for the expansion coefficient of aluminum) 4. Suppose a 200 m long steel pipe is installed in a straight line from one building to the next when the temperature is 20°C. What happens when the pipe comes to equilibrium with a hot fluid at 520°C? By what length will the pipe expand? (Steel has an expansion coefficient of about 0.006 mm/oC for each meter of length). Draw a Sketch below to show a possible remedy for this situation

m? (Assume the accepted value for the expansion coefficient of aluminum)
Rubric: Communication VALUE RUBRIC The Communication Value Rubric developed by the Association of Colleges and Universities (AAC&U) was designed to assess student progress over the course of an extended project did not fit the needs of our particular assessment needs. However the following rubric was developed using the AAC&U project rubric as a guide in conjunction with the work of Larson and LaFasto (Teamwork: What Must Go Right/What Can Go Wrong, Sage Publications 1989).

Source of Evidence: Written assignment(s), usually scored by a rubric

**Target:**
We expect students to obtain at least 75% of the points obtainable from the Rubric.