LABORATORY DESIGN FOR ENHANCED LEARNING OUTCOMES

M S & T Conference 2017 – University Materials Council Meeting

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UF | UNIVERSITY of FLORIDA

The University of Florida has approximately **38,000 employees**, including regular and time-limited faculty, staff, student employees and other temporary employees.

UF has more than **400 endowed faculty chairs** and a goal to add 100 more via the UF Foundation's three-year Preeminence campaign. The Foundation's last capital campaign exceeded its goal and raised $1.7 billion.

85 percent of UF students graduate in six years, **and 67 percent graduate in four years.**

About the Gators.

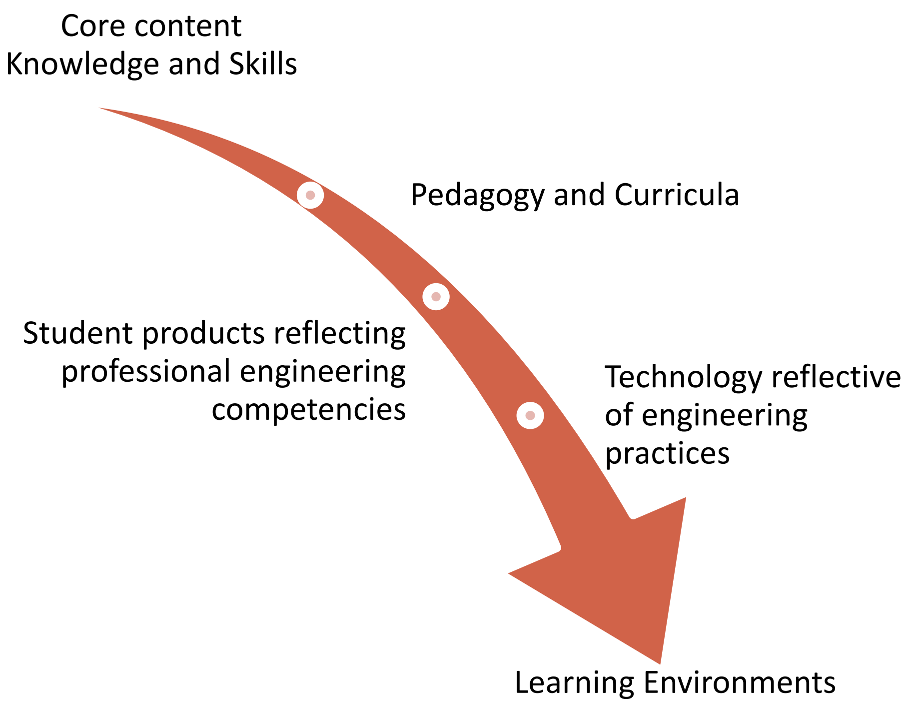
Admitted students at the University of Florida have **an average high school GPA of 4.4.**

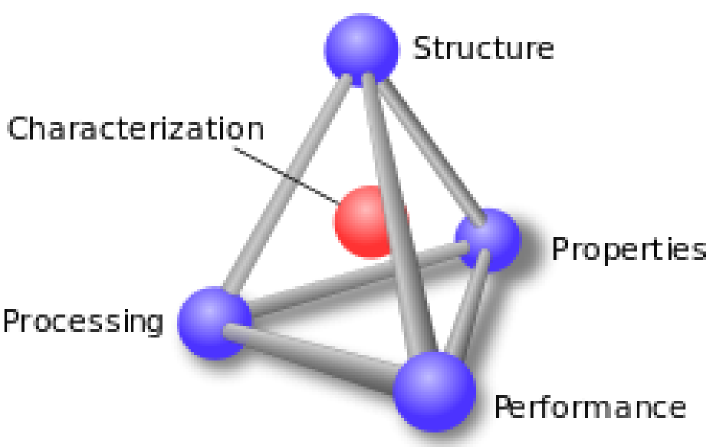
84 percent of UF's undergraduates receive federal, state or private sources of financial aid, and **nearly 60 percent graduate with no student-loan debt.**

The Machen Florida Opportunity Scholars (FOS) program has brought more than **3,000 exceptional first-generation college students** to the University, and the FOS retention rates have been 97.9%.

Undergraduate Laboratory Vision

Students perform a series of collaborative thematic activities integrating core content area knowledge with technical skills & methods, and engineering professional practices. Students apply knowledge to solve engineering problems using methods and practices of engineers.





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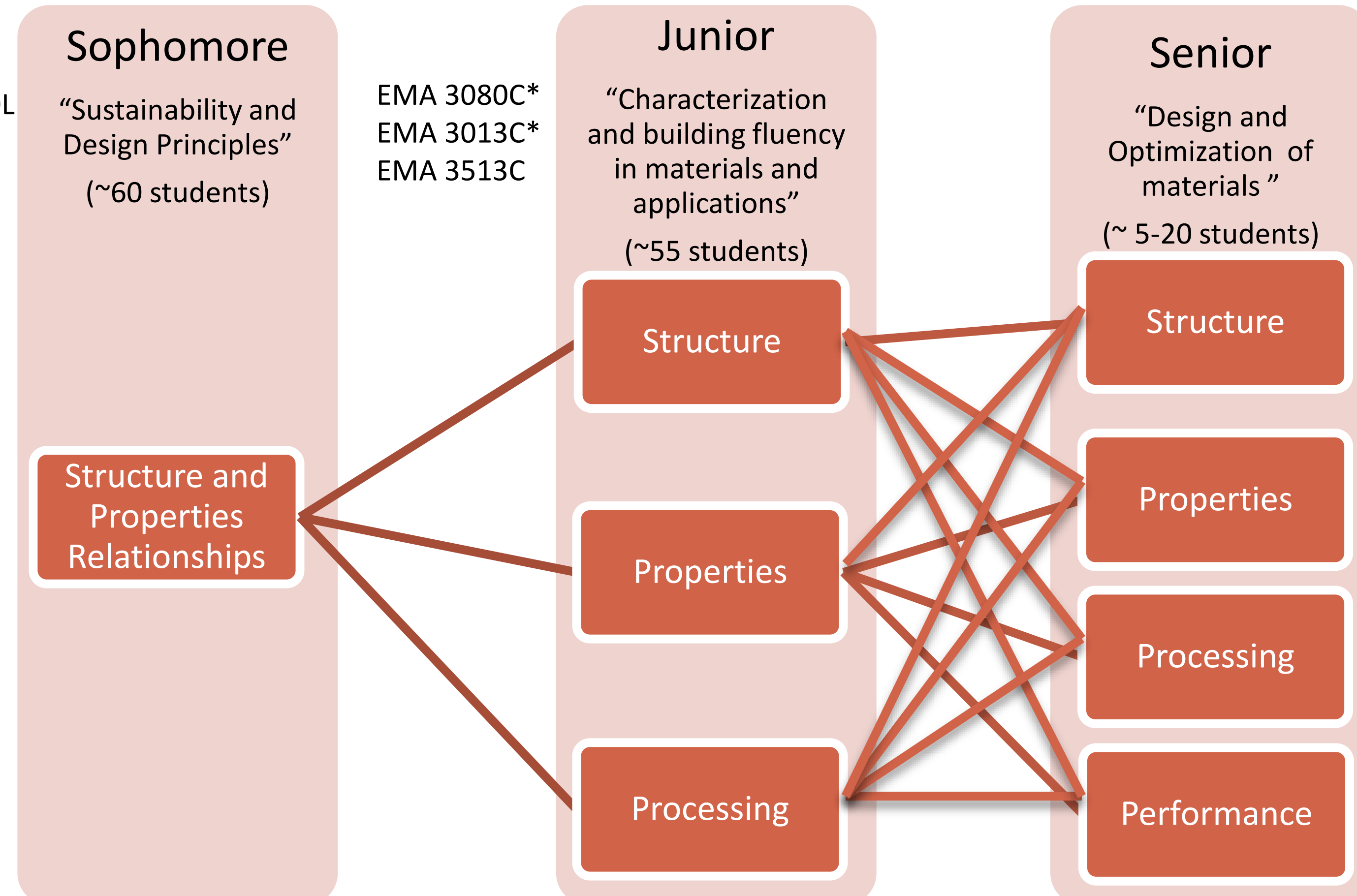
Laboratory module outcomes are designed to build engineering professional identity, social and ethical engineering practices, teamwork, ABET, Systems Thinking , and content knowledge.

As students move through the curriculum, laboratory experiences provide the core application for their coursework knowledge. The complexity of the laboratory experiences changes with the knowledge that students acquire within the courses and laboratories.

EMA 3000L

EMA 3080C*
EMA 3013C*
EMA 3513C



EMA 4041L
EMA 4020L
EMA 4161L
EMA 4061L
EMA 4414L

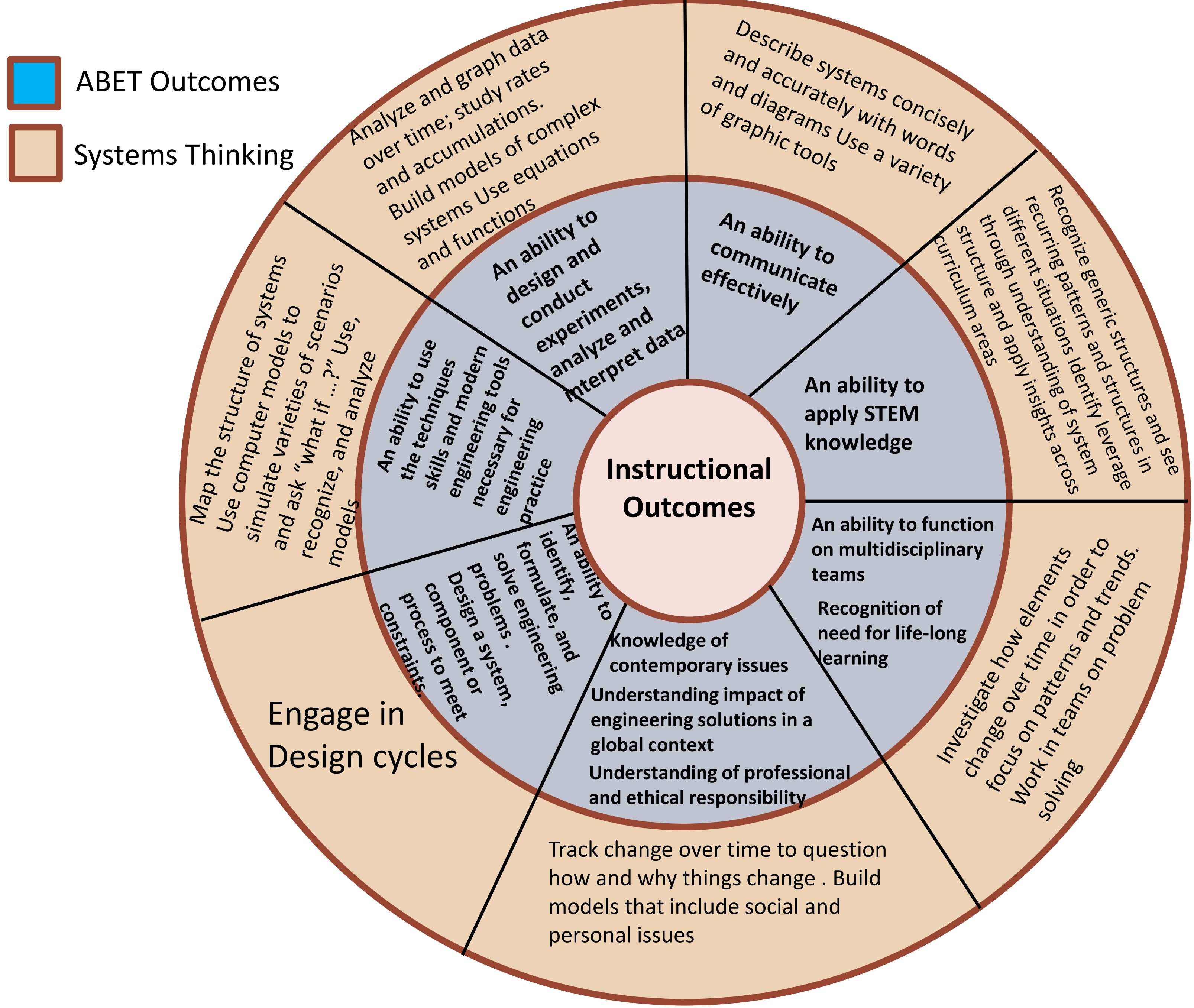
EMA 4913
EMA 4914

* Laboratories receive writing credit for student work products in course (two grades for course)

Laboratory Goals	ABET Goals (2006)	ABET Goals 2015
Conceptual understanding	Illustrate concepts and principles	(a) an ability to apply knowledge of mathematics, science, and engineering (e) an ability to identify, formulate, and solve engineering problems (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
Design Skills	Ability to design and investigate Understand the nature of science (scientific mind)	(b) an ability to design and conduct experiments, as well as to analyze and interpret data (c)an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
Social Skills	Social skills and other productive team behaviors (communication, team interaction and problem solving, leadership)	(d) an ability to function on multidisciplinary teams g) an ability to communicate effectively
Professional Skills	Technical/procedural skills Introduce students to the world of scientists and engineers in practice Application of knowledge to practice	(f) an understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (i) a recognition of the need for, and an ability to engage in life-long learning (j) a knowledge of contemporary issues

Laboratory goals aligned with ABET Criteria, based in work by Ma and Nickerson.

Ma, J., & Nickerson, J. V. (2006). Hands-on, simulated, and remote laboratories: A comparative literature review. *ACM Computing Surveys (CSUR)*, *38*(3), 7.



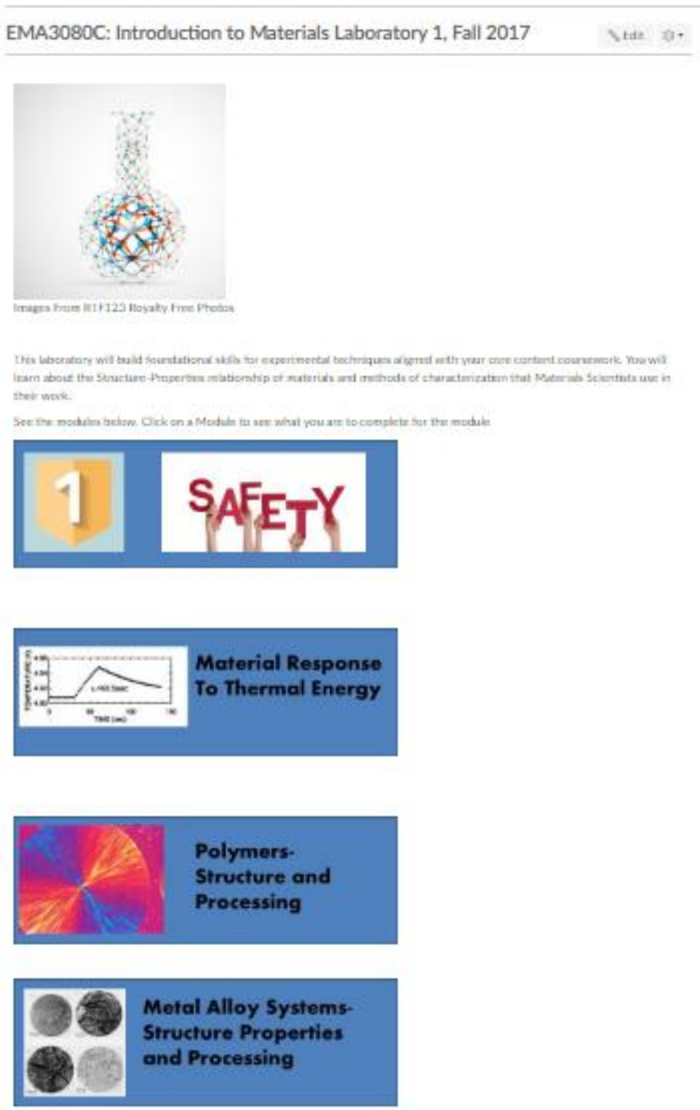
Based on http://www.clexchange.org/curriculum/standards/stem.asp

How are Laboratory Experiences Designed?

- Backwards Design – What outcomes ?
  - **Skills Outcomes** – what do we want them to be able to take away and apply?
  - **Content Outcomes** – what concepts are "big ideas" or difficult for students in the core curriculum?
  - **Technique Outcomes** – what technology should students interface with as engineers?
  - **ABET Outcomes-** what core ABET practices are aligned to the laboratories?

Module #	Concepts	Laboratory Experiences	Skills	Student Products
Structure and properties - Heat, transformations and phase diagrams	Work, heat energy and internal energy Standard enthalpy changes, Dispersal of Energy, entropy, Third Law, Gibbs and Helmholtz energies, Standard molar Gibbs free energies, Combined 1st and 2nd Laws, Phase diagrams, phase boundaries, phase rule, partial molar quantities, thermodynamics of mixing, kinetics of phase transformations, chemical Potentials, diffusivity, conductivity	Arduino programming of TMPs Heat conductivity/ diffusivity experiment MATLAB modeling of heat flow in a bar Labview Programming for Thermocouples ASTM calibration of thermocouples Phase diagram from phase transformation lab for binary alloy system (Sn-Bi) Phase diagram from Free Energy – THERMOCALC program	DAQ programming Simulation and Modeling using MATLAB and ThermoCalc ASTM standards Temperature/Heat measurements Measuring Phase transformation experimentally Phase diagram construction MATLAB programming Data Analysis Error analysis	IEEE style paper (10-20 pages, 2-3000 words)

Laboratory Experiences are “Wrapped” in a current theme for professional development of students – Theme here is “Sustainable Solders ”



Students have a simple interface for access to laboratory experience modules.

This forces students to work through material, rather then by assignment

Within the Module, there is an overview of the experiments that will be conducted for the laboratory

Overview of what you have to do for the entire module

Heat Module – General Guidelines

In this module you have several experiments that lead to a larger experimental paper. The main parts of this experiment are:

1. **Make a program** in Arduino to **measure temperature**. Use this program to measure heat conductivity and diffusivity in different materials. Build a concept for heat flow in materials.
2. Use **MATLAB** to **model heat impulses and visualize heat flow in materials**.
3. **Make a program** in LabView, to do real time data logging of temperature using for a Thermocouple and a program in Arduino to read a heat Thermistor. **Each person does this. Everyone should have their own LabView, and Arduino Program.**
4. **Calibrate a Thermocouple** using ASTM Standards for the LabView program.

Determine the error in measurement for the thermocouple and thermistor. (qualitative and quantitative)

3. Use the calibrated thermocouple to **measure heat concepts in how materials respond to heat by measuring and constructing a phase diagram for a Sn-Bi Alloy.**
4. **Use ThermoCalc** to model the Sn-Bi Alloy and compare to your experimental phase diagram.

This lab involves hazards. Electrical, hot surfaces, boiling liquids, ice, potential for slips and falls. You need to be aware and prepared for all hazards. Wear pants, shirts(no tanks) and non-slip full shoes.

This experiment will require you to keep an extensive notebook to record all of your data, observations and procedures.

Arduino Lab for heat conductivity

1. Arduino Programming of TMPs and measurement of heat flow
2. Post lab Analysis for heat flow
3. Survey Questions for heat flow
4. Lab notebook grade on Heat flow
5. Skills Criteria for Arduino Lab and Heat flow

Labview Programming and Thermocouple Calibration

6. LabView Programming of Thermocouple
7. ASTM calibration of Thermocouple
8. Error Analysis for Thermocouples
9. Survey Questions for Labview Programming and Calibration
10. Lab notebook grade for Labview programming and thermocouple calibration.
11. Skills Criteria for Labview programming and thermocouple calibration
12. IEEE paper section draft for Labview programming and thermocouple calibration

Heat Transformation in binary Alloys

13. Measuring Phase Transformations in Sn-Bi Alloy
14. Data Analysis of Phase transformations
15. Error Analysis of Phase Transformations
16. Lab notebook on Heat Transformations
17. Survey questions for heat transformations
18. Skills criteria for heat transformations
19. Draft version of IEEE paper for heat transformations
20. Final draft of IEEE paper for heat transformations

Within the overview is a list of activities students will engage in and be assessed on for the laboratory experience

Heat Transformation in Materials Sn-Bi Alloys

Heat Transformations in Sn-Bi Alloys

Objectives:

- Student will understand why alternatives to lead free solders are sought, and the role materials engineers and scientists play in determining appropriate alloy systems to replace lead based solders.
- Student will use calibrated TC measurement system to collect phase transformation data for varying compositions of Sn-Bi
- Student will analyze phase transformation data to determine liquidous and solidus lines and use this data to construct a phase diagram for the alloy system, and determine the error in the measurement.
- Student will compare the experimental data to a published phase diagram for the Sn-Bi alloy system.

To Do List:

Objective/Tasks

- Student will understand why alternatives to lead free solders are sought, and the role materials engineers and scientists play in determining appropriate alloy systems to replace lead based solders.
  - Read this article on lead free solder, and take some notes - why is lead solder a candidate for replacement with alternative materials? What Alternative materials are being looked at? What are some materials criteria for use as a solder?
- Student will use calibrated TC measurement system to collect phase transformation data for varying compositions of Sn-Bi.
  - Do this lab experiment: Lesson 2 Lab 3 Sn-Bi Phase Diagram 3080C-Bi Phase Diagram 3080C-1.pd f
- Student will analyze phase transformation data to determine liquidous and solidus lines and use this data to construct a phase diagram for the alloy system, and determine the error in the measurement. student will compare the experimental data to a published phase diagram for the Sn-Bi alloy system. You will use this data to write your IEEE paper
  - Conduct the analysis on the data

Learning Experiences:

Readings:

- Lead -Free Solder reading

Lecture(s):

- Lecture 1 Heat measurements and Thermocouples
- Lecture 2 Phase Transformations in materials
- 2016 Lecture on Heat
- Structure property relationships for heat transfer

Assessments

13. Conducting experiment to measure phase transformations
14. Data Analysis of Phase transformations
15. Error Analysis of Phase Transformations
16. Lab notebook on Heat Transformations
17. Survey questions for heat transformations
18. Skills criteria for heat transformations
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Supplemental Content

Reading on Lead Free Solders from a company that makes one alternative

Background on Transient response of thermocouples

Clicking on one of the links takes students to the page for that experience with all required activities for that experience

Students have rubrics for Notebook and Skills Criteria Assessment for each part of the laboratory

Labview Programming and ASTM Calibration of TCs

You've already rated students with this rubric. Any major changes could affect their assessment results.

Criteria	Ratings			Pts
Student can write a Labview program for two Thermocouples and is able to explain what the program is taking in and how it outputs data. Student has evidence of program and data in notebook	Full Marks 5.0 pts	No Marks 0.0 pts		5.0 pts
Student can correctly wire TC leads into the daq. Student can articulate how a TC works and what the Daq inputs from the TC. Student can correctly wire the DAQ for TC in combination for ASTM Calibration. Student can wire DAQ for two calibrated TCs	Full Marks 5.0 pts	No Marks 0.0 pts		5.0 pts
Student can correctly prepare an ASTM ice bath, and can explain the ASTM standards that govern TC calibration	Full Marks 2.0 pts	No Marks 0.0 pts		2.0 pts
Student can correctly set up the calibrated TCs and can articulate the hazards related to this experiment	Full Marks 2.0 pts	No Marks 0.0 pts		2.0 pts
Student can conduct the ASTM calibration for cold and hot TC measurements, evidence of this is in the notebook	Full Marks 5.0 pts	No Marks 0.0 pts		5.0 pts
Student can find the time response for each of the calibrated TC	Full Marks 2.0 pts	No Marks 0.0 pts		2.0 pts
Student has conducted a data analysis for the TCs and can determine error and offset in the TC and compare to manufacturer datasheet	Full Marks 4.0 pts	No Marks 0.0 pts		4.0 pts
Labview Programming and ASTM TC Calibration view longer description threshold: 3.0 pts	Does Not Meet Expectations 0.0 pts	Exceeds Expectations 0.0 pts	Meets Expectations 0.0 pts	0.0 pts
				Total Points: 25.0

ABET& Professional Outcomes from Laboratory Experience

- Students work together as teams to solve complex engineering problems with a global and social “Wrapper”
- Students learn to communicate effectively as part of a team, and also to communicate in the ways of engineers (written and oral)
- Students interface with common standards, methods and tools used by engineers in practice.
- Students bring together core content knowledge from other core courses in MSE and engineering to apply to laboratory experience.
- Students grapple with data, analysis and interpretation of experimental results.
- Students learn to simulate and model material behavior.

Summary

- Laboratory experiences for students can provide students with a "unique" experience to synthesize core content knowledge
- Laboratories are a way to develop ABET, Systems Thinking and Professional Practices in students
- Laboratories can be designed to help students develop "big ideas" for core content, and deliver skills and techniques to build engineering competencies.
- Laboratories can scaffold students through deliberately staged activities towards learning and skills outcomes.
- Successful practices are not an accident – time must be devoted to designing effective laboratories.

Questions?

Thank you for your time

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