

DEPARTMENT: MECHANICAL ENGINEERING	
COURSE #: EML 4161, 3 credits Course Website	COURSE TITLE: Cryogenics
TYPE COURSE: Technical Elective, Magnet Science and Technology Track	TERMS OFFERED: Alternating Spring
CATALOG DESCRIPTION: This course focuses on the fundamental aspects of cryogenic system engineering: properties of materials and fluids at low temperatures; cryogenic heat transfer and fluid dynamics; low temperature refrigeration and system engineering	PREREQUISITES: Thermal Fluids I & II (EML 3015C & 3016C), and Material Science and Engineering (EML 3234) Recommended: Thermal Fluid Design (EML 4512) Recommended: Intermediate Modern Physics (PHY 3101)
AREA COORDINATOR: Dr. Juan Ordonez RESPONSIBLE FACULTY: Dr. Wei Guo INSTRUCTOR OF RECORD: Dr. Wei Guo COE B316B Phone: (850) 644-3980 Email: wguo@magnet.fsu.edu Office Hours: (asynchronous and synchronous) DATE OF PREPARATION: 09/22/2017 (WG)	CLASS SCHEDULE: Class: Two times weekly for 1 hr. and 15 min. Lab: No
TEXTBOOKS/REQUIRED MATERIAL: 1. Required Text (on reserve at CoE library, pdf available on Blackboard): S.W. Van Sciver, Helium Cryogenics 2nd, Springer, 2012 References, Additional Resources: <ul style="list-style-type: none"> • K. Timmerhaus and T. Flynn, Cryogenic Process Engineering, Plenum, 1989 • R.F. Barron, Cryogenic Systems, 2nd Ed., Oxford, 1985 • J.G. Weisend II ed., Handbook of Cryogenic Engineering, Taylor & Francis, Washington, DC, 1998 • J. W. Ekin, Experimental Techniques at Low Temperature, Oxford, 2006 • REFPROP® - property data base available at http://refprop-mini.software.informer.com/ 	SCIENCE/DESIGN (%): 75% / 25% CONTRIBUTION TO MEETING THE PROFESSIONAL COMPONENT: 75% engineering science 25% engineering design
COURSE TOPICS: The topics to be covered includes (not necessarily in the order shown) 1. Properties of solid materials at low temperatures 2. Cryogenic fluids: classical and quantum fluids 3. Cryogenic insulation systems 4. Low temperature refrigeration 5. Cryogenic fluid mechanics & heat transfer 6. Instrumentation 7. System engineering	ASSESSMENT TOOLS: Undergraduate: 1. Homework (25%) 2. Attendance (5%) 3. Hourly Exams (2 x 25%) 4. Team Project (20%)
Student Learning Objectives for FSU Curriculum File	At the end of the course the student should <ol style="list-style-type: none"> 1. Be able to evaluate properties of cryogenic materials and fluids 2. Be able to describe and optimize cryogenic systems, compare/apply cryogenic instrumentation

Syllabus	3. Be able to recognize cryogenic safety aspects and integrate the gained knowledge
Justification for addition or change	This Course Delivery Method is currently an Online-Asynchronous course which will be taught Traditionally.
Level of computer usage:	None <input type="checkbox"/> Elementary <input checked="" type="checkbox"/> Intermediate <input type="checkbox"/> Advanced <input type="checkbox"/>
Modes of Instruction:	Lecture <input checked="" type="checkbox"/> Lab <input type="checkbox"/> DIS <input type="checkbox"/> Discussion <input type="checkbox"/> Other <input type="checkbox"/>
Core Curriculum Course:	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Availability to other Majors:	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
ME COURSE OBJECTIVES* [related to ABET Student Outcomes]	<p>(Numbers shown in brackets refer to department Student Outcomes) http://www.eng.fsu.edu/me/about_us/accred-info.html</p> <ol style="list-style-type: none"> To be able to compare the properties of cryogenic materials and fluids to facilitate the proper selection for an application. [1,3] To be able to use the unique characteristics of cryogenic fluid mechanics and heat transfer in the design of engineering components. [2 ,3] To be able to describe the different characteristics of cryogenic insulation systems and how they perform in a system. [1,5] To be able to quantitatively optimize cryogenic refrigeration cycles and systems. [1,3,5] To be able to compare different cryogenic instrumentation and how to apply it in engineering systems. [1, 2,3] To recognize the important aspects of cryogenic safety. [6] To be able to integrate the gained knowledge of cryogenic materials, fluids, refrigeration and insulation into an optimized system design. [1,2,3,5,10]. <p>Numbers refer to Departmental Student Outcomes, e.g. for course object 1, [1, 3] refers to student outcomes 1 and 3.</p>
ME COURSE OUTCOMES* [related to ME Course Objective] = FSU Student Learning Objectives	<p>*(Numbers shown in brackets are links to Course Objectives above)</p> <p>At the end of the course, a student should:</p> <ol style="list-style-type: none"> Be able to evaluate properties of cryogenic materials and fluids [1,2] Be able to describe and optimize cryogenic systems, compare/apply cryogenic instrumentation [3,4,5] Be able to recognize cryogenic safety aspects and integrate the gained knowledge [6,7]

ASSESSMENT TOOL DETAILS

GRADING/ EVALUATION:

- Additional assignments: some homework assignments, appropriate to the first-year graduate student level are optional for undergraduate students.
- Project: Undergraduates will work on team projects.

Grades will be based on the following breakdown of graded work:

<p>Undergraduate:</p> <ul style="list-style-type: none"> • Homework (25%) • Attendance (5%) • Hourly Exams (2 x 25%) • Team Project (20%)
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Letter grades will be assigned equivalent to the following:

Undergraduate Grading Scale	
Numerical Score	Letter Grade
90 - 100	A
80 - 89	B
70 - 79	C
60 - 69	D
0 - 59	F

Departmental policy is that a grade of C or better is required to pass this course.

College of Engineering Undergraduate Policy:

- It is the policy of the College not to assign “plus and minus (+/-)” grades for undergraduate engineering courses. <http://www.eng.fsu.edu/current/undergraduate/guide.html>, see Grading Policies.
- Students are required to be familiar with Academic Policies and Requirements as outlined in the COE Student Handbook <http://www.eng.fsu.edu/current/undergraduate/guide.html> page 11

ASSIGNMENTS/RESPONSIBILITIES:

Student Responsibilities

- Class Attendance
- Homework
- Other Daily Responsibilities
- Projects, including information on group processes
- Tests/Exams

Assessment Tools:

1. In-class problems
2. Group project reports
3. Group presentation
4. Homework
5. Quizzes (Quizzes will not be announced ahead of time)
6. Section tests

Examinations:

The date of all exams will be announced at least one (1) week in advance.

Final Examination: on the COE exam date see http://www.eng.fsu.edu/current/exam_schedule.html

Instructional Method(s)

The primary instructional method is a traditional in-class lecture. There will also be extensive use of the Blackboard web delivery system for distribution of course assignments and other materials. Course materials available from the textbook publisher may also be used. The use of online instructional techniques will be introduced.

COURSE SCHEDULE

Week	Topics to be covered (not necessarily in the order shown)
1	Introduction
	Cryogenics and the Temperature Scale
	History of Cryogenics
	Entropy and Thermodynamics
2 / 3	Low Temperature Properties of Materials
	Heat Capacity and Internal Energy
	Thermal Contraction

	Electrical Conductivity
	Thermal Conductivity
	Mechanical properties
	Design Examples (Figure of Merit)
4 / 5	Cryogenic Fluids
	General properties
	Thermodynamic & Transport Properties
	Hydrogen
	Helium Gas
	Liquid Helium
	Superfluid Helium
6 / 7	Cryogenic storage
	Storage systems
	Insulation Modes
	Insulation Materials
	Insulation and Cooldown Requirements
8 / 9	Liquefaction and Refrigeration
	Ideal Refrigeration Process
	Isenthalpic Expansion (Joule Thomson Effect)
	Linde Hampson Refrigeration Cycle
	Cascade Cycle
	Claude Cycle
	Closed Cycle Refrigeration
	Recuperative Refrigerator Examples
	Refrigerator Components (3)
	Regenerative Cycles (Stirling)
	Gifford Mc and Pulse Tube Refrigerators
	Regenerative Cooler Applications
10 / 11	Cryogenic Fluid Mechanics and Heat Transfer
	Single Phase Incompressible Fluids
	Compressible Fluid Dynamics
	Flow Through Porous Media
	Two-phase Flow
	Natural Circulation
	Convective 1P Heat Transfer
	Pool Boiling Heat Transfer
	Peak Heat Flux and Film Boiling
	Internal 2P Flow and Heat Transfer
12	Introduction to Superfluid helium (He II)
	Unique Properties of He II
	Two Fluid Model
	He II Heat Transfer
	Turbulent He II Heat Transfer
	He II Surface Heat Transfer
13 / 14	Instrumentation
	Temperature Measurement
	Pressure & Level Measurement
	Cryogenic Safety (3)
	Pressure Vessel Design
	Combustibility and Asphyxiation

COURSE POLICIES:

Attendance Policy:

First day attendance is mandatory for FSU students, and first week attendance is mandatory for FAMU students. Students not in class during the first day (FSU) or first week (FAMU) are to be dropped from the course.

Excused Absences: Excused absences include documented illness, deaths in the immediate family and other documented crises, call to active military duty or jury duty, religious holy days, and official University activities. These absences will be accommodated in a way that does not arbitrarily penalize students who have a valid excuse. Consideration will also be given to students whose dependent children experience serious illness.

Please note that the College of Engineering has a restrictive interpretation of what is considered a valid excuse for an absence. See: <http://www.eng.fsu.edu/current/undergraduate/guide.html> p. 5. If an absence is to be excused, make sure you check beforehand. In case of excused absence, the instructor will work with you to help you make up for missed time and catch up.

Unexcused Absences: A student having more than four unexcused absences will be dropped from the course and assigned the grade F. No exceptions. Tests and exams missed because of unexcused absence receive the grade 0. No exceptions.

Other projects and activities missed completely receive the grade 0 for those projects or activities. No exceptions.

Other Regulations

Note that the penalties for copying work may result in a failing grade for the course. If you are uncertain, please check with the instructor who assigned the work. Working together is encouraged in this course, but blatant copying is not.

Departmental Policy:

A student may continue in the B.S. in ME degree program unless one or more of the following conditions arise:

- a. A grade below C in the second attempt of the same engineering course
http://www.eng.fsu.edu/me/resources/pdf/ME_Prerequisite_Policy.pdf
- b. More than three (3) repeat attempts in engineering courses.
http://www.eng.fsu.edu/me/resources/pdf/ME_Excessive_Repeat_Policy.pdf
- c. Violation of academic honor code as defined in university bulletin or catalog
- d. Use of grade forgiveness (currently available for FAMU students only) in more than two (2) courses.

Make-up Assignments:

A make-up examination may be granted to students with a valid excused absence. However, you must notify me in advance if your absence involves a planned event or observance of a religious holy day. If an emergency prevents you from attending a scheduled examination, you must notify me at your earliest opportunity. You must obtain a valid excused absence for the emergency to be eligible for a make-up examination. Students with a valid excused absence will not be arbitrarily penalized for missing an assignment. Students without a valid excused absence are not entitled to a make-up examination. However, certain class assignments may be accepted late, with penalty, without a valid excused absence.

DEPARTMENTAL STUDENT OUTCOMES

The department's student outcomes can be found at
http://www.eng.fsu.edu/about/accreditation/program_outcome.html?ID=215&agency=ABET

Program Outcomes/Student Learning Outcomes

Student learning outcomes for students majoring in engineering may be found at
<http://www.eng.fsu.edu/outcomes>

Location of Academic Learning Compacts (ALC)

COE: http://www.eng.fsu.edu/about/accreditation/program_outcome.html?ID=217&agency=ALC
FAMU: <http://www.famu.edu/index.cfm?Assessment&CurrentALCs#engineering>
FSU: <http://learningforlife.capd.fsu.edu/smalcs/learningCompact.cfm?smalcId=62534>

ACADEMIC HONOR POLICY

Students are expected to uphold the University Student Code of Conduct and/or University Academic Honor Code

The Florida A&M University is committed to academic honesty and its core values which include scholarship, excellence, accountability, integrity, fairness, respect, and ethics. These core values are integrated into its academic honesty policy. Being unaware of the Academic Honesty Policy is not a defense to violations of academic honesty. Academic Honesty Policy violations shall be reported and appropriate actions taken by the Department Chair and Associate Dean for Student Affairs and curriculum. The complete Florida A&M Student Code of Conduct - Regulation 2.012 (8a) can be found on (p. 5)

http://www.famu.edu/judicialAffairs/Regulation%202_012%20Student%20Code%20of%20Conduct.pdf and in the Student Handbook “The Fang” p. 61

<http://www.famu.edu/Students/STUDENT%20HANDBOOK%20%28FANG%29%202012-2014.Updated%208.22.13.pdf> p 61

The Florida State University Academic Honor Policy outlines the University’s expectations for the integrity of students’ academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process. Students are responsible for reading the Academic Honor Policy and for living up to their pledge to “. . . be honest and truthful and . . . [to] strive for personal and institutional integrity at Florida State University.” (Florida State University Academic Honor Policy, found at <http://fda.fsu.edu/Academics/Academic-Honor-Policy>.)

AMERICANS WITH DISABILITIES ACT

During the first week of class students with disabilities needing academic accommodation should:

- 1) register with and provide documentation to the FAMU **LDEC** or FSU **SDRC**; and
- 2) bring a letter to the instructor indicating the need for accommodation and what type.

Please note that instructors are not allowed to provide classroom accommodation to a student until appropriate verification from the Student Disability Resource Center has been provided.

For more information about services available to FAMU students with disabilities, contact **The Learning Development and Evaluation Center (LDEC)**

677 Ardelia Court Florida A&M University Tallahassee, FL 32310 Nathaniel Holmes, Director Donna Shell, Asst. Director	599-3180 (phone) 561-2512 (fax) 561-2783 (TDD) http://www.famu.edu/index.cfm?a=EOP&p=ADA
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For more information about services available to FSU students with disabilities, contact the: **Student Disability Resource Center (SDRC)**

874 Traditions Way 108 Student Services Building Florida State University Tallahassee, FL 32306-4167	(850) 644-9566 (voice) (850) 644-8504 (TDD) sdrc@admin.fsu.edu http://www.disabilitycenter.fsu.edu/
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This syllabus and other class materials are available in alternative format upon request.

UNIVERSITY’S NON-DISCRIMINATION POLICY STATEMENT

FAMU: <http://www.famu.edu/index.cfm?EOP&NON-DISCRIMINATIONPOLICYSTATEMENT>
FSU: http://www.hr.fsu.edu/PDF/Publications/diversity/EEO_Statement.pdf

SYLLABUS CHANGE POLICY:

Except for changes that substantially affect implementation of the evaluation (grading) statement, this syllabus is a guide for the course and is subject to change with advanced notice.