FINAL REPORT

Marine Engine Testing and Emissions Laboratory (METEL)

Led by Maine Maritime Academy

Federal Grant Number: DTRT13-G-UTC43

Project Title:

Sustainability Education and Laboratory Training for Workforce Enhancement at Maine Maritime Academy

Project Number:	Project End Date:	Submission Date:
METEL-2014P782	March 31, 2019	April 30 , 2019

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The Marine Engine Testing and Emissions Laboratory is a consortium of 2 Universities funded by the U.S. Department of Transportation - University Transportation Centers Program. Members of the consortium at the Maine Maritime Academy and the University of Maine System. Maine Maritime Academy is the Lead Institution.

Introduction

This project goals are to strengthen the educational pipeline of skilled transportation leaders through developing modern training laboratories for integrated sustainability education. Next generation transportation leaders will be tasked with identification and implementation of emerging technologies while managing operational impacts on the environment. To address this demand, Marine Engine Testing and Emissions Laboratory (METEL) worked with Maine Maritime Academy (MMA) in the following three areas of workforce development efforts under the DOT UTC center:

- Engineering laboratory upgrades for training the future mariner workforce
- Development and implementation of an environmental minor related to transportation environmental areas
- Integration of the Medium Speed Diesel lab with the marine engineering training program at Maine Maritime Academy.

The outcomes of these efforts were to develop a new and enhanced laboratory training capabilities and enhance sustainability curriculum to improve student awareness of environmental concerns and evaluate new technologies for their operational and societal benefits in the transportation sector.

METEL enhanced the educational opportunity to all students on campus through the creation of a Sustainability Minor. New courses developed include Introduction to Environmental Sustainability, Pollution Control and Remediation, Air Pollution and Emissions Testing and Control, and Alternative Fuels. Additionally, curriculum development assesses opportunities in continuing education modules that are based on these new courses. Courses are tailored to transportation and engineering majors, but will be suitable for all majors. The courses introduce current topics, present relevant scientific information and provide laboratory training for modern technology evaluation and environmental monitoring.

Laboratories housed in the Maine Maritime Academy's American Bureau of Shipping Center for Engineering, Science and Research were enhanced by implementing new training equipment to education students for transportation careers. These laboratories include the Materials Science Laboratory, Thermal/Fluid Laboratory, Renewable Energy Laboratory and the Center for Strategic Maintenance and Engineering. This project developed critical training equipment and procedures to increase student access to modern measurement techniques and technology operations.

Finally, the impact of METELs research laboratories on workforce development is discussed. In particular the Medium speed diesel lab project has had a significant impact on the workforce development training at Maine Maritime Academy. This advanced marine Diesel engine research facility has allowed enhancement in student training in important areas for future mariners such as emissions controls and engine automation.

Laboratory upgrades to the Marine Engineering Laboratories at Maine Maritime Academy

The marine engineering laboratories received major upgrades in equipment and capabilities in key labs which service our engineering programs related to marine transportation. The equipment upgrades during this effort were part of the DOT UTC project in the development of workforce development laboratories for the transportation field. The upgrades included the following labs and equipment:

- Electrical, Electronics and Automation lab
  Upgrades to Lab training stations, PLC trainers and measurement instrumentation
- Thermodynamics laboratory
  Upgrades to
- Fluid mechanics laboratory
  Upgrades to hydraulics training equipment
- Capstone Project lab
  Addition of 3D printers
- Materials lab.
  Major materials testing upgrades including modern Ingstrom tensile testers and material science laboratory equipment.

These laboratory upgrades were included in the DOT UTC center effort and used and cost share as they directly served the centers mission of improving the workforce development capabilities for training future maritime workers

Environmental minor development

As part of the METEL workforce development effort the center funded the development of a ne environmental minor that was focused on the environmental issues related to transportation and power at Maine Maritime Academy. The minor requirements are outlined in table 1 and include existing courses already offered at MMA as well as several new courses developed as part of this effort. The new courses developed to support the environmental minor under this effort were:

EN202: Intro to Sustainability

HC260 Sustainable energy and society

NS 496: Oil Pollution Preparedness and Response

EN402: Biofuels: Production and use

EN 420: Air Pollution and Emissions Testing and Control

Copies of the course descriptions/syllabi are included in Appendix 1.

Table 1: Environmental Minor Course Requirements: Minimum 18 credits.

Required Courses	**Spring**	**Fall**	**Interdisciplinary Environmental courses will satisfy the following program electives:**
CH210 Chemistry I, or CH101, CH152, CH301, CH 352 Chemical Principles			
EN202 Introduction to Sustainability		X	Free; departmental elective for IBL, gen ed
HC260 Sustainable Energy and Society	X		Free, humanities/social science, gen ed

Environmental Electives (and prerequisites): **Choose any 2 or 3 of the following courses**	**Spring**	**Fall**	**Will satisfy the following program electives:**
EG350 Introduction to Env. Regulations and Ethical Industrial Compliance (CH210/301/352/101/152)		X	Free, engineering
NS496 Oil Pollution Preparedness & Response	S'19		Free, engineering, marine transportation
EN402 Biofuels: Production & Use (CH210/301/352/101/152)	S'19		Free, gen ed, engineering, ocean studies
EN420 Air Pollution and Emissions Testing and Control (CH210/301/352/101/152 and PS201/162)		F'19	Free, engineering, marine transportation
Additional courses as approved by the minor coordinator, for example, an honors seminar or special topics course may be appropriate			Case-by-case

Supporting Electives: **Choose up to 1 of the following courses**		
Course	**Spring**	**Fall**
NS132 Small Craft Technology	X	X

NS210 Tanker Operations	X	X
OC101 Introduction to Ocean Science	X	X
OS101 Introduction to Marine Science		X
MA101 Intro to Business & Supply Chain Mgmt	X	X
NS496 Polar Operations/Ice Navigation	X	
GE221 Geographic Information Science	X	

To date the courses in the minor have been developed and offed to student at Maine Maritime Academy. In the graduating class of 2019 there are two students who have completed the minor and they are the first class which has been able to take all the necessary courses for the minor. There is significant interest in the minor continuing into the future. One anecdote as to the success of the minor in preparing our graduates for the workplace, one of the two minor recipients graduating in 2019 indicated that having the minor on her resume was indicated by her future employer as being a significant factor in differentiating her from other candidates and led to her be offered employment by this employer.

The environmental minor development by the DOT UTC grant in conjunction with $40k of funding from a donor to MMA to establish the minor. The establishment of the minor has lead MMA to pursue the development of an environmental major following the success of the minor.

Medium speed diesel lab impact on workforce development and student training

The medium speed engine laboratory (MSEL) has been a valuable resource for many courses offered at Maine Maritime Academy related to transportation workforce development. These courses were able to bring students into the MSEL for the METEL staff to assist in fostering the student's practical and theoretical skill formation. METEL lab personnel has been involved in the Maintenance training program. Historically, the maintenance program has been held onboard the TS *State of Maine*, MMA's training ship, but starting fall semester of 2017 groups of students per week have been assigned to the METEL engine lab to perform routine and improvement maintenance procedures on the lab equipment and engine under the supervision of METEL personnel. Figure 8 shows examples of the students working in the lab on maintenance projects, the left picture depicting students working on the fuel system and the right picture showing students working on the charge air cooler.

Figure 8: Students participating in maintenance in the engine lab

The Medium speed diesel lab also continues to be a resource for students in several marine training courses including: EG101 Fundamental of Engineering Operations, EG234 Power Equipment Lab EG 292 and EG392 Diesels I & II and ET 431 Thermal Fluids Laboratory. Students utilize the lab for various labs in the courses including system tracing and identification, Diesel equipment operations, Diesel maintenance and thermal systems labs involving engine performance.

The specific courses that were able to utilize the MSEL and METEL staff were:

EG101 Fundamentals of Engineering is a course designed to teach entry level students introductory skills, safety awareness, and familiarization with standard marine and power plant systems, equipment, and piping components at an operational level. The students in this course were given tours of the MSEL with an explanation of the function of supporting equipment and system layout. Students were also given homework exercises to trace out the support systems piping layout and equipment arrangements.

EG234 Power Equipment Laboratory is a sophomore level course intended to give students an opportunity to learn about marine and stationary power plant operations and maintenance though a hands-on practical experience. Students dismantle and reassemble a number of fluid system components and pieces of equipment, as well as develop skills in proper maintenance techniques for the same. Students in this course were exposed to updated fuel and lubricating oil centrifugal purifiers that are used in the MSEL, as well as usage of plate type heat exchangers, shaft couplings, and duplex strainers.

EG392 Diesel Power II is a course that student expand their working knowledge of the mechanisms and components of a diesel engine, as well as discuss requirements and fluids needed for the proper operation of the engine. Students in this course were brought down to the

MSEL throughout the rebuild of the engine to witness the process of tearing down the engine and reinstalling the components.

A new environmental course, EN401 Air Pollution & Emissions Testing and Control, was offered in the fall 2018 semester and featured emissions testing and control using the DOT UTC METEL Medium Speed Diesel lab as the main laboratory for the course. This lab uses the state of the art emissions monitoring and control systems on this world class laboratory asset. Such exposure to real world, power plant emissions system is an incredible improvement to our ability to train our students on the latest and most advanced equipment that they will see in their industries.

Conclusions and Future Work

The workforce development efforts of the METEL DOT UTC were discussed in three major areas of effort:

- Engineering laboratory upgrades for training the future mariner workforce
- Development and implementation of an environmental minor related to transportation environmental areas
- Integration of the Medium Speed Diesel lab with the marine engineering training program at Maine Maritime Academy.

Given that the majority of Maine Maritime Academy (~80%) students are primarily trained to work in the transportation sector, the aforementioned efforts have had a significant effect of upgrading the training as well as enhancing and expanding the training areas and capabilities relevant to marine transportation industry and workforce.

Appendix I:

Syllabi for new courses developed as part of the METEL workforce development efforts

En202 Introduction to Environmental Sustainability

Class meets: T/Th 1100-1215, 206 ABS

Instructor: Sarah O'Malley 101 Dirigo House 326-2144 or x 2144, or mobile: 207 326 4417
sarah.omalley@mma.edu

Office Hours: M 1300-1500, T 1300-1600 or by appointment

Introduction to Environmental Sustainability - This introductory course will examine the effects of our actions in the areas of business, engineering, science, and transportation as they relate to the marine and terrestrial environment. Students will consider pollutant sources and effects, mitigation affects, regulatory and ethical behavior, environmental health and safety, and financial considerations. At the completion of this course students will have a fundamental understanding of environmental issues and responsibilities as they relate to degree programs at MMA.

Textbooks and Other Required Material: There is no required text book for this course. Required readings and class materials will be distributed via Canvas. I will be using a free online textbook as our primary source document and you are welcome to download it as well: http://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=96

Course content goals:

We will spend our class time:

- defining environmental sustainability
- identifying components of ecological footprint
- understanding the historical context of western approach to sustainability
    - including examples of landmark environmental regulations and events and
    - problem solving that demonstrates the enormity of the task of solving big issues
- understanding the mechanics of climate change

- comprehending the data that support our understanding of climate as a fundamental global sustainability problem
- describing a variety of environmental problems and solutions
- evaluating real world examples to wrestle with the ethics of sustainability

Class Policies: Two scheduled classroom lectures per week, each lasting 75 minutes. Class participation and attendance is mandatory and attendance will be tracked. If you have an excused absence from class (MMA sponsored activity, athletic activity, extreme documented illness, documented family emergency) please let me know ahead of time. **Three unexcused absences will result in a full letter grade drop in the final grade.** This course will use Canvas to distribute assignments, readings and host online discussions.

Please be prepared to keep your phones stashed in a bag or pack NOT on your person. If you are on your phone when it is not appropriate (i.e. anytime in class other than when you are researching a question in a small group as part of an activity) <u>be prepared for me to call on you with a question related to course content.</u>

Course Work: The work in this course will consist of weekly assigned readings (posted weekly/as needed on Canvas), reading response homework, in class participation (discussions-in class and online, response to questions etc), and several in class activities and presentations of specific sustainability case studies. The course will culminate in a final project.

Evaluations:

Reading homework…….25%

Participation……25%

Short presentations and in class activities……25%

Final presentation……..25%

Class Schedule (subject to change)

Week of	Tuesday	Thursday
1. August 27	Introduction, Limits, What is sustainability?	**Discussion**: Ecological footprint (another way to look at limits) History of American ideas about natural resources (how did we get to this place of no limits? uniquely American idea?)
2. Sept 3	Modern environmental movement, Earth Day, Clean Air Act, clean water act	Continue with Tuesday content, Montreal Accord
3. Sept 10	**Discussion**: on how big problems have been solved at large scale In Class Activity: How to solve big environmental problems	**Presenting** our plans for solving big problems.
4. Sept 17	The ground work: Ecological footprint and overshoot, population, consumption	**Discussion**; how do deal with population issue.
5. Sept 24	Climate Change: causes	Climate change impacts
6. Oct 1	Climate Change: solutions	Climate Change: solutions continued
7. Oct 8	Tuesday IS Monday No class meeting	**Discussion**: Climate change and your life.
8. Oct 15	Food systems and sustainable agriculture: does food matter?	Food systems continued
9. Oct 22	Sustainable food systems: **Debate**: Should we be eating meat?	Peak Trash: Waste management, cradle to cradle design and engineering

10. Oct 29	Sustainable business Guest speaker **Discussion**	Sustainable business
11. Nov. 5	Where we live: the Human Wilderness interface (fires, zoonotic disease, habitat destruction)	Sustainability and security Guest speaker **Discussion**
12. Nov. 12	Sustainability and security Guest speaker **Discussion**	Shipping industry sustainability
Nov. 19	THANKSGIVING	
13. Nov. 26	Catch up **Discuss** Final presentations (3 a day)	Catch up **Discuss** Final presentations (3 a day)
14. Dec 3	Catch up **Discuss** Final presentations (3 a day)	Catch up **Discuss** Final presentations (3 a day)

Sample participation criteria

Responds to questions posed by instructor or presenter	Refers to readings by page number or specific reference in paper	Asks clarifying questions of classmates or instructor	Respectfully challenges or builds upon ideas of class mates	Is a useful participant in small group discussion or activities	Responds to peers in online discussions	Provides peer feedback when asked

En402 Biofuels: Production and Use

Instructor information	Office Location	Office Hours	Ext.
Sarah O'Malley sarah.omalley@mma.edu	101 Dirigo	W1315-1600, F1000-1200 and by appointment	2144
Barbara Fleck bfleck@mma.edu	305 ABS	M-W-Th 2 – 2:50 PM and by appointment	2103

Course meeting and location information: M/W 1100-1150 ABS 208, T 1300-1550 Andrews project lab (on the waterfront next to the fire fighting lab)

Online learning: This course will use Canvas and online resources weekly.

Course Description: The class will focus on the development, production and use of 1st and 2nd generation biofuels including biomass, alcohol, biodiesel, biogas and engineered specialty fuels like biojet and biocrude. An overview of the field provides the rationale for biofuels as part of the energy sector. The basic chemistry and energetics of combustion, fermentation and other relevant reactions are considered fundamental to understanding how fuel creates energy, and the subtle differences between fuels that make them more or less valuable. Economic, regulatory, social and environmental considerations will make up a significant percentage of the course content.

Course Goals:
1. Students will develop a basic working understanding of the biofuels industry, locally and globally.
2. Students will understand the science and methods of production and use of various biofuels.
3. Students will be able to appraise the various pros and cons of different biofuels in terms of economic, social and industrial applications.
4. Students will be well versed in the environmental and occupational health and safety aspects of biofuel production and use.

Text book: Bioenergy: Biomass to Biofuels Anju Dahiya ed. 2015 Academic Press, Elsevier Inc. ISBN 978-0-12-407909-0, available on reserve at Nutting Library and electronically through instructors.

Assignments and assessment:

1.**Weekly content reading** from text book or other assigned source. Should be completed for Monday class meeting.

2.**Weekly online quiz** Each week there will be a quiz over the assigned text book reading administered over Canvas. The goal of these quizzes is to assess the students' knowledge and comprehension of basic concepts and vocabulary. Due Sundays at 1159pm. ***15% of final grade***

3. **Weekly current event/case study** reading from assigned source. Should be completed for Wednesday class.

4. **Weekly current event discussion posting** Students will be required to post in Canvas a substantial reaction to the weekly case study reading or as directed. Due by Tuesdays at 1159pm. ***15% of final grade***

5. **Class participation** attendance, class participation in discussions, class activities, field trips, labs ***20% of final grade***

6. **Project**: students will choose a biofuels related topic to investigate, present this investigation to the class and then research follow up questions ***30% of final grade (report 10%, presentation 10% question response 10%)***

7. **Laboratory Exercises** Lab exercises will vary from week to week and may range from collecting data from fuel characterization techniques to construction of bioreactors for generating fuel, to data collection and analysis from emissions testing. Lab grade will be based on completion of assigned deliverable (may range from data sheet to reflection on learning). ***20% of final grade***

Suggested Student Weekly flow:

Monday: Come to class having read content assignment and having taken comprehension quiz. Monday class mostly lecture or activities on content. Tuesday: Lab in afternoon, usually requiring no prep. Participate in activities and complete deliverable.

Wednesday: Come to class having read current events reading and responded in Canvas discussion, ready to participate in class discussion and activities. Content and current events reading for following week assigned.

Thursday through Sunday: Read/view upcoming content assignment, complete content comprehension quiz on Canvas. Bonus, post follow up comments in the week's online current events discussion. Start new current events reading and discussion assignment.

Tentative Course Schedule (subject to change):

Week	Topic
1 Introduction	M: Introduction to class: What are biofuels?
	T: Lab Health and Safety, Intro activity ***Bring computers and headphones to lab***
	W: Safety overview and review of the basics
2 Energy sector	M: The energy sector
	T: Lab-Bomb Calorimeter
	W: Energy and Power
3 Science Basics	M: Science basics-photosynthesis and respiration
	T: Lab-photosynthesis
	W: Science basics –combustion chemistry
4 Science Basics	M:Science basics-fermentation
	T: Lab-fermentation reactions
	W: Science basics-other chemistry
5 Biomass	M: Wood
	T: Lab-Ethanol fermentation
	W: Biomass
6 Alcohol	M: Alcohol fuels-basics
	T: Lab- Ethanol distillation
	W: Alcohol fuels

7 Alcohol and Biogas	M: Alcohol fuels
	T: Lab-fermentation reactors
	W: Biogas fermentation
8 Biogas	M: Biogas generation
	T: Lab-Biogas fermentation
	W: Biogas R&D
9 Lipid based fuels	M: Diesel from vegetable oil
	T: Lab-growing algal cultures
	W: Diesel from algal oil
	Week 7 case study
10 Lipid based fuels	M:Diesel
	T: Lab-algal cultures
	W: Bio oil feedstocks
11 Advanced biofuels	M: Biojet/biocrude
	T: Lab-isolating lipids, making biodiesel
	W: Other advanced biofuels
12 The Future	M: The future of biofuels
	T: Lab- field trip/student choice lab
	W: The future of biofuels
13 Catch up/overflow	M: Catch up
	T: field trip/student choice lab
	W: Catch up
14 Catch up/overflow	M: Catch up
	T: Lab wrap up
	W: Catch up

HC260 Sustainable Energy & Society

Spring Semester 2019

"The most fundamental attribute of modern society is simply this: ours is a high-energy civilization based largely on the combustion of fossil fuels."

Vaclav Smil, geographer (b. 1943)

Instructor: Prof. Barbara Fleck; x 2103; 305 ABS; bfleck@mma.edu

Office hours: M-W-Th, 2 PM – 2:50 PM; additional hours by appointment.

Text: *Sustainable Energy - without the hot air* by David JC MacKay. Available free online from http://www.withouthotair.com/

Energy Within Environmental Constraints – HarvardX ENGSCI137x; available free online at https://www.edx.org/course/energy-within-environmental-constraints-0

Additional on-line readings will be used; reading and assignments will be announced on Canvas.

Catalog Description: Energy use and policy is changing, with increased international energy demand and increasing environmental pressures. This course provides an overview of energy use in the US and the world, looking at how we arrived at our current state of energy consumption. The course will cover energy technology, policy, economics and environmental effects of energy use, and the political and social issues related to energy consumption in the US and worldwide. Sustainability will be examined. This course fulfills the requirements of a Humanities/Social Science elective. Prerequisites: none. Rec. 3, Lab 0, Cr. 3.

Course Goals: After taking this course, a student should understand and be able to discuss the current state of energy development including traditional fossil fuels, renewables, and nuclear technologies. The student will also understand the national and international

political, technical, environmental and economic issues affecting energy policy and use. Goals include identifying and analyzing historical factors that have led to existing energy policies, and understanding the relationship between environmental and energy issues.

Grades: Your grade for the course will depend on:

Individual Assignments 65%

Team Project 35%

Letter grades:

94-100 A	88-90 B+	78-80 C+	68-70 D+	<60 F
91- 93 A-	84-87 B	74-77 C	64-67 D	
	81-83 B-	71-73 C-	60-63 D-	

Class Participation: This course meets twice each week for 1 hour and 15 minutes. Students are expected to attend and participate in each class meeting. A reading assignment with related questions will be assigned before class meetings, with online discussions and response required. Students should be prepared to participate in a class discussion on the assigned reading. Because of the importance of discussion in the course, attendance is required. Each unexcused absences will result in a deduction of 3 points from your overall grade. Excused absences must be made up (email instructor for make-up assignment) or they will also result in a point deduction.

Team Project: Each student will be assigned to a team to work on a project and presentation. In the team project for this course, you and your team will research and present information on at least one category of energy consumption and one category of sustainable energy production. For each category, you will define the current status (including quantities, costs, technology, and policy) and look at future possibilities (including quantities, costs, technology, and policy and any other topics you are interested in).

Schedule (Subject to change; changes will be announced in class and on Canvas)

Week	Lecture topic	Week	Lecture Topic
1	Course introduction: bias and framing Sustainable energy policy examples	8	Offshore Wind Food and Farming
2	Energy & power: the balance sheet Costs	9	Waves and Tides Stuff (manufactured goods)
3	US energy & power statistics Team project assignments	10	Geothermal Public Services
4	Cars Land-based Wind	11	Summary of energy sources and uses Can we live on renewables?
5	Planes Solar: PVs and heating	12	Sustainable fossil fuels? Is nuclear energy sustainable?
6	Biomass Heating and cooling	13	Maine energy policy Energy subsidies
7	Hydroelectricity Lights & Gadgets	14	A sustainable world energy future: possible scenarios

Additional reading:

Energy, A Beginner's Guide by Vaclav Smil; 2012; OneWorld Publications.

Energy, Myths and Realities by Vaclav Smil; 2010; American Enterprise for Public Policy Research.

Children of the Sun, a history of humanity's unappeasable appetite for energy, by Alfred W. Crosby; 2006, W. W. Norton & Co.

NS496
Oil Pollution Preparedness, Response and Cooperation (OPRC)

Spring 2019

Ender ASYALI, PhD, Master Mariner
Dimukes Hall, Room 202, Tel:326 0148
ender.asyali@mma.edu
Office Hours:Mon:13:00-14:00, Wed: 14:00-16:00, Friday: 11:00:12:00
And any other time by appointment

Pete SARNACKI
200 Rodgers Hall, Tel: 207-326-2269
pete.sarnacki@mma.edu
Office Hours: M (BY APPT),T & TH (09:30-12:00 & 14:00-16:00),
W&F(11:00-12:00)

Course Objective

The objective is to increase knowledge about marine oil pollution prevention, preparedness, response and cooperation.

Learning Outcomes of the Course Unit

- Knowledge about MARPOL convention.
- Knowledge about oil pollution, preparedness, response and co-operation convention (OPRC).
- Comprehension of oil spill properties, behavior and fate, health and safety, response organization and control strategies, oil containment booms, oil skimmers
- Learning about cleaning, maintenance and storage of equipment, oil spill compensation.
- Knowledge about international convention on the establishment of an international fund for compensation for oil pollution damage.

Material:
A lab top computer is required for this course
Recommended Reading:
Response to Marine Oil Spills, ITOPF
Oil Spill Response Field Manual, 2014, ExxonMobil Research and Engineering Company
Recommended Web Page: http://www.itopf.com/
Planned Learning Activities and Teaching Methods
Case studies, presentation and discussion, computer based learning, simulators, table top exercises
Assessment Methods:
There will be one case assessment, three midterm examinations and 4 quizzes&homeworks. Participation and attendance is important in this course and will be graded as 10% of the course grade. A final exam will be given during final exams week. Grades will be weighted as follows:
Case assignment = 10% of the course grade
Participation & attendance = 10% of the course grade
Midterm Examinations (3) = 45 % of the course grade
Quizzes and homeworks (4) =20% of the course grade
Final Exam = 15% of the course grade

The following method of assigning a letter grade will be followed.

Grade	Percent	Grade	Percent	Grade	Percent
A	93 and above	B-	80-82.99	D+	67-69.99
A-	90-92.99	C+	77-79.99	D	63-66.99
B+	87-89.99	C	73-76.99	D-	60-62.99
B	83-86.99	C-	70-72.99	F	Below 60

Attendance in class is mandatory and attendance will be taken at each session.

WEEK	DAY	TOPIC
WEEK 1	D1:JAN.14	Introduction
	D2:JAN.16	Marine Environment
	D3:JAN.18	Pollution Prevention
WEEK 2	D1:JAN.21	Prevention of Pollution by Oil
	D2:JAN.23	Carriage of Chemicals by ship
	D3:JAN.25	Prevention of Pollution by Sewage from Ships
WEEK 3	D1:JAN.28	Prevention of Pollution by Garbage from Ships
	D2:JAN.30	Air Pollution, Energy Efficiency and Greenhouse Gas Emissions
	D3:FEB.01	Reception facilities
WEEK 4	D1:FEB.4	Special Areas under MARPOL, Particularly Sensitive Sea Areas
	D2:FEB.6	Oil Pollution Act OPA 90
	D3:FEB.8	Midterm Exam 1
WEEK 5	D1:FEB.11	Pollution Preparedness and Response Introduction to Oil Spills
	D2:FEB.13	Oil Spill Properties, Behaviour and Fate
	D3:FEB.15	Contingency Planning
WEEK 6	D1:FEB.18	Health and Safety
	D2:FEB.20	Environmental Sensitivity and Impacts Response Organisation and Control Strategies
	D3:FEB22	Incident Command System,Trajectory Calculator Software
WEEK 7	D1:FEB.25	GNOME, oil spill trajectory model, ADIOS, oil weathering model
	D2:FEB.27	Oil Containment Booms,Failures of Containment Booms
	D3:MAR.01	Boom Selection, Deployment, Recovery and Configurations of Oil Containment Booms
SPRING BREAK		
WEEK 8	D1:MAR.11	Use of Dispersants, Use of Absorbing Materials
	D2:MAR.13	Boom calculator software,
	D3:MAR.15	Midterm Exam 2
WEEK 9	D1:MAR.18	Oil Skimmers
	D2:MAR.20	Deployment and Operation of Various Types of Skimmer Storage and Transportation of Recovered Oil
	D3:MAR.22	Wild life casualties and rehabilitation, In Situ Burning
WEEK 10	D1:MAR.25	Shoreline Clean-up
	D2:MAR.27	Cleaning, Maintenance and Storage of Equipment Oil Sampling, Cost Recovery and Documentation
	D3:MAR.29	Media Relations ,Communications and Information Sharing
WEEK 11	D1:APR.01	Liability and Compensation
	D2:APR.3	Termination of Response, Post-Incident Debriefing
	D3:APR.5	Exxon Valdez case
WEEK 12	D1:APR.8	Oil in Ice and arctic waters
	D2:APR.10	Table top exercise
	D3:APR.12	Midterm Exam 3
WEEK 13	D1:APR.15	Oil Spill Response Simulation
	D2:APR.17	Oil Spill Response Simulation
	D3:APR.18	Case presentations
WEEK 14	D1:APR.22	Case presentations
	D2:APR.24	Case presentations
	D3:APR.26	Case presentations and Review

EN-420 AIR POLLUTION TESTING & CONTROL

FALL 2018

INSTRUCTOR Dr. Brendyn Sarnacki
111 Andrews Hall
brendyn.sarnacki@mma.edu

OFFICE HOURS MWF 10:00 to 12:00+
Other times available by appointment

TEXT None

USEFUL REFERENCE TEXTS

Flagan, R. C., & Seinfeld, J. H. (1988). *Fundamentals of Air Pollution Engineering*. Prentice Hall.

de Nevers, N. (2016). *Air Pollution Control Engineering* (3rd ed.). Waveland Press, Inc.

Jacob, D. J. (1999). *Introduction to Atmospheric Chemistry* (0th ed.). Princeton University Press.

Lefebvre, A. H., & Ballal, D. R. (2010). *Gas Turbine Combustion: Alternative Fuels and Emissions*. *CRC Press*.

Heywood, J. B. (1988). *Internal Combustion Engine Fundamentals* (Vol. 21). New York: McGraw- Hill.

Vallero, D. (2008). *Fundamentals of Air Pollution* (4th ed.). Academic Press.

CATALOG DESCRIPTION

This course will include an introduction to air pollution regulations, emissions testing, the science of emissions and reduction in emissions through process control and mechanical optimization, air pollution control techniques specifically (but not exclusively) related to marine transportation and power plants. This course will also include a related environmental health and safety component. This course will include hands-on lab components for sample testing and site monitoring. Prerequisites: EN202 and CH210 or CH301 or CH352. Rec. 2. Lab. 2, Cr. 3.

COURSE LEARNING OUTCOMES

The expected outcomes of this course are:

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1. To introduce students to the environmental health and safety of air pollutants.
2. To introduce students to the science of emissions formation and reduction
3. To introduce students to emissions testing procedures
4. To introduce students to air pollution regulations

CLASS / LAB SCHEDULE

ES-420 meets in two 50-minute classroom lectures per week and one 2-hour lab. Bring your calculator, notebook, and pen or pencil to each class. Laptop computers are also required for many of the labs.

ATTENDANCE

You are expected to attend lectures. Attendance of labs is required. Several of the labs cannot be made up if missed due to complexity and time constraints on the Andrews diesel engine lab. If you miss a lab due to an emergency or illness, contact me as soon as possible.

PREREQUISITES

- CH-210 or CH-301 or CH352 – Students are required to understand the basic concepts of chemical bonding, stoichiometry, equilibrium, and kinetics.

TOPICS

- Environmental health and safety of air pollutants
- Fate of air pollutants in the atmosphere
- Air emission regulations
- Combustion fundamentals
- Pollutant formation and mitigation strategies
- Emissions measurement
- Greenhouse gases

GRADING

		87-89	B+	77-79	C+	67-69	D+	< 60 F
93-100	A	83-86	B	73-76	C	63-66	D	
90-92	A-	80-82	B-	70-72	C-	60-62	D-	

The final grade for the class will be comprised of:

- Homework Assignments 40%
- Labs 40%
- Quizzes 20%

COMPUTER USAGE

Many labs require the use of Excel for analysis and graphing. Use of spreadsheets to perform repetitive calculations is required.

EN-420 Schedule (Tentative - any schedule changes will be announced in advance)				
Week #	**Week of**	**Wednesday (Lab 3-5)**	**Thursday (Lec. 12-1)**	**Friday (Lec. 3-4)**
1	08/27/18	Intro to Class HW 1 Assigned	Background/EH&S: NOx, CO, SOx	Background/EH&S: VOCs, PM
2	09/03/18	GCMS Demonstration: Soot Sample	Atmospheric Fate: CO, NOx	Atmospheric Fate: SOx, VOCs, PM HW 1 Due
3	09/10/18	GCMS Demonstration: Air Sample	Emissions Regulations	Emissions Regulations
4	09/17/18	EPA Test Andrews Diesel Engine	Emissions Measurement	Quiz 1 HW 2 Assigned
5	09/24/18	EPA Calculations	Combustion Fundamentals	Combustion Thermodynamics
6	10/01/18	Recitation	Combustion Thermodynamics HW 2 Due	Combustion Equilibrium, Kinetics, and Mixing HW 3 Assigned
7	10/08/18	Emissions Reporting	NOx Formation	NOx Mitigation
8	10/15/18	HFO PM Mass	Quiz 2	SOx Formation and Mitigation HW 3 Due
9	10/22/18	Recitation	CO Formation	CO Mitigation
10	10/29/18	PM Filter Samples Andrews Diesel Engine	VOC Formation	VOC Mitigation HW 4 Assigned
11	11/05/18	PM Filter Sample Calculations	VOCs from Oil and Gas Operations	PM Formation
12	10/12/18	Recitation	PM Mitigation	CO2/Greenhouse Gases
13	11/19/18	**Thanksgiving**	**Thanksgiving**	**Thanksgiving**
14	11/26/18	Emissions Sensitivity Test Andrews Diesel Engine	Quiz 3	Heavy metals and other emissions HW 4 Due
15	12/03/18	Recitation	Advanced Combustion Strategies	Advanced Combustion Strategies
16	12/10/18	**Finals Week**	**Finals Week**	**Finals Week**