MEEM 4200-5290 – Principles of Energy Conversion

Michigan Technological University
Mechanical Engineering - Engineering Mechanics

Lectures
TTh 8:05 - 9:20 am
MEEM 402

Instructor
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Office Hours, MEEM 905
Tue 09:30 - 11:30
Thu 09:30 - 11:30
or by appointment

Course Description

This course will introduce you to the basic language and concepts of energy, energy conversion and energy storage. Current and emerging technologies for conversion of thermal, mechanical, chemical, nuclear, solar and electrical energy will be discussed along with introduction to tools that may be used for comparing competing energy conversion technologies.

Course Objectives

After this course you should be able to:

1. compare competing energy conversion technologies on an economic and efficiency basis;
2. assess the validity of energy conversion claims made in popular media;
3. be familiar with thermodynamic processes and power cycles (thermal and mechanical energy);
4. be familiar with basic principles of thermal, mechanical, chemical, nuclear, and solar energy conversion;
5. be familiar with basic principles of energy storage;
6. serve those around you who are trying to make energy-conscious decisions.

Course Expectation

Prepare to spend 8 to 10 hours per week outside of lectures on this course. Participation in class discussions and homework groups is expected.

Textbook

The textbook for this course is a combination of course notes and a free, online *Energy Conversion* book by Kenneth Weston, Energy Conversions - The eBook. For convenience, a hyperlinked table of contents can be downloaded from the MEEM4200/5290 course website and from Canvas.

Course Website & Canvas

The course materials and lectures will be posted in two places, a public webpage: Principles of Energy Conversion and Canvas. On the website, recently posted material is identified by a red posting date.

Email Correspondence

Electronic correspondence should be through the Michigan Tech email system. Any email correspondence concerning the course should include in the subject line `MEEM4200` or `MEEM5290`.

ADA Compliance

Michigan Tech complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act of 1990 (ADA). If you have a disability and need a reasonable accommodation for equal access to education or services at MTU, please call the Dean of Students at 487-2212. Additional information can be found at Student Disability Services.

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Course Topics

The course topics listed are subject to change based on the interest of the class.

- Energy, Growth Rate & Energy Economics
  - energy, energy classification, units
  - energy conversion, conversion efficiency
  - energy information and perspectives
  - growth rates, peak oil
- Thermal-to-Mechanical Conversion
  - early engines & efficiency
  - Thermodynamics & power cycles & efficiency
  - Rankine Cycle
  - Brayton Cycle
- Chemical-to-Thermal Conversion
  - fuels: coal, petroleum, gas
  - principles of combustion
- Nuclear-to-Thermal Conversion
  - principles of nuclear energy
  - pressurized water reactors
  - boiling water reactors
  - boiling water, graphite-moderated reactors
  - Gen-IV reactors
- Electromagnetic-to-Thermal Conversion
  - principles of solar insolation
  - solar collectors
  - thermal energy storage
- Electromagnetic-to-Electrical Conversion
  - principles of photovoltaics
- Mechanical-to-Mechanical Conversion
  - principles of wind energy
- Chemical-to-Electrical Conversion
  - principles of fuel cells
- Introduction to Energy Storage
  - hydrogen
  - flow batteries
  - compressed gas, flywheels

Difference Between 4200 and 5290 Sections

The graduate section, MEEM5290, will have additional readings and homework assignments.

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Course Policies

Academic Integrity[1]

Academic dishonesty is a serious violation of University Policy and will be dealt with accordingly. Any questions regarding permissible collaborations or information sources should be brought to the instructor for clarification. Academic Misconduct is defined per Senate policy as:

- Plagiarism: Knowingly copying another's work or ideas and calling them one's own or not giving proper credit or citation. This includes but is not limited to reading or hearing another's work or ideas and using them as one's own; quoting, paraphrasing, or condensing another's work without giving proper credit; purchasing or receiving another's work and using, handling, or submitting it as one's own work.
- Cheating: Intentional, unauthorized use of any study aids, equipment, or another's work during an academic exercise. This includes but is not limited to unauthorized use of notes, study aids, electronic or other equipment during an examination; copying or looking at another individual's examination; taking or passing information to another individual during an examination; taking an examination for another individual; allowing another individual to take one's examination; stealing examinations. Cheating also includes unauthorized collaboration. All graded academic exercises are expected to be performed on an individual basis unless otherwise stated by the instructor. An academic exercise may not be submitted by a student for course credit in more than one course without the permission of all instructors.
- Fabrication: Intentional and/or unauthorized falsification or invention of any information or citation during an academic exercise. This includes but is not limited to changing or adding an answer on an examination and resubmitting it to change the grade; inventing data for a laboratory exercise or report.
- Facilitating Academic Misconduct: Knowingly or recklessly allowing or helping another individual to plagiarize, cheat, or fabricate information.

Information on policy and potential sanctions can be found at the Michigan Tech Academic Integrity Policy.

Class Attendance & Participation

You are responsible for the material covered in class. The lectures will be used to supplement and expound upon the assigned readings and homework. Class time is intended to be interactive. Participation during class discussions is expected and will be used as part of your overall grade. Use of any recording or communicating devices of any kind is not permitted in class without prior approval from the instructor. Announcements concerning changes to homework assignments, exam dates, etc. will only be given in class. **Please turn off your cell phones during the class period.**

The material covered in the lectures is not inclusive of everything you are expected to learn during the course. You will be responsible for the material in the assigned readings from books, posted documents, and independent research.

Professional travel to workshops and conferences is required of all tenure/tenure-track faculty. I anticipate being on professional travel for at least three instructional days during the semester; course material for these lecture periods will be covered via alternative means.

Homework & Reading Assignments

Students will be divided into groups and each group will turn in a joint homework assignment. The intent of these groups is for you to work together and learn from one another. Part of your individual participation grade will be determined by group evaluations of the members. Even though the homework is turned in as a joint effort, you are responsible for knowing how to solve every problem assigned. Be prepared to work any of the assigned problems in class on an exam.

All homework must be prepared in a straightforward and neat manner; include all pertinent information such as coordinate axis, control volumes, and units and appropriate sources of information. The solution to each problem should begin on a new page. Convoluted or sloppy work will be returned without a grade. Instructions for electronic submission of homework will be provided during the course.

[1] from Michigan Tech Senate Policy 109.1.1

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Exams & Quizzes

Exams and quizzes will be closed book. There will be two exams. Formula sheets and data tables will be provided. Anticipate unannounced quizzes during lectures. No makeup exams or quizzes will be given. If an absence during an exam or quiz is unavoidable, arrangements must be made with the instructor prior to the date of the absence for an oral exam. Missing an exam due to documented illness or emergency will be handled on a case-by-case basis; also with an oral examination. There will be no final exam.

Research Projects

The purpose of the group research project is to engage in an in-depth study on energy conversion technology to a greater extent than possible through homework assignments. The project will incorporate advanced engineering analysis, methods of conversion, targeted power range, political and economic factors, and competing technologies. The final deliverables for the project are a technical report and a public poster symposium.

Participation & Initiative

Participation and initiative in the learning process is expected.

Archiving of Student Work

A subset of each homework, quiz, exam and project will be archived for the purposes of degree accreditation and instructional review. All names will be redacted from the work prior to archival.

Grading

The grade weighting will be:

20% homework,
20% first exam,
20% second exam,
30% research project,
5% quizzes, and
5% initiative and peer evaluation.

For the **4200 section**, the grade scale will be: A: $\geq$ 93%, AB: 88% – 92%, B: 83% – 87%, BC: 78% – 82%, C: 73% – 77%, CD: 68% – 72%, D: 63% – 67% F: $\leq$ 63%.

For **5290 section**, the grade scale will be: A: $\geq$ 93%, AB: 88% – 92%, B: 83% – 87%, BC: 78% – 82%, C: 68% – 77%, F: $\leq$ 68%.

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Supplementary Texts

Principles of Energy Conversion, 2nd ed., A. W. Culp, Jr., McGraw-Hill, ISBN 0-07-014892-9 (1991).

Power Plant Technology, M. M. El-Wakil, McGraw-Hill Book Company, ISBN 0-07-019288-X (1984)

any Engineering Thermodynamics textbook

Energy Systems Engineering - Evaluation and Implementation, F. M. Vanek & L. D. Albright, McGraw-Hill, Inc., ISBN 978-0-07-149593-6 (2008).

Applied Thermodynamics: Availability Method and Energy Conversion, K. W. Li, Taylor & Francis, ISBN 1-56032-349-3 (1996).

Energy Conversion, D. Yogi Gaswami & F. Kreith, ed., CRC Press, ISBN 978-1-4200-4431-7 (2008).

Handbook of Energy Efficiency and Renewable Energy, F. Kreith & D. Yogi Gaswami, ed., CRC Press, ISBN 0-8493-1730-4, (2007).

Energy and Problems of a Technical Society, 2nd ed., J. J. Kraushaar & R. A. Ristinen, John Wiley & Sons, ISBN 0-471-57310-8 (1993).

Internal Combustion Engines and Air Pollution, E. F. Obert, Harper & Row Publishers, Inc., ISBN 0-352-04560-0 (1973).

Synthetic Fuels, R. F. Probstein and R. E. Hicks, Dover Publications, Inc., ISBN 0-486-44977-7 (2006).

Fundamentals of Nuclear Science and Engineering, 2nd ed., J. K. Shultis and R. E. Faw, CRC Press, ISBN 978-1-4200-5135-3 (2008).

Steam: Its Generation and Use, 40th ed., Babcock and Wilcox, Stultz and Kitto, ed. (1992).

Black & Veatch Power Plant Engineering, Drbal, Boston, Westra, and Erickson, ed., Springer (1996).

Fundamentals of Gas Turbines, W. W. Bathie, John Wiley & Sons, (1984).

Principles of Solar Engineering, 2nd ed., D. Yogi Goswami, F. Kreith, J. F. Kreider, Taylor & Francis, ISBN 1-56032-714-6 (2000).

Solar Engineering of Thermal Processes, 3rd ed., J. A. Duffie and W. A. Beckman, John Wiley & Sons (2006).