



ENGG*4580 Sustainable Energy Systems Design

01

Winter 2024

Section(s): C01

School of Engineering

Credit Weight: 0.75

Version 1.00 - January 12, 2024

1 Course Details

1.1 Calendar Description

The analysis and design of sustainable energy systems are presented in this course. Techniques considered include generation of alternative designs to satisfy a problem definition; evaluation of alternative designs; application of modeling simulations and cost analyses.

Pre-Requisites:

ENGG*3080, ENGG*3370, ENGG*3430

Restrictions:

Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Course Description

The course is a capstone type of course in energy streams of mechanical engineering program. The course is designed in order to demonstrate how knowledge from junior level fundamental classes such as thermodynamics, heat transfer, fluid mechanics, engineering economics, and numerical analysis can be used to design and simulate energy systems. This is also the course to assess the thermal system design capabilities of students with regards to CEAB outcomes. The course is organized into three major sections. The first is on piping systems, blended with economics of pipe size selection and sizing of pumps for piping systems. The second is on heat exchangers or, more generally, devices available for the exchange of heat between two process streams. Finally the third is on modeling and simulation of energy systems.

The course requires the students to complete term projects. Each project has associated with a project description that begins with a few introductory comments and concludes with several tasks that are to be completed. Each project has an estimate of the number of engineers required to finish it in the given school term. The students are responsible for

selecting project partners and , as a group, deciding on which projects they would like to work. Each group elects its own project manager or leader.

1.3 Timetable

Timetable is subject to change. Please see WebAdvisor for the latest information.

LEC Tues, Th 02:30 PM - 03:50 PM Room: MCKN 115

LAB Wed 02:30 PM - 05:20 PM Room THRN 3404/1313

LAB Mon 02:30 PM - 05:20 PM Room THRN 3404/1313

1.4 Final Exam

Exam time and location is subject to change. Please see WebAdvisor for the latest information.

EXAM Friday 8:30AM - 10:30AM (2023/04/19) Room TBA

2 Instructional Support

2.1 Instructional Support Team

Instructor: Animesh Dutta, PhD, P.Eng
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2.2 Teaching Assistants

Teaching Assistant (GTA): Shahin Mazhkoo
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Teaching Assistant (GTA): Mehran Bozorgi
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Office Hours: TBA on CourseLink or by Appointment

3 Learning Resources

3.1 Required Resources

Course Website (Website)

Course material, news, announcements, and grades will be regularly posted to the ENGG*4580 CourseLink site. You are responsible for checking the site regularly.

SI Edition: Design of fluid thermal system by William S. Janna (Textbook)

3.2 Additional Resources

Introduction to Thermo-Fluid Systems Design Andre McDonald, Hugh L. Magande (Textbook)

W. F. Stocker: Design of Thermal Systems, McGraw Hill, 1989 (Textbook)

Duffie and Beckman. Solar Engineering of Thermal Processes (4th Ed.) John Wiley & Sons. 2013. (Textbook)

Available through the University of Guelph library as e-books at no additional cost to students.

IC Engines (Readings)

3.3 Recommended Resources

Software

EES:

Thermal energy system analysis and design often requires the solution of simultaneous nonlinear equations. In addition, quick access to thermophysical properties of the working fluids used in the system is desirable. Modern computer software is available that can be used to solve complex systems of equations while accessing thermophysical properties. In this course, we will be using Engineering Equation Solver (EES). The EES software can be found on the course website. This software is for Mechanical Engineering Student use only. Please do not distribute the software or the EES.DFT file to anyone other than a Guelph Mechanical Engineering student.

MATLAB:

We will also be utilizing MATLAB to simulate engineering systems. Tutorials and refresher material are available at http://www.mathworks.com/academia/student_center/tutorials/launchpad.html It is recommended that students who need a refresher in MATLAB download and refer to the User Guide:

http://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf

Students may find the following electronic text books relevant. All can be accessed (and downloaded in PDF format) through the University of Guelph library web site:

1. Grote, K-H, Antonsson, E. K. (editors). Springer Handbook of Mechanical Engineering. Springer. 2009. ISBN: 978-3-540-49131-6 (Print) 978-3-540-30738-9 (Online)
2. Kutz, M. (editor). Mechanical Engineers' Handbook: Materials and Mechanical Design, Volume 1, Third Edition. John Wiley & Sons Inc. 2006. Print ISBN: 9780471719854, Online ISBN: 9780471777441, DOI: 10.1002/0471777447
3. Bautista Paz, Emilio. A brief illustrated history of machines and mechanisms. Dordrecht, New York: Springer. 2010.

COMSOL:

We also be introducing COMSOL Multiphysics (30 licenses are available in the School) software.

3.3 Additional Resources

Lecture Information: Some lecture notes will be posted on Courselink.

Tutorial Information: Supporting materials will be posted on Courselink.

Project Information: Project requirements and supporting materials will be posted on Courselink

Reading and homework assignments will be posted on the course website. Homework assignments are due at the beginning of the class period posted on the course website. Homework not submitted at the required time is considered late and will receive a grade of zero.

4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Understand the governing principles of energy systems.
2. Integrate prior knowledge of fluid mechanics, heat transfer, thermodynamics and engineering systems in order to compare sustainable energy systems.
3. Apply knowledge of specific renewable energy technologies to assess the feasibility of proposed energy systems in engineering, financial, and social contexts.
4. Critically evaluate proposed energy technologies and systems across a range of parameters, including practicality, potential performance, safety and sustainability.
5. Design energy systems for specific goals and locations.
6. Concisely and articulately communicate the results of an energy system analysis or design process to an engineering audience.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1
1.3	Recall, describe and apply fundamental engineering principles and concepts	1
1.4	Recall, describe and apply program-specific engineering principles and concepts	1
2	Problem Analysis	1, 2, 3
2.1	Formulate a problem statement in engineering and non-engineering terminology	1
2.2	Identify, organize and justify appropriate information, including assumptions	2
2.3	Construct a conceptual framework and select an appropriate solution approach	2
2.4	Execute an engineering solution	2, 3
2.5	Critique and appraise solution approach and results	3
4	Design	1, 2, 3, 4, 5
4.1	Describe design process used to develop design solution	1, 5
4.2	Construct design-specific problem statements including the definition of criteria and constraints	2, 3, 5
4.3	Create a variety of engineering design solutions	2, 3, 5

#	Outcome	Learning Outcome
4.4	Evaluate alternative design solutions based on problem definition	2, 3, 4, 5
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	2, 3, 4, 5
5	Use of Engineering Tools	2, 3
5.1	Select appropriate engineering tools from various alternatives	2, 3
5.2	Demonstrate proficiency in the application of selected engineering tools	3
6	Individual & Teamwork	5
6.1	Describe principles of team dynamics and leadership	5
6.2	Understand all members' roles and responsibilities within a team	5
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	5
6.4	Apply strategies to mitigate and/or resolve conflicts	5
6.5	Demonstrate leadership through, for example, influencing team vision and process, promoting a positive team culture, and inspiring team members to excel	5
7	Communication Skills	6
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	6
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	6
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	6
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	6
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	6
9	Impact of Engineering on Society and the Environment	3

#	Outcome	Learning Outcome
9.1	Analyze the safety, social, environmental, and legal aspects of engineering activity	3
11	Economics and Project Management	3, 4
11.1	Apply project management techniques and manage resources within identified constraints	3
11.2	Identify risk and change management techniques, in the context of effective project management	3
11.3	Estimate economic impact and feasibility of an engineering project or design using techniques such as cost benefit analysis over the life of the project or design	3, 4

5 Teaching and Learning Activities

The following schedule may be modified during the semester depending on course needs.

5.1 Lecture

Topics: Introduction: Design Process of Energy Facilities
References: Janna; Stocker
Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- Design Process
- Bid Process
- Approached to Engineering Design
- Project Management
- Dimensions and Units
- Systems, Distinction Between Workable and Optimum System, Examples
- Design of an Optimum System

Topics: Review of Thermal Processes and Applications
References: Notes provided on Courselink
Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- First and Second Law of Thermodynamics
- Thermodynamic Cycles
- Ideal Gas Mixtures and Psychrometry
- Energy Balance for Closed and Control Volume Systems and its Applications

Topics: Fluid Properties and Basic Equations
References: Janna
Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- Fluid properties
- Measurement of viscosity
- Measurement of pressure
- Basic equations of fluid mechanics

Topics: Piping systems
References: Janna
Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- Pipe and tubing standards
- Friction factor and losses
- Series piping systems
- Flow through pipe network
- Pipes in parallel
- Stresses in thin wall pressure vessels
- Thermal stresses
- Piping system design practices

Topics: Heat transfer fundamentals
References: Janna
Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- Conduction and convection problems with case studies
- Optimum thickness of insulation

Topics: Winter break
Learning Outcome: 1, 2, 3, 6

Topics: Heat exchangers design
References: Janna; Andre McDonald,
Learning Outcome: 1, 2, 3, 6

- Double pipe heat exchangers design
- Shell and tube heat exchangers design
- Plate and frame and cross flow heat exchangers design

Topics: Internal Combustion Engines
References: Notes provided on Courselink

Learning Outcome: 1, 1, 2, 2, 3, 3, 4, 4, 6, 6

Topics: Modeling of Energy Equipments

References: Notes provided on Courselink

Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- Equation Fitting for Characterization of Energy Equipments: Application of Equation Fitting Techniques for Characterization of Energy Processes and Equipments
- Processes and Thermodynamic Properties
- Equipments: Heat Exchanger, Pumps, Turbo-machinery, etc

Topics: Simulation and Optimization of Energy Systems

References: Notes provided on Courselink

Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- Information Flow Diagrams
- Simulation Techniques: Applications of Successive Substitution Method and Newton-Raphson Method to Energy Systems
- Optimisation: Application of Lagrange Multipliers and Search Methods to Energy Facilities

Topics: Pinch Technology

References: Notes provided on Courselink

Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

- Basic Concepts of Pinch Technology
- Stream Networks and Significance of Pinch
- Determination of Heating and Cooling Load by Tabular Method
- Design of Recovery Systems
- Installation of Heat Pumps and Heat Engines and Process Retrofit.

Topics: Sustainable Design: Philosophy of sustainable design Eco audits, critical materials

References: Notes provided on Courselink

Learning Outcome: 6

Case studies electric cars

5.2 Lab

Topics: EES

Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

Design problem

Topics: EES

Learning Outcome: 1, 1, 2, 2, 3, 3, 6, 6

Design Problem

Topics:	EES
Learning Outcome:	1, 1, 2, 2, 3, 3, 6, 6
Design Problem	
Topics:	COMSOL
Learning Outcome:	1, 1, 2, 2, 3, 3, 6, 6
Design Problem	
Topics:	COMSOL
Learning Outcome:	1, 1, 2, 2, 3, 3, 6, 6
Design problem	
Topics:	COMSOL
Learning Outcome:	1, 2, 3, 6
Design Problem	
Topics:	Winter break
Learning Outcome:	1, 2, 3, 6
Topics:	MATLAB
Learning Outcome:	1, 1, 2, 2, 3, 3, 4, 4, 6, 6
Design Problem	
Topics:	MATLAB
Learning Outcome:	1, 1, 2, 2, 3, 3, 6, 6
Design Problem	
Topics:	MATLAB, EES, COMSOL
Learning Outcome:	1, 1, 2, 2, 3, 3, 6, 6
Design Problem	
Topics:	EES, MATLAB, Comsol,
Learning Outcome:	1, 2, 3, 6
Design Problem	
Topics:	Project Submission
Learning Outcome:	1, 1, 2, 2, 3, 3, 6, 6
Question and Answer (Individual)	

5.3 Other Important Dates

Monday, January 9: Classes commence

ENGG*4030 first lecture on Wednesday Jan 11.

Week of Monday, February 20: WINTER BREAK

Friday March 10: 40th class day.

Thursday April 6: Last day of classes.

Friday, April 7: Holiday -- No Classes Scheduled -- classes rescheduled to Monday, April 10

Monday, April 10: Classes rescheduled from Friday, April 7. Friday schedule in effect, Classes conclude

Important dates can be found here:<https://calendar.uoguelph.ca/undergraduate-calendar/schedule-dates/winter-semester/>

6 Assessments

6.1 Assessment Details

Design Problem (30%)

Learning Outcome: 1, 2, 3, 5, 6

Due at start of tutorial. Presented during tutorial. Submit zipped file package on Courselink, and bring presentation materials to tutorial.

three software EES, MATLAB and COMSOL will be used to solve the problems.

Midterm Test (20%)

Date: Tue, Feb 27, 2:30 AM - 3:50 AM, In Class

Learning Outcome: 1, 2, 3, 5
Feb 27 (Week 7)

Final design (Group) (25%)

Date: Week 12, In tutorial

Learning Outcome: 2, 3, 4, 5, 6

Design documentation due during the last week of tutorial.

1/2 individual grading

1/2 group grade

Final Exam (25%)

Date: Fri, Apr 19, 8:30 AM - 10:30 AM, TBA, see the Webadvisor

Learning Outcome: 1, 2, 3, 5

Monday, April 19 2024, 8:30 AM- 10:30 AM.

Exam time and location is subject to change. Please see WebAdvisor for the latest information

6.2 Test

The test will be closed book, however, each student may bring a sheet of 8.5 inch by 11 inch paper containing notes, equations and other material chosen by the student. Both sides of the paper may contain material. No programmable calculators will be permitted. The test will cover all material in the course up to the date of the test, including material from lectures, tutorials and projects. The test will be held during the lecture period.

6.3 Design Project

A central theme of the course will be a team-based design project. Design teams will consist of three or four students. Students will be expected to develop and utilize simulation tools using EES, MATLAB or COMSOL as part of their design process. Details, requirements and other supporting materials will be posted on Courselink.

6.4 Team Work

Team work is required for several parts of this course, particularly the design project. If there is some observation or evidence that you have not been contributing appropriately to the team, then you will be asked to provide evidence of your individual efforts, contributions and results. Keeping a log book may be one effective means to help demonstrate your contributions. *If it is determined that a student has not made a good-faith effort to contribute to the team, the entire course mark for the student will be reduced. In extreme cases, the student's course mark could be reduced to a below-passing level and the student could fail the course, even if the student has high marks on exams and the individual portions of the projects.*

7 Course Statements

7.1 Passing grade

The passing grade for this course is 50%.

7.2 Late Deliverables

Late (> 4 hours) written or code submissions will be penalized if there are not acceptable compassionate or medical grounds. A one letter grade penalty will be applied for deliverables submitted between 4 and 72 hours late. Deliverables received more than 72 hours late will be assigned a grade of zero. Students not ready to present/review/defend during a scheduled presentation time will be assigned a grade of zero for that component.

7.3 Minimum Quality of Written Deliverables

All written deliverables must be written clearly in grammatically correct English. Deliverables that do not meet a minimum writing quality will be returned unmarked, and the student or group will be required to rewrite and resubmit the deliverable by a specified date. If the student or group does not resubmit the deliverable, or the resubmission is also poorly written, the student or group will receive a mark of zero for the deliverable. The final mark for a rewritten deliverable will be reduced by a full letter grade after marking is completed as a late penalty.

7.4 Grading Philosophy

The grading philosophy used in this course is based on the concept that design has a significant creative component, that there are many possible solutions, and that much of design does not result in right or wrong understanding or results. Marking in this course will be based on the premise that your work is assumed to be a "B" until there is evidence that the work is exemplary or aspects that are disappointing. Exemplary and disappointing components are integrated to produce a final assessment. Letter grades are used to reflect that the process is not $\pm 2\%$ accurate and that design could never be assessed with fine resolution.

The following letter grade translation will be used to convert letter grades to numeric form:

A+	Really Exemplary	100
A	Exemplary	90
A-		82
B+		78
B	Expected	75
B-		72
C+		68
C	Satisfactory	65
C-		62
D+		58
D	Disappointing, serious flaws	55
D-		52
F	Inadequate	35
X	No submission or wholly inadequate	0

8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during

lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

Graduate Calendar - Grounds for Academic Consideration

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions

<https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml>

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml>

Graduate Calendar - Registration Changes

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml>

Associate Diploma Calendar - Dropping Courses

<https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml>

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
<https://www.uoguelph.ca/sas>

For Ridgetown students, information can be found on the Ridgetown SAS website
<https://www.ridgetownc.com/services/accessibilityservices.cfm>

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community—faculty, staff, and students—to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse

students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml>

Graduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars

<https://www.uoguelph.ca/academics/calendars>

9.9 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).
