Mechanical Engineering 2W04: Engineering Thermodynamics

McMaster University, Faculty of Engineering, Winter 2025

INSTRUCTOR

Dr. Jim Cotton, JHE 212a, cottonjs@mcmaster.ca

Please email me if you would like to see me at a particular time.

Objectives

To teach the fundamental concepts in thermodynamics and the application of these principles in engineering.

CalendAr Description

Mech Eng 2W04: Introduction to the principles of thermodynamics, and applications in engineering. Basic concepts: energy systems, properties of pure substances, entropy. Laws of thermodynamics, power and refrigeration cycles. Three lectures, one tutorial;

PRESCRIBED TEXTBOOK

- Thermodynamics – An Engineering Approach: Eighth, Ninth or Tenth Edition, Yunus A. Cengel, Michael A. Boles, McGraw Hill. (Chapters 1-7 and 10)

COURSE WEBSITE

Avenue to Learn: http://avenue.mcmaster.ca/

- Avenue - You can view and download course information from this site.
    - Students are expected to stay abreast of announcements and schedule changes made in lectures and posted on Avenue to Learn.

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows:

- 3 classroom-based live lectures per week
- 1 tutorial 2 hours/week
- 8 assignments

- 2 midterm tests (2 hours)
- 1 final exam (2.5 hours)

LECTURES

Monday, Wednesday, & Thursday – 1:30 to 2:20 hours – MCDL 1102

TUTORIALS

Tutorial participation is a mandatory aspect of course assessment. Evaluation is based on participation in 10 of the 11 tutorials

T03 Group A-	Monday	10:30 - 12:20pm	@ T13 107
T04 Group B-	Wednesday	10:30 - 12:20pm	@ KTH 104
T01 Group C-	Wednesday	2:30 - 4:20pm	@ HH 305
T02 Group D-	Thursday	2:30 - 4:20pm	@ ITB 139

Grade allocation of an MSAF Tutorials Assignments will be redistributed to the remaining Tutorials

ASSIGNEMENTS

8 Assignments - Problem sets are planned for roughly every week. Schedule on page 5.

MID-TERM

Mid-term examinations: There will be two tests of 2 hour duration.

Midterm #1: Monday February 10, 2025 – 6:30pm – 8:30pm

Location: PGCLL 127

Midterm #2: Monday March 17, 2025 – 6:30pm – 8:30pm

Location: PGCLL 127

Final examination: 2.5 hours in duration.

The final exam will cover all lecture material.

Calculators: Only McMaster Standard Calculator (Casio fx-991) may be used during term tests and the final examination.

ASSESSMENT

The following distribution of marks will be used unless there is a valid and compelling reason to use an alternative weighting. Missed assignments and tests will have a grade of zero entered without legitimate and documented reason. The course of action for missed mid-terms with Associate Dean's (MSAF) approval is the weight of the mid-term or assignment will be re-distributed to the final exam.

		Tutorials	10%
		Problem sets:	10%
Mid Tests:	30%		
Final Exam:	50%		

DETAILED COURSE DESCRIPTION

Introduction:

- Definitions
- Defining Systems (closed, open)
- Fundamental Properties (intensive, extensive),
- Forms of Energy
- Temperature & Pressure
- Problem Solving Methodology

Properties of Pure Substances

- Phase Change Process of Pure Substances
- Property Diagrams & Tables
- The Ideal Gas Equation of State
- Specific Heats

Energy Transfer

- Heat Transfer
- Mechanical Forms of Work
- Non-Mechanical Forms of Work
- Conservation of Mass Principle
- Flow Work and Energy

First Law of Thermodynamics:

- Fundamental Concepts
- Energy Balance for Closed Systems
- Energy Balances for Steady-Flow Systems
- Steady-Flow Engineering Devices

(nozzles, turbine, compressors, pumps, heat exchangers)

- Energy Balances for Unsteady-Flow Systems

Second Law of Thermodynamics:

- Thermal Energy Reservoirs
- Heat Engines
- Clausius statement, Kelvin-Planck statement
- Reversible/Irreversible processes
- `Black-box' Cycles : heat pumps, refrigerators, power cycles
- Carnot Cycles
- The Carnot Principles

Entropy:

- Clausius Inequality,
- The Increase of Entropy Principle
- Entropy Change of a Pure Substance
- Isentropic Processes
- Process Diagrams Involving Entropy
- Entropy Data (steam tables), TdS equations
- Special Cases: ideal gas, incompressible substance
-

Vapor Power Cycles

- The Carnot Vapor Cycle
- Rankine Cycle
- Deviations of Actual Cycle from Ideal
- Methods to Increase the Efficiency of Rankine Cycle

LEARNING OUTCOMES: Upon successful completion of the course the student are expected to demonstrate the ability to:

1. Identify the unique vocabulary associated with thermodynamics and explain the basic concepts of thermodynamics

2. Determine thermodynamics properties of pure substances, apply the ideal-gas equations, account for compressibility and equations of state.

3. Solve the first law of thermodynamics and mechanisms of energy transfer to and from a system and for common steady-flow and unsteady devices.

4. Solve the conservation of mass principle on various systems including steady- and unsteady-flow control volumes.

5. Apply the Second Law and Carnot principles and solve for the thermal efficiencies and coefficients of performance for reversible heat engines, heat pumps, refrigerators and solve for isentropic efficiencies for various steady-flow devices.

6. Analyze vapor power cycles in which the working fluid is alternately vaporized and condensed.

GRADUATE ATTRIBUTES: This course provides the students opportunity to develop the following measures of graduate attributes

Graduate Attributes	Learning Objectives where it is measured
Knowledge base for Engineering (Indicator 1.03)	1-6
Problem Analysis (Indicator 2.02)	3-6

Teaching Assistants

Ethan Chariandy	chariane@mcmaster.ca
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Eduardo (Akira) Shiguemoto	shigueme@mcmaster.ca
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Francois (Frank)Albert	albertf@mcmaster.ca
Nada Zaher	zahern1@mcmaster.ca

Assignments Collection and Evaluation

Assessment: TOTAL 10% of Grade

Assignments will be evaluated out of 10 marks.

Missed assignments will have a grade of zero entered without legitimate and documented reason.

Home Work No.	Due Date	Day	Marking TA In-Charge*
1	January 23	Thursday	Anurag
2	January 30	Thursday	Akira
3	February 6	Thursday	Eduardo
4	February 27	Thursday	Oorja
5	March 6	Thursday	Anurag
6	March 13	Thursday	Eduardo
7	March 27	Thursday	Oorja
8	April 3	Thursday	Akira

*marking TA subject to change, ChaNges will be posted in avenue.

Assignment Solutions Format and Evaluation

Format¿All homework submissions should adhere to the following format. Adherence to format will help us grade faster and more efficiently. So, help us give you a better grade.

- Use a clean 8-1/2” x 11” (letter size) or digital paper.
- Follow the approach to problem solving described below:

    - Problem Statement
    - Schematic and Given Data
    - Assumptions
    - Physical Laws
    - Know Data & Properties
    - Analysis/Calc's – with Units
- Numerical substitutions should be made after an algebraic solution has been formulated. You may get a good grade even if your numerical answer is wrong but your algebraic approach is reasonable. Try restraining yourself from numerical substitutions as long as you can.
- Highlight your final answer and be sure to not forget the UNITS.

If a computer program is used to attain a solution, attach a copy of the program and the data sheet.

ASSIGNMENT SUBMISSIONS

All homework should be submitted to Avenue to Learn\Assessments\Assignment\ by 11:59pm on the due date.

NO late submissions will be accepted without permission from the Associate Dean's Office (MSAF).

Grade allocation of an MSAF Assignments will be redistributed to the completed Assignments

Procedure for Remarking Term Test Answer Books:

In the event that a student has an issue with the way in which a term test has been evaluated, he/she may lodge their objections within a week of returning the marked papers.

Please.follow.the.steps.below.while.submitting.material.for.remarking¿

Compare your solutions to that posted on the course website. Write your concern in a separate piece of paper or email memo indicating: (i) Problem number(s) you have concerns about, (ii) Detailed nature of the discrepancy, and (iii) The marks you think you should have received, in reference to the solution/marking scheme posted on the course website. Please submit this along with your answer book personally to the instructor or TA.

The student will receive a written response from the TA that marked the paper; if the student does not agree

with the response, the student may submit the whole documentation to the instructor for arbitration/remarking.

ACADEMIC.INTEGRITY.

You.are.expected.to.exhibit.honesty.and.use.ethical.behaviour.in.all.aspects.of.the.learning.process¡. Academic.credentials.you.earn.are.rooted.in.principles.of.honesty.and.academic.integrity¡.It.is.your. responsibility.to.understand.what.constitutes.academic.dishonesty¡.

Academic.dishonesty.is.to.knowingly.act.or.fail.to.act.in.a.way.that.results.or.could.result.in.unearned. academic.credit.or.advantage¡.This.behaviour.can.result.in.serious.consequences?e¡g¡.the.grade.of.zero. on.an.assignment?loss.of.credit.with.a.notation.on.the.transcript.(notation.reads¿»Grade.of.F.assigned.for. academic.dishonesty‹)?and ~~or~~.suspension.or.expulsion.from.the.university¡.For.information.on.the. various.types.of.academic.dishonesty.please.refer.to.the.Academic.Integrity.Policy?located.at. https¿ ~~se~~cretariat¡mcmaster¡ca ~~u~~niversity_policies_procedures_guidelines ~~.~~

The.following.illustrates.only.three.forms.of.academic.dishonesty¿

/ .plagiarism?e¡g¡.the.submission.of.work.that.is.not.one's.own.or.for.which.other.credit.has.been. obtained¡.

/ .improper.collaboration.in.group.work¡.

/ .copying.or.using.unauthorized.aids.in.tests.and.examinations¡.

AUTHENTICITY.–.PLAGIARISM.DETECTION.

Some.courses.may.use.a.web_based.service.(Turnitin¡com).to.reveal.authenticity.and.ownership.of. student.submitted.work¡.For.courses.using.such.software?students.will.be.expected.to.submit.their.work. electronically.either.directly.to.Turnitin¡com.or.via.an.online.learning.platform.(e¡g¡.A8L?etc¡).using. plagiarism.detection.(a.service.supported.by.Turnitin¡com).so.it.can.be.checked.for.academic.dishonesty¡.

Students.who.do.not.wish.their.work.to.be.submitted.through.the.plagiarism.detection.software.must. inform.the.Instructor.before.the.assignment.is.due¡.No.penalty.will.be.assigned.to.a.student.who.does.not. submit.work.to.the.plagiarism.detection.software¡.All.submitted.work.is.subject.to.normal.verification. that.standards.of.academic.integrity.have.been.upheld.(e¡g¡?on_line.search?other.software?etc¡)¡.For. more.details.about.McMaster"s.use.of.Turnitin¡com.please.go.to.www¡mcmaster¡ca–academicintegrity¡.

COURSES.WITH.AN.ON_LINE.ELEMENT.

Some.courses.may.use.on_line.elements.(e¡g¡.e_mail?Avenue.to.Learn.(A8L)?LearnLink?web.pages? capa?Moodle?ThinkingCap?etc¡)¡.Students.should.be.aware.that?when.they.access.the.electronic. components.of.a.course.using.these.elements?private.information.such.as.first.and.last.names?user. names.for.the.McMaster.e_mail.accounts?and.program.affiliation.may.become.apparent.to.all.other. students.in.the.same.course¡.The.available.information.is.dependent.on.the.technology.used¡. Continuation.in.a.course.that.uses.on_line.elements.will.be.deemed.consent.to.this.disclosure¡.If.you.have. any.questions.or.concerns.about.such.disclosure.please.discuss.this.with.the.course.instructor¡.

ONLINE.PROCTORING.

Some.courses.may.use.online.proctoring.software.for.tests.and.exams¡.This.software.may.require. students.to.turn.on.their.video.camera?present.identification?monitor.and.record.their.computer. activities?and–or.lock–restrict.their.browser.or.other.applications–software.during.tests.or.exams¡.This. software.may.be.required.to.be.installed.before.the.test–exam.begins¡.

CONDUCT.EXPECTATIONS.

As.a.McMaster.student?you.have.the.right.to.experience?and.the.responsibility.to.demonstrate? respectful.and.dignified.interactions.within.all.of.our.living?learning.and.working.communities¡.These. expectations.are.described.in.the.Code.of.Student.Rights.™.Responsibilities.(the»Code‹)¡.All.students. share.the.responsibility.of.maintaining.a.positive.environment.for.the.academic.and.personal.growth.of. all.McMaster.community.members?whether.in.person.or.online¡.

It.is.essential.that.students.be.mindful.of.their.interactions.online?as.the.Code.remains.in.effect.in. virtual.learning.environments¡.The.Code.applies.to.any.interactions.that.adversely.affect?disrupt?or. interfere.with.reasonable.participation.in.University.activities¡.Student.disruptions.or.behaviours.that. interfere.with.university.functions.on.online.platforms.(e¡g¡.use.of.Avenue.8.Learn?WebEx.or.Zoom.for.

delivery)?will.be.taken.very.seriously.and.will.be.investigated¡.Outcomes.may.include.restriction.or.removal.of.the.involved.students".access.to.these.platforms¡.

EQUITY?DIVERSITY?AND.INCLUSION

Every.registered.student.belongs.in.this.course¡.Diversity.of.backgrounds.and.experiences.is.expected.and.welcome¡.You.can.expect.your.Instructor.to.be.respectful.of.this.diversity.in.all.aspects.of.the.course?and.the.same.is.expected.of.you¡

The.Department.of.Mechanical.Engineering.is.committed.to.creating.an.environment.in.which.students.of.all.genders?cultures?ethnicities?races?sexual.orientations?abilities?and.socioeconomic.backgrounds.have.equal.access.to.education.and.are.welcomed.and.treated.fairly¡.If.you.have.any.concerns.regarding.inclusion.in.our.Department?in.particular.if.you.or.one.of.your.peers.is.experiencing.harassment.or.discrimination?you.are.encouraged.to.contact.the.Chair?Associate.Undergraduate.Chair?Academic.Advisor.or.to.contact.the.Equity.and.Inclusion.Office.¡

ACADEMIC.ACCOMMODATION.OF.STUDENTS.WITH.DISABILITIES.

Students.with.disabilities.who.require.academic.accommodation.must.contact.Student.Accessibility.Services.(SAS).at.905_525_9140.ext¡.24028.or.sas® mcmaster¡ca.to.make.arrangements.with.a.Program.Coordinator¡.For.further.information?consult.McMaster.University's.Academic.Accommodation.of.Students.with.Disabilities.policy¡.

REQUESTS.FOR.RELIEF.FOR.MISSED.ACADEMIC.TERM.WORK.

McMaster.Student.Absence.Form.(MSAF)¿In.the.event.of.an.absence.for.medical.or.other.reasons?students.should.review.and.follow.the.Academic.Regulation.in.the.Undergraduate.Calendar»Requests.for.Relief.for.Missed.Academic.Term.Work‹¡.

ACADEMIC.ACCOMMODATION.FOR.RELIGIOUS?INDIGENOUS.OR.SPIRITUAL.OBSERVANCES.(RISO).

Students.requiring.academic.accommodation.based.on.religious?indigenous.or.spiritual.observances.should.follow.the.procedures.set.out.in.the.RISO.policy¡.Students.should.submit.their.request.to.their.Faculty.Office.normally.within.76.working.days.of.the.beginning.of.term.in.which.they.anticipate.a.need.for.accommodation.or.to.the.Registrar¾s.Office.prior.to.their.examinations¡.Students.should.also.contact.their.instructors.as.soon.as.possible.to.make.alternative.arrangements.for.classes?assignments?and.tests¡.

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The.recording.of.lectures?.tutorials?.or.other.methods.of.instruction.may.occur.during.a.course¡.Recording.may.be.done.by.either.the.instructor.for.the.purpose.of.authorized.distribution?.or.by.a.student.for.the.purpose.of.personal.study¡.Students.should.be.aware.that.their.voice.and.~~or~~.image.may.be.recorded.by.others.during.the.class¡.Please.speak.with.the.instructor.if.this.is.a.concern.for.you¡.

EXTREME.CIRCUMSTANCES.

The.University.reserves.the.right.to.change.the.dates.and.deadlines.for.any.or.all.courses.in.extreme.circumstances.(e¡g¡?.severe.weather?.labour.disruptions?.etc¡)¡.Changes.will.be.communicated.through.regular.McMaster.communication.channels?.such.as.McMaster.Daily.News?.A8L.and.~~or~~.McMaster.email¡