ENGG*3370 Applied Fluids and Thermodynamics

01

Winter 2021
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 08, 2021

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1 Course Details

1.1 Calendar Description

This course builds on the fundamentals of fluid dynamics and thermodynamics introduced in previous courses by looking at relevant applications. Topics to be covered include: heating, ventilation and air conditioning (HVAC); heat engine systems such as the Carnot cycle for refrigeration and heat pumps and the Rankine cycle for vapour power systems; compressible flow, turbomachinery such as pumps, turbines, and propellers; and an introduction to combustion.

Pre-Requisites:	ENGG*2230, ENGG*3260
Restrictions:	This is a Priority Access Course. Enrolment may be restricted to the MECH specialization in the BENG and BENG:C programs. See department for more information.

1.2 Course Description

The fundamental knowledge obtained in the introductory Thermodynamics and Fluid Mechanics courses will be utilized to study and design the applied thermofluid systems. For example, power plant, refrigerator, heat pump, gas turbine, compressor, air-conditioning system, hydraulic pump, and hydraulic turbine, internal combustion engine, and jet engine.

1.3 Timetable

Lectures

Tuesday, Thursday
01:00pm–2:20pm (Virtual)

Tutorials (Week 1 to Week 12)

Wednesday Sec 01 12:30PM - 02:20PM (Virtual)
Wednesday Sec 02 08:30AM - 10:20AM (Virtual)
Thursday Sec 03 08:30AM - 10:20AM (Virtual)

Laboratory (Week 1 to Week 12)

Wednesday Sec 01 12:30PM - 02:20PM (Virtual)
Wednesday Sec 02 08:30AM - 10:20AM (Virtual)
Thursday Sec 03 08:30AM - 10:20AM (Virtual)

1.4 Final Exam

Final Exam:
Date: Saturday, 24th April, 2021
Time: 4:00pm to 6:30pm
Location: Virtual

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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Shohel Mahmud Ph.D., PEng
Email:	smahmud@uoguelph.ca
Telephone:	+1-519-824-4120 x54058
Office:	RICH 3519
Office Hours:	TBA on Courselink or by appointment
Lab Technician:	Michael Speagle
Email:	mspeagle@uoguelph.ca
Telephone:	+1-519-824-4120 x56803
Office:	RICH 1102

2.2 Teaching Assistants

Teaching Assistant:	Mohammadreza Mohaghegh
Email:	mohaghem@uoguelph.ca
Office Hours:	Office Hours: TBA Link for Virtual Communication: https://uoguelph.webex.com/meet/mohaghem
Teaching Assistant:	Bassel Abdelkader
Email:	babdelka@uoguelph.ca
Office Hours:	Office Hours: TBA Link for Virtual

Communication: https://uoguelph.webex.com/meet/babdelka

Teaching Assistant:	Arthur Rosenfield
Email:	arosenfi@uoguelph.ca
Office Hours:	Office Hours: TBA Link for Virtual Communication: https://teams.microsoft.com/l/meetup-join/19%3ameeting_NjI2NmM2YzgtZGU4MS00ZDY0LTlhZDktYTQ5YzA5MzC 2cad-49a1-a5fa- 85f4f3156a7d%22%2c%22Oid%22%3a%22879587ba-f4a2- 48cb-ac3b-0c541ab0b787%22%7d

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3 Learning Resources

3.1 Required Resources

Course Website (Website)
Course material, news, announcements, and grades will be regularly posted to the ENGG*3370 Courselink site. You are responsible for checking the site regularly.

Thermodynamic Property Table (Other)
Y. Cengel and M. Boles

3.2 Recommended Resources

Thermodynamics: An Engineering Approach, 9th Ed. (Textbook)
Y. Cengel and M. Boles, McGraw-Hill, 2018.

Thermodynamics: An Engineering Approach (Textbook)
Y. Cengel and M. Boles, 8^{th} Ed., McGraw-Hill, 2014.

Fluid Mechanics (Textbook)
F.M. White, 8^{th} Ed., McGraw-Hill, 2015.

Refrigeration and Air Conditioning (Textbook)
C.P. Arora, 3^{rd} Ed., McGraw-Hill, 2008.

ASHRAE Handbook – Fundamentals (Other)
(Chapters 17 and 21), American Society of Heating Refrigerating and Air-Conditioning Engineers, 2009.

3.3 Additional Resources

Lecture Information: A summary of the lecture notes will be posted on the courselink.

Lab Information: The lab manuals and lab schedule will be posted on the courselink. You are responsible for printing the lab manuals and having them with you during the laboratory sessions.

Home Assignments: There will be approximately 8 problem sets posted in Courselink during the term. These problem sets will not be marked, but it is recommended that you do each problem set, as practice problems are the best way to learn the course. All the solutions will be posted.

Miscellaneous Information: Other information related to Applied Fluids and Thermodynamics will be posted on the web page.

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4 Learning Outcomes

4.1 Course Learning Outcomes

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

1. Analyze different types of thermodynamic cycles
2. Apply thermodynamic cycles to practical devices
3. Evaluate the performance of ideal and real thermodynamic cycles
4. Differentiate between power generating and power consuming devices
5. Understand the properties of moist air and use the psychrometric chart as a tool to determine the properties of atmospheric air
6. Apply the principles of the conservation of mass and energy to various air-conditioning processes
7. Determine the cooling/heating load for rooms and buildings
8. Apply the conservation of mass to reacting systems to determine balanced reaction equations
9. Calculate the enthalpy of reaction, enthalpy of combustion, and the heating values of fuels
10. Develop the general relations for compressible flows encountered when gases flow at high speeds
11. Develop exergy balance equation and apply it for different thermofluid systems
12. Analyze different types of turbomachines and develop their performance parameters
13. Select an appropriate class of turbomachines for particular applications
14. Conduct Applied Fluids and Thermodynamic laboratory tests through collecting and analyzing data using the appropriate sensors and instruments and write clear, concise and professional laboratory reports

15. Demonstrate effective skills in teamwork during group activities; demonstrate respectful interactions with peers, lab technician, teaching assistants, and instructor, self assessment

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 3, 5, 9
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 3, 5, 9
2	Problem Analysis	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
2.4	Execute an engineering solution	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
2.5	Critique and appraise solution approach and results	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
3	Investigation	14
3.3	Analyze and interpret experimental data	14
5	Use of Engineering Tools	14, 15
5.3	Recognize limitations of selected engineering tools	14, 15
7	Communication Skills	14, 15
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	14, 15
10	Ethics & Equity	14, 15
10.3	Demonstrate values consistent with good ethical practice, including equity, diversity, and inclusivity	14, 15

5 Teaching and Learning Activities

5.1 Lecture

Topics: Review of Thermodynamics

Learning Outcome: 1, 2, 3, 4

Topics: Vapor and combined power cycles
Learning Outcome: 1, 2, 3, 4
[1]Chapter 10

Learning Objectives 1-4

Topics: Refrigeration cycles and special refrigeration systems
Learning Outcome: 1, 2, 3, 4
[1]Chapter 11

Learning Objectives 1-4

Topics: Introduction to Turbomachinery
Learning Outcome: 12
[2]Chapter 11

Learning Objective 12

Topics: Hydraulic turbines
Learning Outcome: 12, 13
[2]Chapter 11

Learning Objectives 12-13

Topics: Hydraulic pumps
Learning Outcome: 12, 13
[2]Chapter 11

Learning Objectives 12-13

Topics: Thermodynamics of gas-vapor mixture
Learning Outcome: 1, 2, 5, 6
[1]Chapter 14

Learning Objectives 1-2, 5-6

Topics: Introduction to air-conditioning
Learning Outcome: 2, 5, 6, 7
[1]Chapter 14

Learning Objectives 2, 5-7

Topics: Introduction to combustion

Learning Outcome: 8, 9
[1]Chapter 15

Learning Objective 8-9

Topics: Gas power and propulsion cycles
Learning Outcome: 1, 2, 3, 4
[1]Chapter 09

Learning Objectives 1-4

Topics: Introduction to compressible flow
Learning Outcome: 10
[1]Chapter 17, [2]Chapter 09

Learning Objective 10

Topics: Exergy - A measure of work potential
Learning Outcome: 4, 11
[1]Chapter 08

Learning Objective 4, 11

Topics: Review

5.2 Lab

Topics:

1 Refrigeration and Heat Pump cycles

Equipment: Heat pump setup

2 Special refrigeration systems (a) thermoelectric refrigerator and (b) vortex tube coolers

Equipment: thermoelectric refrigerator and vortex tube cooler

3 Impulse Turbine

Equipment: Pelton Wheel Turbine

4 Reaction Turbine

Equipment: Francis Turbine

5 Rotadynamic Pump

Equipment: Centrifugal pump setup

6 Positive Displacement Pump

Equipment: Reciprocating pump setup

7 Steam power plant

Equipment: Mini steam power plant

8 Air-conditioning systems

Equipment: Complete HVAC setup

9 Window air-conditioner

Equipment: Window type air-conditioning unit

10 Heating values of a solid fuel and a liquid fuel

Equipment: Bomb calorimeter

11 Exergy analysis of a body loosing heat

Equipment: Transient cooling of hot water experimental setup

12 Demonstration of Stirling Engine

Equipment: low ΔT Stirling engine, medium ΔT Stirling engine, and high ΔT Stirling engine in Sustainable Energy Lab)

Learning Outcome: 14, 15

5.3 References

[1] Y. Cengel and M. Boles, Thermodynamics: An Engineering Approach, 8th Ed., McGraw-Hill, 2014.

[1] Y. Cengel and M. Boles, Thermodynamics: An Engineering Approach, 9th Ed., McGraw-Hill, 2018.

[2] F.M. White, Fluid Mechanics, 7th Ed., McGraw-Hill, 2011.

[3] C.P. Arora, Refrigeration and Air Conditioning, 3rd Ed., McGraw-Hill, 2008.

[4] ASHRAE Handbook – Fundamentals (Ch.17 & Ch.21), American Soc. Heating Refrigerating and Air-Conditioning Engineers

5.4 Other Important Dates

Monday, 11th January, 2021: Winter 2021 Semester Starts
Tuesday, 13th January, 2021: First lecture of Applied Fluids and Thermodynamics
Monday, 15th February to Friday, 19th February, 2021: Winter Break
Thursday, 8th April, 2021: ENGG*3370 Class concludes
Thursday, 15th April, 2021: Examinations commence
For other Important Dates please check the following link:https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c03/c03-wintersem.shtml

5.5 Tutorial and Cooperative Learning Exercises

Tutorial, Quiz, and Thermofluid System Demonstration: Usually, **THRN 3402** and **THRN 3404** (Sustainable Energy Lab) are booked for **weekly tutorial, thermofluid system demonstration, and lab experiment**. However, due to the Covid-19 restrictions, all of these activities will be virtual. Each tutorial and lab hour is 1 hour 50 minutes combined. Your TA will solve and discuss a maximum of 2 problems in the first half of the tutorial (approximately 50 minutes, but it may vary depending on the topic(s) covered in the lecture for a particular week – from **Week 1 to Week 7 and Week 10 to Week 12)**. TA will also answer your question regarding the "Problem Set" available in the course website. You are going to solve one or two problems in the next half of the tutorial (approximately 50 minutes, but it may vary depending on the chapter covered in the lecture for a particular week – from Week 1 to Week 7 and Week 10 to Week 12) as a part of the tutorial quiz. At the end of each tutorial you must submit your solution to your TA for marking. You are heavily encouraged to attend the tutorial regularly. **In addition** to the problem solving and tutorial, your TA and Lab Technician will **demonstrate**, time to time, different types of thermofluid systems (e.g., pumps, turbines, refrigerators, engines, and so on) during this tutorial hour.

5.6 Lab Experiments

Lab Experiments: The purpose of performing the Lab is to verify some of the theoretical learning in our class by experiments. Applied Fluids and Thermodynamics Lab is located inside the "Sustainable Energy Lab (THRN 3402 and THRN 3404)". Lab experiments will be executed **from Week 8 to Week 9 (and may be extended to Week 10 in case if it is required)**. However, due to the Covid-19 restrictions, all the lab experiments will be virtual. There will be no problem solving during these weeks. 'Lab Manual' and schedule will be available in the COURSE LINK. Students must submit a lab report (details on the lab report will be available in the COURSE LINK). Individual Lab Report is due one week after the last lab experiment is conducted. Please submit a softcopy (PDF only) in the dropbox.

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Assignments	0
Cooperative Learning Exercises in Tutorial	5
Labs	15
Midterm Exam	25
Final Exam	55
Total	100

6.2 Assessment Details

Assignments (0%)
Approximately 8 Problem Sets (0% Mark Assigned)

Cooperative Learning Exercises in Tutorial (5%)
Learning Outcome: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Each tutorial is divided into two parts. In the first part, your GTA will solve and discuss some problems. In the second part of your tutorial you will be asked to solve one or two problems. You need to make a group of two students (including yourself) for solving the problem in the second part of the tutorial. At the end of each tutorial you must submit your solution to your GTA for marking. A total 5% mark is allocated for such problem solving activities. **You are heavily encouraged to attend your Registered Section of tutorial regularly.**

Tutorial Exercise Schedule:

Week 1- Problem Solving Activity 1

Week 2- Problem Solving Activity 2

Week 3- Problem Solving Activity 3

Week 4- Problem Solving Activity 4

Week 5- Problem Solving Activity 5

Week 6- Problem Solving Activity 6

Week 7- Problem Solving Activity 7

Week 10- Problem Solving Activity 8

Week 11- Problem Solving Activity 9

Week 12- Problem Solving Activity 10

Labs (15%)

Learning Outcome: 1, 3, 5, 9, 14

The purpose of performing the Applied Fluids and Thermodynamics Lab is to verify a portion of the theoretical learning in your lectures by conducting experiments. Applied Fluids and Thermodynamics Lab is located inside the "**Sustainable Energy Lab (THRN 3402**)". However, all the lab experiments will be virtual due to the Covid-19 restrictions. The detailed schedule will be posted on your courselink. Experiments are designed to cover most of the basic aspects of Applied Fluids and Thermodynamics. The 'Lab Manual' will be available in courselink. **A total 15% mark is allocated for performing all lab components**

Midterm Exam (25%)

Learning Outcome: 1, 2, 3, 4, 12, 13

Midterm Exam (25%): Midterm Exam

Date:Saturday, 27th February, 2021

Time: 7:00PM to 09:00PM

Location: Virtual

Final Exam (55%)

Learning Outcome: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

Final Exam (55**%**)

Date: Saturday, 24th April, 2021
Time: 4:00pm to 6:30pm
Location: Virtual

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7 Course Statements

7.1 Communication & Email Policy

Please use lectures and lab help sessions as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. **It is your responsibility to check the course website regularly**.

7.2 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Missed Midterm Exam: If you miss your midterm due to grounds for granting academic consideration or religious accommodation, the weight of the missed midterm will be added to the final exam. **There will be no makeup midterm tests.**

Lab Work: **You must attend and complete all laboratories in order to pass this course**. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup lab.

Late Lab Reports: Late submissions of lab reports will not be accepted.

Passing Grades: The passing grade of this course is 50% and every student must obtain a grade of 50% or higher in the Final Exam portion of the course in order for the midterm exam, laboratory write-up, and Quizzes portion of the course to count towards the final grade.

7.3 Relationships with other Courses & Labs

Previous Courses:

ENGG*2230: Steady and unsteady state; 1st law and Bernoulli equation; fluid flow rate and friction; laminar and turbulent flows; non-dimensional parameters (e.g., Reynolds number)
ENGG*2400: Modeling of engineering systems
MATH*2270: Solving differential equations
ENGG*3260: System and control volume; work and heat and their interaction with the boundary and direction; energy efficiency and effectiveness of systems; thermodynamic losses;

Follow-on Courses:

ENGG*3430: Foundation for application of heat transfer in various types of systems
ENGG*3470: Foundations of energy balances, thermal flow, thermal properties; Mass transfer through fluid flows (convection), thermal fluid properties
ENGG*3830: Foundations of heat and mass balance and bioreactor design
ENGG*4230: Foundations for design of energy conversion processes

ENGG*4300: Foundations for design of food engineering process
ENGG*4330: Foundation for performance analysis of combustion systems

7.4 Lab Safety Specific for ENGG*3370

- You must read and follow safety rules posted on the door of the Sustainable Energy Lab (THRN3402).
- You must read the experiment manuals carefully. You will find additional safety requirement related to specific experiments in the manuals. Follow them accordingly.
- Always wear safety glasses during lab time.
- Your lab technician and teaching assistants will deliver a short lecture on lab safety during the first lab session.

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 book their exams at least 7 days in advance and not later than the 40th Class Day.

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 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings and academic schedules. Any such changes will be announced via CourseLink and/or class email. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

9.10 Illness

The University will not normally require verification of illness (doctor's notes) for fall 2020 or winter 2021 semester courses. However, requests for Academic Consideration may still require medical documentation as appropriate.
