



Faculty of Engineering and Applied Science

# CHEE 224 – TRANSPORT PHENOMENA FUNDAMENTALS

## Course Syllabus – Fall 2021

This is your course syllabus. Please download the file and keep it for future reference.

### LAND ACKNOWLEDGEMENT

Queen's University is situated on traditional Anishinaabe and Haudenosaunee Territory.  
See: <http://www.queensu.ca/encyclopedia/t/traditional-territories>

### INCLUSIVITY STATEMENT

Queen's students, faculty, and staff come from every imaginable background – small towns and suburbs, urban high rises, Indigenous communities, and from more than 100 countries around the world. You belong here: <https://www.queensu.ca/inclusive/>.

## TEACHING TEAM

### COURSE INSTRUCTOR

#### Carlos Escobedo, PhD

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Queen's University  
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### TEACHING ASSISTANT

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### TEACHING ASSISTANT

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# CHEE 224 (F 2–0–1 3)

## COURSE DESCRIPTION<sup>1</sup>

The theory and mathematical framework of transport phenomena are introduced. Mass, energy and momentum balances are developed using the integral and differential methods of analysis. The tools used to formulate and solve the problems include representation of physical entities in vector form, multivariable functions and vector operations in 2D and 3D. Specific topics of Chemical Engineering interest include moments of a force, work done by a force, moments of inertia, control surfaces and control volumes and fluid kinematics (21/0/0/21/0).

This course develops the following attributes at the 2<sup>nd</sup> year level:

**Knowledge Base (KB): Mathematics** Demonstrate competence in university-level mathematics.

**Knowledge base, Engineering Science (KB-ES): Applied Math (a)** Selects and applies appropriate mathematical tools to solve problems that arise from modeling a real-world problem. **KB-TrPh(a)** Formulates and applies integral mass, momentum and energy balances to do engineering calculations. **KB-TrPh(b)** Formulates and applies differential mass, momentum and energy balances to do engineering calculations.

**Problem Analysis (PA): PA-Formulate** Develop appropriate frameworks for solving complex engineering problems. **PA-Solve** Implement solutions for complex engineering problems.

## Relevance to the Program

The course introduces fundamental concepts that will be useful for the suite of courses known as “transport courses” (CHEE 223 – Fluid Mechanics, CHEE 330 – Heat and Mass Transfer, CHEE 412- Transport Phenomena in Chemical Engineering), which deal with the transport properties of matter. It lays the mathematical background and deepens student confidence in mathematical techniques and problem solving, needed throughout the curriculum. The course assumes working knowledge of 1<sup>st</sup> year mechanics and calculus.

Refer to Solus or OnQ for times and locations.

## Resources

Custom courseware. Pearson – eText “Transport Phenomena Fundamentals”:  
<https://console.pearsoned.com/enrollment/68yqxa>

All course lecture slides, assignments and tutorials will be posted on the OnQ site. If you are registered for the course, you can access this information by logging in at <https://courses.engineering.queensu.ca/>

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<sup>1</sup> Course Author(s): Carlos Escobedo. 1st Edition (initial development): Fall term, 2021; Queen's University holds a license for the use of the Course Author's Intellectual Property for CHEE 224.

## COURSE EVALUATION

The course emphasizes in-class learning activities during the term, in tutorial sessions. Assessment will be based on assignments submitted throughout the term and tutorial activities, quizzes and a final exam.

All assessments in this course will receive numerical percentage marks. The final grade for the course will be derived by converting a numerical course average to a letter grade according to the established [Grade Point Index](#).

Students must pass the individual examination component to pass the course, as stated in Departmental Policy. Attendance at exams is mandatory. Stipulations of the departmental policy on missing exams can be found in the following website: <http://www.chemeng.queensu.ca/undergraduate-studies/Departmental-Undergraduate-Policies.html>.

## ASSESSMENT WEIGHTING

Assessment Tool	Due Date (before 23:59 ET)	Weight	Alignment with CLOs
<b>Midterm Exams</b>		<b>60% total</b>	
Midterm Exam 1	Week 6	30%	CLO1, CLO2, CLO3
Midterm Exam 2	Week 11	30%	CLO3, CLO4, CLO5
<b>Assignments</b>		<b>40% total</b>	
Assignment 1	Week 3	10%	CLO1
Assignment 2	Week 5	10%	CLO2
Assignment 3	Week 7	10%	CLO3
Assignment 4	Week 9	10%	CLO4, CLO5

## ASSESSMENT DESCRIPTIONS

### Assignments

There are four assignments to be solved individually in this course. Each assignment will require you to solve a problem set with questions of different levels of complexity. Submissions must be handed in through the LMS. Assignment solutions and reports may be hand-written (pen or pencil), or typed, but must be complete and fully support the answers.

Students are expected to complete their work on time. Submissions after the due date will not be accepted without prior arrangement and may be penalized at up to 20% per day (24-hour period following due date/time) unless a suitable justification is provided.

### Midterm Exams

There are two midterm exams in this course. The exams are closed book. Students must write their exam on the day and time scheduled by the instructor. You should not schedule vacations, travel, etc. during the exam period.

### GRADING

All assessments in this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to the established [Grade Point Index](#).

### Feedback on Assessments

The teaching team will provide feedback on graded activities. You can expect feedback on your assessments within seven days of the due date.

### Accessing Your Final Grade

Your final grades will show on SOLUS. Official transcripts showing final grades will be available on the Official Grade Release Date. Please note that in official transcripts, a mark of IN (incomplete) is considered a grade, and your transcript is released with this grade.

### COURSE MATERIALS

#### Required Textbook

Transport Phenomena Fundamentals, Custom Edition for Queen's University, Pearson-ISBN 9781269829434.

#### Other Material

All course lecture slides, assignments and tutorials will be posted on the LMS site. If you are registered for the course, you can access this information by logging in at <https://onq.queensu.ca/d2l/home>.

#### Required Calculator

A Casio 991 is required. **ONLY** this type of non-programmable, non-communicating calculator will be allowed during tests and exams.

#### Suggested Time Commitment

This course represents a study period of one semester spanning 12 weeks. Learners can expect to invest on average 7-9 hours per week in this course. Learners who adhere to a pre-determined study schedule are more likely to successfully complete the course.

## WEEKLY COURSE OUTCOMES

Week	Learning Outcomes	Activity; Assessment; CLO
1, 2	<p><b>Transport Phenomena Fundamentals</b></p> <p>By the end of this week, learners will be able to:</p> <ul style="list-style-type: none"> <li>• Find unknown and resultant forces in 2D and 3D</li> <li>• Calculate the moment of a force</li> <li>• Replace a system of forces by an equivalent single force or force-moment acting in a body</li> <li>• Calculate the resultant moment from a system of moments acting on a body</li> </ul>	<p>Tutorial 1, Assignment 1; Midterm Exam 1 [CLO1]</p>
3	<p><b>Transport Phenomena Fundamentals</b></p> <p>By the end of this week, learners will be able to:</p> <ul style="list-style-type: none"> <li>• Calculate the work done by a force or system of forces acting on a rigid body</li> <li>• Analyze the displacement of a particle and calculate its velocity and acceleration as vectors in space</li> </ul>	<p>Tutorial 2, Assignment 1; Midterm Exam 1 [CLO1]</p>
4	<p><b>Hydrostatic Forces on Surfaces</b></p> <p>By the end of this week, learners will be able to:</p> <ul style="list-style-type: none"> <li>• Calculate Surfaces and Volumes using integrals</li> <li>• Calculate the location of the centroid, the centre of mass and the centre of gravity of 1D, 2D and 3D bodies</li> <li>• Calculate the moment of Inertia of 2D and 3D bodies</li> </ul>	<p>Tutorials 3 and 4, Assignment 2; Midterm Exam 1 [CLO2]</p>
5, 6	<p><b>Multivariable Transport Functions</b></p> <p>By the end of this week, learners will be able to:</p> <ul style="list-style-type: none"> <li>• Derive heat and momentum transport equations using partial derivatives</li> <li>• Define and work with multivariable functions</li> <li>• Define and work with differentials and the chain rule for multivariable functions</li> <li>• Define and work with directional derivatives</li> </ul>	<p>Tutorials 5 and 6, Assignment 3; Midterm Exam 1 [CLO3]</p>

Week	Learning Outcomes	Activity; Assessment; CLO
7, 8, 9	<p><b>Fluid Kinematics</b></p> <p>By the end of this week, learners will be able to:</p> <ul style="list-style-type: none"> <li>Define and calculate streamlines, streaklines and pathlines</li> <li>Define the Reynolds transport theorem</li> <li>Define and work with volumetric and mass flows</li> <li>Define and apply the conservation of mass in problems involving fluids in motion</li> </ul>	Tutorials 7 and 8, Assignment 4; Midterm Exam 2 [CLO4]
10, 11	<p><b>Differential Analysis of Fluid Flows</b></p> <p>By the end of this week, learners will be able to:</p> <ul style="list-style-type: none"> <li>Define and calculate the linear and angular motion of fluids</li> <li>Obtain the differential form of the continuity equation (Cartesian and polar forms)</li> <li>Define stream functions</li> <li>Define potential functions</li> </ul>	Tutorials 9 and 10, Assignment 4; Midterm Exam 2 [CLO5]

## COURSE COMMUNICATION

### NETIQUETTE

In this course, you may be expected to communicate with your peers and the teaching team through electronic communication. You are expected to use the utmost respect in your dealings with your colleagues or when participating in activities, discussions, and online communication.

Following is a list of netiquette guidelines. Please read them carefully and use them to guide your online communication in this course and beyond.

1. Make a personal commitment to learn about, understand, and support your peers.
2. Assume the best of others and expect the best of them.
3. Acknowledge the impact of oppression on the lives of other people and make sure your writing is respectful and inclusive.
4. Recognize and value the experiences, abilities, and knowledge each person brings.
5. Pay close attention to what your peers write before you respond. Think through and re-read your writings before you post or send them to others.
6. It's alright to disagree with ideas, but do not make personal attacks.
7. Be open to be challenged or confronted on your ideas and challenge others with the intent of facilitating growth. Do not demean or embarrass others.
8. Encourage others to develop and share their ideas.

## QUESTIONS ABOUT COURSE MATERIAL

Questions or comments regarding the course material that can be of benefit to other students should be posted in the Q&A forum on the class website or during the tutorials. The instructor, TAs, and students are encouraged to answer these questions directly in the discussion forum or tutorials for the benefit of everyone in the course.

## COURSE ANNOUNCEMENTS

The instructor will routinely post course news using the Announcements feature on OnQ. Please sign up to be automatically notified by email when the instructor posts new information in the Announcements section. Instructions on how to modify your notifications are found in the **Begin Here** section of the onQ course site.

## OFFICE HOURS

In addition to interaction in the Q&A discussion forums, you will have the opportunity to interact with either a TA or the instructor through office hours. The instructor will provide a schedule of availability at the beginning of the term.

## CONFIDENTIAL MATTERS

If you have a confidential matter you would like to discuss with your instructor, their contact details are on the first page of this document. Expect email replies within 48 hours.

# STANDARD FEAS INFORMATION

## COURSE POLICIES

Please review the following policies concerning copyright, academic integrity, absences and academic accommodations:

### COPYRIGHT

Course materials created by the course instructor, including all slides, presentations, synchronous and asynchronous course recordings, handouts, tests, exams, and other similar course materials, are the intellectual property of the instructor. It is a departure from academic integrity to distribute, publicly post, sell or otherwise disseminate an instructor's course materials or to provide an instructor's course materials to anyone else for distribution, posting, sale or other means of dissemination, without the instructor's **express consent**. A student who engages in such conduct may be subject to penalty for a departure from academic integrity and may also face adverse legal consequences for infringement of intellectual property rights and, with respect to recordings, potentially privacy violations of other students.

### ACADEMIC INTEGRITY

As an engineering student, you have made a decision to join us in the profession of engineering, a long-respected profession with high standards of behaviour. As future engineers, we expect you to behave with integrity at all times. Please note that Engineers have a duty to:

- Act at all times with devotion to the high ideals of personal honour and professional integrity.
- Give proper credit for engineering work

The standard of behaviour expected of professional engineers is explained in the [Professional Engineers Ontario Code of Ethics](#). Information on policies concerning academic integrity is available in the [Queen's University Code of Conduct](#), in the [Senate Academic Integrity Policy Statement](#), on the [Faculty of Engineering and Applied Science website](#), and from your instructor.

Departures from academic integrity include plagiarism, use of unauthorized materials or services, facilitation, forgery, falsification, unauthorized use of intellectual property, and collaboration, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the University.

In the case of online or remotely proctored exams, impersonating another student, copying from another student, making information available to another student about the exam questions or possible answers, posting materials to online services, communicating with another person during an exam or about an exam during the exam window, or accessing unauthorized materials, including internet sources and using unauthorized materials, including smart devices, are actions in contravention of academic integrity.

### **LATE POLICY**

Any applicable late penalties are described in the details for each assessment. In the event of extenuating circumstances, you must follow the policies for requesting an academic consideration (please see below). Note that unacceptable reasons include extra-curricular activities, travel plans, generally behind on schoolwork, etc. In the absence of an approved consideration request, the normal late penalty will apply as described in the assignment or any course/departamental policies.

### **INVALID EXAMS**

An exam may be declared invalid in case of an interruption in an in-person examination; if the instructions in a remote or online exam were not followed; if the student uploads wrong materials; or if a situation arises where the integrity of the exam cannot be verified. If an exam is declared invalid, the student may be granted a re-write.

### **ABSENCES (ACADEMIC CONSIDERATIONS) AND ACADEMIC ACCOMMODATIONS**

For absences and academic accommodations please review the information on the [FEAS website](#).

## **ACADEMIC AND STUDENT SUPPORT**

Queen's has a robust set of supports available to you including the [Library](#), [Student Academic Success Services \(Learning Strategies and Writing Centre\)](#), and [Career Services](#). Learners are encouraged to visit the Faculty of Engineering and Applied Science [Current Students](#) web portal for information about various other policies such as academic advisors, registration, student exchanges, awards and scholarships, etc.



## INDIVIDUAL NEEDS AND SUPPORT

If you have a disability or health-related condition that may require academic accommodations, please approach the [Queen's Accessibility Services](#). The staff at Accessibility Services are available by appointment to develop individualized accommodation plans, provide referrals, and assist with advocacy. The sooner you let us know your needs, the better we can assist you in achieving your learning goals. For questions or assistance with requesting Academic Consideration or Accommodation, contact the FEAS Academic Accommodation Coordinator at [engineering.aac@queensu.ca](mailto:engineering.aac@queensu.ca)

Every effort has been made to provide course materials that are accessible. For further information on accessibility compliance of the educational technologies used in this course, please consult the links below.

EDUCATIONAL TECHNOLOGY	ACCESSIBILITY COMPLIANCE INFORMATION
onQ (Brightspace Learning Management System by D2L)	<a href="https://www.d2l.com/accessibility/standards/">https://www.d2l.com/accessibility/standards/</a>
MS-Teams	<a href="https://support.microsoft.com/en-us/office/accessibility-support-for-microsoft-teams-d12ee53f-d15f-445e-be8d-f0ba2c5ee68f">https://support.microsoft.com/en-us/office/accessibility-support-for-microsoft-teams-d12ee53f-d15f-445e-be8d-f0ba2c5ee68f</a>
Zoom	<a href="https://zoom.us/accessibility">https://zoom.us/accessibility</a>

If you find any element of this course difficult to access, please discuss with your instructor how you can obtain an accommodation.

## RELIGIOUS OBSERVANCE

Students in need of accommodation for religious observance are asked to speak to their professor within a week of receiving their syllabus. Note also that alternative assignments are considered a "reasonable accommodation" under the Ontario Human Rights Code. Students with questions about their rights and responsibilities regarding religious accommodation should contact the Chaplain via [Chaplain@queensu.ca](mailto:Chaplain@queensu.ca).

## TECHNICAL SUPPORT

Some basic comfort level with basic hardware and software skills are required for this course. If you require technical assistance, please contact [Technical Support](#).

## SUPPORTIVE PERSONAL COUNSELLING

If at any time you find yourself feeling overwhelmed, anxious, sad, lonely, or distressed, consider confidential supportive counselling offered by the [embedded counselors](#) at the Student Wellness Service Faculty of Engineering and Applied Science.