PHY454H1: Continuum Mechanics

Lecturer: Nicolas Grisouard, MP703, nicolas.grisouard@physics.utoronto.ca
I will try to reply to emails within 48 hours (week-ends and holidays excluded) and I may address it in a tutorial session (not without asking for permission from the person who emailed in the first place).
I also have a research webpage: https://sites.physics.utoronto.ca/nicolasgrisouard

Marker: Brendan Byrne, bbyrne@physics.utoronto.ca

Class Website available through Blackboard.
I will use it a great deal and you are responsible for checking it regularly, as well as your email address that is attached to it. Note that smartphone or tablet apps can automatically keep you up-to-date on the content of the portal.

Lecture times: MW 11-12 am in MP134. Note that I will be absent for the 12 and 14 February lectures. Prof. Stephen Morris will substitute for me for these two lectures.

Tutorials: Thursdays 11-12 am in MP134. Note that I will be absent for the 15 February tutorial. The tutorial session that week will be canceled, but I will distribute a question set along with its solution.

The previous years, I was able to move those sessions to a smaller room in the Burton tower. Too many of you are signed up this year, and I cannot presently offer this option. However, if some of you decide to drop the course, we might move it again to a cozier place.

In the absence of questions from you, we will usually go through classic exercises and textbook examples in the form of tutorials, but I reserve the right to use this hour for other purposes (mid-term, etc.) or to simply cancel them (in which case I would warn you via email or BB). Office hours can also be held at other times on a case-by-case basis. Request via email to know if possible.

Office hours: M2-3, R10-11 in my office (MP703), and by request if necessary.

Marking Scheme:	Final exam (April exam period)	35%
	Mid-term exam (late Feb. or early March)	15%
	Three (3) problem sets	45% (15% each)
	Participation	5%

The problem sets will be posted on Blackboard every three to four weeks, and will be collected in class three to four weeks after. **Late policy:** Your mark will be multiplied by 0.7^n, where n is how late (in days, week-end and holidays included) you hand in your assignment. If you hand it in on the day it is due but *after* the class (say, in the afternoon), $n=1/2$. If the work is 5 days late or more, the mark will be zero. Scan or take pictures of your assignment and email it to me in order to freeze n, and then hand in the assignment either in my office (MP703), or to Brendan Byrne (MP710), or to Ana Sousa (MP716A). We will use a plagiarism detecting software (e.g. Turnitin.com) if we deem it necessary.

The problem sets will mostly involve mathematical exercises but might involve numerical exercises based on the Python programming language and software packages. See http://compwiki.physics.utoronto.ca to get started.

Participation grade will be based on a few different criteria. Note that not all of them need to be fulfilled for you to get all the points.

- Participation in class: asking questions, noticing mistakes, taking on an active role during tutorials.
- Participation online: I will set up a forum on Blackboard, where you can ask questions about the lectures, the assignments, or else. Ideally, you would help each other and I would intervene as little as possible. Using this channel of communication will count towards your participation grade, emailing me directly won't. Note that you can post questions anonymously, while emailing me directly should be a last resort kind of thing. I will also create a wiki, where you can summarize the contents of the class.
- Others: if somehow you are helpful to me during the term, it will help you.

Textbooks I used to prepare the lectures (NOT required); cf. "topics" to see which book covers what:

- "Physics of Continuous Matter, Exotic and Everyday Phenomena in the Macroscopic World" (PCM), (2nd ed., CRC Press), by Benny Lautrup.
  Both 1st and 2nd editions are available in the Physics library (2nd ed. in course reserves). 1st edition is also available at Gerstein Science.
- "Physical Hydrodynamics" (PH), (2nd ed., Oxford University Press), by Étienne Guyon, Jean-Pierre Hulin, Luc Petit and Catalina Mitescu.
  Available in course reserves of the Physics library, and online:
  http://go.utlib.ca/cat/10103908
  Because it is available online, I may treat it as a requested book, asking you to read chapters of it.
- "Fluid Mechanics" (FM), by Pijush K. Kundu and Ira M. Cohen (and additional authors, depending on the edition). *This book is usually the go-to textbook for fluid mechanics' instructors in the Anglophone world, but I find it somewhat dry. An excellent resource nonetheless, which you might actually prefer. There are several editions to this book, the current one is the 6th I believe. The Physics library has several copies of the 2nd to 5th editions. I personally have the 4th on my shelf, which happens to be available online: http://go.utlib.ca/cat/8220558*

Description and Objectives: Continuum mechanics is a description of the collective behaviour of matter when subjected to various stresses and boundary conditions. Some effects are local, some are global, and causes (forces, stresses) act in various ways to create different shapes and patterns (translations, rotations, deformations), be they static (bent beams, drops…) or dynamic (currents, waves…). The vast majority of this class will be devoted to fluid dynamics, with a hint of solid mechanics to illustrate concepts related to the stress tensor. The description of fluid flows is often more powerful when using conservation of mass, (angular) momentum and/or energy. Finally, fluid flows can be complex phenomena which can be divided into different classes, and for each of them, different tools are used to describe them. In this context, the main objectives of this class are for you to be able to to:

- remember the foundations and limitations of the continuous approximation;
- understand the various components of the stress tensor, and in particular the difference between normal and tangential stress;
- understand the difference between the stress and strain tensors;
- compute the effects of a stress on a solid body: static shape, rotation and deformation (strain);

- know the basic words describing the kinematics aspects of fluid flow;
- understand the role of non-dimensional numbers in simplifying the non-approximated equations of motion;
- analyse the respective roles of the terms entering the equations of motion of fluids and their conservation laws;
- in simple cases, evaluate how to simplify the fundamental equations of motion in order to elaborate an analytical solution to a problem;
- given simplified sets of basic equations, compute simple fluid flows;
- understand the nature, phenomenology, and consequences of viscosity;
- know what creates vorticity, and how vortices behave;
- know some basic facts about potential flows, what underlies the superposition principle, and how to use it to construct solutions to some simplified sets of equations.

Topics: see Blackboard website for up to date info, lecture notes & other material.
The book references are indicative of what I used to prepare the lectures. Topics might evolve over the course of the term, and extra topics might be added at the end depending on the progression of the course.

Chapter	**Books & Chapters**
Intro: states of matter, continuum approximation	PH §1.1, §3.1.1; PCM §1.2
Intro to normal stress: pressure, surface tension	PCM §§2-4; PH §§1.4.1-4
Intro to tangential stress: viscosity	PH §§2.1-2
Stress and Strain tensors	PCM §6-7; PH §3.2, §4.1
Solid Mechanics: Hooke's law, Navier equation	PCM §8
Solid Mechanics: Settling, Bending, Twisting	PCM §9
Fluid Kinematics	PH §§3.1-4
Fluid Dynamics, Navier-Stokes equation	PH §§4.1-3
Conservation Laws in Fluids	PH §5; §7.2.1
Vorticity	PH §7
Potential Flows	PH §6
Quantum fluids (time permitting)	Off-script.
Flow Instabilities (time permitting)	FM §12; PH §11

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The University of Toronto treats cases of academic misconduct very seriously. All suspected cases of academic dishonesty will be investigated following the procedures outlined in the Code. The consequences for academic misconduct can be severe, including a failure in the course and a notation on your transcript. If you have any questions about what is or is not permitted in this course, please do not hesitate to contact me. If you are experiencing personal challenges that are having an impact on your academic work, please speak to me or seek the advice of your college registrar.

Accommodations: If you have a learning need requiring an accommodation the University of Toronto recommends that students immediately register at Accessibility Services at http://www.studentlife.utoronto.ca/as.

Location: 4th floor of 455 Spadina Avenue, Suite 400
Voice: 416-978-8060
Fax: 416-978-5729
Email: accessibility.services@utoronto.ca

The University of Toronto supports accommodations of students with special learning needs, which may be associated with learning disabilities, mobility impairments, functional/fine motor disabilities, acquired brain injuries, blindness and low vision, chronic health conditions, addictions, deafness and hearing loss, psychiatric disabilities, communication disorders and/or temporary disabilities, such as fractures and severe sprains, recovery from an operation, serious infections or pregnancy complications.

As the instructor of this course, you are also invited to communicate with me at any time about your learning needs. Confidentiality of learning needs is respectfully and strictly maintained.

Equity, Diversity and Excellence (from http://www.hrandequity.utoronto.ca/about-hr-equity/diversity.htm): At the University of Toronto, we strive to be an equitable and inclusive community, rich with diversity, protecting the human rights of all persons, and based upon understanding and mutual respect for the dignity and worth of every person. We seek to ensure to the greatest extent possible that all students enjoy the opportunity to participate as they see fit in the full range of activities that the University offers, and to achieve their full potential as members of the University community.

Our support for equity is grounded in an institution-wide commitment to achieving a working, teaching, and learning environment that is free of discrimination and harassment as defined in the Ontario Human Rights Code. In striving to become an equitable community, we will also work to eliminate, reduce or mitigate the adverse effects of any barriers to full participation in University life that we find, including physical, environmental, attitudinal, communication or technological.

Our teaching, scholarship and other activities take place in the context of a highly diverse society. Reflecting this diversity in our own community is uniquely valuable to the University as it contributes to the diversification of ideas and perspectives and thereby enriches our scholarship, teaching and other activities. We will proactively seek to increase diversity among our community members, and it is our aim to have a student body and teaching and administrative staffs that mirror the diversity of the pool of potential qualified applicants for those positions.

We believe that excellence flourishes in an environment that embraces the broadest range of people, that helps them to achieve their full potential, that facilitates the free expression of their diverse perspectives through respectful discourse, and in which high standards are maintained for students and staff alike. An equitable and inclusive learning environment creates the conditions for our student body to maximize their creativity and their contributions, thereby supporting excellence in all dimensions of the institution.