Course Information

Course Number: MATH 666
Course Title: Seminar in Geometry: Gromov's h-principle, MATH 666
Section: 600
Time: **MW 4:10-5:25 pm via Zoom**

Location: TBA
The links to the course zoom meeting can be find in the Zoom linls section in the eCampus or CAnvas
Credit Hours: 3

Instructor Details

Instructor: **Igor Zelenko**
Office: 601J
Phone: 979-820-0620
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Office Hours: **Tuesday , 11:30 a.m.- 1 p.m. , and Friday, 1:00 p.m. -1:50 pm via Zoom.**

Textbook and/or Resource Materials

Main Text:

Y. Eliashberg, N. Mishachev, Introduction to h-principle. Graduate Studies

in Mathematics, Vol. 48 AMS, Xiii+202

For references:

M. Gromov, Partial differential relations, Ergebnisse der Mathematik und

ihrer Grenzgebiete, Vol. 9, Springer-Verlag, Berlin, Heidelberg, New York,

London, Paris and Tokyo, 1986, be + 363 pp.,

We also will discuss the following papers:

1. Eliashberg, Yakov, Classification of overtwisted contact structures on 3-manifolds, Invent. Math. 98 (1989), no. 3, 623–637.

2. Borman, Matthew Strom; Eliashberg, Yakov; Murphy, Emmy Existence and classification of overtwisted contact structures in all dimensions. Acta Math. 215 (2015), no. 2, 281–361

3. Casals, Roger; Pérez, José Luis; del Pino, Álvaro; Presas, Francisco Existence h-principle for Engel structures. Invent. Math. 210 (2017), no. 2, 417–451.

4. D. McDuff, Application of convex integration to symplectic and contact geometry, Ann. Inst. Fourier, (Grenoble) 37(1987), no. 1, 107-133

Course Prerequisites

Differential Geometry 1(MATH 622) and Topology 1 (MATH 636) are recommended but not required. You only need to know some basics about manifolds and bundles (mainly definition) and the definition of homotopy.

Course Description

The course is devoted to the h-principle, the powerful collection of tools for proving of existence of geometric structures (symplectic , contact, even-contact and others) with prescribed properties, defined by differential relations (equalities or inequalities involving derivatives) on manifolds and approximation of maps between manifolds by maps with prescribed differential properties (isosymplectic, isometric, Lagrangian etc). The methods of h-principle also used actively in the study of equations of fluid mechanics. We will discuss two main technical tools in the theory: holonomic approximation and the method of convex integration.

Among the highlights of applications that will be discussed are Smale sphere eversion theorem, Nash-Kuiper theorem about approximation by isometric immersions/embeddings, classification of overtwisted contact structures on 3-dimensional manifolds (Eliashberg) and its generalization to higher dimension and other types of distributions. The latter topic is the subject of active current research.

Course Learning Outcomes

You will be able to join the active research, mainly on existence of vector distributions with prescribed properties, involving the methods discussed in the course. Apart of the geometry, you gain tools for studying existence of solutions of various type of PDE's in Mathematical Physics and Fluid Mechanics.

Grading Policy

Your final grade will be determined by your performance on the homework and the final presentation. The grade ingredients are:

• Activity	• %
• Participation	• **30%**: It will include discussions during the classes and out of class times , i.e. by email and in person (office hours, Zoom meetings) and submitting solution of selected exercises

• **Final presentation**	• **70%:** It will be assigned to you in advanced on a topic which continues some topic discussed in a class or on a new topic which was not covered in class. The presentations will be during the last 3 weeks of the semester in the class time. The schedule will be determined later.
• **Total:**	• 100%

Grading Scale

• Range	• Grade
• **90 -100 %**	• A
• **80- 89 %**	• B
• **70-79 %**	• C
• **60-69 %**	• D
• **0-59 %**	• F

Exams: There will not be exams in this class.

Grade Complains: *There will not be official homework assignment in this course, but occasional selected exercises submission of which may contribute to the participation portion of your grade.* If you think that your solution of a selected exercise was graded incorrectly you have two weeks from the time the graded assignment was returned to you to bring the issue to the instructor's attention.

Late Work Policy

There will be the target dates for submission of selective exercises and the submission a week after those target dates will not be accepted.

Course Schedule

WEEK	EM BELOW MEANS THE ELIASHBERG-MISHACHEV, E89 IS ELYSHABERG 1989 PAPER.
WEEK 1	Jets and holonomy (EM, chapter 1), Sard lemma and Tho transversality theorem (EM , Chapter 2)
WEEK 2	Holonomic approximation (EM Chapter 3)
WEEK 3	Applications of holonomic approximation theorem: Functions without critical points, Smale's sphere eversion theorem, how to apply homotopic approximation to differential relations

	on open manifolds, approximations of differential forms by closed forms, and others (EM Chapter 4)
WEEK 4	Differential relations, h-principle, open Diff-Invariant Relations, microextension trick and application to closed manifolds (EM Chapters 5-8)
WEEK 5	Basic on symplectic and contact geometry, symplectic and contact structure on open manifolds (EM Chapters 9, 10)
WEEK 6	Symplectic and contact structures on closed manifolds (EM Chapter 11). Overtwisted 3D contact structures (based on E89 paper)
WEEK 7	Continuation of discussion of E89 paper and more recent papers on higher dimensional contact structures
WEEK 8	One-dimensional convex integration (EM Chapter 17)
WEEK 9	Ampleness in coordinate directions, iterated convex integration (EM, Chapter 18)
WEEK 10	Application of convex integration to h-principle for even-contact structures (Chapter 20) and other types of distributions (the latter is a work in progress and has open directions)
WEEK 11	Nash-Cuiper Theorem (EM Chapter 21)
WEEK 12-15	Presentation on selected topics based on methods studied in the course.

Zoom Etiquette (in case the course will be online)

- **When joining class remotely via ZOOM**, please join with your audio off. When you have a question duringclass you may (1)use the "CHAT to everyone" feature to type your question, (2) use the "raise your hand" feature and wait for me to call on you, or(3) unmute yourself, politely interrupt me, and I will pause and give you time to ask your question. It is important to me that the students joining remotely are involved in the class discussion, but it is best if we do this in an organized way.
- **OFFICE HOUR ATTENDEES** When joining office hours via ZOOM, please join with your audio off. Everyone attending office hours will be joining one room, so if you would like to ask a question during office hours, please "raise your hand" and wait to be called on. If you need to speak to me privately, and have not made an individual appointment with me, please let me know through a private CHAT message and I will move you to a breakout room where we can talk one-on-one.

University Policies

Attendance Policy

The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to Student Rule 7 in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to Student Rule 7 in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" (Student Rule 7, Section 7.4.2).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See Student Rule 24.)

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" (Section 20.1.2.3, Student Rule 20).

You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at aggiehonor.tamu.edu.

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact Disability Resources in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu. Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.

Title IX and Statement on Limits to Confidentiality

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking.

With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see University Rule 08.01.01.M1):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention – including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, you will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University's goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need.

Students wishing to discuss concerns in a confidential setting are encouraged to make an appointment with Counseling and Psychological Services (CAPS).

Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University's Title IX webpage.

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors that influence a student's academic success and overall wellbeing. Students are encouraged to engage in proper self-care by utilizing the resources and services available from Counseling & Psychological Services (CAPS). Students who need someone to talk to can call the TAMU Helpline (979-845-2700) from 4:00 p.m. to 8:00 a.m. weekdays and 24 hours on weekends. 24-hour emergency help is also available through the National Suicide Prevention Hotline (800-273-8255) or at suicidepreventionlifeline.org.

COVID-19 Temporary Amendment

Campus Safety Measures

To promote public safety and protect students, faculty, and staff during the coronavirus pandemic, Texas A&M University has adopted policies and practices for the Fall 2020 academic term to limit virus transmission. Students must observe the following practices while participating in face-to-face courses

and course-related activities (office hours, help sessions, transitioning to and between classes, study spaces, academic services, etc.):

- Self-monitoring—Students should follow CDC recommendations for self-monitoring. **Students who have a fever or exhibit symptoms of COVID-19 should participate in class remotely and should not participate in face-to-face instruction.**
- Face Coverings—Face coverings (cloth face covering, surgical mask, etc.) must be properly worn in all non-private spaces including classrooms, teaching laboratories, common spaces such as lobbies and hallways, public study spaces, libraries, academic resource and support offices, and outdoor spaces where 6 feet of physical distancing is difficult to reliably maintain. Description of face coverings and additional guidance are provided in the Face Covering policy and Frequently Asked Questions (FAQ) available on the Provost website.
- Physical Distancing—Physical distancing must be maintained between students, instructors, and others in course and course-related activities.
- Classroom Ingress/Egress—Students must follow marked pathways for entering and exiting classrooms and other teaching spaces. Leave classrooms promptly after course activities have concluded. Do not congregate in hallways and maintain 6-foot physical distancing when waiting to enter classrooms and other instructional spaces.
- To attend a face-to-face class, students must wear a face covering (or a face shield if they have an exemption letter). If a student refuses to wear a face covering, the instructor should ask the student to leave and join the class remotely. If the student does not leave the class, the faculty member should report that student to the Student Conduct office for sanctions. Additionally, the faculty member may choose to teach that day's class remotely for all students.

Personal Illness and Quarantine

Students required to quarantine must participate in courses and course-related activities remotely and **must not attend face-to-face course activities**. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities.

Students experiencing personal injury or Illness that is too severe for the student to attend class qualify for an excused absence (See Student Rule 7, Section 7.2.2.) To receive an excused absence, students must comply with the documentation and notification guidelines outlined in Student Rule 7. While Student Rule 7, Section 7.3.2.1, indicates a medical confirmation note from the student's medical provider is preferred, **for Fall 2020 only, students may use the Explanatory Statement for Absence from Class form in lieu of a medical confirmation. Students must submit the Explanatory Statement for Absence from Class within two business days after the last date of absence.**