



## Course Syllabus: Contemporary Topics in PDE - AMCS 394B

<b>Division</b>	Computer, Electrical and Mathematical Sciences & Engineering
<b>Course Number</b>	AMCS 394B
<b>Course Title</b>	Contemporary Topics in PDE
<b>Academic Semester</b>	Fall
<b>Academic Year</b>	2019/2020
<b>Semester Start Date</b>	08/25/2019
<b>Semester End Date</b>	12/10/2019
<b>Class Schedule</b> (Days & Time)	02:30 PM - 04:00 PM   Sun Wed

Instructor(s)				
Name	Email	Phone	Office Location	Office Hours
Diogo Gomes	Diogo.Gomes@KAUST.EDU.SA	+966128080208	4116, 1, Al-Khwarizmi (bldg. 1)	by email appointment
Athanasios Tzavaras	athanasios.tzavaras@kaust.edu.sa	+966128080699	4426, 1, Al-Khwarizmi (bldg. 1)	by email appointment

Teaching Assistant(s)	
Name	Email

Course Information	
<b>Comprehensive Course Description</b>	The objective of this course is to introduce students to various topics of current interest in the theory of Hyperbolic Conservation Laws and the theory of Mean Field Games as they have developed in the modern theory of Partial Differential Equations. We will present the advanced topics of current interest in these subjects, their interconnections, and also how various mathematical questions reflect to or are motivated from ideas in applied fields where these models are used.
<b>Course Description from Program Guide</b>	
<b>Goals and Objectives</b>	Introduce students to various topics of current interest in the theory of Hyperbolic Conservation Laws and the theory of Mean Field Games.
<b>Required Knowledge</b>	<b>A solid course on Graduate Real Analysis (Measure and Integration). A course on the theory of weak solutions of PDE</b>

<b>Reference Texts</b>	<p>J. M. Ball, A version of the fundamental theorem for Young measures. PDEs and continuum models of phase transitions (Nice, 1988), 1988.</p> <p>L. Tartar, Compensated compactness and applications to partial differential equations, in Nonlinear Analysis and Mechanics), Knops, ed., Heriot-Watt Symposium, Vol. IV, Pitman Research Notes in Mathematics, Pitman, Boston, 1979, pp. 136-192.</p> <p>C.M. Dafermos, Hyperbolic Systems of Conservation Laws, Vol. 4, Springer.</p> <p>L.C. Evans, Mass transfer lecture notes, 2001, Berkeley Lecture Notes.</p> <p>Villani, Cédric Topics in optimal transportation. Graduate Studies in Mathematics, 58.</p> <p>Gomes, Diogo A.; Pimentel, Edgard A.; Voskanyan, Vardan Regularity theory for mean-field game systems. SpringerBriefs in Mathematics.</p>
<b>Method of evaluation</b>	100.00% - Research Project
<b>Nature of the assignments</b>	The students will have to develop a topic and do one or more presentations in class. They also have to submit a report on which their presentation will be based. Their grade will be based on this project.
<b>Course Policies</b>	to be discussed in class
<b>Additional Information</b>	

## Tentative Course Schedule

*(Time, topic/emphasis & resources)*

<b>Week</b>	<b>Lectures</b>	<b>Topic</b>
1	Sun 08/25/2019 Wed 08/28/2019	Quick review of weak convergence properties
2	Sun 09/01/2019 Wed 09/04/2019	Young measures, concentration measures
3	Sun 09/08/2019 Wed 09/11/2019	Compensated compactness, Compensated integrability
4	Sun 09/15/2019 Wed 09/18/2019	Compensated compactness, Compensated integrability
5	Sun 09/22/2019 Wed 09/25/2019	Div-Curl Lemma, Murat's lemma
6	Sun 09/29/2019 Wed 10/02/2019	Reduction of Young measures for scalar conservation laws, the kinetic formulation of scalar conservation laws
7	Sun 10/06/2019 Wed 10/09/2019	Entropy-flux pairs, the kinetic formulation for systems and the reduction of Young measures.
8	Sun 10/13/2019 Wed 10/16/2019	The Monge-Kantorovich problem and the Wasserstein distance, the Brenier-Benamou minimization schemes
9	Sun 10/20/2019 Wed 10/23/2019	The method of minimizing movements, the JKO scheme and gradient flows.
10	Sun 10/27/2019 Wed 10/30/2019	An introduction to deterministic and stochastic control. Hamilton-Jacobi equations, Fokker-Planck equations and Transport equation.
11	Sun 11/03/2019 Wed 11/06/2019	Derivation of mean-field game models.
12	Sun 11/10/2019 Wed 11/13/2019	Variational structures in mean-field games. Direct method in the calculus of variations. Some non-coercive mean-field games.
13	Sun 11/17/2019 Wed 11/20/2019	An introduction to variational inequalities. Minty's method.
14	Sun 11/24/2019 Wed 11/27/2019	Applications of variational inequalities to mean-field games. Numerical methods. Hessian gradient flows.
15	Sun 12/01/2019 Wed 12/04/2019	Complements and extensions
16	Sun 12/08/2019	Student presentations

### Note

The instructor reserves the right to make changes to this syllabus as necessary.