



**MASC 520: Mathematical Methods for Deep Learning**

**Units: 4**

**Time: Fall 2021, T/Th 10:00-11:50pm**

**Location: TBD**

**Instructor: Rajiv K. Kalia**

**Office: VHE614**

**Office Hours: TBD**

**Contact Info: [rkalia@usc.edu](mailto:rkalia@usc.edu)**

**Teaching Assistant:**

**Office: TBD**

**Office Hours: TBD**

**Contact Info: TBD**

## Course Description

MASC 520 is a foundational mathematical course for deep learning. It provides graduate students with in-depth knowledge of mathematics needed to understand deep learning. The course covers a variety of topics such as linear algebra, probability and statistics, optimization, Fourier series and Fourier transforms, ordinary and partial differential equations, and Markov Chain Monte Carlo methods. Each topic is introduced with an application of deep learning to problems in the physical sciences and engineering. Students are required to do four projects chosen from the following topics: feed forward neural network, convolutional neural network, recurrent neural network, neural network solvers for differential equations, autoencoders, deep generative models such as Restricted Boltzmann Machine and Deep Boltzmann Machine, Deep Reinforcement Learning, and graph neural networks.

## Learning Objectives

The course aims to provide graduate students with in-depth mathematical knowledge to design and implement deep learning algorithms for analyses of experiments and simulations in the physical sciences and engineering.

**Prerequisite(s):** None

**Co-Requisite(s):** None

**Concurrent Enrollment:** None

**Recommended Preparation:** None

## Course Notes

Grading type: letter grade. All course notes will be provided on Blackboard.

## Required Readings and Supplementary Materials

Deep Learning by I. Goodfellow, Y. Bengio and A. Courville (ISBN-13 : 978-0262035613)

Mathematical Methods for Physicists 7<sup>th</sup> Ed by G. Arfken. (ISBN-13 : 978-0123846549)

## Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Homework	100	33%
Midterm	100	33%
Projects	100	34%
<b>TOTAL</b>	<b>300</b>	<b>100%</b>

## Course Breakdown

- Introduction to Machine Learning
- Linear Vector Spaces, Operators, Matrices and Tensors
- Probability and Information Theory
- Fourier Series and Fourier Transforms
- Differential Equations
- Machine Learning Basics
- Deep Networks
- Optimization for Training Deep Models
- Convolutional Neural Networks
- Recurrent Neural Networks
- Structured Probabilistic Models for Deep Learning
- Deep Generative Models
- Deep Reinforcement Learning
- Graph Neural Networks

## Statement on Academic Conduct and Support Systems

### Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” [policy.usc.edu/scampus-part-b](http://policy.usc.edu/scampus-part-b). Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, [policy.usc.edu/scientific-misconduct](http://policy.usc.edu/scientific-misconduct).

### Support Systems:

*Counseling and Mental Health - (213) 740-9355 – 24/7 on call*  
[studenthealth.usc.edu/counseling](http://studenthealth.usc.edu/counseling)

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

*National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call*  
[suicidepreventionlifeline.org](http://suicidepreventionlifeline.org)

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

*Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call*  
[studenthealth.usc.edu/sexual-assault](http://studenthealth.usc.edu/sexual-assault)

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

*Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298*  
[equity.usc.edu](http://equity.usc.edu), [titleix.usc.edu](http://titleix.usc.edu)

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

*Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298*  
[usc-advocate.symplicity.com/care\\_report](http://usc-advocate.symplicity.com/care_report)

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity | Title IX for appropriate investigation, supportive measures, and response.

*The Office of Disability Services and Programs - (213) 740-0776*  
[dsp.usc.edu](http://dsp.usc.edu)

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

*USC Campus Support and Intervention - (213) 821-4710*  
[campussupport.usc.edu](http://campussupport.usc.edu)

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

*Diversity at USC - (213) 740-2101*  
[diversity.usc.edu](http://diversity.usc.edu)

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

*USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call*  
[dps.usc.edu](http://dps.usc.edu), [emergency.usc.edu](http://emergency.usc.edu)

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

*USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call*  
[dps.usc.edu](http://dps.usc.edu)

Non-emergency assistance or information.