# Mathematics for Inference and Machine Learning

## CO-496

Autumn 2016

# Lecturers

**Bayesian Linear Regression: Marc Deisenroth** (Statistical Machine Learning)

- Mathematical Methods (CO-145)
- Data Analysis and Probabilistic Inference (CO-493)

**PCA/SVMs: Stefanos Zafeiriou** (Computer Vision)

- Advanced Statistical Machine Learning
  and Pattern Recognition (CO-495)

# Course Aims

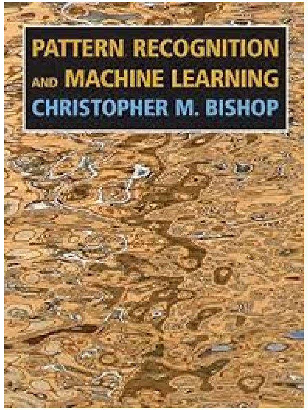
- **Mathematical background** to understand, design and implement basic concepts in machine learning:
    - Probability theory
    - Bayesian inference
    - Vector calculus
    - Optimization
    - Linear algebra II
- **Basic machine learning concepts**
    - Model selection
    - Graphical models
- By the end of the course, you will be familiar with the following **applications:**
    - Bayesian Linear Regression (MD)
    - Principal Component Analysis (SZ)
    - Support Vector Machines (SZ)

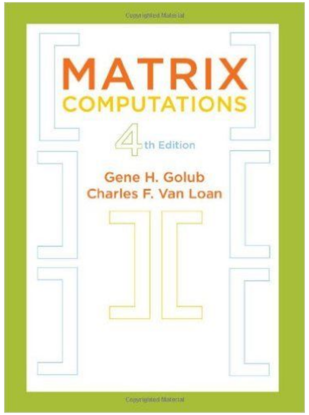
# CO-496

- Provides:
  - **Hard pre-requisite**
    - CO-424H: Learning in Autonomous Systems (Term 1)
    - CO-433: Advanced Robotics (Term 2)
    - CO-493: Data Analysis and Probabilistic Inference (Term 2)
    - CO-495: Advanced Statistical Machine Learning and Pattern Recognition (Term 2)
  - Soft co-requisite (recommendation)
    - CO-477: Computational Optimisation (Term 1)
- Requires:
  - Linear algebra (see CO-145 notes), e.g., matrix multiplication, eigenvalues, determinants
  - Basic probability theory and statistics (see CO-245), e.g., conditional probabilities, univariate distributions

# Material

- Lecture notes (continuously being updated)
- Hand-written notes (usually no slides)
- Panopto recording (if possible)
- Key books:
    - Bishop: Pattern Recognition and Machine Learning
        - Chapters 1, 2.2–2.3, 3, 8.1, 12.1–12.2
    - Golub & Van Loan: Matrix Computations
        - Chapters, 1 (w/o 1.5, 1.6), 2 (w/o 2.6, 2.7), 5.2
- Tutorial and research papers (specified in lecture notes)



# Tutorials

- Mix of short and long in-class exercises to deepen understanding of mathematical concepts
- Tutorial helpers:
    - Hugh Salimbeni (CSL)
    - Feryal Mehraban Pour Behbahani
    - Marta Garnelo Abellanas
    - Kyriacos Nikiforou
    - Matthew Lee
    - Stelios Moschoglou

# Coursework

- **Electronic submission only** (via CATe)
    - LaTeX template available
    - Fully computer-generated submissions only
- Current submission deadlines:
    - **Monday, November 7 (10:00)** → Coursework already available
    - **Monday, November 28 (10:00)** → Coursework available on October 31
- Coursework counts 10% or 15% (depending on your degree)

# Piazza for Q&A and Discussions

Enroll here: [http://piazza.com/imperial.ac.uk/fall2016/496](http://piazza.com/imperial.ac.uk/fall2016/496)

- Useful forum
- Usually quick response time
  - Example (last year's Maths course)

no unread posts

no unanswered questions

no unresolved followups

| | |
|---|---|
| 158 | total posts |
| 823 | total contributions |
| 140 | instructors' responses |
| 198 | students' responses |
| 17 min | avg. response time |

question

## Convergence test

For questions like $\sum_{n=1}^{\infty} \frac{n}{2n^3+n-2}$, which test should I be using? Intergral test?

Also what is the approach of this type of questions?

exam

edit · good question | 0

**the students' answer,** *where students collectively construct a single answer*

How I would approach the question:
(1) Since n starts from 1, aka n is not 0, so we can divide by n safely: $\sum_{n=1}^{\infty} \frac{1}{2n^2+1-2/n}$
(2) We note that $\forall n \geq 1 [2n^2+1-2/n \geq n^2 \implies \frac{1}{2n^2+1-2/n} \leq \frac{1}{n^2}]$
(3) Comparison test with $\sum_{n=1}^{\infty} \frac{1}{n^2}$, a series that converges
(4) Let $a_n = \frac{1}{2n^2+1-2/n}$, $c_n = \frac{1}{n^2}$
(5) By (2), we know that $a_n \leq c_n$
(6) Suppose x = 1, $a_n \leq xc_n$ stands, therefore $\exists x \forall n > 0 [a_n \leq xc_n]$
(7) By comparison test, $\sum_{n=1}^{\infty} \frac{n}{2n^3+n-2}$ converges

Might be slightly unconventional, but seems logical to me haha.

Hope this helps :)

edit · good answer | 2

**the instructors' answer,** *where instructors collectively construct a single answer*

When you are not asked for a specific test, you are free to choose any test that is

That of course includes integral test, but in your example it take a bit of effort to co

In this example, the denominator for large n is somewhere between $n^3$ and $3n^3$ (
$n/(3n^3)$, both of which converge. Now that you know the status of the converger

# SOLE (Teaching Evaluation)

- Constructive feedback (free text possible) is important to us and will be taken into account
- **<u>Do NOT vote “Neutral” (N):</u>** College counts this as negative:

  Neutral = not positive = negative
- If you are unhappy with the course, vote negative (and provide feedback)
- Example (anon. course):