

Course Structure

- Lectures
 - ★ Tuesday 14:00-14:45 (02/1039)
 - ★ Thursday 16:00-16:45 (54/5025)
 - ★ Friday 17:00-17:45 (35/1005)
- Assessment
 - ★ 80% Exam
 - ★ 20% Problem Sheet

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Problem Sheets

- I am going to provide many problem sheets
- One problem sheet will be marked and worth 20% (you will know which one this is)
- The other problem sheets are optional, but some small proportion of the questions will be on the exam
- I will go through the problem sheets, but if you have not attempted the questions you won't learn that much

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What's in the Course

- This course is going to cover the core principles and mathematics behind machine learning
- It is not going to explicitly teach different machine learning algorithms
- We are not looking at advanced algorithms but cover the principles
- There are very good implementation available (e.g. scikit-learn)
- Along the way though we will meet (often many times) particular algorithms

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Cracking the Code

- Mathematics is the language of machine learning
- You can do machine learning without mathematics, but if you want to develop and understand advanced algorithms then you have no choice
- This course invites you on a journey to crack the code of mathematics for machine learning
- If this isn't a challenge you want, then this is probably not the course for you

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Topics

- Learning Theory
 - ★ Bias-Variance
 - ★ Overfitting, symmetry and regularisation
 - ★ Ensembling, bagging and boosting
- Mathematics
 - ★ Function Spaces: Kernel Methods and Gaussian Processes
 - ★ Linear Algebra, embeddings, positive definiteness, subspace, determinants

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Topics Continued

- Optimisation
 - ★ Newton/Quasi-Newton Methods: convergence rates
 - ★ SGD, momentum, ADAM
- Constrained Optimisation
 - ★ KKT conditions
 - ★ Duality Linear/Quadratic Programming
 - ★ SVMs
- Convexity
 - ★ Convex sets: linear constraints, PD matrices
 - ★ Convex functions
 - ★ SVMs, Lasso
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 - ★ Naive Bayes
 - ★ Gaussian Processes
 - ★ Dependencies and Graphical Models
 - ★ Expectations and MCMC
- Variational Methods
 - ★ Divergences: KL and Wasserstein
 - ★ VAEs and GANs
 - ★ Entropy and information theory
 - ★ Variational Approximation

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