

# Weekly Learning Plan — MATH20802

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20 January 2021

## Overview

### General plan

This module is taught based on the concept of “flipped learning”:

- 1) First, you study the asynchronous material by yourself:
  - i) read the [lecture notes](#),
  - ii) watch the [lecture videos](#) and
  - iii) try to solve the questions and problems given in the [worksheets](#) and study their solutions.

For each of the semester weeks 1–12 the following pages provide a detailed list which material you will need to study in a specific week.

- 2) Subsequently, you attend the live synchronous sessions:
  - i) the review lecture and
  - ii) the tutorial session.

The review lecture recapitulates the key content from the lecture notes and videos each week. The tutorial session discuss the questions and problems in an interactive fashion.

### Links

You can find the course material both on [Blackboard](#) and on the [MATH20802 course homepage](#). There can also find the scheduled times and locations for the two weekly live sessions.

### Workload

For this course you will need to spend about 6-8 hours study each week:

- 2-3h watching videos, reading and understanding lecture notes
- 2-3h working on the problems in the worksheets
- 2h attending live sessions

The in-semester assessment in Week 6 will be a 40 minute online test.

## Week 1 (from 8 February 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week first a broad overview over the course content and course organisation is given. Next, we provide a refresher of the statistical concepts required as foundation for this module.

*Study:*

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**Video 1** Introduction to the course

**LN Chapter 1**

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**Video 2** Refresher of statistics

**LN Appendix**

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*Problem solving:*

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**No worksheet this week**

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There are no tutorials in the first week of the course.

## Week 2 (from 15 February 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we study entropy and its close link to maximum likelihood. Specifically, we discuss the properties of relative entropy, also known as Kullback-Leibler (KL) divergence, and show how it gives rise to the method of maximum likelihood. We also introduce the expected Fisher information as local approximation of the KL divergence.

*Study:*

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**Video 3** Entropy and Kullback-Leibler divergence

**Video 4** Expected Fisher information

**Video 5** Entropy learning and maximum likelihood

**LN Chapter 2**

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*Problem solving:*

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**Worksheet 1**

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## Week 3 (from 22 February 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we study maximum likelihood estimation in more detail and illustrate the approach by a number of worked examples. Furthermore, the observed Fisher information is introduced.

*Study:*

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**Video 6** Principles of maximum likelihood estimation

**Video 7** Observed Fisher information

**LN Chapter 3**

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*Problem solving:*

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**Worksheet 2**

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## Week 4 (from 1 March 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we introduce the covariance and correlation matrix as well as the multivariate normal distribution. Subsequently, we investigate second order approximation of the log-likelihood function and the asymptotic normality of maximum likelihood estimates. Furthermore, it is shown how the normal approximation can be used to construct corresponding confidence intervals, and also discuss a case where the quadratic approximation is not available.

*Study:*

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**Video 8** Quadratic approximation and normal asymptotics

**Video 9** Normal-approximation interval estimation

**Video 10** Non-regular models

**LN Chapter 4**

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*Problem solving:*

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**Worksheet 3**

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## Week 5 (from 8 March 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we introduce the likelihood ratio and show how to compute likelihood-based confidence intervals. We also discuss generalised likelihood ratio statistics. Finally, we summarise estimation and inference by maximum likelihood and discuss optimality properties.

*Study:*

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**Video 11** Likelihood ratio and Likelihood-based interval estimation

**Video 12** Generalised likelihood ratio test

**LN Chapter 5**

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**Video 13** Optimality properties of maximum likelihood and summary

**LN Chapter 6**

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*Problem solving:*

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**Worksheet 4**

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## Week 6 (from 15 March 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we start investigate the principles of Bayesian learning and discuss how to estimate a proportion in the Bayesian framework. In this week there is also the midterm test (focusing on maximum likelihood).

*Study:*

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**Video 14** Introduction to Bayesian learning  
**LN Chapter 7**

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**Video 15** Bayes model for a proportion  
**LN Chapter 8**

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*Problem solving:*

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**No worksheet this week**

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There are no tutorials this week.

*In-semester assessment:*

The online midterm test takes place this week. Further details are found on Blackboard.

## Week 7 (from 22 March 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we continue with the study of Bayesian statistics and investigate two further standard models, for estimating the mean and the variance, respectively. Furthermore, we discuss the James-Stein estimator, an empirical Bayes estimator of the mean.

*Study:*

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**Video 16** Properties of Bayesian learning  
**LN Chapter 9**

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**Video 17** Bayes models for the mean and the variance  
**LN Chapter 10**

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**Video 18** Shrinkage estimation and James-Stein estimator  
**LN Chapter 11**

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*Problem solving:*

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**Worksheet 5**

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## Week 8 (from 12 April 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we consider two Bayesian ways of conducting statistical test: the Bayes factor and its BIC approximation, and (local) false discovery rates. Finally, we give a summary of the optimality properties of Bayesian learning.

*Study:*

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**Video 19** Bayes factor and BIC approximation

**LN Chapter 12**

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**Video 20** False discovery rates

**LN Chapter 13**

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**Video 21** Optimality of Bayesian learning and summary

**LN Chapter 14**

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*Problem solving:*

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**Worksheet 6**

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## Week 9 (from 19 April 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we first provide an overview over the problem of regression in general and then introduce the linear regression model.

*Study:*

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**Video 22** Introduction to regression models  
**LN Chapter 15**

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**Video 23** Linear regression model  
**LN Chapter 16**

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*Problem solving:*

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**Worksheet 7**

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## Week 10 (from 26 April 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we discuss how to estimate coefficients of the linear regression model from data.

*Study:*

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**Video 24** Estimating regression coefficients by least squares and maximum likelihood

**Video 25** Three further ways to estimate regression coefficients

**LN Chapter 17**

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*Problem solving:*

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**Worksheet 8**

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## Week 11 (from 3 May 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

In this week we introduce the squared multiple correlation and its use in linear regression. In particular, we show how the decomposition into explained and unexplained variance is linked to squared multiple correlation. Furthermore, we discuss ways how to assign variable importance to predictor variables and how to select variables most relevant for prediction.

*Study:*

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**Video 26** Squared multiple correlation

**Video 27** Variance decomposition in regression

**LN Chapter 18**

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**Video 28** Prediction and variable selection

**LN Chapter 19**

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*Problem solving:*

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**Worksheet 9**

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## Week 12 (from 10 May 2021)

**LN:** lecture notes — [view online](#)

**Video:** lecture videos — [view online](#)

**Worksheets:** [download worksheets](#)

*Topics:*

This week is revision week with no new content. Revisit the lecture videos and worksheets of Weeks 1–11.

*Study:*

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**No videos this week**

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*Problem solving:*

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**No worksheet this week**

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The tutorial this week is a revision Q & A.