

MATHEMATICS OF INFECTIOUS DISEASES

Syllabus of the fall 2017 book reading course based on Diekmann, Heesterbeek & Britton: Mathematical tools for understanding infectious disease dynamics (Princeton University Press 2012). Numbers x.y.z refer to the sections of the book; [#] marks individual assignments. The Presentation assignment file pairs the assignments to the course participants. The syllabus is updated as the course proceeds.

6 – 25 September

Six lectures of introduction, covers sections 1.1-1.2 and other material.

1.3 THE FINAL SIZE

27 September

Quick test: first six lectures AND sections 1.1, 1.2 of the book

- [1] 1.3.1 The standard final-size equation and its heuristic derivation (exercises 1.19-1.20; show also the numerical solution of the final-size equation (1.11) as a function of R_0 , see exercises 3.13-3.14, Fig 16.14)
- [2] 1.3.2 Derivation of the standard final-size equation (exercise 1.22 partly done already; exercises 1.23-1.24)
- [3] 1.3.3 The final size of epidemics within herds, part 1: pp. 21-22 (exercises 1.25-1.28)

2 October

- [4] 1.3.3 The final size of epidemics within herds, part 2: pp. 23-24 (exercises 1.29-1.33)
- [5] 1.3.4 The final size in a finite population: exercise 1.34; ADD: carry out the numerics and show the final-size distribution (1.35 optional)
- [E] EXERCISES done by all and discussed as in an ordinary exercise class: 1.39-1.41 plus replace 1.37 with this: Obtain the final size of the epidemic as a function of v , the fraction of the population vaccinated before the outbreak.

4 October

2.1 DIFFERENCES IN INFECTIVITY

- [6] part 1 of 2.1: pp. 33-35 (exercises 2.1-2.4)
- [7] part 2 of 2.1: bottom of p 36 ("An attractive class of sub-models...") – halfway p 38 (exercises 2.7-2.9 and also add 2.5, but skip 2.6 [later])
- [8] part 3 of 2.1: halfway p 38 ("In concluding this section...") – halfway p 39 (exercises 2.10-2.11)

9 October

2.2 DIFFERENCES IN INFECTIVITY AND SUSCEPTIBILITY – *Eva presents this*

2.3 THE PITFALL OF OVERLOOKING DEPENDENCE – *Eva presents this, including also exercise 3.3 from Chapter 3 (same issue)*

3.1 THE PROTOTYPE STOCHASTIC EPIDEMIC MODEL

3.2 TWO SPECIAL CASES

Pp. 45-50 is mostly covered already, but do read it yourself because new terms (used in stochastic models) are introduced

3.3 INITIAL PHASE OF THE STOCHASTIC EPIDEMIC IN A LARGE POPULATION

Much of pp. 51-58 is a review of previous material, but do read it yourself. Exercise 3.10 is important!

- [9] 3.3.1 Continuous-time branching processes; and
 - 3.3.2 Approximation of the initial phase of the epidemic
- Present only the distribution of the final size (including exercises 3.8-3.9 [compare with exercise 1.41] and exercise 3.12)

11 October

3.4 APPROXIMATION OF THE MAIN PART OF THE EPIDEMIC – *Read it yourself.*

3.5 APPROXIMATION OF THE FINAL SIZE: THE SELLKE CONSTRUCTION

3.5.1 Law of large numbers limit: a heuristic argument – *review of previous material, read it yourself*

3.5.2-3.5.4 The Sellke construction – *Eva presents this. We omit what is not in the presentation, you do not have to read the book.*

3.6 THE DURATION OF THE EPIDEMIC – *Read it, prepare for a brief discussion of Fig 3.8.*

16 October

Quick test

4.1 REPEATED OUTBREAKS VERSUS PERSISTENCE – *Read it yourself.*

[10] **4.2 FLUCTUATIONS AROUND THE ENDEMIC STEADY STATE:** pp. 75-77 (exercises 4.1-4.5, linear stability analysis)

[11] **4.3 VACCINATION** (exercises 4.19-4.22; ADD modelling the possibilities described in the last paragraph)

[12] **4.4 REGULATION OF HOST POPULATIONS** (exercises 4.23-4.27) – *we shall take this on 18 Oct because Pentti cannot be here*

18 October

[E] EXERCISES done by all and discussed as in an ordinary exercise class: 4.6, 4.8, 4.10, 4.14, 4.16 (NB 4.15 already done; 4.17 left for later)

----- **TEACHING BREAK** -----

30 October – 1 November

4.5 TOOLS FOR EVOLUTIONARY CONTEMPLATIONS – *Eva presents this and other evolutionary models*

6 November

Quick test

6. THE CONCEPT OF STATE – *read this short chapter yourself. The concepts introduced here are essential for the remainder of the course!*

[13] **7.1 THE DEFINITION OF R_0** (exercises 7.1, 7.2, 7.5, 7.7). Use the example of section 2.2 to illustrate (this is also the basis of 7.7).

7.2 NEXT-GENERATION MATRIX FOR COMPARTMENTAL SYSTEMS

[14] Pp. 166-170 (exercises 7.8-7.10, ADD exercise 2.6; recall material from section 2.1 as needed)

8 November

[E] EXERCISES done by all and discussed as in an ordinary exercise class: 7.11-7.14

- [15] **7.3 GENERAL h-STATE** and
7.4 CONDITIONS THAT SIMPLIFY THE COMPUTATION OF R_0 (exercises 7.17-7.19; section 7.4.3 is optional)

13 November (Eva not here)

- [16] **7.5 SUB-MODELS FOR THE KERNEL** (exercise 7.22, ADD one concrete example of your choice, where each part of the model is derived from specific assumptions about contact, infectivity, etc.)

7.6 SENSITIVITY ANALYSIS OF R_0 – *read it yourself, optional.*

- [17] **7.8 PAIR FORMATION MODELS:** pp. 189-top of p. 192, exercises 7.40-7.43

7.7 EXTENDED EXAMPLE: TWO DISEASES

- [E] EXERCISES done by all and discussed as in an ordinary exercise class (as much as time allows, continue next time):
7.23-7.30 (7.31-7.32 omitted); 7.33-7.34 (7.35-7.38 omitted)

15 November (Eva not here)

- [E] EXERCISES done by all and discussed as in an ordinary exercise class: exercises from Chapter 7.7 left from last time

- [E] EXERCISES done by all and discussed as in an ordinary exercise class: 7.44-7.48

20 November

Quick test

- [18] **4.6 MARKOV CHAINS: MODELS OF INFECTION IN THE ICU** (exercises 4.28-4.32)
4.7 TIME TO EXTINCTION AND CRITICAL COMMUNITY SIZE – *We omit this chapter*

5. INFERENCE

- [19] 5.1-5.2 Maximum likelihood estimation

- [20] 5.3 An example of estimation
(we omit the rest of Chapter 5)

22 November

7.9 INVASION UNDER PERIODIC ENVIRONMENTAL CONDITIONS – *Eva presents this*

27 November

[21] **7.10 TARGETED CONTROL**

8.1 THE PROBABILITY OF A MAJOR OUTBREAK

[22] 8.1.1 A simplistic model for an STD in a heterosexual community

29 November

[23] 8.1.2 Partially vaccinated populations

8.2 THE INTRINSIC GROWTH RATE – *we omit this section*

[24] **8.3 A BRIEF LOOK AT FINAL SIZE AND ENDEMIC LEVEL**

[25] **8.4 SIMPLIFICATIONS UNDER SEPARABLE MIXING** (skip exercise 8.33)

4 December

Recap and discussion of the additional exercises

11 December

[26] **9.1 DEMOGRAPHY** and

9.2 CONTACTS and

9.3 THE NEXT-GENERATION OPERATOR (exercises 9.1-9.6)

[E] EXERCISES done by all and discussed as in an ordinary exercise class: 9.7-9.9

9.4 INTERVAL DECOMPOSITION – *read it yourself*

[27] **9.5 THE ENDEMIC STEADY STATE** and

9.6 VACCINATION