GRADUATE DIPLOMA IN STATISTICS

MODULE 3 – STOCHASTIC PROCESSES AND TIME SERIES

NOTE: While the RSS has made every effort to ensure that the material and information in this document is accurate and up-to-date when published, it is only general information and may be out-of-date when accessed.

Books for the Stochastic Processes section of syllabus*

Jones and Smith, Pinsky and Karlin** or Ross, Introduction to Probability Models, are texts at about the right level for the module. They also provide suitable revision of the relevant results in probability. Reference should be made to Ross, Stochastic Processes or Grimmett and Stirzaker for deeper coverage of some of the more advanced topics.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Edition</th>
<th>Title</th>
<th>Publisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ross S M</td>
<td>1996</td>
<td>2nd Ed</td>
<td>Stochastic Processes</td>
<td>Wiley</td>
</tr>
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</table>

**Early editions were by Taylor and Karlin and contained much of the same content.

Books for the Time Series section of syllabus*

The books by Janacek and by Cryer and Chan would be an excellent starting point, especially on the more practical aspects of the module. Chatfield or Kendall and Ord would also provide good introductory reading, while providing a more wide-ranging and comprehensive text. The books by Box, Jenkins and Reinsel and by Brockwell and Davis are recommended for their thorough treatment and their coverage of the required theory though both extend to advanced topics beyond the syllabus of this module. Bowerman, O'Connell and Koehler is recommended for its coverage of exponential smoothing methods and data analysis but should be complemented by a text which covers the theory.

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<tbody>
<tr>
<td>Cryer J D and Chan K-S</td>
<td>2008</td>
<td>2nd Ed</td>
<td>Time series analysis: with applications in R</td>
<td>Springer</td>
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Advice on Reading

This module provides an extended coverage of stochastic processes, including Markov chains and various forms of Poisson processes, and of time series, including ARIMA modelling.

The syllabus concentrates on underlying theory, but applications in various substantive areas are also important and will be represented in examination questions.

The advice below indicates relevant Chapters (and sometimes Sections in brackets) for a selection of the recommended books. Similar material is, of course, available in other textbooks including those on the module booklist. Candidates will be able to get a good idea of the potential range of examination questions by studying the past papers for the module.

### Stochastic processes

The references below are to relevant chapters of:

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<tr>
<td>Ross (IPM)</td>
<td>2014</td>
<td>11th Ed</td>
<td>Introduction to Probability Models</td>
<td>Academic Press</td>
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- **Introduction and general stochastic process models.**
  
  Ross (IPM) Chapter 2.9  
  Pinsky & Karlin Chapter 1 (1.1)

- **Random walks. Reflecting and absorbing barriers. Mean recurrence time, mean time to absorption. Difference equations. Use of generating functions.**
  
  Jones & Smith Chapters 2 & 3  
  Pinsky & Karlin Chapter 3 (3.5, 3.6)  
  Ross (IPM) Chapter 4 (Examples throughout)

- **Branching processes. Recurrence relations for size of n\textsuperscript{th} generation; probability of extinction.**
  
  Jones & Smith Chapter 9 (9.1 - 4)

- Poisson processes. Differential-difference equations. Birth and death processes

Queues (1) The M/M/1 queue. Differential-difference equations. Conditions for equilibrium. Equilibrium distributions of queue size and waiting time for first-come-first-served queues. *Equilibrium behaviour for queues with transition rates dependent on queue size.* Extensions to M/M/\(k\) and M/M/\(\infty\) queues. *In examination questions, the word "queue" will refer to all units in a system, i.e. those being served as well as those still waiting to be served.*

Queues (2) The M/G/1 queue, imbedded Markov chain analysis. The Pollaczek-Khintchine formula. *Equilibrium treatment only.* Mean queue length and waiting time.

**Time Series**

The references below are to relevant chapters of:

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<tbody>
<tr>
<td>Cryer &amp; Chan</td>
<td>Cryer J D and Chan K-S</td>
<td>2nd Ed</td>
<td>2008</td>
<td>Springer</td>
</tr>
<tr>
<td>Janacek</td>
<td>Janacek G J</td>
<td></td>
<td>2001</td>
<td>Arnold</td>
</tr>
</tbody>
</table>
• Time series models; trend and seasonality. *Additive and multiplicative models.*

  Cryer and Chan  Chapter 3  
  Bowerman et al  Chapters 6 & 7  
  Janacek  Chapter 1 (1.1)

• Stationarity. Autocovariance, autocorrelation and partial autocorrelation functions. Correlograms.

  Cryer and Chan  Chapters 2 & 6 (6.2)  
  Janacek  Chapter 3  
  Box et al.  Chapter 2 (2.1)  
  Bowerman et al.  Chapters 6 (6.6) & 9


  Cryer and Chan  Chapters 4 & 6 (6.2)  
  Janacek  Chapter 3  
  Box et al.  Chapters 1 & 3  
  Bowerman et al.  Chapters 6 (6.6) & 9

• ARIMA processes and Box-Jenkins methods. *Identification, estimation, checking, forecasting. Box-Pierce and Ljung-Box statistics.*

  Cryer and Chan  Chapters 5 to 9  
  Janacek  Chapters 3 and 5  
  Box et al.  Chapters 4 to 8  
  Bowerman et al.  Chapters 6, 9 & 10

• Forecasting and minimising expected prediction variance. *Exponential smoothing, Holt-Winters.*

  Janacek  Chapter 2  
  Bowerman et al.  Chapter 8  
  Box et al.  Chapter 5  
  Cryer and Chan  Chapter 9 (9.7)

• Introduction to frequency domain analysis. Spectral density function. Periodograms. *Candidates will be expected to have some familiarity with the fast Fourier transform.*

  Cryer and Chan  Chapters 13 & 14  
  Janacek  Chapters 6 & 7  
  Box et al.  Chapter 2 (2.2)

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