

CM2208: Scientific Computing

Module Introduction

Prof. David Marshall & Dr. Yukun Lai

School of Computer Science & Informatics

Outline: Scientific Computing

Module Leader : Prof. David Marshall

Lecturers : Prof. David Marshall & Dr. Yukun Lai

Full contact details on Learning Central

Course Web Site: <http://www.cs.cf.ac.uk/Dave/CM2208/>

Module Format

10 Credit Module:

- 22 lectures on key principles:
 - **2 per week**
- In-lab instruction (10 sessions):
 - 1 hour per week (from week 2)

What do you want to get out of this module?

- What do you think this module is about?
- Why are you doing this module?
- What skills from the module are important to you?
 - Why?

Any Interest in?

- Scientific Computing?

Any Interest in?

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- Signal Processing?

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- Image Processing?

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- Image Processing?
- Computer Vision?
- Multimedia?
- Computer Graphics?
- Numerical Analysis?

Module Description

- Gives a **broad grounding**
 - Basic digital signal processing (DSP)
 - Basic image processing
 - Basic Scientific Computing
 - Basic Numerical Analysis Techniques
- Applications in **signal processing/ audio, image and graphics.**
- Provides continuous mathematical and programming skills necessary for a computer scientist specialising in **Multimedia, Graphics, Image Processing or Scientific Computing.**
- Provides the **fundamental mathematical background** for an understanding of these topics.
- Underpinned by **MATLAB examples**

Underpins theory for modules in the final year

Basic Syllabus Outline

CM2208 Module Schedule

| <i>Topic</i> | <i>Lecturer</i> | <i>Number of Lectures</i> |
|---|-----------------|---------------------------|
| 1. Complex Numbers | DM | 3 |
| 2. Basic Digital Signal Processing | DM | 3 |
| 3. Basic Digital Image Processing | DM | 2 |
| 4. Fourier Transform and Its Applications | DM | 4 |
| 5. Numerical Analysis | YL | 8 |

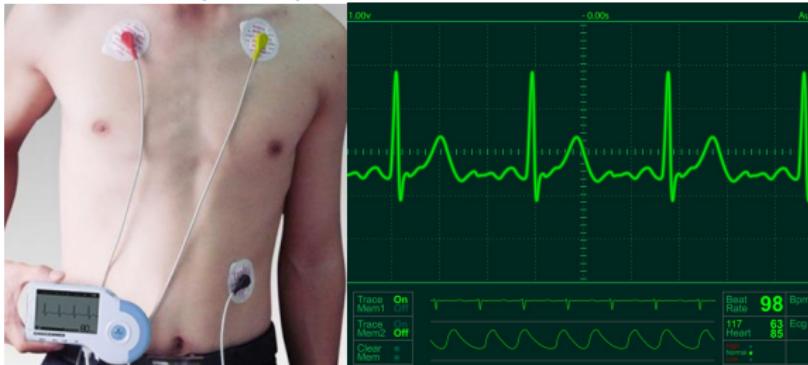
DM = David Marshall, YL = Yukun Lai

Selected Example Applications

- Digital Signal Processing: Medicine: EEG, Heart Rate, ECG.
Audio: Synthesis (making sounds), Audio Effects, Analysis
(e.g. Speech Recognition)
- Image Processing/Computer Vision: Images = 2D matrices,
Tracking objects, Object Recognition, Image Analysis, Camera
Calibration ...
- Data Compression: Use Data Statistics to compress data
(Signal and Imagery/Video): GIF, JPEG, MPEG,
Image/Video/Audio Compression, Vector Quantisation,
security coding/transmission.
- Numerical Analysis — scientific computing and practical
Scientific Computing
- Computer Graphics: Transformations, moving object around
the screen, 3D deformations ...

Digital Signal Processing Example: Medical

Electrocardiogram (ECG):

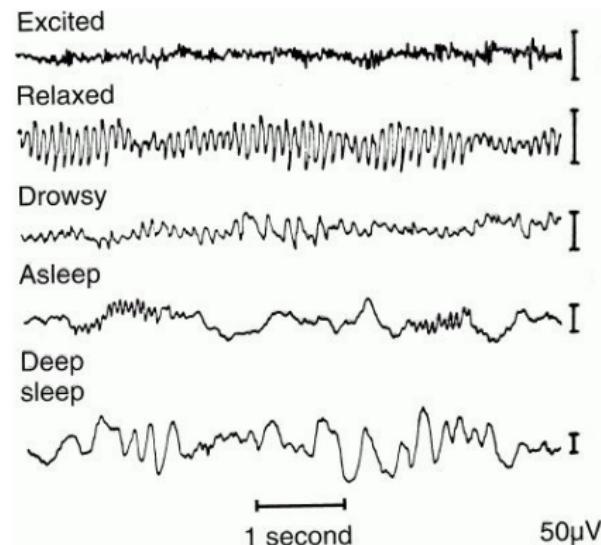


Smart Watch Heart Rate Monitor:

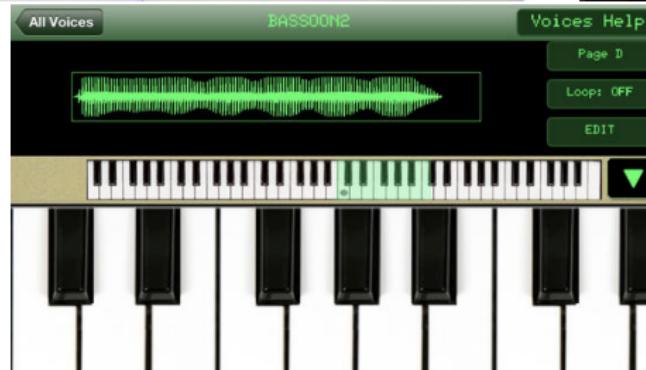


Digital Signal Processing Example: Medical

Electroencephalogram (EEG) :

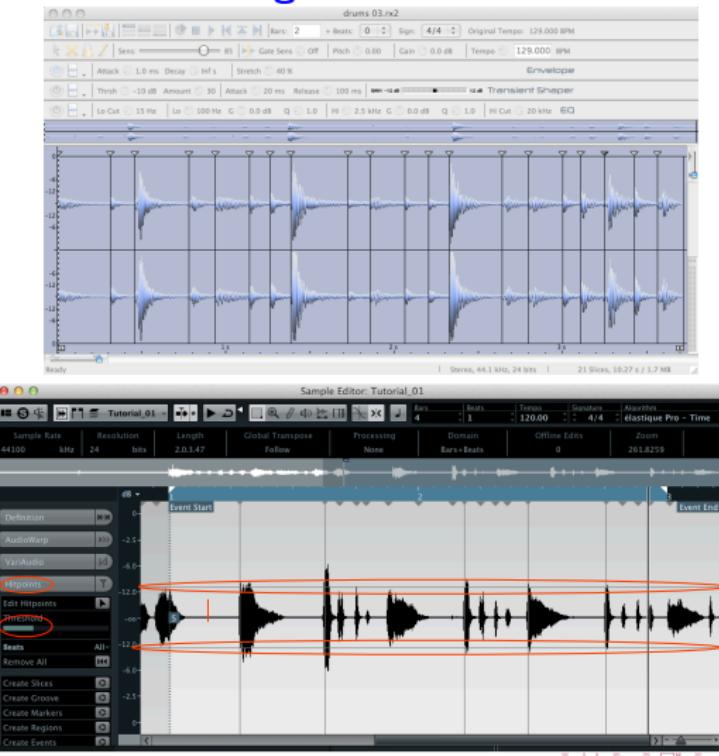


Audio Synthesis Example

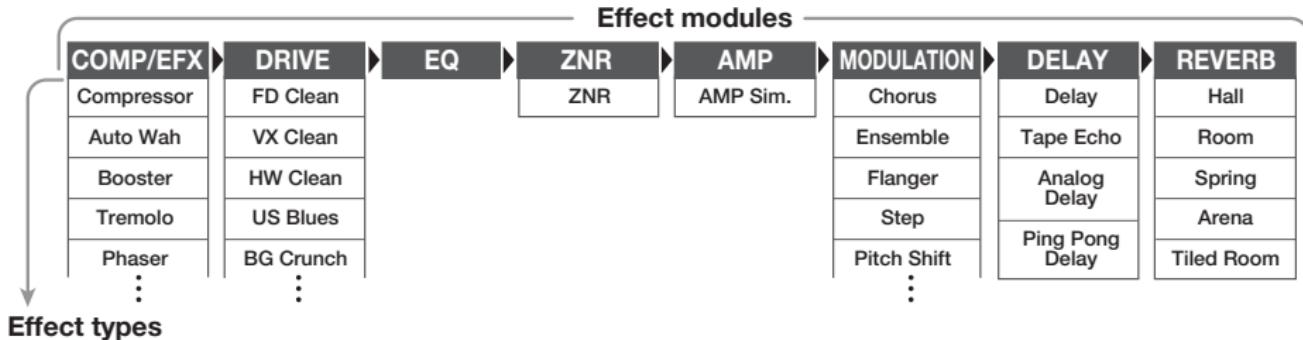


Audio Analysis/Editing

Beat Detection and Slicing:



Audio Effects



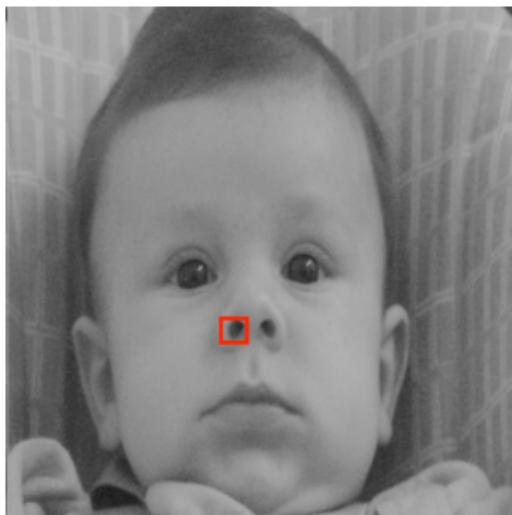
Speech Recognition Example



Speech Recognition + Synthesis Example

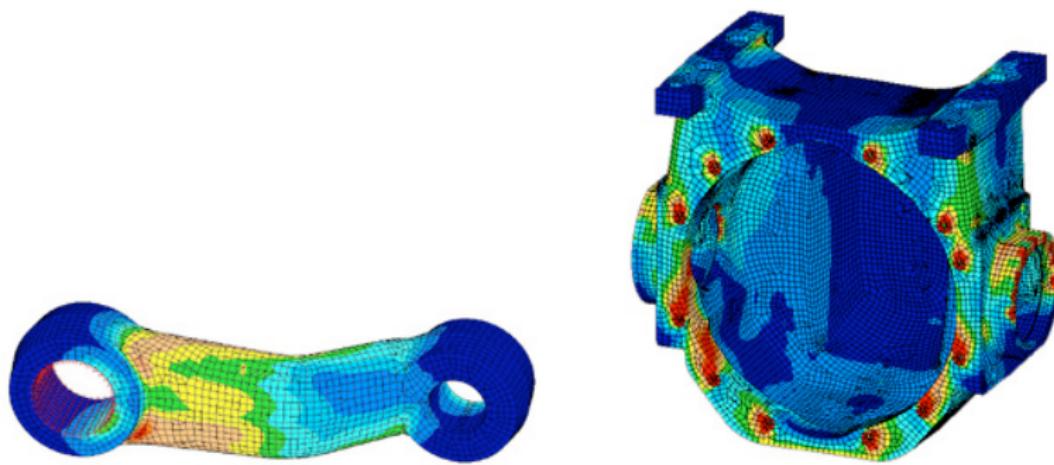


Image Representation: Matrices Example

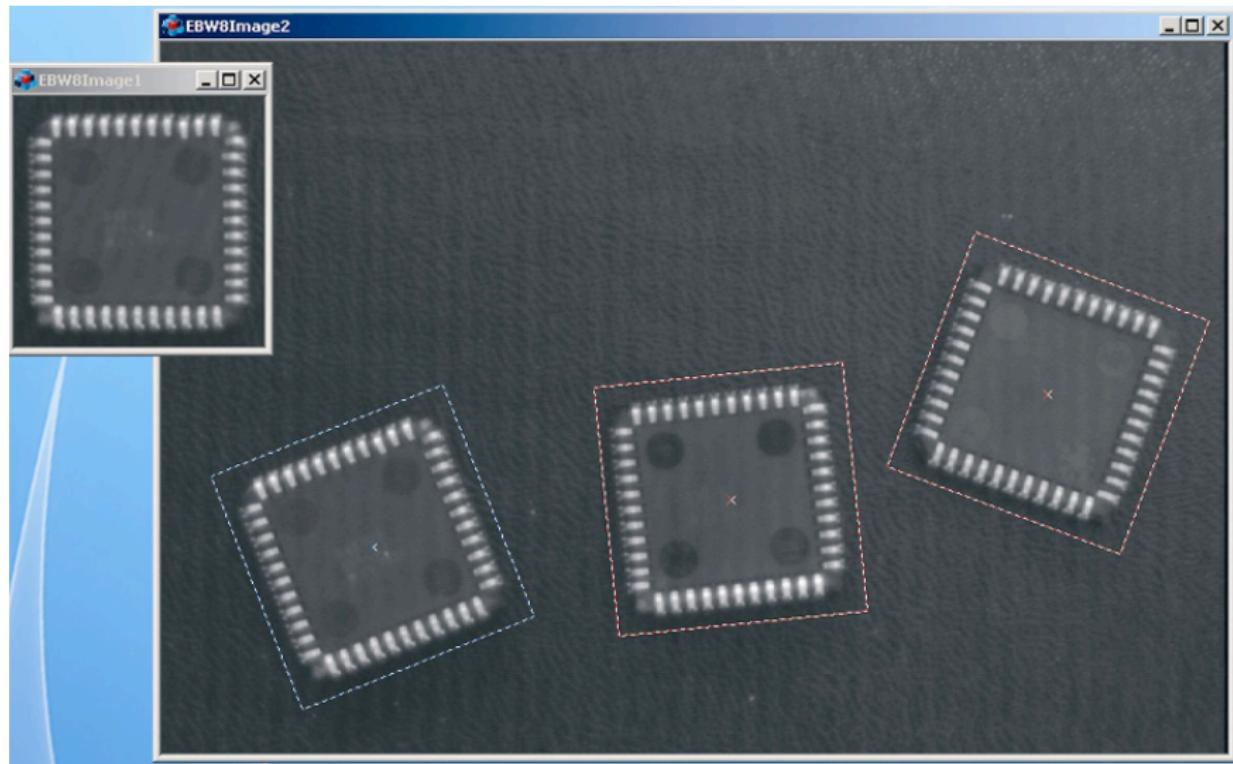


| | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 99 | 71 | 61 | 51 | 49 | 40 | 35 | 53 | 86 | 99 |
| 93 | 74 | 53 | 56 | 48 | 46 | 48 | 72 | 85 | 102 |
| 101 | 69 | 57 | 53 | 54 | 52 | 64 | 82 | 88 | 101 |
| 107 | 82 | 64 | 63 | 59 | 60 | 81 | 90 | 93 | 100 |
| 114 | 93 | 76 | 69 | 72 | 85 | 94 | 99 | 95 | 99 |
| 117 | 108 | 94 | 92 | 97 | 101 | 100 | 108 | 105 | 99 |
| 116 | 114 | 109 | 106 | 105 | 108 | 108 | 102 | 107 | 110 |
| 115 | 113 | 109 | 114 | 111 | 111 | 113 | 108 | 111 | 115 |
| 110 | 113 | 111 | 109 | 106 | 108 | 110 | 115 | 120 | 122 |
| 103 | 107 | 106 | 108 | 109 | 114 | 120 | 124 | 124 | 132 |

Algebra/Graphs Example: Finite Element Modelling



Matrices Example: Object Registration/Matching



Matrices Example: Image Warping (Transformation)



Matrices/Vector Example: Image Compression



Relevant Final Year Modules

Precursor Module for Year 3 Modules

CM3106 Multimedia

CM3113 Computer Vision

CM3114 Computer Graphics

which either use MATLAB as a base programming language and/or build on some theory developed in this module.

Some potential relevance to:

CM3203 : Individual Project

Lecture Schedule

| | | |
|---------|------------------|---|
| Week 1 | 1 | 1 |
| Week 2 | 1 | 2 |
| Week 3 | 2 | 2 |
| Week 4 | 3 | 3 |
| Week 5 | 4 | 4 |
| Week 6 | 4 | 4 |
| Week 7 | 5 | 5 |
| Week 8 | 5 | 5 |
| Week 9 | 5 | 5 |
| Week 10 | 5 | 5 |
| Week 11 | Flexible/Catchup | |

| Topic |
|---|
| 1. Complex Numbers |
| 2. Basic Digital Signal Processing |
| 3. Basic Digital Image Processing |
| 4. Fourier Transform and Its Applications |
| 5. Numerical Analysis |

Assessment

| Type | % | Title | Approx. Date of Assessment |
|-----------------------|----|-------------------------|------------------------------------|
| Written Assessment | 30 | Individual Project Work | Hand out: Week 4; Hand in: Week 11 |
| Examination (2 hours) | 70 | Examination | Autumn Exam Weeks |

Recommended Reading

- DAFX: Digital Audio Effects, U. Zölzer, John Wiley and Sons Ltd (2002) ISBN 013-978-0471490784
- Digital Signal Processing using MATLAB, V Ingle and J Proakis, Brooks Cole Thomson Learning, (2000) ISBN 013-978-0534371746
- Digital Image Processing Using MATLAB, Gonzalez, Woods and Eddins Prentice Hall, ISBN 9780982085400 (2009)

All books in library: Plenty of other related books there too

Recommended Reading

DAFX: Digital Audio Effects

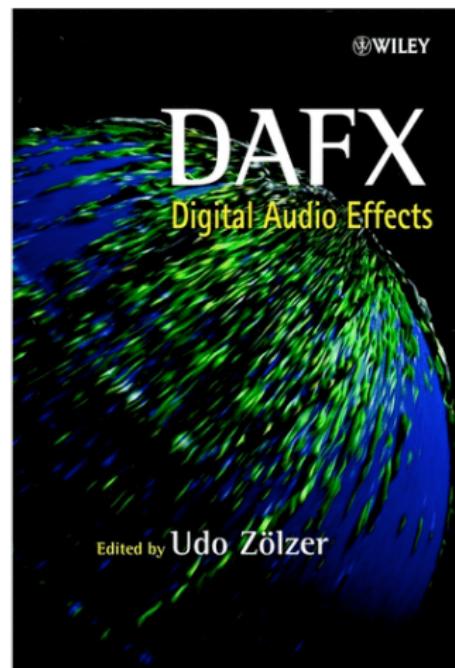
Udo Zölzer

John Wiley and Sons Ltd , 2002
(ISBN-13: 978-0471490784)

Excellent coverage of audio signal processing effects and synthesis plus a lot more

All MATLAB examples

Copies in library



Recommended Reading

Digital Signal Processing using MATLAB

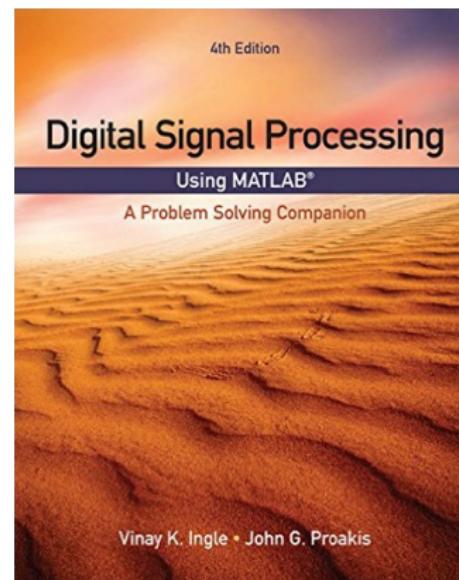
V Ingle and J Proakis

Brooks Cole Thomson Learning,
2016
(ISBN-13: 978-1305635128)

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Recommended Reading

Digital Image Processing Using MATLAB

Rafael C. Gonzalez,

Richard E. Woods,

and Steven L. Eddins

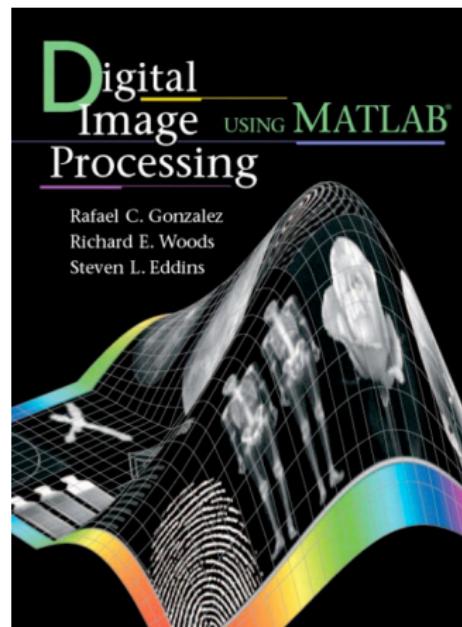
Prentice Hall, 2004

(ISBN-13: 978-0130085191)

*Excellent coverage of Image
processing examples*

All MATLAB examples

Copies in library



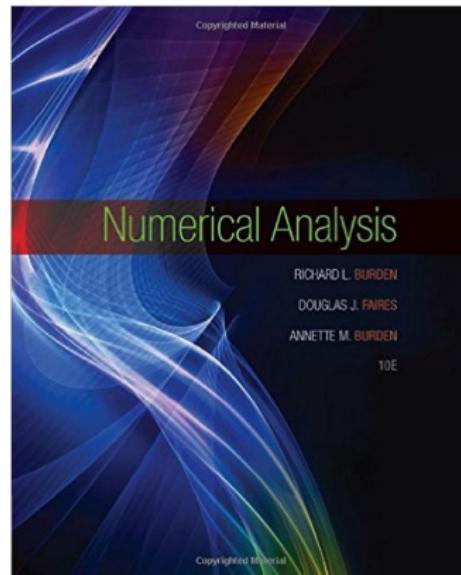
Recommended Reading

Numerical Analysis

Richard L. Burden, J. Douglas Faires and Annette M. Burden
Cengage Learning, 2016
(ISBN-13: 978-0-538-73351-9)

Excellent coverage of Numerical Analysis topics

All MATLAB examples
Copies in library



Recommended Reading

MATLAB Programming for Numerical Analysis

Cesa Lopez

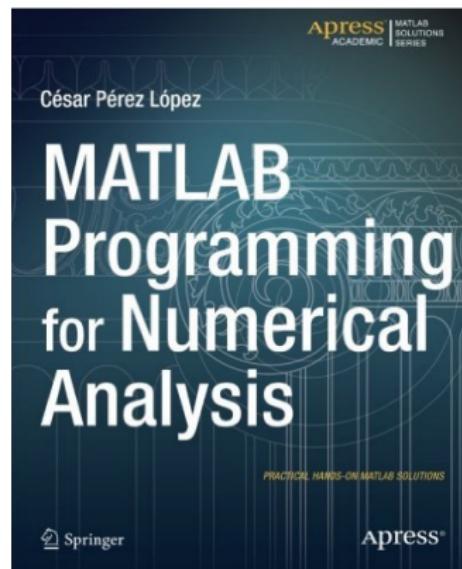
Apress, 2014

(ISBN-13: 978-1-4842-0295-1)

Excellent coverage of Numerical Analysis topics

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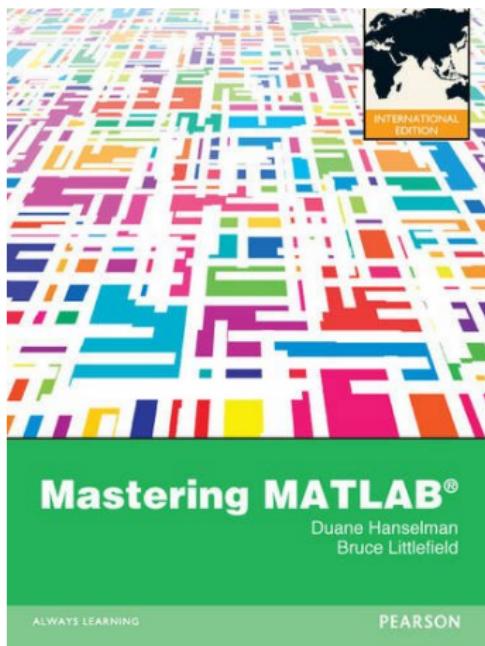


Useful Reference

Mastering MATLAB

Duane C. Hanselman and Bruce L. Littlefield
Pearson Education, 2012
(ISBN-13: 978-0273752134)

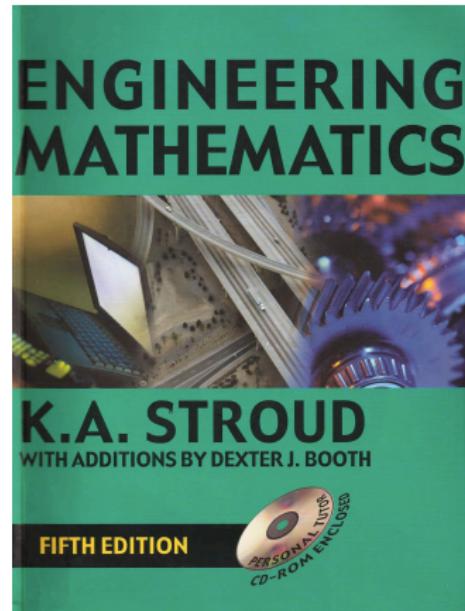
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Useful Reference

If you need more Maths:
Engineering Mathematics,
K.A. Stroud and Dexter – Any
Edition Cover the Material.

- General Maths



Library well stocked these with other relevant Maths Books