University of Nottingham

Computer Programming with MATLAB

MM1CPM – Welcome!

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Autumn 2014

www.facebook.com/mm1cpm

Outline of the lecture

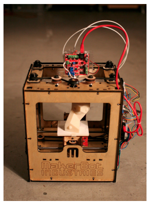
- **Why do I need to learn to program a computer?**
- Examples of computing in Engineering.
- About the module
- Introduction to programming
- First steps with MATLAB

Why do mechanical engineers need to learn to program computers?

- Think of, Jet engines, ABS brake systems, air bags, aircraft control systems, 3D printers etc.....
- There is almost no device that you as a mechanical engineer will design that does not have a computer in it.
- Very often computer scientists won't understand the device well enough to write a program to control it – this means that **you** as the engineer will have to do it.

Jet engine – FADEC

Can you spot the computers?


http://www.flickr.com/photos/bre/3458247336/

MakerBot -3D printer

What will you lean in this module?

- This module will teach you to how to **write your own programs for computers in an language called MATLAB**.
- This module is about giving you a **tool box** of simple but very powerful computing concepts.
- This will enable you to easily **solve extremely complex engineering** problems which are impossible to solve with pen and paper – and robots.
- Computer programming for an engineer is about making your life easier **– so we don't have to spend our day doing mathematics**!

Erik Strandberg

Outline of the lecture

- Why do I need to learn to program that's the computer scientists job isn't it?
- **Examples of computing in Engineering.**
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Computers in engineering 1: Controlling objects

- Rocket flight is expensive this is because **rockets can only be used once**.
- Can you imagine how expensive traveling by bike would be if you had to throw your bicycle away each time you used it?
  - The answer reusable rockets (Video).
- In this video the computer is constantly adjusting the direction and thrust of the rocket motor to stop the rocket crashing to the ground.
- A mechanical engineer wrote the program to do that.

NASA

Computer failure: Russian Proton-M

Computers in engineering 2: Simulating the real world

•Crash testing cars is very expensive!

•A way around this is to do the simulations on computer, then only do one crash test.

•Video.

•An engineer will have written the program to do this crash test or at the very least modified a program to make it work how he want's it to work.

•Often as an engineer you will have to modify code to make it do what you want it to do.

Insurance Institute for Highway Safety

Computers in engineering 3: Acquiring data from experiments and processing it

•Very often you will have an experiment where you need to record many temperature, pressure, airflow readings at the same time. The only way to do this is to write ***your own*** computer program.

•After you have collected the data you will need to process it to understand what it means.

•MS Excell will only get you so far, almost always as a professional engineer you will have to write ***your own code*** (MATLAB) to process the data.

•You will use MATLAB throughout your course, to plot graphs, process data, control robots, do simulations. It's well worth learning!

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How are we going to learn MATLAB?

•Every week we will have a **one hour lecture in this room**.
- •In this lecture I will introduce the concepts of computer programming and we will go through examples.

•Then following this you will have a **two hour lab session** where you can **practice these concepts**. This will be in Coates **C20** (95 computers), Coates **C19** (100 computers), **POPE A-14** (70 computers).

•There will be **8 demonstrators (and me)** on hand to help you with any questions you may have.

•I will give you work sheets to work through every week.

•The work sheets are staggered to allow for different speeds of learning. Don't worry if you can't finish them – use any questions you don't finish for exam revision later.

How do you get your marks?

•There will be two pieces of coursework and an exam

- •**Coursework 1 (20%)**
  - •You should have a copy of this now.
  - •You will have four weeks to finish it
- •**Coursework 2 (20%)**
  - •Will be handed out in five weeks time
  - •You will have four weeks to finish it.
- •**Exam (60%)** 1.5 hr written exam will be in January
  - •Exam timetables not published yet.

Note the pass mark is only 40%, so you can actually pass this module by just doing the coursework alone... but I don't recommend trying this, please come to the exam too!

Everybody passes this module, I want you to focus on enjoying learning this new skill.

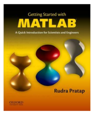
Supporting material

•You will find all the lecture notes and example sheets on **moodle**.

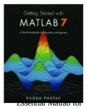
•Everything in the lecture notes and example sheets could be in the exam.

•On the moodle site are also a couple of quick start guides some more in depth than others.

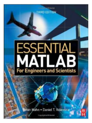
•You don't need a book to do well in this subject, but some people find these helpful**:**



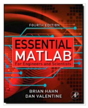
Getting Started with Matlab. R Pratap, Oxford University Press (2010), ISBN 0199731241.



Essential Matlab for Scientists and Engineers. Brian D Hahn and Daniel T Valtentine, Elsevier (2009), ISBN 0123748836.


THIRD EDITION
ESSENTIAL
MATLAB
For Engineers and Scientists
Brian Hahn • Daniel T. Valentine

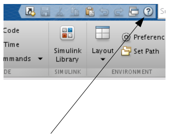
Getting Started with Matlab 7. R Pratap, Oxford University Press (2006), ISBN 0-19-517937-4.



Essential Matlab for Scientists and Engineers. Brian D Hahn and Daniel T Valtentine, Elsevier (2002), ISBN 0-7506-84178, and also 2007 edition.

Supporting material

George Green Library



Matlab help function

Google/youtube

•When ever I am stuck with a computer problem I always find the answer via ***google***.

•Because this is a computer based subject **everything is on the internet** – don't underestimate this when later when working on your 3rd/ 4th year projects.

Help!

•If you get stuck on example sheets during the week or have general questions please bring your questions to the 2 hour lab (after this lecture). This is the best way to get help. We are here to help you!

•If you feel that you are falling behind at all or feel over whelmed please e-mail me *roderick.mackenzie@nottingham.ac.uk*, so I can advise corrective action.

•Facebook general discussion page:

https://www.facebook.com/mm1cpm

•If I see that more a few people are discussion one question I will try to cover it in the lecture again.

You can also get hold of me via twitter: @rcimackenzie #MM1EM1

Coursework 1

•You should have in your hand, **coursework 1** and the **preliminary mark scheme for coursework 1**.

•The coursework is designed to help you learn and embed what we cover in the first three lectures.

•By the end of next week you should be able to do most of the coursework but not the last question.

•The deadline for the work is on the 5th November 2014, at 3pm via Moodle.

Plagiarism

- The coursework for this module is individual work not group work.
- Work handed in must be entirely your own and not copied from anyone else. By all means discuss the coursework with your friends BUT then go away and write the programs yourself.
- Please, please, please, please, please don't send your answers to coursework to other people. You don't know what they will do with them.
- I once had a case where 17 people handed in the same work.

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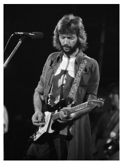
Is programming difficult?

•**No not really**.

•Most of it is common sense, can you guess what these MATLAB commands might do?

•**beep**, **plot**, **save**

•However, when learning MATLAB you must recognize that it is ***different*** from anything you have done before. **Unlike Maths and Physics**, it is **brand new** and will require **practice** and **patience**.



Eric-Clapton 1975

photo: Matt Gibbons

•Learning programming is a bit like learning a **musical instrument**, the music teacher can **explain** to you how to **play music** and show you. But you can only become great by having a go and **practicing**.

Thinking like a programmer

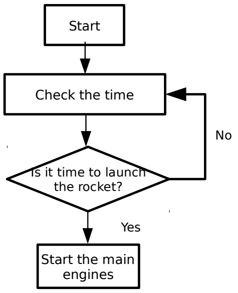
•Writing computer code and remembering commands is easy!

•The tricky part is understanding how to break a real world problem down into manageable chunks which you can program.

•Before we start with programming. Let's have a look at breaking down some problems into flow diagrams...

Launching a rocket

•This simple program decides if it is time to launch a rocket...



•Square boxes represent operation or things that happen.

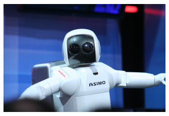
•Diamond boxes represent questions or decisions.

•Follow the program through from the start, note the computer only does one thing at a time.

•Computers only do one thing at a time and follow the program.

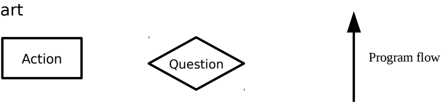
•Your go!

Making a cup of tea



•Making a cup of tea has the following steps. In groups of three draw a program diagram for a robot to follow to make a cup of tea, it should have the following steps:

- •Add mink
- •Is the tea the correct strength?
- •Switch on the power to the kettle
- •Has the water boiled
- •Poor the water into the cup
- •Fill the kettle with water
- •Finish
- •Start



Making a cup of tea

André Karwath

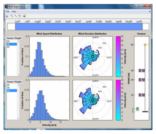
Part 2 – MATLAB first steps

- **•Frist steps in MATLAB**
- •Basic mathematics in MATLAB
- •Variables
- •Scientific notation
- •Built in fuctions

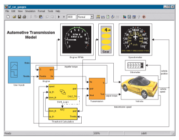
MATLAB is a very powerful tool and can be used to automate the solution of any engineering problem.

- Improve aerodynamic design of a wing
- Write graphical user interfaces
- Control whole factories
- Design car transmission systems

Steve Jurvetson



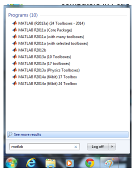
Mathworks



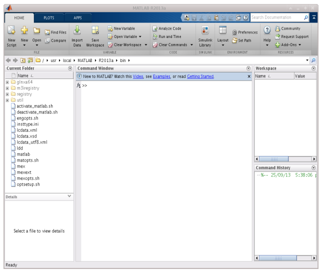
But before you can run we need to learn how to walk….

Starting MATLAB

- MATLAB can be found on all University of Nottingham computers.
- Click on the start menu
- Type MATLAB
- Select **MATLAB 2014a 64bit**
- You will then get this window

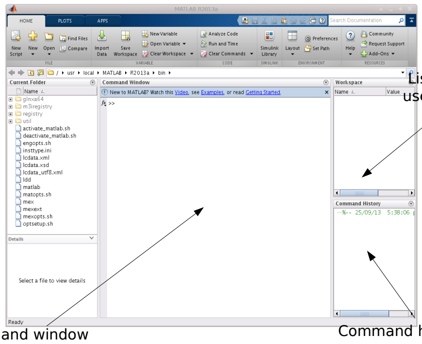


Programs (10)
MATLAB (R2013a) (24 Toolboxes - 2014)
MATLAB R2011a (Core Package)
MATLAB R2011a (with many toolboxes)
MATLAB R2011a (with selected toolboxes)
MATLAB R2012b
MATLAB R2013a (10 Toolboxes)
MATLAB R2013a (17 toolboxes)
MATLAB R2013a (Physics Toolboxes)
MATLAB R2014a (64bit) 17 Toolbox
MATLAB R2014a (64bit) 24 Toolbox
See more results
matlab



- There are various versions of MATLAB I'm using R2013a – but you can use which ever one you like.

The main MATLAB window



New to MATLAB? Watch this Video, see Examples, or read Getting Started.

```
>>
```

List of all used variables

Command window

Command history

Part 2 – MATLAB first steps

- Frist steps in MATLAB
- **Basic mathematics in MATLAB**
- Variables
- Scientific notation
- Built in fuctions

Let's have a play

- MATLAB is controlled using commands typed into the command window.
- For example if we want to know what 8 multiplied by 3 is we would type:

> 8*3 **<enter>**

- Examples of other mathematical operators

>7/10	<**enter**>	dividing
>7^3	<**enter**>	raise to the power
>3+7	<**enter**>	adding
>(3+7)/4	<**enter**>	brackets

- Mathematics on a computer is identical to mathematics with pen and paper. However...

Youtube example

You must tell MATLAB exactly what to do...

- For example if we wanted to know what 2(1+3) was, we would have to type:

  > 2*(1+3) **<enter>**

This (below) would not work, can anybody guess why?

>> 2(1+3) <**enter**>

You must tell MATLAB exactly what to do...

- For example if we wanted to know what 2(1+3) was, we would have to type:

```
> 2*(1+3) <enter>
```

This (below) would not work, can anybody guess why?

```
>> 2(1+3) <enter>
```

- It would not work because we have not told it exactly what to do
  - We have missed out a multiply – computers can't guess.
- Think of the programmer and the 6 pints of milk.

Part 2 – MATLAB first steps

- Frist steps in MATLAB
- Basic mathematics in MATLAB
- **Variables**
- Built in fuctions
- Scientific notation

Variables

- Imagine I said to you:

Solve the equation in mathematics

y=a+b+c for **a=1, b=2, c=3**

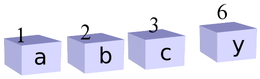
- You would be able to do it very easily.
- What's the answer?
- In MATLAB it's also very easy.....

Variables

- You would type:

```
> a=1 <enter>
> b=2 <enter>
> c=3 <enter>
> y=a+b+c <enter>
        y=6
```

- That's it.
- In MATLAB the letters **a, b, c** and **y** are called **variables**



Variables

- You can call variables anything you want to

```
> alfred=1 <enter>
> bob=2 <enter>
> chris=3 <enter>
> yan=alfred+bob+chris <enter>
        yan=6
```

- But some variable names are not allowed, for example spaces are not allowed so are variables starting with numbers.

chr is ✗ 1chris ✗

Variables – another example

- Imagine I said to you: Solve the equation

$y=4a^4+2b^3+2c^2$ for **a=1,b=2, c=3**

- In MATLAB this is easy, just type:

```
> a=1 <enter>
> b=2 <enter>
> c=3 <enter>
> y=4*(a^4)+2*(b^2)+2*(c^2) <enter>
```

Youtube example

More variables...

•Note '=' sets the variable on the **LHS** equal to the **RHS**

> a=1 ✓

> 1=a ✗

(computers are very fussy – and expect code in a certain way)

•If you want to see what variables you have previously defined you can type

who <enter>

If you have defined too many variables and you want to get rid of them all simply type

clear <**enter**> (You will play with these functions in the lab.)

Built in functions

•Matlab already knows lots of mathermatical functions:

```
>sin(0)          %sin of zero
>sin (1)         %sin of one
>sin (pi/2)      %sin of pi/2
>cos (pi/2)      %cos of pi/2
>sqrt(2)         %This command is very useful you guess what it is?
>exp(1)          %exponential of 1
>log(10)         %log of 10
>log(exp(10))    %log of exponential of 10
>cosh (4)        %cosh of 4
>asin(0.5)       %asin of 0.5
>acos(0.5)       %acos of 0.5
etc.....
```

•Notice that MATLAB already knows about sin,cos, asin etc... these are called **built in functions** – you can guess what most commands do just from the name.

•MATLAB also knows about ***pi*** this is a **built in constant**.

A word on brackets

Note different types of brackets mean different things in MATLAB, functions will only accept curved brackets

sin(0)

Don't try use any other type of bracket with functions:

~~{ } [ ] < >~~

It will not work!

We will cover what these brackets mean later.

Variables – your go!

Q1: Write the MATLAB commands to solve the following equation using MATLAB for a=1,b=2,c=3,d=4:

$$y=\frac{a^4+b^3}{c+d}$$

Q2: What would you type to evaluate,

$$y=\cos(x)+(20+2x)3$$

at x=100.7

Variables – answers

Part 2 – MATLAB first steps

- Frist steps in MATLAB
- Basic mathematics in MATLAB
- Variables
- Built in fuctions
- **Scientific notation**

Scientific notation

- If you wanted to type in one million. You could type but this means I have to press 7 keys, which is a lot of work!

```
> 1000000
```

- But MATLAB can understand scientific notation
  - So a quicker way to type this would be to type

```
> 1e6
```

(only three keys – much better!)

- Can you see what we have done? **The 'e' represents x10**
- Other examples could be

```
>3e8 as 3x10^8
>4.123e4 as 4.123x10^4
```

Summary

- In today's lecture we have covered:
  - How computers are used in engineering.
  - That computers follow instructions exactly(!)
  - We have learnt that problems need to be broken down into steps to be solved by a computer.
- We have learnt the basics of MATLAB
  - Know how to convert a mathematical equation in to a MATLAB code.
  - We now know how to evaluate equations
  - We have learnt about scientific notation.

Off to the lab..

- Please now go to the labs, the demonstrators will be there already and I will be there in a moment.
- I have booked the computer rooms for you, if there are other students, not in this class, using the computers and you can't find your own. Please politely ask the students to leave.

Can I please see all the students who were in the foundation year last year AND all students who are taking this module as an option.