EECS 1011 – Lab C: Two-Dimensional Plots in MATLAB

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Summary: Get some practice doing 2D plotting in MATLAB.

Pre-Lab: Do the following before the lab:

1. Look over Section 3.5.1 (plotting) Attaway's 2019 MATLAB book
    a. Connect to the Library's entry and select "**view full text**"
    b. Link: https://ocul-yor.primo.exlibrisgroup.com/permalink/01OCUL_YOR/mc13rm/alma991030744509705164
    c. "Short" links: https://tinyurl.com/y5qd8a4e or https://bit.ly/2QlJ1cd
2. Make a graph
    a. Execute the code for plotonepoint.m from Ch. 3
    b. "print to PDF" the figure.
    c. Submit the figure to eClass under the Lab C heading.
3. Explore Maple software for analytic math
    a. Use it online (or buy the app, if you want)
    b. Intro video to Maple :
        i. https://youtu.be/eHVBQisWDNE
    c. Use YorkU's "App Anywhere" to use Maple on the web:
        i. https://myapps.yorku.ca
    d. Example of Maple online for differentiation
        i. https://maple.cloud/app/14675100

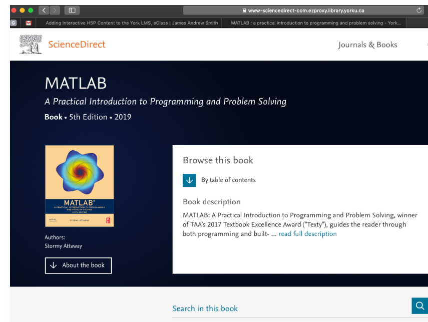


Figure 1 Use the Stormy Attaway book. It's fantastic! And it's free through the YorkU Library: https://bit.ly/2QlJ1cd

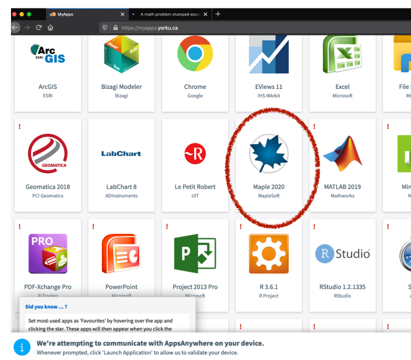


Figure 2 You can access Maple from YorkU's https://myapps.yorku.ca

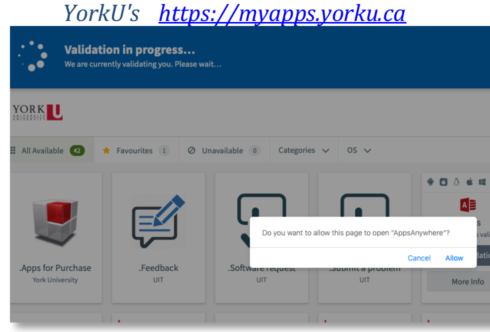


Figure 3 Download the AppAnywhere application and make sure (1) it's running in parallel to your browser and (2) that you give your browser permission to use it.

Intro

The lab is divided up into two parts:

- **Part 1**: Sketch, by hand, plots of a function and its derivative.
- **Part 2**: Draw the equations *from Part 2* in MATLAB.

We'll be looking at "derivatives" a topic that you'll also cover in your Calculus class. Intuitively, you already know the concept, even if you don't know the strange name. The derivative of a series of data is the "rate of change" of that data… the *speed* of the data. Is the graph's slope steep? Then the derivative is big. Is the slope shallow? Then then derivative is small.

Maple, the math program, can take an equation and spit out another equation that describes the derivative. We can then feed that equation into Matlab to see what it looks like graphically. Maple is available to you via YorkU's AppAnywhere webpage. But first, let's focus on plotting…

Why are we doing a lab on plotting? Because **visualizing data is important** in <u>all</u> engineering disciplines. For example, we program equations and their derivatives into robots to make their joints move in a particular way. Visualizing these trajectories (and their first, second and third order derivatives) allows us to analyze how smooth the motion will be. Comparing desired and actual movements allows us to debug robot behavior when things go wrong. In later labs you will have to interface hardware to MATLAB and plots will be used to visualize data from the hardware and will help you debug when things don't work out like you planned.

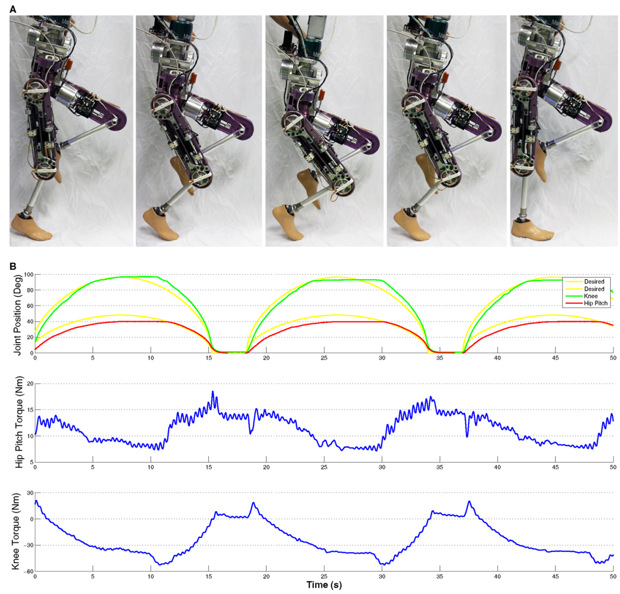


Figure 4 A robot's joints are programmed to follow equations (source: http://bit.ly/2bVEHw4)

Due date. Submit a one page lab report to eClass by Sunday, September 27, 2020 at 11:55pm.

Marking Guide: see the eClass page for a breakdown.

Lab Instructions

Part 1: Hand-Sketch a Function and its Derivative

Figure 5 You need derivatives of the robot joints during surgery, otherwise you'll poke a hole in your patient! (c/o https://bit.ly/32m4s28)

Whether you're controlling a robot arm joint, a prosthetic leg joint, or the descent of a rocket onto a floating barge, it's important to get your derivatives right! Often, you start with an equation that describes desired trajectory (position over time) and then you calculate the derivative of that equation to see the desired rates of chang within that equation. Basically, we can ensure that the joint motion will be smooth by looking at the derivatives of the original equations. Here, you will take an equation, in analytical form, and then find its derivative. Then you will sketch both equations.

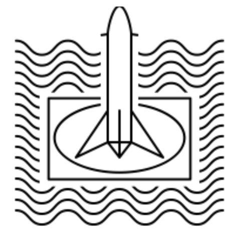
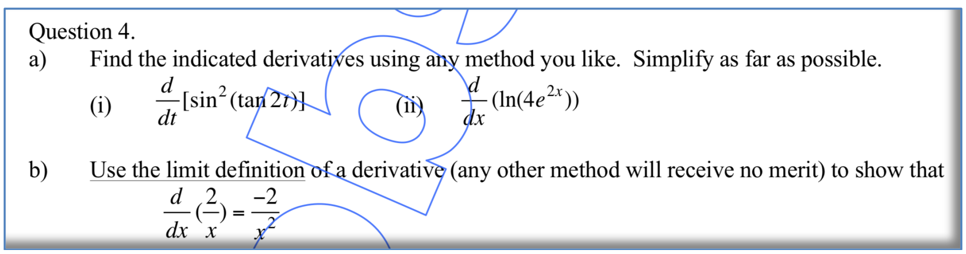


Figure 6 Controlled descent of a rocket requires measuring speed (i.e. the deriviative of position) (c/o https://bit.ly/34CnVPa)

You'll encounter derivatives and graphing of functions in your first Calculus class, MATH 1013. Here's a sample question from the 2009 final exam (http://www.math.yorku.ca/~lamzouri/pastexams.pdf).



Question 4.

a) Find the indicated derivatives using any method you like. Simplify as far as possible.

(i) $\frac{d}{dt}[\sin^2(\tan 2t)]$ (ii) $\frac{d}{dx}(\ln(4e^{2x}))$

b) Use the limit definition of a derivative (any other method will receive no merit) to show that $\frac{d}{dx}(\frac{2}{x}) = \frac{-2}{x^2}$

Figure 7 Example question from a previous MATH 1013 test. Derivatives are common in engineering!

From the following table, look up your lab section and the function associated with it. Take note of the boundary values for the x-value. There are differences in the boundaries based on your last (family) name.

Lab Section	**Original Equation**	**MATLAB version of the Equation**	**Maple Version of the Equation**	***x*-value Boundaries** *(for the horizontal axis)*		
		(note the periods in some equations)	*(note the colons in the equations)*	**Your Last Name (A to H)**	**Your Last Name (I to O)**	**Your Last Name (P to Z)**
Sect. 1	y = x^3+x+1	y = x.^3+x+1	y := x^3+x+1	-10 to -5	-5 to +5	+5 to +10
Sect. 2	y = 1/(x*(x-3))^3	y = 1./(x.*(x-3)).^3	y := 1/(x*(x-3))^3	-4.3 to -0.3	0.3 to 1.3	3.3 to 5.3
Sect. 3	y = x-sqrt(x)*sin(x)	y = x-sqrt(x).*sin(x)	y := x-sqrt(x)*sin(x)	0 to pi/2	pi/2 to pi	pi to 3*pi/2
Sect. 4	y = 4*x-tan(x)	y = 4.*x-tan(x)	y := 4*x-tan(x)	-4 to -2	-pi/4 to pi/4	2 to 3
Sect. 5	y = x*sqrt(5-x)	y = x.*sqrt(5-x)	y := x*sqrt(5-x)	-10 to -5	-5 to 0	0 to 4
Sect. 6	y = (1+2)*cos(x)-2*cos((1+2)*x)	y = (1+2)*cos(x)-2*cos((1+2)*x)	y := (1+2)*cos(x)-2*cos((1+2)*x)	-pi/2 to 0	0 to pi/2	pi to 3*pi/2
Sect. 7	y = (x^3-3^3)^(1/3)	y = (x.^3-3.^3).^(1/3)	y := (x^3-3^3)^(1/3)	3.5 to 5.5	5 to 7	7 to 9
Sect. 8	y = cosh(x)	y = cosh(x)	y := cosh(x)	-6 to -2	-2 to +2	+2 to +6
Sect. 9	y = sqrt(2*x+3)	y = sqrt(2.*x+3)	y := sqrt(2*x+3)	-1 to 1	1 to 3	3 to 5
Sect. 10	y = 3*x^2+5	y = 3*x.^2+5	y := 3*x^2+5	-10 to -5	-5 to 0	0 to 10
Sect. 11	y = 3*x^2+4*x-3	y = 3*x.^2+4*x-3	y := 3*x^2+4*x-3	-10 to -5	-2 to +2	+2 to 10
Sect. 12	y = (1+2)*cos(x)-2*cos((1+2)*x)	y = (1+2)*cos(x)-2*cos((1+2)*x)	y := (1+2)*cos(x)-2*cos((1+2)*x)	-pi/2 to 0	0 to pi/2	pi to 3*pi/2

To find the derivative, here are some options:

1. Do it manually, on paper, based on your Calculus knowledge

2. On your own computer, use **Maple** on York's "**AppAnywhere**" system
   a. Watch the 2 minute Maple tutorial on YouTube. (https://youtu.be/eHVBQisWDNE)
   b. Go to Maple in AppAnywhere (https://myapps.yorku.ca/login)
   c. Open a Worksheet.
   d. Type in the equation.
   e. Remember to use ":=" (without the quotation marks) as the "equal sign"
   f. Remember that when you type in "*" for the multiplication, it will show up as a dot.
   g. Use your mouse / trackpad to highlight the equation.
   h. Right-click on the equation
   i. Select Plots and then Plot Builder
   j. In Plot Builder, set your x-axis boundaries.
   k. Click on Plot.

3. Online, with a Maple App:
   a. **Maple** online differentiation app: https://maple.cloud/app/14675100

Now you have to **sketch the plot for the function, by hand**. Having a little trouble? Load up Maple on AppAnywhere for help.

Now**, sketch the first plot, by hand, on paper**. Second, take the **derivative** of the function and **plot it.** Make sure to only plot between the x-value boundaries specified for you.

If you are having trouble calculating the derivative of the function, head back to Maple on AppAnywhere and following the instructions in the YouTube video (https://youtu.be/eHVBQisWDNE) .

Log in to the video conference for your lab session and **show your TA** the **hand sketched plots**. Use this as an opportunity to ask your TA any questions you may have about plot generation in MATLAB.

Part 2: Draw Two Plots in MATLAB

Now you will need to convert the equations from Part 1 into a form that is suitable for plotting in MATLAB. You will need to extract discrete points from the equations and create your plots from these points.

Here's an example. Given an equation, y = 2*x, find the value of y for 11 values of x. These 11 values of x need to be between the certain boundaries. In this case, from 1 to 6. So if your x-axis boundary values are 1 and 6, then you need to plot for x=[1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0]. Then, write out your equation in MATLAB, y as a function of x. If y = 2*x and you need 11 datapoints from 1.0 to 6.0 do the following:

```
>> x=[1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0]
```



```
>> y=2*x
```


Then, to **plot it**, do the following:

```
>> plot(x,y)
```


And you should get a plot of the function on the screen.

Let's do the same thing for your function and its derivative. **Create two MATLAB plots**:

- The **first** is for the original function from Part 2
- The **second** is for the derivative of that function.

Each time you call MATLAB's plot() function, a new figure window should appear. When the plot is done, you will need to export it. In the File menu of the plot window choose export. In the export menu that appears you will need to select **JPG** so that you can import it into your word processor.[1]

Include **two** MATLAB plots in your **report**, *in addition* to your two hand-drawn plots.

[1] JPG is a default export that works for most users. Better options are PDF or WMF, depending on your setup. You can print to PDF if your word processor (like Word for Mac) accepts the import of PDFs. Windows users can export to Windows Meta File (WMF) for Word on Windows.

Writing a Report

You need to submit a lab report as a single, **one page PDF** to eclass.yorku.ca that includes

1. Name of the course
2. Name of the lab ("Lab C")
3. Your name and your numeric, 9-digit student ID
4. Two hand-drawn sketches (from Part 1)
5. Two MATLAB-generated plots (from Part 2)

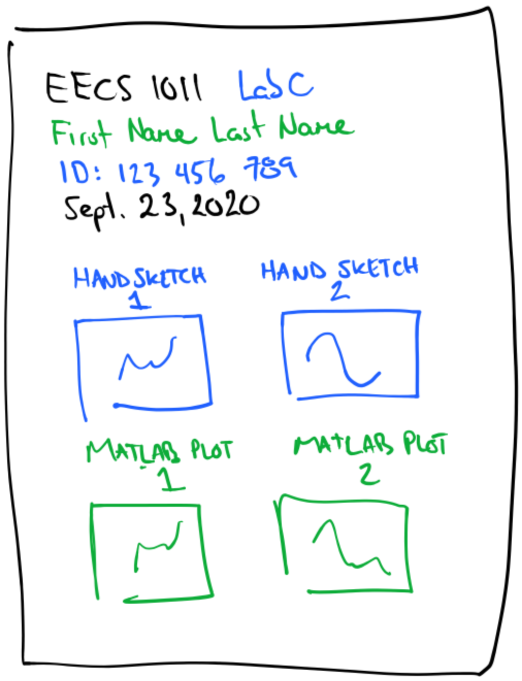


Figure 8 Example layout for a lab report. Label everything so that the TA knows what to mark.

Only person per lab report.

Submit a PDF to eclass.yorku.ca!

You must submit a **single PDF** to the eclass.yorku.ca site. Mac OS X, Windows 10 and Linux all support printing to PDF natively. For older Windows machines use the free PDFCreator (https://sourceforge.net/projects/pdfcreator/). All of your written material, the cover sheet, the sample code, scanned images, etc. should be included in the PDF.

If it's not a PDF it won't be accepted or graded.