Lecture 1: Introduction and Course Description

Sept. 6 2006

These notes and all course materials will available at http://pruffle.mit.edu/3.016-2006. Students should bookmark this site use it to download lecture notes, homework assignments, and reading assignments for laboratories and lectures.

The web materials for 3.016 are revised each year. This year I am doing substantial revision on how the lecture notes are designed and some revision on lecture content. The site will develop throughout the semester.

Previous years' notes are available at http://pruffle.mit.edu/3.016 and may be useful to you.

Preface

The subject is for undergraduate materials scientists and engineers who wish to learn about the mathematics that is essential to their chosen field.

Materials science and engineering is a discipline that combines knowledge of chemistry, mechanics, and physics and then applies them to the study of materials and their properties. It is a challenging and diverse enterprise—obtaining expertise in a large set of diverse subjects—but a career devoted to diverse study and applications will be very rewarding and fulfilling.

Mathematics is the *language* that binds together disparate topics in physics, engineering, and chemistry.

While it is possible to become an excellent materials scientist and engineer without some working knowledge of a large subset of mathematical topics, it is much easier to master this discipline with mathematics to guide you. Through mathematics, you will discover that some topics have similarities that are not obvious—and not taught to you as *being* similar. Such similarities and analogies will make learning much, much easier—and I think much more enjoyable.

MIT's Department of Materials Science and Engineering has determined that students benefit from a background and a working knowledge of many more mathematics topics that pertain specifically to MS&E than are taught in a one-semester subject in the mathematics department. It is reasonable to ask, "Is this subject a substitute for a mathematics subject such as linear algebra or partial differential equations taught by a mathematics professor as part of the mathematics department?" No, this is not a replacement for such a subject and I encourage you to take subjects in mathematics in the future. This subject is designed to be very broad in scope and therefore its depth in any one topic is limited.

I do believe very strongly that you will enjoy studying math more after taking this introduction and that the mathematical background you will receive this semester will make your materials science education richer and more rewarding.

I have designed this subject to help you learn as much essential mathematics as possible in a short time. To this end, this subject has several unusual aspects that you will need to know.

3.016 Mathematical Software

Symbolic mathematical computer software is a tool used by almost every applied scientist. Such software helps produce results quickly, visualizes and documents the results, and minimizes the silly errors that creep into complicated mathematical manipulations. Although there are many other good choices, I have decided to use MATHEMATICA® as a vehicle for learning and doing mathematics. It has a fairly steep learning curve, but it probably repays the time investment with powerful (once learned) language syntax and packages. Such symbolic mathematical software is an aid to help you think about and perform mathematics—it is not a replacement for mathematical understanding.

MATHEMATICA® is available for all MIT students, both on Athena (free) and via licenses for personal laptop and desktop machines ($30 for students, a useful investment for other subjects). The process to access MATHEMATICA® on Athena and the steps to download a license will be explained to you; the pertinent website is http://web.mit.edu/is/products/vsls/ http://web.mit.edu/is/products/vsls/. You will need MATHEMATICA® for your first homework set and laboratory; you should try to get it working someplace very soon. If you have a laptop, I suggest that you install MATHEMATICA® on it as soon as possible.

Laboratory assignments must be completed during the laboratory period and are to be emailed as an electronic copy of a MATHEMATICA® notebook to the instructor and the TA.

3.016 Examination Philosophy

Tests and exams are powerful motivators to get students to take a subject seriously but I think that working through homework problems better promotes learning, particularly for self-motivated students.

Therefore, there will be no exams, tests, or quizzes in 3.016. Your grade will be based on your homeworks and laboratories. These will graded carefully (described below) and there will be about one homework set every week and a half while the subject is meeting (i.e., no homework will be assigned during the weeks that the laboratory 3.014 meets).

3.016 Homework

The purpose of the homework is to help you solidify your understanding of *mathematics applied to engineering and science problems* by working through examples. Some examples may be exercises in mathematics; others will be exercises in application of mathematics to solving engineering and science problems. I encourage you to use MATHEMATICA® to solve your homework problems, and you may turn in solutions as printed MATHEMATICA® notebooks. Nevertheless to appreciate what symbolic mathematics programs can do for you, there will be some exercises that I will ask you to do with pencil and paper. However, there is no harm in checking your "by-hand" results with MATHEMATICA® .

Of course when you do homework, you are not under the potentially menacing eyes of an exam proctor. This means that you can receive help in the form of:

Books Go to the library and find solutions to problems. It is good practice and you will learn quite a bit by doing so. I recommend that you attempt to find a solution before going to the library—not only will it help you appreciate the solution, it will also make your search a bit easier!

Experts By all means, consult with experts on your homework. It is a good idea as long as you understand what *you* turn in.

Classmates This is the best choice of all. I think it is both inevitable and beneficial to give and receive help. Cooperating on homework will help you learn to communicate your ideas and begin to appreciate the difficulties and rewards of teamwork.

As explained below, the homework assignments in 3.016 will be, in part, cooperative.

You will find that you are more busy some weeks than others and relying on a classmate during a busy week can be a life-saver. However, if you start slacking off and don't hold up your end of the bargain when you are able, you will engender resentment and endanger professional and friendly relationships. I leave it to your own conscience to play fairly and contribute when you can—and, while understanding that everyone experiences different kinds of pressures, to be forthright and honest with others who do not contribute consistently.

It is fairly easy for the instructor to ascertain who is slacking and who is not. I can't say that my good opinion has any particular value, but keep in mind: it is possible, but slackers will have hard time regaining my good opinion.

If you turn in work that you did not do, and do not attribute the solution to its rightful author(s), then you are plagiarizing. As a first assignment in this course, every one of you should read MIT's policy on academic integrity (html) or (pdf) immediately.

Homework cooperation has a potential downside because you all receive individual grades. We will attempt to mitigate this downside by dividing the homework into two parts:

Group For each homework set, a few problems will be designated as *Group Exercises*. For these problems, the entire group will turn in *one homework*. Every member of the group *who puts their name on the turned-in assignment* will receive exactly the same credit for the homework grade.

Homework groups will be *assigned* with each homework set. The groups will change from week to week and the members will be assigned randomly. Each group will be assigned a homework leader who will be responsible for arranging meetings and turning in the homework.

Individual Each problem set will contain a few problems for each student to complete individually. These problems will come out of the textbook and tend to be a bit easier than the group exercises. They are designed to maintain a sufficient amount of currency and emphasize that reading the textbook is an essential part of this course.

By putting each individual's name on a homework assignment, the group verifies that each indicated person has contributed to the assignment. By putting your own name on the group's turned-in assignment, indicates that you have reviewed *all* of the assignment; if questioned, each person should be able to describe how each problem was done. MIT's policy on academic integrity is also the policy for 3.016.

3.016 Laboratory

There will be a laboratory each week that 3.016 meets. The labs will be practical and focused on using MATHEMATICA® effectively.

There will be assigned reading from the MATHEMATICA® help browser that comes with the software. *You should always do this reading before the laboratory, or you may not be able to* FINISH YOUR ASSIGNMENT AND TURN IT IN BEFORE THE END OF THE LABORATORY IN ORDER TO GET CREDIT.

If you stay current in the course material and do the homeworks, you should have no difficulty doing the laboratory assignments *if you do the pre-assigned reading.*

It is not necessary, but if if you have your own laptop running MATHEMATICA® , it will be helpful to bring it to the lab with you.

Grades

As stated above, all of the final grade will depend on the homeworks and the laboratory assignments. There is no fixed average grade for this course; the average will depend on the entire class performance. However, if your homework grades and your laboratory reports are consistently within the top quartile, then it is extremely likely that you will receive an **A**. Homeworks will be graded by ranking them in order from *Best Homework* to *Least Best Homework*. A decision will be made regarding how many points (out of a possible 100) the *Least Best Homework* deserves, and the homework scores will be interpolated between a score of 99 for the *Best Homework* and that of the *Least Best*.

Homeworks will be evaluated on the basis of:

Accuracy The solution must be a reasonable and correct answer to the homework question.

Exposition The solution must clearly show the reasoning that was utilized to find it and the method of solution should be clearly apparent. Exegetic solutions will be ranked higher.

Beauty Good solutions will often require graphics and, with care, graphics can often beautifully explain the solution. The layout of the page, the quality of the supporting prose, the clarity of the graphics, and all that "je ne sais quoi" is fairly subjective but very important. The reader will include a judgment of your art in the ranking of homeworks.

Observation Supplemental observations provide aids in understanding and demonstrate mastery of a topic. An example of a supplemental observation might be something like, "Note that in the limit of long times, that the total concentration goes to zero. This is sensible because the boundary condition on mass flux is directed outward everywhere on the finite domain."

Laboratories will be graded on their completeness, demonstrated mastery of MATHEMATICA® for that assignment, and exposition.

Note that there will be times when you have two homework sets pending—this is done so that you can arrange your time conveniently.

Homework Calendar and Weighting

Homework Schedule			
Homework Assignment Set	**Available After** Lecture	**Available Date** Date	**Due Date** Date
1	Lect. 1	6 Sept.	14 Sept.
2	Lect. 4	13 Sept.	28 Sept.
3	Lect. 6	27 Sept.	12 Oct.
4	Lect. 13	23 Oct.	9 Nov.
5	Lect. 17	8 Nov.	30 Nov.
6	Lect. 21	20 Nov.	7 Dec.

Late Policy

Students will be allowed to turn in one homework up to 3 days late, for the individual portion only. No second late homework will be allowed without formal documentation about an unforeseeable emergency. No late group homework portions will be accepted—no exceptions.

Laboratory assignments must be turned in during the laboratory period. You must show documentation of unforeseeable emergencies that prevent you from attending a laboratory period. Any missed laboratories must be made up by special arrangement. If for some reason, you cannot complete a laboratory during the laboratory period, you should send a paragraph explaining why you could not finish.

It is your responsibility to do the assigned reading before the laboratory.

Textbook

We will use a fairly general textbook on applied mathematics (E. Kreyszig, *Advanced Engineering Mathematics*, ninth ed., J.W. Wiley, ≈ 1200 pages). You'll notice that reading assignments do not follow the table of contents—while I like the book, there are pedagogical reasons for studying mathematics in the sequence we will follow in this subject. Extra material pertaining to materials science specifically will be created and placed on the web.

I have identified 66 sections of the book (330 pages in total) as required reading. The readings for each lecture will appear in the Lecture Notes and always posted on the web at: http://pruffle.mit.edu/3.016-2006. I hope you will keep up with the reading—I think it would be wise to give the material a cursory reading prior to the lecture and then read it more carefully before starting the homework.

This course is designated as a 12 (*3-1-8*) unit subject[1] Time spent awake at lectures and recitations is less than half of your job—reading and doing homework is the greater part.

Lecture Notes

Lecture notes (like these) will be available for you to print out for each lecture. The lecture notes will be available at: http://pruffle.mit.edu/3.016-2006. These will supplement (not replace) the textbook. The lecture notes also serve as a guide to help the student understand what parts of the text are considered more relevant or important.

The specific purpose of the notes is to provide neatly typeset equations and graphics that will be used in the lecture along with a few observations. This will eliminate the time required to write and draw, perhaps a bit sloppily, for you in your notes and for me on the blackboard.

The lecture notes will have reading assignments printed at the beginning of each lecture; they will look like this:
Kreyszig **6.1, 6.2, 6.3, 6.4** (pages: 304–309, 312–318, 321–323, 331–336). Part of the units for this course involve reading. You are receiving an expensive education—you should strive to make your education valuable by doing all the required reading. Your intellect will profit even more by doing outside reading.

Those concepts that are fundamental to this course will be presented in lectures by the lecturer (or in the form of welcome questions and points of clarification by the students) and some explanatory notes will be written upon the blackboard.

The notes will have places for you to fill in auxiliary discussion and explanation. Those places will look like this:

You can use these notes in several ways. You could print them out before lecture and write your own lecture notes directly during the lecture. You could take lecture notes on your own paper and then neatly copy them onto a printout later. You could print them before lecture and write on them rapidly and then copy—neatly and thoughtfully—notes onto a freshly printed set of lecture. I recommend the latter for effective learning and the creation of a set of notes that might provide future reference material—but do whatever works for you.

The lecture notes will also refer to MATHEMATICA® notebooks available on the 3.016 website for downloading. These notebooks will be used as MATHEMATICA® sessions during the lectures to illustrate specific points and provide examples for you to help solve homework problems.

References to MATHEMATICA® notebooks look like the ones given at the end of this lecture's notes in section 1-0.0.15.

[1]Units at MIT are assigned under the following schema: *lec-lab-out* where *lec* is the number of lecture/recitation hours, *lab* is the number of laboratory hours, and *out* is the number of outside (reading, preparation, homework) hours per week. One MIT unit represents about 14 hours of semester work on the average.

These examples will serve as place-holders in the lecture note when we switch from chalkboard and/or projected display of the notes to a live MATHEMATICA® session.

Lecture and Laboratory Calendar

This calendar will be updated throughout the semester: students should consult this calendar weekly to obtain the required reading assignments for the laboratory.

1-0.0.1 Week of 4–8 September

Lectures		
	Topics	**Reading**
M 09/04	Labor Day, No Lectures	
W 09/06 Lect. 1	Course organization and introduction to Mathematica	Mathematica Notes *I*
F 09/08 Lect. 2	Introduction to Mathematica, assignment and evaluation, rules and replacement, procedural and functional programming	Mathematica Notes *II*
Laboratory		
F 09/08 Lab 1 (Not Graded)	Getting started with Mathematica	*Mathematica Help Browser* **Online Tutorial**

Homeworks		
Homework Set	Available	Due Date
1	Wednesday 6 Sept	

1-0.0.2 Week of 11-15 September

Lectures		
	Topics	**Reading**
M 09/11 Lect. 3	Mathematica graphics: basic plotting, data, two- and three-dimensional plotting, graphics primitives, formatting	Mathematica Notes *III*
W 09/13 Lect. 4	Mathematica: symbolic and numeric calculations, linear algebra, roots of equations	Mathematica Notes *IV*
F 09/15 Lect. 5	Mathematica: functional programming, packages, and file input/output	Mathematica Notes *V*
Laboratory		
F 09/15 Lab 2	Symbolic calculations and plotting	*Mathematica Help Browser* **Mathematica Book: sections 1.4.2, 1.7.1; Functions: Integrate, Simplify, NIntegrate, Plot, Plot3D, ContourPlot**

Homeworks		
Homework Set	Available	Due Date
1		Thursday 14 Sept
1	Wednesday 13 Sept	

1-0.0.3 Week of 18-22 September

3.014 Laboratory Week: 3.016 does not meet.

1-0.0.4 Week of 25-29 September

Lectures		
	Topics	**Reading**
M 09/25	MIT Holiday, No Lectures	
W 09/27 Lect. 6	Linear algebra: matrix operations, interpretations of matrix operations, multiplication, transposes, index notation	*Kreyszig* **7.1, 7.2, 7.3, 7.4** (pages: 272–276, 278–286, 287–294, 296–301)
F 09/29 Lect. 7	Linear algebra: solutions to linear systems of equations, determinants, matrix inverses, linear transformations and vector spaces	*Kreyszig* **7.5, 7.6, 7.7, 7.8, 7.9** (pages: 302–305, 306–307, 308–314, 315–323, 323–329)
Laboratory		
F 09/29 Lab 3	Solving linear systems of equations	*Mathematica Help Browser* **Mathematica Book Section 1.8.3, Functions: Inverse, Transpose, Eigensystem, matrix multiplication "."**

Homeworks		
Homework Set	Available	Due Date
2		Thursday 28 Sept
3	Wednesday 27 Sept	

1-0.0.5 Week of 2–6 Oct.

Lectures		
	Topics	**Reading**
M 10/02 Lect. 8	Complex numbers: complex plane, addition and multiplication, complex conjugates, polar form of complex numbers, powers and roots, exponentiation, hyperbolic and trigonometric forms	*Kreyszig* **13.1, 13.2, 13.5, 13.6** (pages: 602–606, 607–611, 623–626, 626–629)
W 10/04 Lect. 9	Matrix eigenvalues: eigenvalue/eigenvector definitions, invariants, principal directions and values, symmetric, skew-symmetric, and orthogonal systems, orthogonal transformations	*Kreyszig* **8.1, 8.2, 8.3** (pages: 334–338, 340–343, 345–348)
F 10/06 Lect. 10	Hermitian forms, similar matrices, eigenvalue basis, diagonal forms	*Kreyszig* **8.4, 8.5** (pages: 349–354, 356–361)
Laboratory		
F 10/06 Lab 4	File input/output, plotting data	*Mathematica Help Browser* **Mathematica Book 2.12.7, 2.12.8; Functions: Dimensions, Append. AppendTo, Do, Mean, StandardDeviation, ListPlot, Table, Graphics‘MultipleListPlot, Fit**

1-0.0.6 Week of 9–13 October

Lectures		
	Topics	**Reading**
M 10/09	Holiday, No Lectures	
W 10/11 Lect. 11	Vector calculus: vector algebra, inner products, cross products, determinants as triple products, derivatives of vectors	*Kreyszig* **9.1, 9.2, 9.3, 9.4** (pages: 364–369, 371–374, 377–383, 384–388)
F 10/13	3.014 Laboratory, no 3.016 lecture	

Homeworks		
Homework Set	Available	Due Date
3		Thursday 12 Oct

1-0.0.7 Week of 16–20 October

Lectures		
	Topics	**Reading**
M 10/16	3.014 Laboratory, no 3.016 lecture	
W 10/18	3.014 Laboratory, no 3.016 lecture	
F 10/20 Lect. 12	Multi-variable calculus: curves and arc length, differentials of scalar functions of vector arguments, chain rules for several variables, change of variable and thermodynamic notation, gradients and directional derivatives	*Kreyszig* **9.5, 9.6, 9.7** (pages: 389–398, 400–403, 403–409)
Laboratory		
F 10/20 Lab 5	Statistics, fitting data, error analysis	*Mathematica Help Browser* **Mathematica Book: 3.8.2; Functions: Fit, FindFit; Package: Statistics‘NonlinearFit**

1-0.0.8 Week of 23–27 October

Lectures		
	Topics	**Reading**
M 10/23 Lect. 13	Vector differential operations: divergence and its interpretation, curl and its interpretation	*Kreyszig* **9.8, 9.9** (pages: 410–413, 414–416)
W 10/25 Lect. 14	Path integration: integral over a curve, change of variables, multidimensional integrals	*Kreyszig* **10.1, 10.2, 10.3** (pages: 420–425, 426–432, 433–439)
F 10/27 Lect. 15	Multidimensional forms of the Fundamental theorem of calculus: Green's theorem in the plane, surface representations and integrals	*Kreyszig* **10.4, 10.5, 10.6, 10.7** (pages: 439–444, 445–448, 449–458, 459–462)
Laboratory		
F 10/27 Lab 6	Graphical representations in three and higher dimensions	*Mathematica Help Browser* **Mathematica Book: 1.9.1—1.9.7, 1.9.9—1.9.11**

Homeworks		
Homework Set	Available	Due Date
4	Thursday 23 Oct	

1-0.0.9 Week of 30 Sept–3 Nov

Lectures		
	Topics	**Reading**
M 10/30 Lect 16	Multi-variable calculus: triple integrals and divergence theorem, applications and interpretation of the divergence theorem, Stokes' theorem.	*Kreyszig* **10.8, 10.9** (pages: 463–467, 468–473)
W 11/01 Lect. 17	Periodic functions: Fourier series, Interpretation of Fourier coefficients, convergence, odd and even expansions	*Kreyszig* **11.1, 11.2, 11.3** (pages: 478–485, 487–489, 490–495)
F 11/03 Lect. 18	Fourier theory: complex form of Fourier series, Fourier integrals, Fourier cosine and sine transforms, the Fourier transforms	*Kreyszig* **11.4, 11.7, 11.8, 11.9** (pages: 496–498, 506–512 513–517, 518–523)
Laboratory		
F 11/03 Lab 7	Review of Mathematica functions and graphics	*Mathematica Help Browser* **Mathematica Book: 1.9.1–1.9.9, 2.1.1, 2.2.1. 2.3.1, 2.4.1, 2.5.1, 2.6.1, 2.7.1**

1-0.0.10 Week of 6–10 November

Lectures		
M 11/06 Lect 19	Ordinary differential equations: physical interpretations, geometrical interpretations, separable equations	*Kreyszig* **1.1, 1.2, 1.3** (pages: 2–8, 9–11, 12–17)
W 11/08 Lect. 20	ODEs: derivations for simple models, exact equations and integrating factors, the Bernoulli equation	*Kreyszig* **1.4, 1.5** (pages: 19–25, 26–32)
F 11/10	Holiday, no 3.016 lecture	

Homeworks		
Homework Set	Available	Due Date
4		Thursday 9 Nov
5	Wednesday 8 Nov	

1-0.0.11 Week of 13–17 November

3.014 Laboratory Week: 3.016 does not meet.

1-0.0.12 Week of 20–24 November

Lectures		
	Topics	**Reading**
M 11/20 Lect. 21	Higher order differential equations: homogeneous second order, initial value problems, second order with constant coefficients, solution behavior	*Kreyszig* **2.1, 2.2** (pages: 45–52, 53–58)
W 11/22 Lect. 22	Differential operators, damped and forced harmonic oscillators, non-homogeneous equations	*Kreyszig* **2.3,2.4, 2.7** (pages: 59–60, 61–69, 78–83)
F 11/24	Holiday, no 3.016 lecture	

Homeworks		
Homework Set	Available	Due Date
6	Monday 20 Nov	

1-0.0.13 Week of 27 Nov–1 Dec

Lectures		
	Topics	**Reading**
M 11/27 Lect. 23	Resonance phenomena, higher order equations, beam theory	*Kreyszig* **2.8, 2.9, 3.1, 3.2, 3.3** (pages: 84–90, 91–96, 105–111, 111–115, 116–121)
W 11/29 Lect. 24	Systems of differential equations, linearization, stable points, classification of stable points	*Kreyszig* **4.1, 4.2** (pages: 131–135, 136–139)
F 12/01 Lect. 25	Linear differential equations: phase plane analysis and visualization	*Kreyszig* **4.3, 4.4** (pages: 139–146, 147–150)
Laboratory		
F 12/01 Lab 8	Solutions to ordinary differential equations	*Mathematica Help Browser* **Mathematica Book: 1.5.9, 3.5.11; Function: DSolve, NDSolve, NIntegrate**

Homeworks		
Homework Set	Available	Due Date
5		Thursday 30 Nov

1-0.0.14 Week of 4–8 December

Lectures		
	Topics	**Reading**
M 12/04 Lect. 26	Solutions to differential equations: Legendre's equation, orthogonality of Legendre polynomials, Bessel's equation and Bessel functions	*Kreyszig* **5.3, 5.5, 5.6** (pages: 177–180, 189–197, 198–202)
W 12/06 Lect. 27	Sturm-Louiville problems: eigenfunction, orthogonal functional series, eigenfunction expansions	*Kreyszig* **5.7, 5.8** (pages: 203–208, 210–216)
F 12/08	3.014 Laboratory continues, No more Maths lectures	

Homeworks		
Homework Set	Available	Due Date
6		Thursday 7 Dec

1-0.0.15 Week of 11–15 December

3.014 Laboratory Week: 3.016 does not meet.

Beginners to Mathematica

Beginners to Mathematica® tend to make the same kinds of mistakes. I've been collecting a list of such mistakes and present them to you as a reference tool.

Lecture 01 MATHEMATICA® Example 1

Common Mathematica Mistakes

Download notebooks, pdfs, or html from http://pruffle.mit.edu/3.016-2006.

A list of common beginner MATHEMATICA mistakes. The entries here are typical **mistakes**. I welcome input from others to might add to this list
1-4 are examples of confusing usages of parentheses (—), curlies {—}, and square brackets [—].

1: Parentheses are used for logical grouping, not for function calls (first line) or lists (lines 2–3).

2: Curlies usually group lists of things; in item two multiplcation of a list of length 1 is left-multiplied by a list of length 3 which may not be what was intended.

3: Single brackets are for function arguments—and not for list extraction as in line 2 or grouping in line 3.

4: Double brackets are usually for list extraction, not function calls.

5: MATHEMATICA® is case sensitive and functions are usually made by concatenating words with their first letters capitalized.

6: Functions are *usually* created designed with patterns (i.e., x_, y_) for variables. This is an error if `x` is a defined variable. This line is correct in using the appropriate *delayed assignment :=*.

7: Here a function is defined with a direct assignemt (=) and not *delayed assignment :=*.

8: In the first line, assignments (=) are used instead of the double equals (==) which is a *logical equality*. In the second line, a logical equality is queried and no value is assigned to δ.

9: Missing commas: `Plot` requires at least two arguments separated by commas or it doesn't know what to return.

```
1  Cos(k x)
   Plot[Sin[x], (x, 0, π)]
   Sort[(x, y, z)]

2  {√2/2} {a, b, c}

3  SomeList = {a, b, c, d};
   SomeList[1]
   [(z^2 + y^2) c + b y^3] a

4  Exp[[1]]

5  arccos[1]
   Arccos[1]

6  MyFunction[x, y, z] :=
     Sin[x] Sin[y] Sin[z]
   MyFunction[π, π/2, 0]

7  x = π/2;
   AbsSin[x_] =
     Abs[Sin[Abs[x]]]
   Plot[AbsSin[z], {z, −2π, 2π}]

8  Solve[{β = 3 p + 4 q,
       α = 5 p − q}, {p, q}]

   δ == 24

9  Plot[Sin[x + Exp[−x]] {x, 0, Pi}]
```

Lecture 01 MATHEMATICA® Example 2

Common Mathematica Mistakes

Download notebooks, pdfs, or html from http://pruffle.mit.edu/3.016-2006.

(continued) list of common beginner MATHEMATICA® mistakes. The entries here are typical **mistakes**.

1: Because `x` was defined above, it retains its value; so the function can't iterate over the x-coordinate. Also, because `ContourPlot3D` is defined in the `Graphics` package, it is unknown to the system. Loading the packing is the right thing to do, but because their are two symbols `ContourPlot3D` defined, their will be ambiguity for *which one to use*.

2: Practical advice is to clear the variable definitions with `Clear`.

3: More powerful practical advice, but slight overkill, is to clear all user-defined variables. As a last resort when everything seems awry, kill the kernel with the menu and restart it. This starts up a new MATHEMATICA® session, but does not destroy the text in the `Notebook`.

4: Sometimes the form of an expression is part of its definition. In this case, a `MatrixForm` of a matrix *is not* a matrix and so matrix operations are not defined.

1
```
ContourPlot3D[
  Cos[Sqrt[x^2 + y^2 + z^2]],
  {x, -2, 2}, {y, 0, 2}, {z, -2, 2}]
<< Graphics`ContourPlot3D`
ContourPlot3D[
  Cos[Sqrt[x^2 + y^2 + z^2]],
  {x, -2, 2}, {y, 0, 2}, {z, -2, 2}]
```

Practical Advice 1:
Clear Variables

2
```
Clear[k];
A = e^(-1.2/(k 373))
```

Practical Advice 2:
Second to last resort, clear everything

3
```
Clear["Global`*"];
<< Graphics`ContourPlot3D`;
ContourPlot3D[
  Cos[Sqrt[x^2 + y^2 + z^2]],
  {x, -2, 2}, {y, 0, 2}, {z, -2, 2}]
```

Practical Advice 3:
Last resort, kill the kernel and restart it Use menu: kernel

4
```
mymat = {
         {1, 3, 7},
         {3, 2, 4},
         {7, 4 , 3}
        } // MatrixForm
Eigenvalues[mymat]
```

Lecture 01 MATHEMATICA® Example 3

Common Mathematica Mistakes

Download notebooks, pdfs, or html from http://pruffle.mit.edu/3.016-2006.

(continued) list of common beginner MATHEMATICA® mistakes. The entries here are typical **mistakes**.

1: Practical advice is to separate the definition from the display of the assigned variable. Here a matrix is defined; its `MatrixForm` is display, and `Eigenvalues` of the matrix are calculated.

2: Some functions, such as `Plot`, evaluate their arguments in a round-about way. Graphical output does not appear here, because `Plot` doesn't bother evaluating the `Table` function first.

3: If a computationally intensive function is not doing what you expect, then try to wrap an expression in an `Evaluate` function.

```
1   Cos(k x)
    Plot[Sin[x], (x, 0, π)]
    Sort[(x, y, z)]

2   {√2/2} {a, b, c}

    Practical advice,
    define and display with separate
    commands

3   mymat = {
              {1, 3, 7},
              {3, 2, 4},
              {7, 4 , 3}
            };
    mymat // MatrixForm
    Eigenvalues[mymat]

4   Plot[Table[LegendreP[i, z],
        {i, 1, 11, 2}], {z, -1, 1}]

    Practical advice:
    Use
    Evaluate in Plot when in doubt

5   Plot[
      Evaluate[Table[LegendreP[i, z],
        {i, 1, 11, 2}]], {z, -1, 1}]
```