MATHEMATICA ABC

TRAINIER: DR REEM ALTUWIRQI

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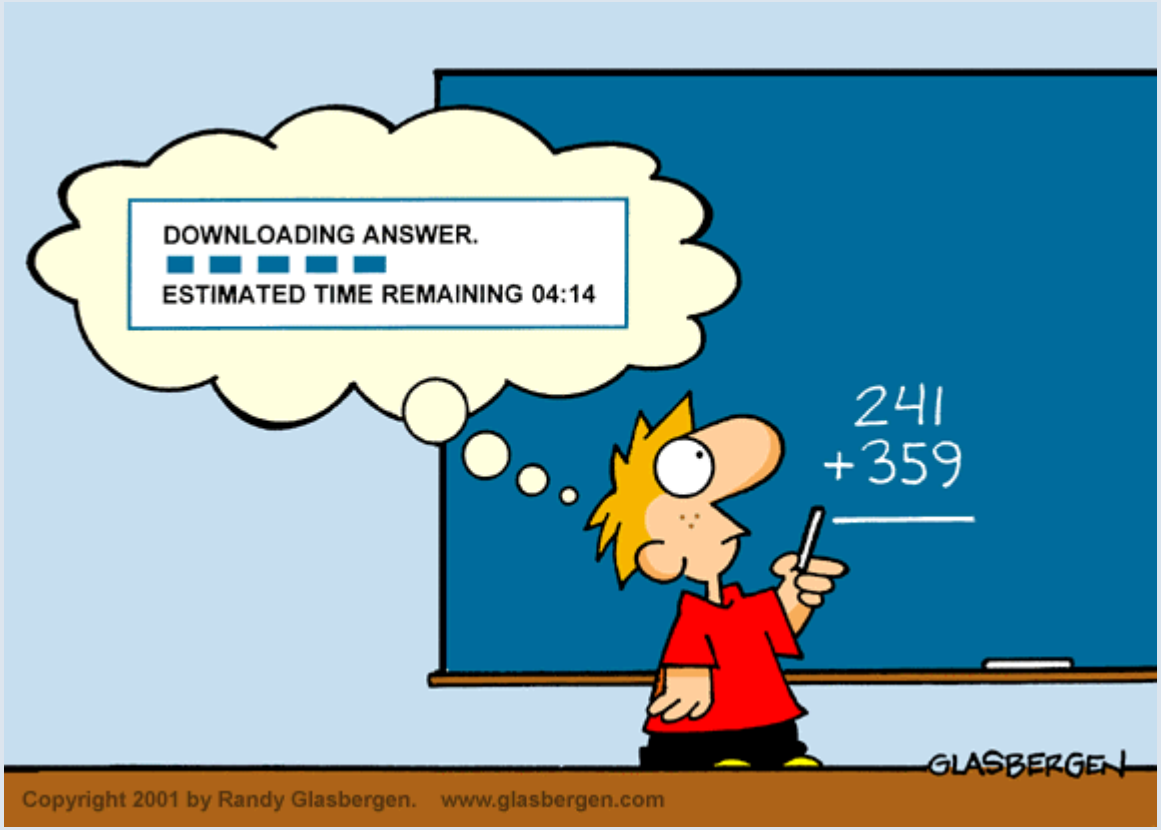
Timetable and Syllabus…

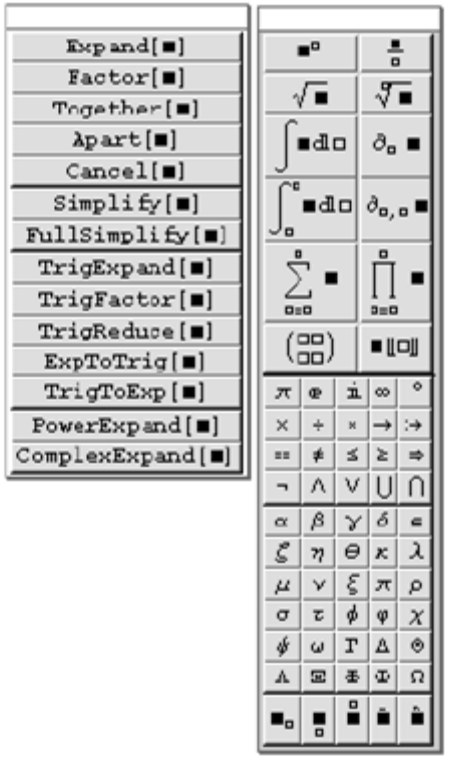
Session 1	Session 2	Session 3	Session 4	Session 5
Getting Started	User defined functions and plotting	Calculus	Vector analysis	Examples and Closing
- Syntax - Packages - Help - Numerical calculations - Built-in constants and functions - Word processing	-Variables, equations and functions - Plotting functions - Solving equations and inequalities	- Limits - Derivatives - Integration	- Series - Sum - Matrices	- Some examples in physics - Course project - Closing
Worksheet 1	Worksheet 2	Worksheet 3	Worksheet 4	



SESSION 1: Getting Started

Starting Mathematica

- Menu
- Palettes
- Activating the kernel
- Right-side brackets

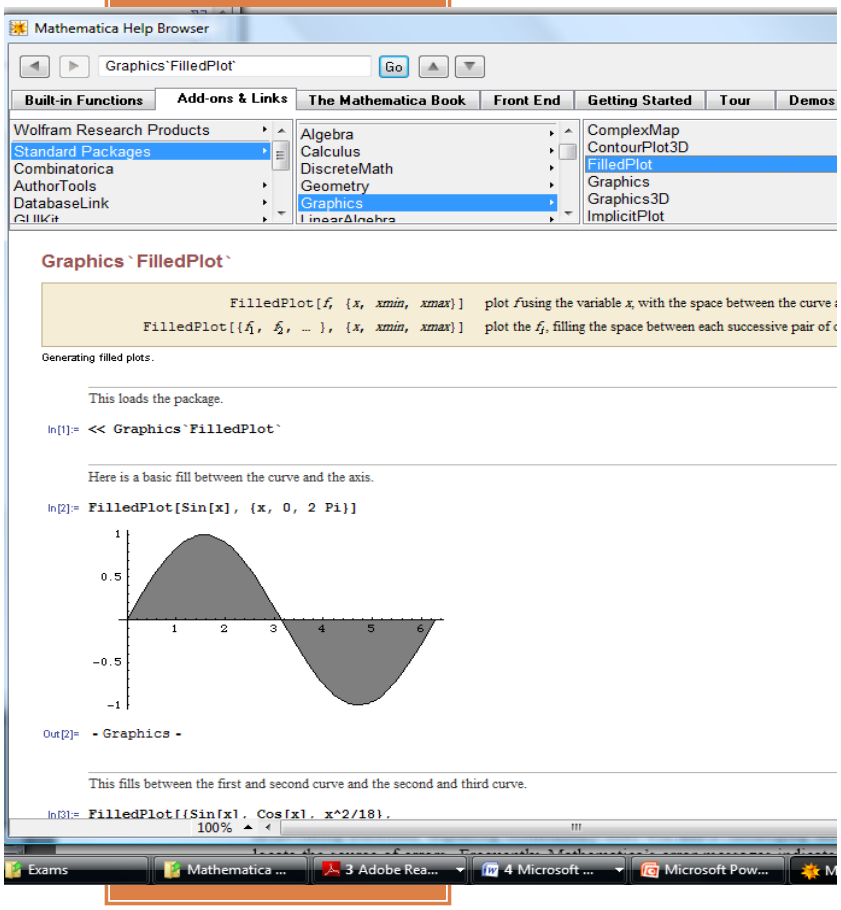


Mathematica Syntax

Five Basic Rules of Mathematica Syntax

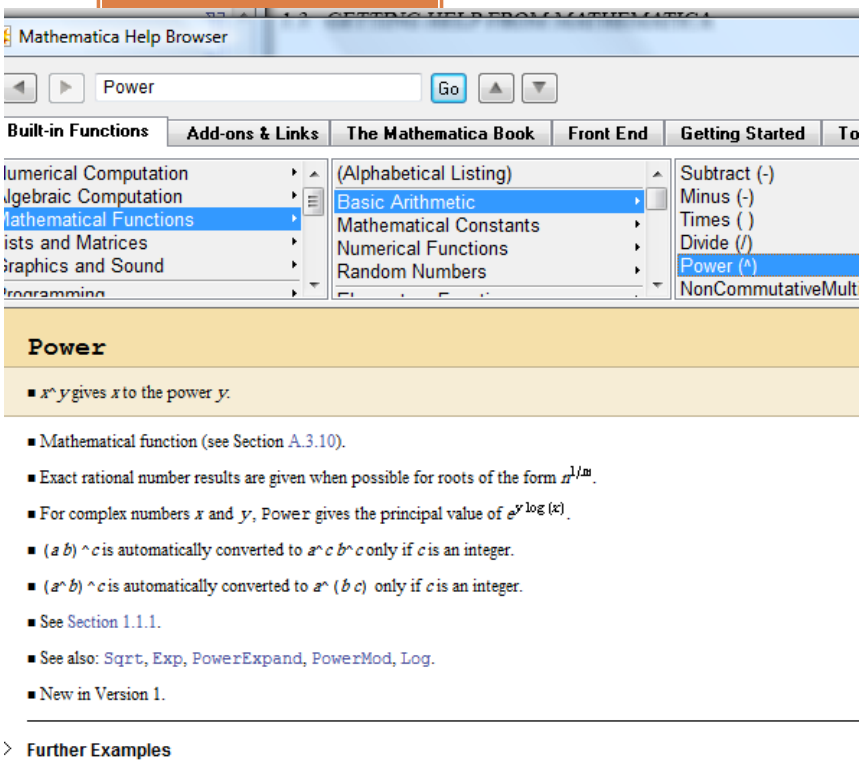
- The arguments of functions are given in brackets [….]
- Every word of a built-in Mathematica function begins with a capital letter, e.g. Sin[x]
- Multiplication is represented by a * or space between characters. Enter 2*x*y or 2 x y to evaluate 2xy not 2xy.
- Powers are denoted by ^. Enter (8*x^3)^(1/3) to evaluate $(8x^3)^{(1/3)} = 8^{1/3}(x^3)^{1/3} = 2x$ instead of 8x^1/3 which returns 8x/3
- Mathematica follows the order of operations exactly. Thus, entering (1+x)^1/x returns $\frac{(1+x)^1}{x}$ while (1+x)^(1/x) returns $(1+x)^{1/x}$

Loading Packages



- Mathematica contains many built-in functions that are loaded immediately when called.
- Some other functions are contained in packages that must be loaded separately to minimize memory requirements.
- A list of available package groups are in the help facility
- Example, Graphics → FilledPlot

Getting Help



- Becoming competent with Mathematica can take a great time!
- Errors can rise so do not get frustrated!
- Error's messages can indicate where the errors occurred.
- You can access Mathematica's help facility directly from the menu.
- Using ? And ?? → ?Plot, ?Int*
- Tour of Mathematica

Numerical Calculations

- Basic arithmetic operations are preformed in the natural way
- a plus b → a+b
- a minus b → a-b
- a times b → a*b
- a divided by b → a/b
- a raised to the power b → a^b

Numerical Calculations

Example:

- 121+542
- 3231-9876
- (-23)(76)
- (22341)(832748)(387281)
- $\frac{467}{31}$
- $\frac{12315}{35}$

Numerical Calculations

- The term $a^{n/m}$ when $n/m = 1/2$ we can use the command Sqrt[a].
- Example: Compute
  1. $\sqrt{27}$
  2. Use N[….]
  3. (-27/64)^(2/3)
  4. Use N[…]
  5. Repeat 3 by hand

<<Miscellaneous 'RealOnly'

Built-in Constants

- Mathematica has built-in definitions of commonly used constants.
  - e ≈ 2.71828 → E
  - $\pi \approx 3.14159$ → Pi
  - $i = \sqrt{-1}$ → I , complex arithmetic is done automatically. Re[z], Im[z], Conjugate[z], Abs[z], Arg[z]
- Example: Compute
  - N[e,50]
  - (3+i) / (4-i)

Built-in Functions

- Mathematica contains numerous mathematical functions.
  - Exp[x] : exponential function
  - Log[x] : natural logarithm
  - Abs[x] : absolute value
  - Sin[x], Cos[x], Tan[x], Sec[x], Csc[x] and Cot[x] : trigonometric functions
  - ArcSin[x], ArcCos[x], ArcTan[x], ArcSec[x], ArcCsc[x] and ArcCot[x] : inverse trigonometric functions
  - Sinh[x], Cosh[x] and Tanh[x] : hyperbolic trigonometric functions

Built-in Functions

- Example: Compute
  - N[Exp[-5]]
  - Log[Exp[x]]
  - Exp[Log[4]]
  - Abs[-π]
  - Sin[π/12] → add N[….]

Built-in Functions

- Example: What does these functions do? If you don't know how can you find out?
  - TrigExpand
  - TrigReduce
  - ExpToTrig
  - TrigToExp
  - Simplify

Built-in Functions

- Example: Compute
  - Cos[x]^2+Sin[x]^2
  - Simplify the last expression
  - TrigExpand[Cos[3x]]
  - TrigReduce[Sin[3x] Cos[4x]]
  - ExpToTrig[1/2 (Exp[x]+Exp[-x])]
  - TrigToExp[Sin[x]]

Word Processing in Notebooks

- You can set the following cell options from the Format menu
  - Font
  - Size
  - Text color
  - Background color
  - Word wrapping
  - Justification
  - Style
  - Text alignment
- Check spelling can be found under Edit
- Inserting a formula in a text cell (Press CTRL 9) then use keystrokes
- Copy and paste between cells as usual

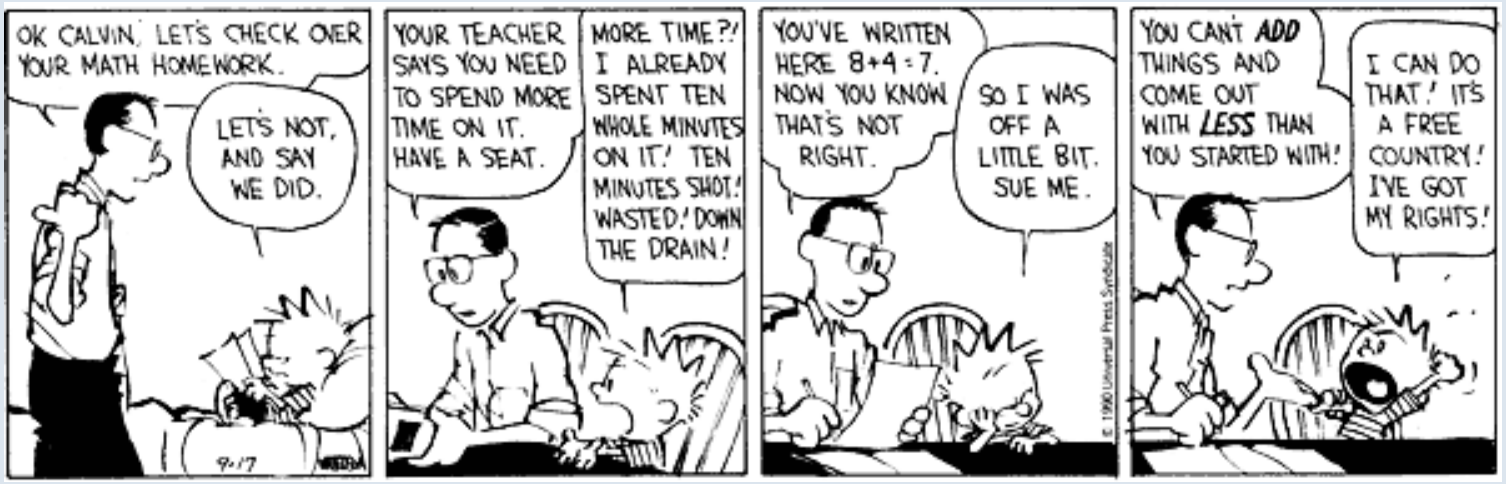
Word Processing in Notebooks

Example:

- Change the background color of your cell
- Change the content of a cell to text style
- Insert a formula into a text cell

Work Session

Please solve the question given to you in worksheet 1



SESSION 2: User Defined Functions and Plotting

Variables, Equations and Functions

- To define a variable:
  - x = a (begins with a small letter)
- To define an equation:
  - eq==a ; x+5==b
- To define a function:
  - f[x_]:= expression in x
  - Evaluate a function: f[a]

Plotting Functions

- To plot a function:
  - Plot[f[x],{x,a,b}]
- Example:
  - Expand (2x+1)(3x-1)(x-1)
  - Define a function f(x) and make its form the previous expanded terms
  - Plot the function f(x) with -1<<x<<3/2

Solving Equations and Inequalities

- To solve an equation we use:
  - Solve[lhs==rhs,x]
- To solve a system of equations:
  - Solve[{system of equations},{variables}]
- To solve an inequality (load package):
  - InequalitySolve[inequality,x]
- Solving equation by finding the root:
  - FindRoot[equation of x, {x,a}]

Solving Equations and Inequalities

- Example:
  - Solve the equation $x^2 - 1 = 0$
  - Solve the inequality $4 - x^2 \geq 0$
  - Solve the system of equations

    $x = y - 1$

    $x^2 = 2y + 6$
  - Solve $eq = x^2 + bx + 1$ then substitute b=9, you should get two roots.

More Plotting

- To graph the parametric equations

$$x = x(t), y = y(t), a \le t \le b$$

we use:

ParametricPlot[{x[t],y[t]},{t,a,b}]

- To graph a polar function

$$r = r(\theta), \alpha \le \theta \le \beta$$

we use:

PolarPlot[r[theta],{theta,alpha,beta}]

More Plotting

- 3D plotting we use:

  Plot3D[f[x,y],{x,a,b},{y,c,d}]
- We can also do a contour plot using

  ContourPlot[f[x,y],{x,a,b},{y,c,d}]

More Plotting

- Example:
  - Graph the parametric equation

$$x = Cos(5t), y = Sin(3t), 0 \le t \le 2\pi$$

  - Graph a polar function

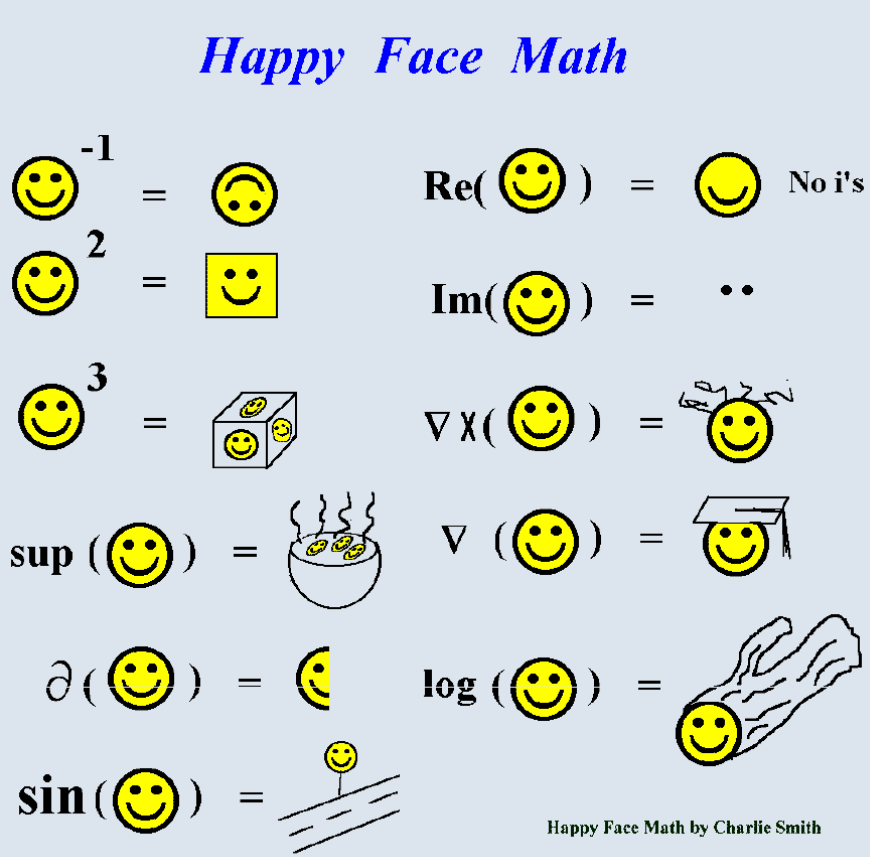
$$r = Cos(8\theta/3), 0 \le \theta \le 6\pi$$

  - Do a 3D plot and a contour plot of

$$Sin(xy), 0 \le x \le 4, 0 \le y \le 4$$

Work Session

Please solve the question given to you in worksheet 2



SESSION 3: Calculus

Limits…

- For finding limits we use:

  Limit[f[x],x->a]

  - a can be +/- infinity just write Infinity
- Example:
  - Plot the function $\frac{Sin3x}{x}$ then find its limit when x→0

Derivatives…

- We can find the derivative by using its definition: $\lim_{h\to 0} \frac{f(x+h)-f(x)}{h}$
- Or by using the function D and ‘:

  D[f[x],x] , f’[x], f’’[x], D[f[x],{x,n}]

  D[f[x,y],{x,n},{y,m}]
- Example:
  - Write the following command

    D[f[x] g[x],x]
  - Compute the first and second derivative of:

$$f(x) = 4x^5 - \frac{5}{2}x^4 - 10x^3$$

Integration…

- We can integrate a function by using:

  Integrate[f[x],x]
- We can also perform definite integration

  Inegrate[f[x],{x,a,b}]

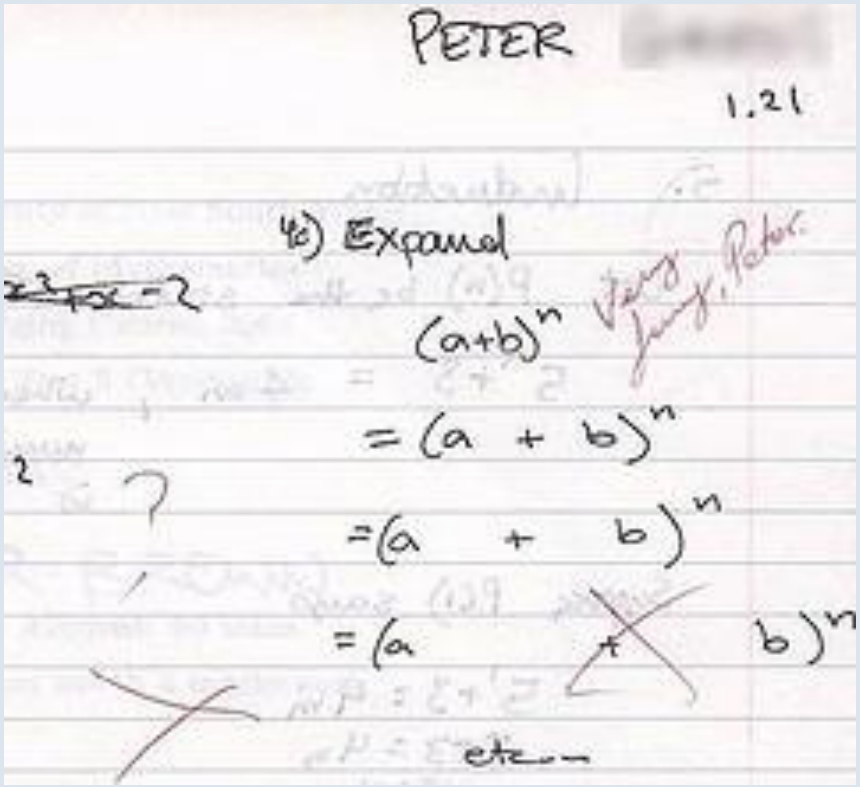
  Integrate[f[x,y],{y,ymin,ymax},{x,xmin,xmax}]
- When we can't get an exact solution of the integration, we can use a numerical approximation t the integral

  NIntegrate[f[x],{x,a,b}]
- Example:
  - Evaluate

$$\int_1^4 (2x^2+1)/\sqrt{x}\,dx$$

Work Session

Please solve the question given to you in worksheet 3



SESSION 4: Series, Sums and Matrices

Sums and Series…

- We can obtain the sum of a series by writing:

  Sum[a[k],{k,1,∞}]

- We can find the Maclaurin series or the Taylor series using:

  Series[f[x],{x,x0,n}]

- Example:
  - Execute Series[Cos[x],{x,0,4}]

Vectors and Matrices…

- We can define a vector as:
  r={x,y,x} , r1={x1,y1,z1}
- Operations on vectors:
  r-r1
  a r ← scalar multiplied by a vector
  r.r1 ← dot product
  Cross[r,r1] ← cross product
- Array[v,n] ← n-dimensional vector
- Table[f[k],{k,n}]
- {a,b}=Take[{l,m,n},2]

Vectors and Matrices…

- MatrixForm[name] ← output form
- Det[A] ← determinant of a matrix
- Inverse[A] ← inverse of a matrix
- Transpose[A] ← transpose of a matrix
- Part[A,I,j] ← gives the element Aij
- IdentityMatrix[n] for an nxn matrix
- DiagonalMatrix[list], list={a,b,c,d,…}

Work Session

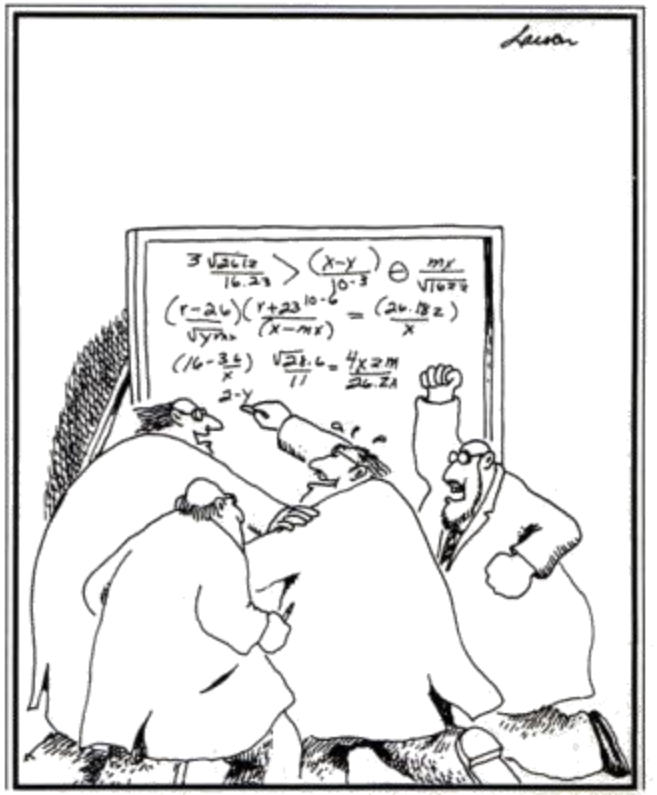
Please solve the question given to you in worksheet 4

Some Examples in Physics

- Interference and diffraction from multiple slits
- Fourier transform

Notes…

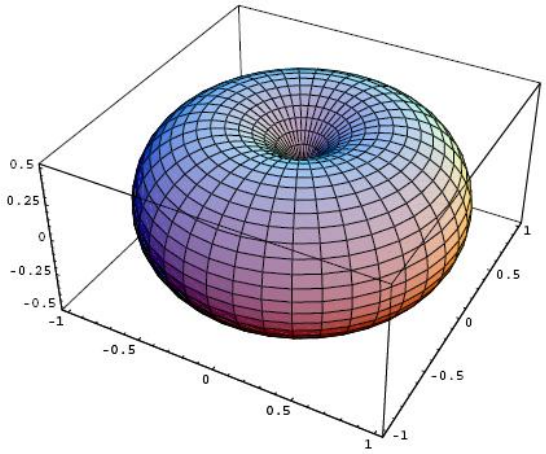
- Clear variable before using them! Clear[x] or x=.
- Don't say I don't know!! Use ? or ??
- /. Frustration → fun



"Go for it, Sidney! You've got it! You've got it! Good hands! Don't choke!"

So much more…

- Differential equations
- Animations
- Fitting data
- Programming
- Iterations (Do, For, While)
- Visit www.wolfram.com



Your Project…

Must be handed in by the end of the second week of next semester

Wednesday 23/3/1432 H

Submission through email: raltuwirqi@kau.edu.sa