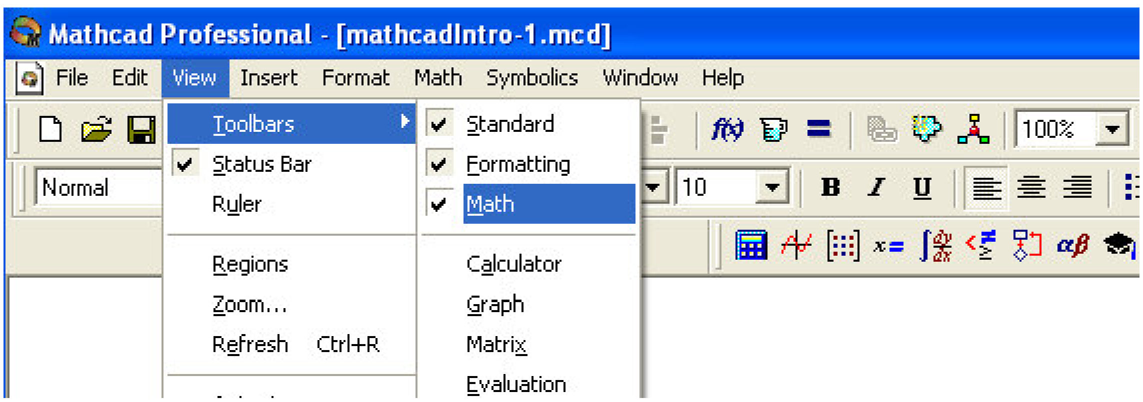
Project: Introduction to Mathcad

Student Name:___________

Part 1

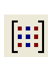
Setting up and basic menus

Depending on the default setup of your system, the menu bars may need to be activated by checking the three checkboxes Math, Standard, Formatting under the MenuBar::View::Toolbars menu, as shown below.



Of particular interest are the buttons on the Math menu:

 Accesses the greek alphabet for use in formulas and equations

 Accesses matrix functions to creat matrices, transpose, inverse, etc.

 Accesses integrals, summations, limits

 Accesses plotting functions

 Accesses symbolic functions solve, fourier, laplace, ztrans, etc.

 Accesses the various types of equal signs, symbolic evaluation, numerical evaluation

Note: it is important to realize that there are different types of equal signs!

Part 1

Plotting Simple Functions

Just type in the formulas for what you want to plot,
just as you would in a word processor.

$\omega := 1000 \cdot \pi$

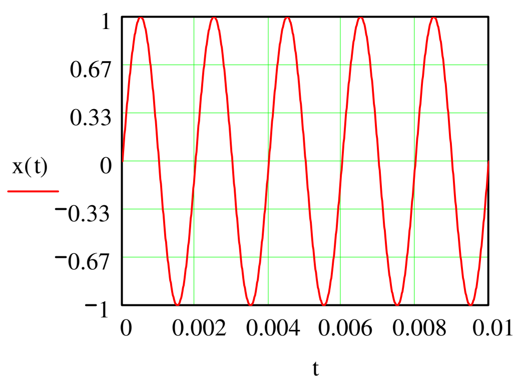
$x(t) := \sin(\omega \cdot t)$

$y(t) := \cos(\omega \cdot t)$

Note: here the ":=" equal sign was used. This equal sign is the "definition" equal sign, used to fefine formulas. It is typed by entering ":" on the keyboard.
Below, the numerically evaluate equal sign "=" is used to evaluate the numerical value of y(t) at t=0. This equal sign is typed on the keyboard as "="

.

$x(0) = 0$



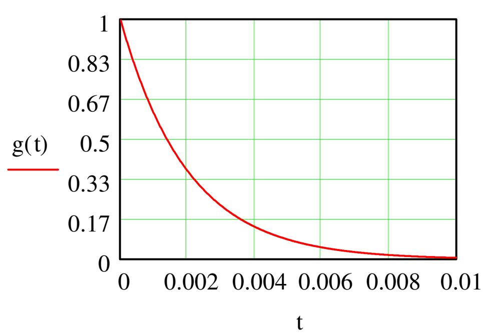
Here is a plot of the function, y(t), and two more function examples below, g(t) and h(t).

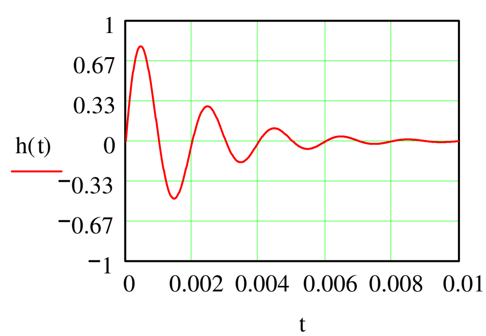
Double click the plots to experiment with plot setting, axis limits, etc.

See Mathcad help pages for more.

$g(t) := e^{-500t}$

$h(t) := g(t) \cdot x(t)$





Q1 & Q2. Change the formula to $\omega := 2 \pi f$, set the frequency to correspond to f=2000 Hz, and Replot x(t) above.
Also look up Heaviside, Dirac, delta functions in the help menu.

Part 2

Symbolic evaluation

Mathcad Symbolic calculation .
Sometimes it is useful to see a result in symolic form, rather than seeing a numerical answer.
Enter the integral at the left below, then type "control-period" followed by carriage return to get the symbolic result "->" as shown . Try this on the integral of x(t) to the right.

$$\int g(t)\,dt \rightarrow \frac{-1}{500}\cdot\exp(-500\cdot t) \qquad\qquad \int x(t)\,dt$$

Another example using ":=" to define a polynomial, and then using "->" to symbolically expand it

$$f(t) := \sum_{n=0}^{2} (n+1)^2 t^n \qquad\qquad f(t) \rightarrow 1 + 4\cdot t + 9\cdot t^2$$

Mathcad definite integral calculation .
Sometimes it is useful to see the numerical result of a definite integral.
First enter the equation using a definite integral and using the ":" key for equals sign,
then evaluate the result on the right using the "=" key.

$$Eg := \int_0^\infty g(t)\,dt \qquad Eg = 2\times 10^{-3}$$

Is this correct?

Note: Problems/limitations of MathCad.
Sometimes you can get the wrong answer in poorly behaved integrals.
Especially be careful when using infinite limits.
Compare the results below with each other.
It is likely that the one with finite limits is more trustworthy, since virtually all of the area under h(t) would lie between 0 and 0.1 (no need to go to infinity).
Try decreasing the upper limit to 0.05, and then increasing to 0.2.

Engineering judgement must detect and over-ride limitations of engineering tools.

$$Eh := \int_0^{.1} (h(t))^2\,dt \qquad Eh = 5.501\times 10^{-4}$$

$$Eh := \int_0^\infty (h(t))^2\,dt \qquad Eh = 1.239\times 10^{-4}$$

Q3. What is the correct result for Eh?

Part 3

Matrix Functions

Use View::Toolbars::Matrix to bring up the matrix toolbar

$v := \begin{pmatrix} 1 \\ 2 \end{pmatrix}$ $\quad M := \begin{pmatrix} 1 & 2 \\ 4 & 3 \end{pmatrix}$ $\quad v \cdot v = 5$ $\quad v^T = (1 \;\; 2)$

$M \cdot v = \begin{pmatrix} 5 \\ 10 \end{pmatrix}$

$M^{-1} = \begin{pmatrix} -0.6 & 0.4 \\ 0.8 & -0.2 \end{pmatrix}$ $\quad |M| = -5$

$M \cdot M^{-1} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$

Lots of examples of matrix funcrions.
Inverse, transpose, dot product,
determinant, matrix-vector multiplication,
matrix-matrix multiplication.

Vectors and matrices can also be created from range variables.
To create a "range variable", n, use the ";" to enter the "..." in the range 0 to 3 below

$n := 0..3$

n =

0
1
2
3

$m := 0..3$

Note: use the ";" key to get the ".."
when creating the range.

Then create a vector and matrix using the range variable as an index
(use the "[" left square bracket key to enter the subscripts.
This can be a good way to load values into a matrix based on some formula
as illustrated below..

$vv_n := n + 1$

$vv = \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \end{pmatrix}$

$MM_{n,m} := 4n + m$

$MM = \begin{pmatrix} 0 & 1 & 2 & 3 \\ 4 & 5 & 6 & 7 \\ 8 & 9 & 10 & 11 \\ 12 & 13 & 14 & 15 \end{pmatrix}$

$vv \cdot vv = 30$

$MM \cdot vv = \begin{pmatrix} 20 \\ 60 \\ 100 \\ 140 \end{pmatrix}$

$vv^T \cdot MM = (80 \;\; 90 \;\; 100 \;\; 110)$

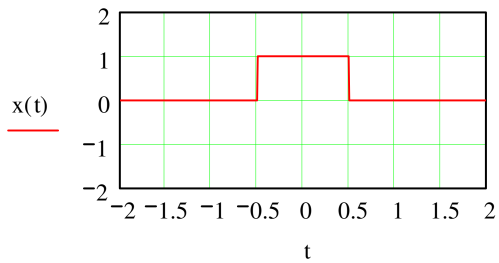
Part 4

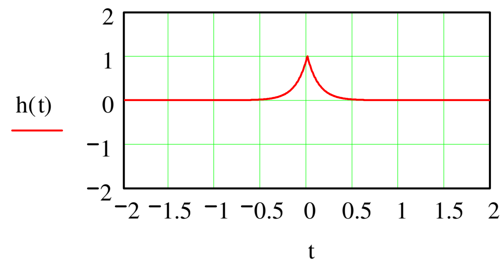
Convolution and differentiation.

$$\mathrm{rect}(t) := \Phi(t + 0.5) - \Phi(t - 0.5)$$

$$x(t) := \mathrm{rect}(t)$$

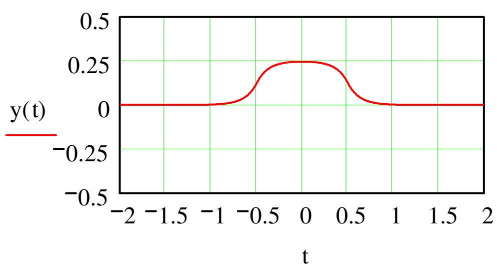
$$h(t) := e^{-8|t|}$$





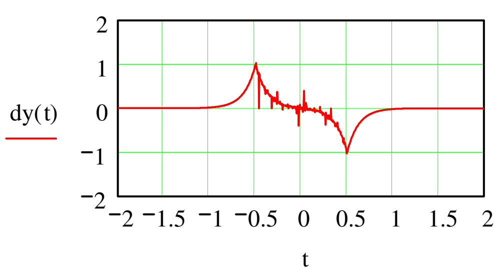
$$y(t) := \int_{-\infty}^{\infty} x(a)\, h(t - a)\, da$$

y(t)=Convolution of x(t) with h(t)



$$dy(t) := \frac{d}{dt} y(t)$$

Diffentiation (this may take some time)



Part 5

Statistical functions.

$npts := 15 \qquad n := 0 .. npts$

Create a binomial distributed vector of random data, with vaues of +/- .

$a := rbinom(npts + 1, 1, 0.5) \qquad a := 2a - 1$

a =

	0
0	-1
1	-1
2	1
3	-1
4	1
5	-1
6	1
7	-1
8	-1
9	-1
10	1
11	-1
12	-1
13	1
14	1
15	-1

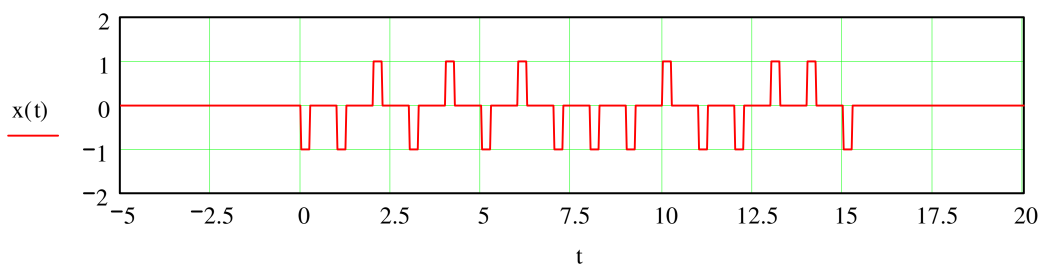
Create a pulse function, using the Heaviside function.

$p(t) := \Phi(t) - \Phi(t - 0.5)$

Create a pulsetrain from the random data.

$T0 := 1 \qquad tau := 0.5$

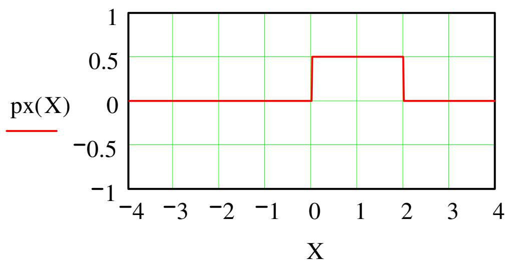
$$x(t) := \sum_{nn=0}^{npts} a_{nn} \cdot p\left(\frac{t - nn \cdot T0}{tau}\right)$$



Uniform pdf, px(x) where x is uniformly distributed between 0 and 2.

$$px(x) := 0.5\left(\Phi(x) - \Phi(x-2)\right)$$

$$px(1) = 0.5$$



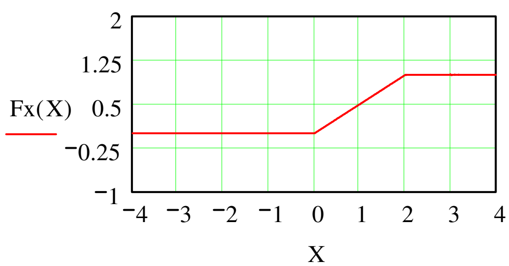
To generate uniform rand numbers:

$$xx := runif(5,0,2)$$

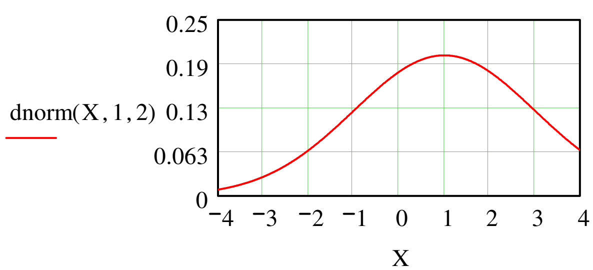
$$xx = \begin{pmatrix} 0.902 \\ 0.114 \\ 1.567 \\ 1.04 \\ 1.752 \end{pmatrix}$$

The CDF, Fx(x) where is.

$$Fx(x) := \int_{-\infty}^{x} px(a)\, da$$



Example Gaussian pdf with mean 1 and sigma =2..



To generate gaussian rand numbers:

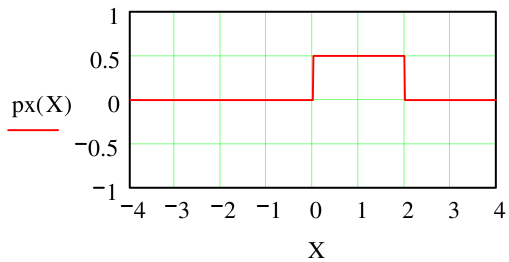
$$xx := rnorm(5,1,2$$

$$xx = \begin{pmatrix} 1.141 \\ 3.69 \\ -0.312 \\ 0.493 \\ -1.489 \end{pmatrix}$$

Uniform pdf, px(x) where x is uniformly distributed between 0 and 2.

$$px(x) := 0.5(\Phi(x) - \Phi(x-2))$$

$$px(1) = 0.5$$



To generate uniform rand numbers:

$$xx := runif(5, 0, 2)$$

$$xx = \begin{pmatrix} 0.552 \\ 1.176 \\ 1.675 \\ 0.97 \\ 1.487 \end{pmatrix}$$

mean

$$Ex := \int_{-\infty}^{\infty} a \cdot px(a)\, da \qquad Ex = 1$$

2nd moment

$$Ex2 := \int_{-\infty}^{\infty} a^2 \cdot px(a)\, da \qquad Ex2 = 1.333$$

2nd Central moment

$$Excm2 := \int_{-\infty}^{\infty} (a - Ex)^2 \cdot px(a)\, da \qquad Excm2 = 0.333$$

Standard deviation

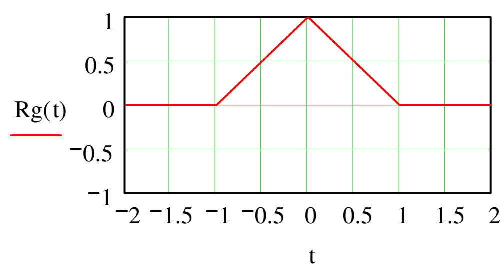
$$\sigma := \sqrt{Excm2} \qquad \sigma = 0.577$$

Part 5

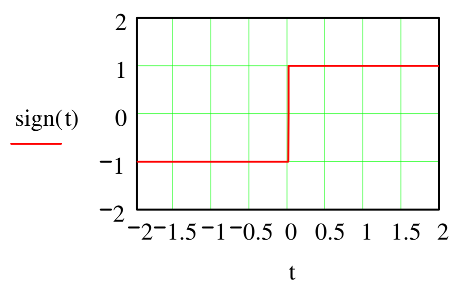
Other

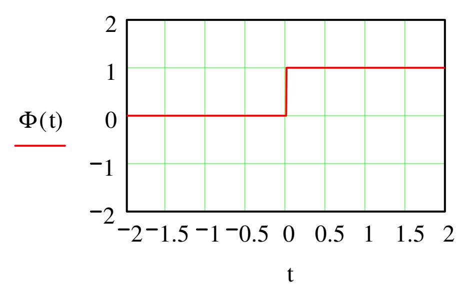
Many functions must be constructed from other functions.
Create a triangular function, using the Heaviside function.

$$Rg(t) := (\Phi(t) - \Phi(t-1))\cdot(1-t) + (\Phi(t+1) - \Phi(t))\cdot(1+t)$$

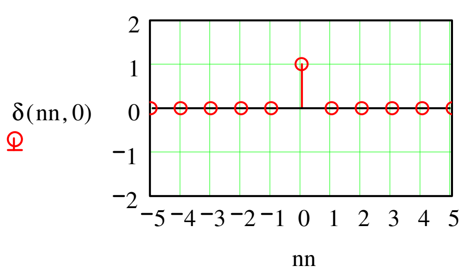


other useful functions





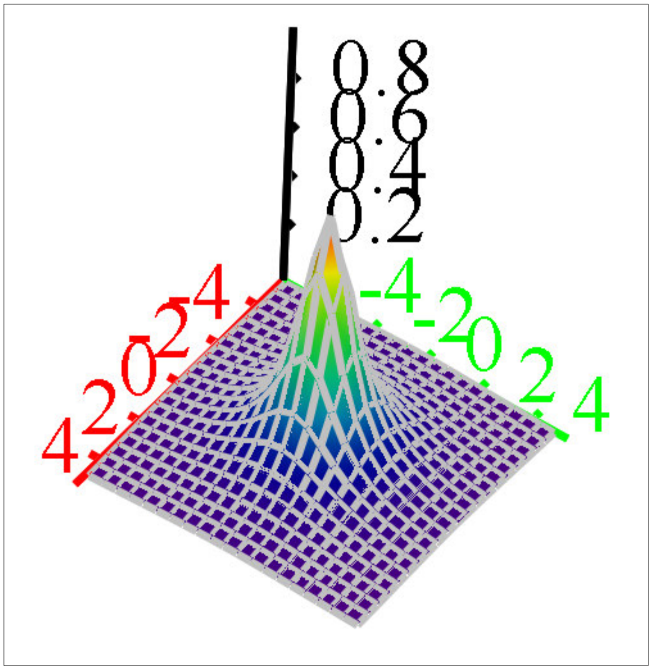
$nn := -5 .. 5$



Double click above plot and see "traces tab"
trace1=stem type.

And here is a 3D plot example.
Drag the mouse to rotate the figure, scroll button to zoom.
Double-click the plot to experiment with settings.

$$\text{plot3d}(x, y) := \frac{1}{1 + \left(x^2 + y^2\right)}$$



plot3d