Workshop: Introduction to Scilab

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(The sequence of spoken tutorials to be listened/followed is same as that of exercise sets below.)

1. **Getting Started**
   Solve the following examples on the Scilab Console as soon as the relevant topic is explained in the tutorial.

   (a) Perform the following calculations on the scilab command line:

   $$\text{phi} = \frac{\sqrt{5}+1}{2} \qquad \text{psi} = \frac{\sqrt{5}-1}{2}$$

   Find 1/phi and 1/psi.

   (b) tan(45)

   (c) $tan^{-1}(1)$

   (d) Verify Euler's identity: Is $e^{\pi i} + 1$ close to zero?

   (e) $\sqrt[4]{256}$

   (f) $256^{0.25}$

   (g) $e^{i\pi}$

2. **Matrix Operations**

   (a) 03:15: In Scilab, enter the following Matrices:

   $$A = \begin{bmatrix} 1 & 1/2 \\ 1/3 & 1/4 \\ 1/5 & 1/6 \end{bmatrix}$$

   $$B = \begin{bmatrix} 5 & -2 \end{bmatrix}, \quad C = \begin{bmatrix} 4 & 5/4 & 9/4 \\ 1 & 2 & 3 \end{bmatrix}$$

   Using Scilab commands, compute each of the following, if possible.

   i. $A * C$
   ii. $A * B$
   iii. $A + C'$
   iv. $B * A - C' * A$
   v. $(2 * C - 6 * A') * B'$
   vi. $A * C - C * A$
   vii. $A * A' + C' * C$

   Explain the errors, if any.

   (b) 04:15: From the video:

   i. Find E(:, :)
   ii. Extract the second column of E
   iii. Display just the first and last columns[1] of E.

   (c) 05:46: If A = $\begin{bmatrix} 1 & -1 & 0 \\ 2 & 3 & 1 \\ 4 & 1 & 5 \end{bmatrix}$

   Use a suitable sequence of row operations on A to bring A to upper triangular form.[2]

   (d) 07:28: Represent the following linear system as a matrix equation. Solve the system using the inverse method:

   $$\begin{aligned} x + y + 2z - w &= 3 \\ 2x + 5y - z - 9w &= -3 \\ 2x + y - z + 3w &= -11 \\ x - 3y + 2z + 7w &= -5 \end{aligned}$$

   (e) 08:01: Try solving the above system using the backslash method.

   (f) 08:38: Verify the solution from the previous question.

   (g) 09:38: Try det(A), A^2, A^3 and Eigenvalues of A (from the previous question).
   Also multiply A by an identity matrix of the same size.

3. **Scripts and Functions**

   (a) 02:48:

   i. Create a scilab script file to display time on console window. (hint: clock())
   ii. Create a scilab script file to display product of a matrix A and inverse of A. $A = [1, 1; 1, -1]$

   (b) 05:04:

   i. Create a function file to calculate sum and difference of any two numbers. The output should be the sum and the difference of numbers.

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[1]Tip: from a given matrix E, desired columns can be specified by defining a vector v consisting of just the desired column indices and using $E(:, v)$. Similarly for rows also.

[2]Upper triangular matrix: all elements below the North-West to South-East diagonal of the matrix are zero.

ii. Create a function file to calculate the rowwise and columnwise mean and standard deviation of a user defined matrix. Display the matrix, its mean and standard deviation in output. (hint; mean(), stdev())

(c) 09:05:

i. Create an inline function to sort the elements of a random vector in descending order. (hint: gsort())

ii. Create an inline function to round off the elements of a vector [1.9, 2.3, -1.1, 50.5] to the nearest integer. (hint: round())

(d) 10:30: Create a function file to calculate LU factorization of a matrix. (hint: lu()).

4. **Plotting**

(a) 01:12: Create a linearly spaced vector from 0 to 1 with 10 points

(b) 01:12: Also create a linearly spaced vector from 0 to 1 with 11 points

(c) 01:35: plot sin(x) versus x.

(d) 02:50: Use plot2d and try changing the color to red. Also try style = -1

(e) 03:53: Put a title: "Sine", and labels, 'x axis' and 'y axis'

(f) 05:50: Plot sin(x) and cos(x) on the same window.

(g) 06:08: Create a legend for the above plots.

(h) 09:25: Now plot sin(x) and cos(x) as subplots within the same window.

(i) 10:10: Save your plot as a file.

5. **Conditional Branching**
Note the importance of 'end' at the end of the 'if-then-else-end' construct.

(a) Write a code to check if a given number n is less than or equal to 10, if yes, display its square.(for $n = 4, 13$ and 10)

(b) Write a code to check if a number is less than 10, if yes, then display '$>$ 10', if it is greater than 10, then display '$>$ 10', else display the number. (for $n = 4, 13$ and 10)

6. **Iteration**

(a) Write a for loop to display all the even numbers between 1 to 50

(b) Find summation of vector x = [1 2 6 4 2], using iterative procedure. Hint: Check length(), add each number using 'for' loop.

(c) Write a code using while loop to display odd numbers in the range 1 to 25.

7. **Polynomials**

(a) Construct a polynomial with 3 repeated roots at 4 and 2 repeated roots at 0. Check the roots of the derivative of this polynomial. (Use derivat)

(b) Write a function that takes a polynomial and gives out only real roots as output.
(hint isreal)

(c) Write a function that takes a polynomial and gives the INVERSE polynomial, i.e. all roots are inverses of each other.
(Hint: Coefficients are to just be reversed.)
(Check that no root was at zero: check this within the function, and display error, and exit.)

(d) Write a function that takes a polynomial and gives all the maxima/minima candidates.
(Hint: find all real roots of the derivative).

8. **Ordinary Differential Equations**

Solve the follwoing differential equations using Scilab and plot the dependent variable vs independent variable

(a) $dy/dx + y/x = -x^3; (x > 0)$

(b) $cos(x)dy/dx + sin(x)y = x^2; y(0) = 4$

(c) $dy/dx = (-x^3 - y)/x; (y(1) = 0)$

(d) $dy/dx + y = 2x + 5; (y(1) = 1)$

(e) $dy/dx + y = x^4; (y(0) = 0)$

(f) $dy/dt + (t - 1)y = 0; (y(4) = 5)$

(g) $dy/dt + 2ty = t; (y(2) = 4)$

(h) $dy/dx + 2xy = 10xe^{-x^2}; (y(0) = 1)$

(i) $2x^2dy/dx - yx = 3; (y(1) = 0)$

9. **Control Systems**

(a) Find the step response of the sytem described by the transfer function:

$$\frac{1}{s^2 + 2s + 9}$$

(b) Define a system whose open loop transfer function has roots at -1, -2 and -3. From the root locus of this system, find the value of gain K for which the system becomes unstable in the closed loop.