AV336 – Digital Signal Processing for Engineering Physics
Labsheet 1

1. Create a vector of the even numbers between 31 and 75.

2. Let x = [2 5 1 6].
a. Add 16 to each element
b. Add 3 to just the odd-index elements
c. Compute the square root of each element
d. Compute the square of each element

3. Let x = [3 2 6 8]' and y = [4 1 3 5]' (NB. x and y should be column vectors).
a. Add the sum of the elements in x to y
b. Raise each element of x to the power specified by the corresponding element in y.
c. Divide each element of y by the corresponding element in x
d. Multiply each element in x by the corresponding element in y, calling the result "z".
e. Add up the elements in z and assign the result to a variable called "w".
f. Compute x'*y - w and interpret the result

4. Evaluate the following MATLAB expressions by hand and use MATLAB to check the answers
a. 2 / 2 * 3
b. 6 - 2 / 5 + 7 ^ 2 - 1
c. 10 / 2 \ 5 - 3 + 2 * 4
d. 3 ^ 2 / 4
e. 3 ^ 2 ^ 2
f. 2 + round(6 / 9 + 3 * 2) / 2 - 3
g. 2 + floor(6 / 9 + 3 * 2) / 2 - 3
h. 2 + ceil(6 / 9 + 3 * 2) / 2 - 3

5. Given a vector, t, of length n, write down the MATLAB expressions that will correctly compute the following:
a. ln (2 + t + t2)
b. et (1 + cos(3t))

6. Plot the expression (determined in modelling the growth of the US population) $P(t) = 197{,}273{,}000/(1 + e^{-0.0313(t - 1913.25)})$ where t is the date, in years AD, using t = 1790 to 2000. What population is predicted in the year 2020?

7. Make a good plot (i.e., a non-choppy plot) of the function f(x) = sin(1/x) for 0.01 < x < 0.1. How did you create the vector x so that the plot looked good?

8. Given x = [3 1 5 7 9 2 6], explain what the following commands "mean" by summarizing the net result of the command.
a. x(3)
b. x(1:7)
c. x(1:end)
d. x(1:end-1)
e. x(6:-2:1)
f. x([1 6 2 1 1])
g. sum(x)

9. Given the array A = [2 4 1 ; 6 7 2 ; 3 5 9], provide the commands needed to
a. assign the first row of A to a vector called x1
b. assign the last 2 rows of A to an array called y

c. compute the sum over the columns of A

d. compute the sum over the rows of A

e. compute the standard error of the mean of each column of A (NB. the standard error of the mean is defined as the standard deviation divided by the square root of the number of elements used to compute the mean.)

10. Given the arrays x = [1 4 8], y = [2 1 5] and A = [3 1 6 ; 5 2 7], determine which of the following statements will correctly execute and provide the result. If the command will not correctly execute, state why it will not. Using the command whos may be helpful here.

a. x + y
b. x + A
c. x' + y
d. A – [x' y']
e. [x ; y']
f. [x ; y]
g. A – 3

11. Given the array A = [2 7 9 7 ; 3 1 5 6 ; 8 1 2 5], explain the results of the following commands

a. A'
b. A(:,[1 4])
c. A([2 3],[3 1])
d. reshape(A,2,6)
e. flipud(A)
f. fliplr(A)
g. [A A(end,:)]
h. A(1:3,:)
i. [A ; A(1:2,:)]
j. sum(A)
k. sum(A')
l. sum(A,2)
k. [[A ; sum(A)] [sum(A,2) ; sum(A(:))]]

12. Evaluate the given MATLAB code fragments for each of the cases indicated. Use MATLAB to check your answers.

```
if z < 5
  w = 2*z
elseif z < 10
  w = 9 - z
elseif z < 100
  w = sqrt(z)
else
  w = z
end
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a. z = 1 w = ?
b. z = 9 w = ?
c. z = 60 w = ?
d. z = 200 w = ?

13. Given x = [4 1 6] and y = [6 2 7], compute the following arrays

a. x > y
b. y < x
c. x == y
d. x <= y
e. y >= x
f. x | y

g. x & y
h. x & (~y)
i. (x > y) | (y < x)
j. (x > y) & (y < x)
k. $a_{ij} = x_i y_i$
l. $b_{ij} = x_i / y_i$
m. $c_i = x_i y_i$, then add up the elements of c.
n. e_{ij} = reciprocal of the lesser of x_i and y_i

14. The exercises here show the techniques of logical-indexing (indexing with 0-1 vectors). Given x = 1:10 and y = [3 1 5 6 8 2 9 4 7 0], execute and interpret the results of the following commands:
a. (x > 3) & (x < 8)
b. x(x > 5)
c. y(x <= 4)
d. x((x < 2) | (x >= 8))
e. y((x < 2) | (x >= 8))
f. x(y < 0)

15. The introduction of the logical data type has forced some changes in the use of non-logical 0-1 vectors as indices for subscripting. You can see the differences by executing the following commands that attempt to extract the elements of y that correspond to either the odd (a.) or even (b.) elements of x:
a. y(rem(x,2)) vs. y(logical(rem(x,2)))
b. y(~rem(x,2)) vs. y(~logical(rem(x,2)))

16. Write a script that asks for a temperature (in degrees Fahrenheit) and computes the equivalent temperature in degrees Celsius. The script should keep running until no number is provided to convert. [NB. the function isempty will be useful here.]

17. Write a script that will use the random-number generator rand to determine the following:
a) The number of random numbers it takes to add up to 20 (or more).
b) The number of random numbers it takes before a number between 0.8 and 0.85 occurs.
c) The number of random numbers it takes before the mean of those numbers is within 0.01 of 0.5 (the mean of this random-number generator).
It will be worthwhile to run your script several times because you are dealing with random numbers. Can you predict any of the results that are described above?

18. Write a MATLAB program to generate and display a random signal of length 100 whose elements are uniformly distributed in the interval [−2, 2].

19 . Write a MATLAB program to generate and display a Gaussian random signal of length 75 whose elements are normally distributed with zero mean and a variance of 3.

20. Write a MATLAB program to generate and display five sample sequences of a random sinusoidal signal of length 31 $\{X[n]\} = \{A \,.\, \cos(\omega o n + \varphi)\}$ where the amplitude A and the phase φ are statistically independent random variables with uniform probability distribution in the range $0 \le A \le 4$ for the amplitude and in the range $0 \le \varphi \le 2\pi$ for the phase.

21. Write a script that asks for an integer (n) and then computes the following based on the value of the integer: While the value of n is greater than 1, replace the integer with half of its value (n/2) if the integer is even. Otherwise, replace the integer with three times its value, plus 1 (3*n + 1). Make provision to count the

number of values in (or the length of) the resulting sequence. Example calculation: If n = 10, the sequence of integers is 5, 16, 8, 4, 2, 1 and so the length is 6.

22. Generate standard signals with a single MATLAB command: Use “stem” command to plot them and label and mark values on x- and y- axis.

a) unit impulse signal with x-axis range -10 to 10

b) unit step signal with x-axis range -10 to 10

c) ramp signal with x-axis range 0 to 10

d) real exponential signal with a = 0.9 and x-axis range 0 to 10

e) Modify a to generate a delayed unit sample sequence with a delay of 11 samples.

f) Modify b to generate advanced unit step sequence with an advance of 7 samples.

23. Generate and plot the following sinusoidal signals by exploring the MATLAB vector handlingcapability

a) $x[n] = 3\sin(2\pi n+\pi/3)$, for $-10 <= n <= 10$

b) $x[n] = 5\cos(2\pi n/3+\pi/4) + 2.5\sin(\pi n/3+\pi/4)$, for $-10 <= n <= 10$

24. In signal processing, it is often needed to deal with complex exponentials. Plot real and imaginary parts of complex exponential signal: $y[n] = r^n \exp(j\pi n/3)$, where r = 0.8; (and r = 1.2) and $0 <= n <= 20$. Plot magnitude and phase signals of the above complex exponential using appropriate MATLAB functions