Selected exercices from

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2.1 Answer the following questions for the array shown below.

$$\texttt{array1} = \begin{bmatrix} 1.1 & 0.0 & 2.1 & -3.5 & 6.0 \\ 0.0 & 1.1 & -6.6 & 2.8 & 3.4 \\ 2.1 & 0.1 & 0.3 & -0.4 & 1.3 \\ -1.4 & 5.1 & 0.0 & 1.1 & 0.0 \end{bmatrix}$$

a. What is the size of `array1`?

b. What is the value of `array1(4,1)`?

c. What is the size and value of `array1(:,1:2)`?

d. What is the size and value of `array1([1 3],end)`?

2.6 Assume that `a`, `b`, `c` and `d` are defined as follows, and calculate the results of the following operations if they are legal. If an operation is, explain why it is illegal.

$$a = \begin{bmatrix} 2 & -2 \\ -1 & 2 \end{bmatrix} \quad b = \begin{bmatrix} 1 & -1 \\ 0 & 2 \end{bmatrix}$$
$$c = \begin{bmatrix} 1 \\ -2 \end{bmatrix} \qquad d = \texttt{eye}(2)$$

a. `result = a + b;`

b. `result = a * d;`

c. `result = a .* d;`

d. `result = a * c;`

e. `result = a .* c;`

f. `result = a  b;`

g. `result = a . b;`

h. `result = a .^ b;`

2.10 Position and velocity of a ball If a stationary ball i released at a height h_0 above the surface of the Earth with a vertical velocity v_0, the position and velocity of the ball as a function of time will br given by the equations

$$h(t) = \frac{1}{2}gt^2 + v_0 t + h_0 \quad (1)$$

$$v(t) = gt + v_0 \quad (2)$$

where g is the acceleration due to gravity (-9.81 m/s^2), h is the height above the surface of the Earth (assuming no air friction), and v is the vertical component of the velocity. Write a Matlab program that prompts a user for the initial height of the ball in meters and the velocity of the ball in meters per second, and plots the height and velocity as a function of time. Be sure to include proper labels in your plots (Use the functions `xlabel`, `ylabel` and `title`.).

2.14 Energy stored in a spring The force required to compress a linear spring is given by the equation

$$F = kx \quad (3)$$

where f is the force in newtons and k is the spring constant in newtons per meter. The potential energy stored in the compressed spring is given by the equation

$$E = \frac{1}{2}kx^2 \quad (4)$$

where E is the energy in joules. The following information is available for the four strings:

spring	**1**	**2**	**3**	**4**
force (N)	20	24	22	30
spring constant k (N/m)	500	600	700	800

Determine the compression of each spring, and the potential energy stored in each spring. Which spring has the most energy stored in it?

3.3 The following statements are intended to alert a user to dangerously high oral thermometer readings (values are i degrees Farenheit). Are they correct or incorrect? If they are incorrect, explain why and correct them.

```
if temp < 97.5
   disp('Temperature below normal');
```

```
elseif temp >97.5
   disp('Temperature normal');
elseif temp > 99.5
   disp('Temperature slightly high');
elseif temp > 103.0
   disp('Temperature dangerously high');
end
```

3.7 Write a program that allows a user to enter a string containing a day of the week ('Sunday', 'Monday', etc.). and uses a `switch` construct to convert the day to its corresponding number, where Sunday is day number 1. Print out the resulting day number. Also, be sure to handle the case of ann illegal day name! (*Note:* Be sure to use the `'s'` option on function `input` so that the input is treated as a string.)

Suggested extension: Modify the program to accept also Swedish day names ('måndag', 'tisdag', 'onsdag', 'torsdag', 'fredag', 'lördag', 'söndag'). Day number 1 is måndag. Accept also any unique beginning of a day name.

4.7a Examine the following loop and determine the value of `ires` at the end of the loop, and also the number of times the loop executes.

```
ires = 0;
for index = -10:10
ires = ires+1;
end
```

4.9a What is contained in array `arr1` after the following set of statements is executed?

```
arr1 = [1 2 3 4; 5 6 7 8; 9 10 11 12];
mask = mod(arr1,2) == 0;
arr1(mask) = -arr1(mask);
```

4.19 Fibonacci numbers The nth Fibonacci number is defined by the following recursive equations:

$$\begin{aligned} f(1) &= 1 \\ f(2) &= 2 \\ f(n) &= f(n-1) + f(n-2) \end{aligned}$$

Therefore, $f(3) = f(2) + f(1) = 2 + 1 = 3$, and so forth for higher numbers. Write an M-file to calculate and write out the nth Fibonacci number for $n > 2$, where n is input by the user. Use a `while` loop to perform the calculation.

5.2 When a function is called, how is data passed from the caller to the function, and how are the results of the function returned to the caller?

5.9 Dice simulation It is often useful to be able to simulate the throw of a fair dice. Write a Matlab function `dice` that simulates the throw of a fair dice by returning some ramdom integer between 1 and 6 every time it is called. (*Hint:* Call `rand`, generate a random number between 0 and 6 and round up to next integer.)

5.17 Maxima and minima of a function Write a function that attempts to locate the maximum and minimum values of an arbitrary function $f(x)$ over a certain range. The function being evaluated should be passed to the function as a calling argument. The function should have the following input:

`first_value`—The first value of x to search
`last_value`—The last value of x to search
`num_steps`—The number of of equidistant x values to include in the search
`func`—The name of the function to search

The function should have the following output arguments:

`xmin`—The value of x at which the minimum was found
`min_value`—The minimum value of $f(x)$ found
`xmax`—The value of x at which the maximum was found
`max_value`—The maximum value of $f(x)$ found

Be sure to check that there are a valid number of input arguments, and that the Matlab `help` and `lookfor` commands are properly supported.

5.24 The birthday problem The birthday problem is as follows: if there are a group of n people in a room, what is the probability that two or more of them have the same birthday? It is possible to determine the answer to this question by simulation. Write a function that calculates the probability that two or more of n people will have the same birthday, where n is a calling argument. (*Hint:* To do this, the function should create an array of size n and generate n birthdays in the range 1 to 365 randomly. It should check to see if any of the n birthdays are identical. The function should perform this experiment at least 5 000 times and calculate the fraction of those times in which two or more people had the same birthday.) Write a test program that calculates and prints out the probability that 2 or more of n people will have the same birthday for $n = 2, 3, \ldots, 40$.

Possible extension Work out an analytical solution.

6.11 Create a mesh, surface, and contour plot of the function $z = e^{x+iy}$ for the interval $-1 \leq x \leq 1$ and $-2\pi \leq y \leq 2\pi$. In each case, plot the real

part of z versus x and y.

6.12 Write a program that accepts an input string and a character from the user and determines how many times the character appears within the string. (*Hint:* Use the `'s'` option of the `input` command.)

6.22 Plot the function $f(x) = 1/\sqrt{x}$ over the range $0.1 \leq x \leq 10.0$ using `fplot`. Be sure to label your plot properly.

7.3 Create a sparse 100×100 array `a` in which about 5 % of the elements contain normally distributed random values and all of the other elements are zero (use function `sprandn` to generate these values). Next, set all of the diagonal elements in the array to 1. Next, define a 100-element sparse column array `b` and initialize that array with 100 uniformly distributed values produced by function `rand`. Answer the following questions about these arrays:

a. Create a full array `a_full` from the sparse array `a`. Compare the memory required to store the full array and the sparse array. Which is more efficient?

b. Plot the distribution of values in array `a` using function `spy`.

c. Create a full array `b_full` from the sparse array `b`. Compare the memory required to store the full array and the sparse array. Which is more efficient?

d. Solve the system of equations `a * x = b` for both the full arrays and the sparse arrays. How do the two sets of answers compare? Time the two solutions. Which one is faster?

8.8 Write a program that reads an arbitrary number of real values from a user-specified input data file, rounds the values to the nearest integer, and writes the integers out to a user-specified output file. Make sure that the input file exists, and if not, tell the user and ask for another input file. If the output file exists, ask the user whether or not to delete it. If not, prompt for a different output file name.

8.11 Interest calculation Suppose that you have a sum of money P in an interest-bearing accout at a local bank (P stands for *present value*). If the bank pays you interest monthly, the amount of money that you will have in the bank after n months is given by the equation:

$$F = P\left(1 + \frac{i}{1200}\right)^n$$

where f is the future value of the account and $\frac{i}{12}$ is the monthly pecentage interest rate (the extra factor of 100 in the denominator converts

the interest rate from percentages to fractional amounts). Write a Matlab program that will read an initial amount of money P and an annual interest rate i, and will calculate and write a table showing the future value of the account every month for the next 5 years. The table should be written to an output file called '`interest`'. Be sure to properly label the columns of your table.