

## 1 Basics

1. What is the main purpose of a variable?
  - A. to use in arithmetic expressions
  - B. to store a value and refer to the value by name
  - C. to pass values to functions
  - D. to make code easier to read and understand
2. What can a script do that a function cannot?
  - A. carry out a complex calculation
  - B. change the values of variables in the main workspace
  - C. call other functions
  - D. call other scripts
3. MATLAB seems to use call by value when calling a function. What does call by value mean?
  - A. the function can modify the value of the arguments in the function workspace
  - B. the function can modify the values of the arguments in the main workspace
  - C. the function receives arguments by copying their values into the function workspace
  - D. the function can use the values given by the arguments
4. Which choice best completes the following sentence fragment: An `if` statement lets the programmer...
  - A. choose which statements should run based on a logical condition
  - B. create a loop to repeat code based on a logical condition
  - C. find a particular value based on a logical condition
  - D. store the result of a logical condition
5. In general, when would you choose to use a `while` loop instead of a `for` loop?

6. We use four steps to convert a temperature in degrees Fahrenheit to degrees Kelvin:

1. Subtract 32 from the Fahrenheit temperature
2. Multiply the result from Step 1 by 5
3. Divide the result from Step 2 by 9
4. Add 273.15 to the result from Step 3

Write a MATLAB statement that converts 42 degrees Fahrenheit to degrees Kelvin.

7. What is the main purpose of testing?

- A. to find errors in your code
- B. to make sure that every line of code is necessary
- C. to make sure that every line of code is run at least once
- D. to prove that your code is correct

8. When unit testing a function, what makes up a test case?

- A. an oracle to determine the expected output
- B. some way to compare the output of the function to the expected output
- C. the output of the function
- D. the specific inputs to the function and the expected output

9. When integrating a function using the composite midpoint rule with  $n$  panels how many times is the function evaluated?

- A.  $n - 1$  times
- B.  $n$  times
- C.  $n + 1$  times
- D.  $2n - 1$  times

10. What is a recursive function?:

- A. a function that calls another function
- B. a function that calls itself
- C. a function that repeatedly calls another function
- D. a function that uses a function handle

## 2 Lab Questions

11. In the labs, why did we use a resistor in series with an LED?
- A. to make sure the positive terminal of the LED was connected to the +5 volts
  - B. to increase the amount of current that flows through the resistor
  - C. to limit the amount of current that flows through the resistor
  - D. to make sure the negative terminal of the LED was connected to ground
12. How is an audio signal represented in MATLAB?
- A. a sampling frequency
  - B. a vector of values representing time
  - C. a vector of values between 0 and 1
  - D. a vector of values between -1 and 1
13. What is an image mask?
- A. The part of the image that we are interested in
  - B. A matrix used to select the part of the image that we are interested in
  - C. A matrix used to create an image
  - D. A matrix used to delete an image
14. How do you make a differential drive robot spin in place?
- A. turn the wheels in the same direction at different speeds
  - B. turn the wheels in the same direction at the same speed
  - C. turn the wheels in opposite directions at different speeds
  - D. turn the wheels in opposite directions at the same speed

## 3 Code comprehension

15. How many values are in the vector `x` shown below?

```
x = -5 : 0.5 : 5;
```

- A. 10
- B. 11
- C. 20
- D. 21

16. Which statement best describes the result of the following code?

```
x = -5 : 0.5 : 5;  
y = sin(x) ./ x;
```

- A. the calculation of  $y$  should have used  $/$  instead of  $./$
- B. no values in  $y$  are unusual
- C. one value in  $y$  is unusual
- D. several values in  $y$  are unusual

17. Consider the following function:

```
function swap(x, y)  
  
tmp = x;  
x = y;  
y = tmp;
```

Suppose that you call the `swap` function using variables `a` and `b` like so:

```
swap(a, b);
```

After calling the function, the value of `a` is 5 and the value of `b` is 10. What values of `a` and `b` were used to call the function? Explain your answer.

18. What is the value of the following MATLAB expression?

```
x < -2 | x > 2
```

- A. always equal to `true`
- B. always equal to `false`
- C. true if  $x$  is outside of the range  $-2$  to  $2$  (and is not  $-2$  or  $2$ )
- D. true if  $x$  is between  $-2$  to  $2$  (including  $-2$  and  $2$ )

19. What is the value of the following MATLAB expression?

```
x < -2 & x > 2
```

- A. always equal to `true`
- B. always equal to `false`
- C. true if  $x$  is outside of the range  $-2$  to  $2$  (and is not  $-2$  or  $2$ )
- D. true if  $x$  is between  $-2$  to  $2$  (including  $-2$  and  $2$ )

20. What is the value of the following MATLAB expression?

`~(x < -2 | x > 2)`

- A. always equal to `true`
- B. always equal to `false`
- C. true if `x` is outside of the range `-2` to `2` (and is not `-2` or `2`)
- D. true if `x` is between `-2` to `2` (including `-2` and `2`)

21. Consider the following MATLAB code where `s` is a vector of integer values:

```
t = s;  
n = numel(s);  
for i = n : -1 : 1  
    t = [t s(i)];  
end
```

After running the code once, the value of `t` is `[1 2 3 4 4 3 2 1]`.

What was the original value of `s`?

22. Suppose that you have a vector `x` containing at least one element and no more than one hundred elements. What does the following code do assuming that the code is in fact correct?

```
n = numel(x);  
i = 1;  
while x(i) < x(i + 1)  
    i = i + 1;  
end  
x(i)
```

- A. finds a local maximum in `x`
- B. finds a local minimum in `x`
- C. find the number of values in `x`
- D. finds the smallest value in `x`

23. What is wrong with the code in Question 22?

24. What does the following program print?

```
for i = 1:3
    for j = i:3
        fprintf('*');    % prints a single *
    end
    fprintf('\n');        % goes to the next line
end
```

- A. \*  
\*\*  
\*\*\*
- B. \*\*\*  
\*\*  
\*
- C. \*\*\*  
\*\*\*  
\*\*\*
- D. \*\*\*\*\*

25. `[y, i] = min(x);` finds the smallest value `y` in the vector `x` and also returns the index `i` where `y` can be found in `x`.

`x(j) = [];` removes the element at index `j` from the vector `x`.

What does the following code do?

```
z = [];
while numel(x) > 0
    [y, i] = min(x);
    z = [z y];
    x(i) = [];
end
```

## 4 Identify the error

26. A student wants to compute the value of  $y = \frac{1}{1+x}$  for some vector of values  $x$ ; the student writes the following:

```
y = 1 ./ 1 + x;
```

What is wrong with their code?

- A. should have used / instead of ./
- B. should have used a loop
- C. should have used parentheses
- D. the code produces an error if  $x$  contains the value  $-1$

27. A student is trying to check if a scalar value  $x$  is exactly equal to 0.5 by writing:

```
if x = 0.5
    % something happens here
end
```

What is wrong with their code?

- A.  $x$  is being assigned a value
- B.  $x$  might be the empty array
- C. 0.5 cannot be represented exactly using the IEEE 754 standard
- D. the `else` part of the statement is missing

28. Consider the user-defined function `shmotion2` from the lecture notes. The help documentation for the function is:

```
SHMOTION2 Position of a simple harmonic oscillator.
X = shmotion2(T, A, K, M) computes the position X of a simple harmonic
oscillator for each time in the vector T. The amplitude of oscillation
is A, the spring constant is K, and the mass is M.
```

A student tries to use the function like so:

```
time = linspace(0, 10);
mass = 1;
amp = 0.5;
springC = 3.33;
shmotion2(time, mass, amp, springC);
```

Which choice best describes your assessment of the student's code?

- A. the student has used the function correctly
- B. the student has specified the arguments in the wrong order
- C. the student has assigned the wrong number of return variables
- D. the student has supplied the wrong number of arguments

29. Consider the user-defined function `newton` from the lecture notes. The help documentation for the function is:

```
NEWTON Newton's method for  $x^2 - 1$ 
    ROOT = newton(X0, EPSILON) finds a root of  $f(x) = x^2 - 1$  using
    Newton's method starting from an initial estimate X0 and a tolerance
    EPSILON

    [ROOT, XVALS] = newton(X0, EPSILON) also returns the iterative estimates
    in XVALS
```

A student tries to use the function like so:

```
[r, x] = newton(-5);
```

Which choice best describes your assessment of the student's code?

- A. the student has used the function correctly
- B. the student has specified the arguments in the wrong order
- C. the student has assigned the wrong number of return variables
- D. the student has supplied the wrong number of arguments

30. Consider the following code that tries to compute the sum of the values  $-5, -6, -7, \dots, -10$ :

```
x = -5:-10;
n = numel(x);
theSum = 0;
for i = 1:n
    theSum = theSum + x(i);
end
```

The value of `theSum` is 0; why?

- A. the vector `x` has too many elements
- B. the vector `x` is empty
- C. `theSum` is not computed correctly
- D. `theSum` is not printed out after the loop



## 5 How would you....

31. One of the two possible roots of the quadratic equation  $ax^2 + bx + c = 0$  is

$$x = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

Assuming that the scalar valued variables  $a$ ,  $b$ , and  $c$  exist, how do you compute  $x$  in MATLAB?

- A. `x = (-b + sqrt(b * b - 4 * a * c)) / (2 * a);`
  - B. `x = -b + sqrt(b * b - 4 * a * c) / (2 * a);`
  - C. `x = (-b + sqrt(b ^ 2 - 4 * a * c)) / 2 * a;`
  - D. `x = (-b + sqrt(b ^ 2 - 4 a c)) / (2 a);`
32. How could you add (concatenate) the value 5 to the beginning of an existing column vector  $x$ ?
33. If  $v$  is a vector of having 2 elements, which statement computes the unit vector  $u$  having the same direction as  $v$ ?
- A. `u = v / numel(v);`
  - B. `u = v / norm(v .* v);`
  - C. `u = v / sqrt(sum(v));`
  - D. `u = v / sqrt(v(1) ^ 2 + v(2) ^ 2);`
34. Loops in MATLAB are very slow compared to the built-in operators that work with arrays; how could you replace the following loop with a single MATLAB statement?

```
n = numel(x);
for i = 1:n
    if x(i) < 0
        x(i) = 0;
    end
end
```

35. An  $n \times n$  matrix  $A$  is said to be upper triangular if all of the elements below the main diagonal are equal to 0 (the remaining elements can have any value). For example, the following matrix is an upper triangular matrix (the elements on the main diagonal are circled):

$$\begin{bmatrix} 1 & 4 & 2 & 1 \\ 0 & 3 & 4 & 2 \\ 0 & 0 & 1 & 4 \\ 0 & 0 & 0 & 6 \end{bmatrix}$$

Consider the following MATLAB code that sets `isUpper` to `true` if  $A$  is an upper triangle matrix and `false` otherwise:

```
isUpper = true;
for i = ???
    for j = ???
        if A(i, j) ~= 0
            isUpper = false;
        end
    end
end
```

What are the two missing vectors indicated by the ???

36. As a quality control engineer at a food packaging plant, you want to know how often the packaging machinery is underfilling and overfilling containers of product that should weigh 500 grams. Because the packaging machinery cannot always measure out exactly 500 grams of product, your employer has decided that any container that weighs less than 475 grams or weighs more than 525 grams should be rejected. If `wt` is a vector of packed container weights, how would you find the total number of packed containers that should be rejected?

- A. `rej = sum(wt < 475 | wt > 525);`
- B. `rej = sum(wt < 475 & wt > 525);`
- C. `rej = sum(wt > 475 & wt < 525);`
- D. `rej = sum(wt > 475) + sum(wt < 525);`

37. A digital signal is a vector of values that are all zeros and ones; for example, a digital signal might look like:

```
x = [0 0 0 0 1 1 1 0 0 0 0 1 1 0 0 0 1 1 1 0 0 0];
```

In the vector `x`, a sequence of 1s indicates a peak in the signal. Given a vector such as `x`, how could you compute the number of peaks in `x`; that is to say, how could you compute the number of sections in `x` that are made up of a sequence of 1s? You may assume the signal does not start or end with a 1. Your answer should consist of at most 2 lines of MATLAB code.

38. Suppose that you wrote the following code to find the second largest value in a vector  $z$ :

```
largest = -Inf;  
secondLargest = -Inf;  
for i = 1:numel(z)  
    zi = z(i);  
    if zi >= largest  
        secondLargest = largest;  
        largest = zi;  
    end  
end
```

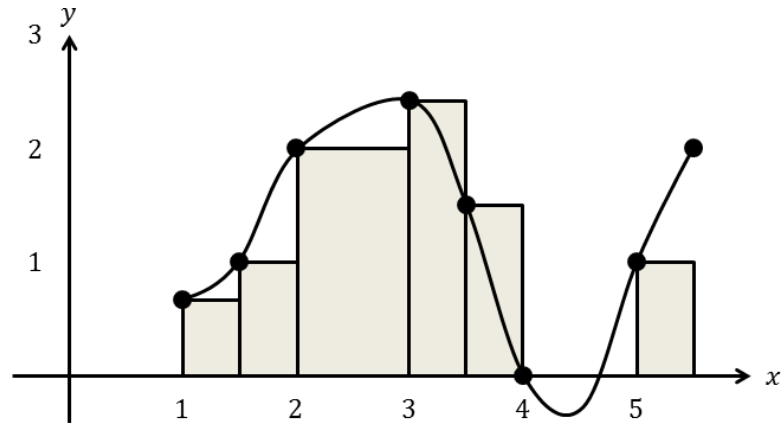
Which test case input would reveal an error in your code?

- A. no test case will reveal an error
- B.  $z = [6 \ 8 \ 10 \ 12 \ 14]$
- C.  $z = [6 \ 8 \ 12 \ 7 \ 14]$
- D.  $z = [5 \ 10 \ 8 \ 1 \ 3]$

39. Finding the area under a curve is equivalent to evaluating a definite integral. Suppose that we have points on a curve defined by the following coordinates:

```
x = [ 1    1.5    2    3    3.5    4    5    5.5];
y = [ 0.7    1    2    2.4    1.5    0    1    2];
```

We can approximate the area under the curve (i.e., we can numerically integrate the function) by summing the area of the rectangles shown below:



How can you compute such a sum in MATLAB?

- A. `area = 0;`  
`for i = 2:numel(x)`  
`area = area + (x(i - 1) - x(i)) * y(i - 1);`  
`end`
- B. `area = 0;`  
`for i = 2:numel(x)`  
`area = area + (x(i - 1) - x(i)) * y(i);`  
`end`
- C. `area = 0;`  
`for i = 2:numel(x)`  
`area = area + (x(i) - x(i - 1)) * y(i - 1);`  
`end`
- D. `area = 0;`  
`for i = 1:(numel(x) - 1)`  
`area = area + (x(i + 1) - x(i)) * y(i + 1);`  
`end`

40. What is a one- or two-line solution to Question 39 that does not use a loop nor any MATLAB function that performs numerical integration?

41. How could you find the index  $i$  of the last element equal to 1 in a vector  $x$ ?

It might be the case that no element of  $x$  has the value 1.

It might be the case that more than one element of  $x$  has the value 1.

- A. `i = 0;`  
    `for j = numel(x) : -1 : 1`  
        `if x(j) == 1`  
            `i = j;`  
        `end`  
    `end`  
    `i`
- B. `i = 0;`  
    `for j = 1:numel(x)`  
        `if x(j) == 1`  
            `i = j;`  
        `end`  
    `end`  
    `i`
- C. `i = 1;`  
    `while x(i) ~= 1`  
        `i = i + 1;`  
    `end`  
    `i`
- D. `i = 1;`  
    `while x(i) ~= 1 & i <= numel(x)`  
        `i = i + 1;`  
    `end`  
    `i`

42. For each incorrect answer in Question 41, explain what the code in the incorrect answer actually does.

43. A year is always a leap year if it is evenly divisible by 400. If a year is not divisible by 400, then it is a leap year if it is evenly divisible by 4 and not evenly divisibly by 100.

Provide a list of test cases that you would use to test a function that determines if a specified year is a leap year (returns true if a year is a leap year and returns false otherwise). For each test case state the input year, the expected return value, and a reason why you chose to use this particular test case.

44. A PIN for a bank card is a sequence of 4 to 8 digits where any digit is allowed to be a zero (for example, 0009 is a valid 4-digit PIN and 01020304 is a valid 8-digit PIN).
- (a) Using only a single variable how would you represent a PIN in MATLAB?
  - (b) Suppose that you write a function in MATLAB that determines if a variable is a valid PIN. Describe what steps such a function would need to take given your answer to part (a). Try to be as specific as possible.
  - (c) Give a substantially different answer to part (a).

45. Suppose that you drop a ball at time  $t = 0$  and record a video of the ball falling. From the video you estimate the distance that the ball has fallen at regular time intervals. In other words, you can obtain a vector  $\mathbf{t}$  of time in seconds and a corresponding vector  $\mathbf{d}$  of distance in meters that the ball has fallen. From physics you expect that the distance travelled by the ball is given by

$$d = \frac{1}{2}gt^2$$

where  $g$  is the acceleration due to gravity.

- (a) How can you use line fitting with the points defined by  $\mathbf{t}$  and  $\mathbf{d}$  to obtain an estimate of  $g$ ?  
 (b) Consider the following set of measurements of  $\mathbf{t}$  and  $\mathbf{d}$ :

| $\mathbf{t}$ (seconds) | $\mathbf{d}$ (metres) |
|------------------------|-----------------------|
| 0.0                    | 0.000                 |
| 0.1                    | 0.050                 |
| 0.2                    | 0.200                 |
| 0.3                    | 0.465                 |
| 0.4                    | 0.773                 |
| 0.5                    | 1.270                 |
| 0.6                    | 1.801                 |
| 0.7                    | 2.507                 |
| 0.8                    | 3.103                 |
| 0.9                    | 3.952                 |
| 1.0                    | 4.908                 |

Describe how you can estimate the downwards speed of the ball using the measurements.

- (c) Using the measurements in part (b), estimate the downwards speed of the ball at 0.5 seconds. Show all of your work.



46. Suppose that you have vector  $v$  of numeric values where the elements of the vector are not necessarily unique.
- (a) If the elements of  $v$  are sorted from smallest to largest value what can you say about the value of  $v(1)$ ?
  - (b) If the elements of  $v$  are sorted from smallest to largest value what can you say about the vector  $v(2:end)$ ?
  - (c) If  $v$  has only one element is  $v$  sorted?
  - (d) Write a recursive function in MATLAB that returns true if the input vector  $v$  is sorted from smallest to largest value and false otherwise.

47. Consider the mathematical operation of raising a real number  $x$  to an integer exponent  $n$ .
- (a) For every real valued  $x$  what is  $x^0$  equal to?
  - (b) For every real valued  $x$  what is  $x^n$  equal to if  $n$  is negative?
  - (c) For every real valued  $x$  and positive integer value  $n$  what is the relationship between  $x^n$  and  $x^{n-1}$ ?
  - (d) Write a recursive function in MATLAB that returns the value of  $x^n$  where  $x$  is a floating-point number and  $n$  is an integer (possibly negative) value. You may not use any MATLAB function that computes a power and you may not use the exponentiation operator  $^$ .