CS 101 Practice Final Exam

- **Be sure to enter your information below, enter your answers for multiple-choice questions on the next page, and your code for the last two coding questions on the last two pages**. Do not turn this page until instructed to.
- This is a 180-minute exam with 30 questions:
  - 12 MATLAB multiple-choice questions worth 5 points each;
  - 16 Python multiple-choice questions worth 5 points each; and
  - 2 coding questions worth 30 points each

  for a total of 200 possible points.
- **Your are NOT allowed to take any page of this final exam out of the final exam classroom. In other words, all pages of your final exam must be submitted.**
- Each multiple choice question has only *one* correct answer.
- You must not communicate with other students during the exam.
- No books, notes, or electronic devices are permitted. In other words, you are not allowed to use a dictionary on your mobile phone or other electronic devices. However, if you don't understand the meaning of a particular English word in this exam, please raise your hand and the instructor will explain the meaning of the English word to you.

1. Fill in your information:

Full Name: ________________________________

Student ID: ________________________________

Zone 1

The following 12 questions involve MATLAB.

1/1. (5 points) Consider the following MATLAB program:

```
x = [ 1 2 ];
y = [ 3 4 ];
z = [ x' [ y ; y ] ]';
```

What is the **value** of `z` after this program executes?

A. $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 3 & 4 \end{bmatrix}$

B. $\begin{bmatrix} 1 & 3 & 3 \\ 2 & 4 & 4 \end{bmatrix}$

C. $\begin{bmatrix} 1 & 3 & 4 \\ 2 & 3 & 4 \end{bmatrix}$

D. $\begin{bmatrix} 1 & 2 \\ 3 & 3 \\ 4 & 4 \end{bmatrix}$

E. None of the other answers are correct

Solution.

2/1. (5 points) Consider the following MATLAB program:

```
A = ones( 4,4 ) + 2 * eye( 4,4 );
A = A - 2;
A( :,3:4 ) = A( :,3:4 ) + 2;
```

What is the **value** of `A` after this program executes?

A. $\begin{bmatrix} 1 & -1 & 1 & 1 \\ -1 & 1 & 1 & 1 \\ -1 & -1 & 3 & 1 \\ -1 & -1 & 1 & 3 \end{bmatrix}$

B. $\begin{bmatrix} 0 & -2 & 0 & 0 \\ -2 & 0 & 0 & 0 \\ -2 & -2 & 2 & 0 \\ -2 & -2 & 0 & 2 \end{bmatrix}$

C. $\begin{bmatrix} -1 & -1 & 1 & 1 \\ -1 & -1 & 1 & 1 \\ -1 & -1 & -3 & 1 \\ -1 & -1 & 1 & -3 \end{bmatrix}$

D. $\begin{bmatrix} 1 & 1 & 3 & 3 \\ 1 & 1 & 3 & 3 \\ 1 & 1 & 3 & 3 \\ 1 & 1 & 3 & 3 \end{bmatrix}$

E. None of the other answers are correct

Solution.

3/1. (5 points) Consider the following MATLAB function stored in `prink.m`:

```
function [ f g ] = prink( x,y )
  f = x .^ -0.5;
  g = y + f .* 2;
end
```

Which of the following correctly assigns the results of a call to `prink` `f` to `F` and `g` to `G`, respectively?

A. `F,G = prink( 2,3 );`

B. `[ F G ] = prink( [ 2 3 ] );`

C. `[ F G ] = prink( 2 3 );`

D. `[ F G ] = prink [ 2 3 ];`

E. `[ F G ] = prink( 2,3 );`

Solution.

4/1. (5 points) Recollect that MATLAB represents polynomials as an array of coefficients from the highest-order coefficient to the lowest. For instance,

$$x^3 + x + 2$$

is written as the array `[ 1 0 1 2 ]`.

How would we represent the summation of the two polynomials

$$x^2 + x + 1$$

and

$$x^3 + x^2 - 1$$

as a MATLAB polynomial array?

A. `[ 1 1 1 ] + [ 1 1 0 -1 ]`

B. `[ 1 1 1 ] + [ -1 0 1 1 ]`

C. `[ 0 1 1 1 ] + [ 1 1 0 -1 ]`

D. `[ 1 1 1 0 ] + [ 1 1 0 -1 ]`

Solution.

5/1. (5 points) Consider the following two-dimensional MATLAB array, stored in the variable `A`:

$$\begin{bmatrix} 1 & 1 \\ 3 & 6 \\ 9 & 36 \\ 27 & 216 \end{bmatrix}$$

How can we index and retrieve the value 36 from this array?

A. `A( 2,1 )`

B. `A( 3,2 )`

C. `A( 2,3 )`

D. `A[ 2,1 ]`

E. `A[ 3,2 ]`

Solution.

6/1. (5 points) *For this problem, you should compose a function which accomplishes a given task using the available code blocks arranged in the correct functional order.*

The Levi-Civita symbol represents a direction of travel through the permutations of the elements of a vector (or higher-order tensor). For a 3D vector, given numbers i, j, k,

$$\varepsilon_{ijk} = \left\{ \begin{bmatrix} +1 & \quad (1,2,3),(2,3,1),(3,1,2); \\ -1 & \quad (3,2,1),(2,1,3),(1,3,2); \\ 0 & \quad \text{if}\, i=j, j=k, \text{ or}\, k=i. \end{bmatrix} \right.$$

Compose a function `epsilon` which accepts a vector `ind` representing the three values i, j, k in the above definition. The function should return the value of ε_{ijk} for those values.

```
1 end

2 s = 0;

3 s = -1;

4 s = +1;

5 if ind(1) == ind(2) | ind(2) == ind(3) | ind(3) == ind(1)

6 elseif ind(1) == 1 & ind(2) == 2 & ind(3) == 3

7 elseif ind(1) == 2 & ind(2) == 3 & ind(3) == 1

8 elseif ind(1) == 3 & ind(2) == 1 & ind(3) == 2

9 elseif ind(1) < ind(2) & ind(2) < ind(3) & ind(3) < ind(1)

10 function [ s ] = epsilon( ind )

11 function epsilon( ind )

12 else

13 if ind(1) == 1 & ind(2) == 2 & ind(3) == 3
```

A. 10, 5, 2, 6, 3, 7, 3, 8, 3, 12, 4, 1

B. 10, 5, 2, 6, 4, 7, 4, 8, 4, 12, 3, 1, 1

C. 10, 2, 13, 4, 12, 3, 1, 1

D. 11, 5, 2, 6, 4, 7, 4, 8, 4, 12, 3, 1

Solution.

7/1. (5 points) Consider the following MATLAB program:

```
s = (2 < 3) & ((2 > 3) | (1 ~= 0))
```

What is the final value of `s`?

A. `True`

B. `1`

C. `0`

D. `false`

Solution.

8/1. (5 points)

```
x = eye( 2,2 );
y = [ x(:,1) x(:,2) ];
A = [ x y ; y x ];
```

What is the final value of `A( 1:2,1:2 )`?

A. `[ 0 1 ; 1 0 ]`

B. `[ 1 1 ; 1 1 ]`

C. `[ 0 0 ; 0 0 ]`

D. `[ 1 0 ; 0 1 ]`

Solution.

9/1. (5 points)

```
x  = linspace( -1,1,101 );
y1 = exp( x );
y2 = tan( x );
y3 = rand( 1,numel(x) );
```

How would you successfully plot all three of these data series as points? (Assume any given plot format strings are valid.)

A. `plot( x, y1,'r.', x,y2,'g.', x,y3,'b.' );`

B. `plot( x, y1,'r.', y2,'g.', y3,'b.' );`

C.
```
hold on;
plot( x, y1 );
plot( x, y2 );
plot( x, y3 );
```

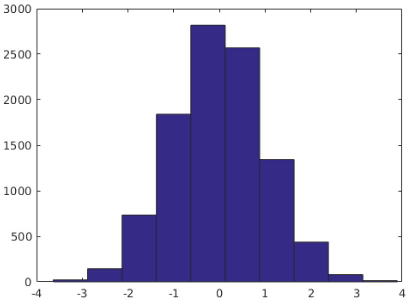
D. `plot( x,y1, x,y2, x,y3 );`

Solution.

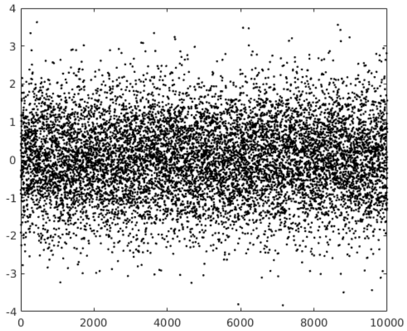
10/1. (5 points) Consider the following program, which produces 10,000 random numbers selected from a certain distribution and plots them:

```
x = randn( 10000,1 );
plot( x,'k.' );
```

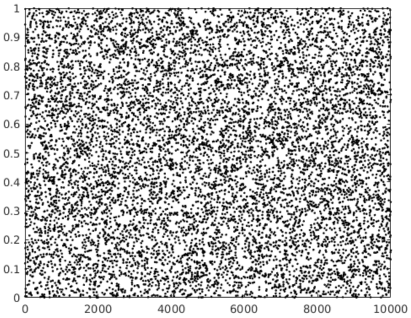
Which of the following plots could result from executing this program?



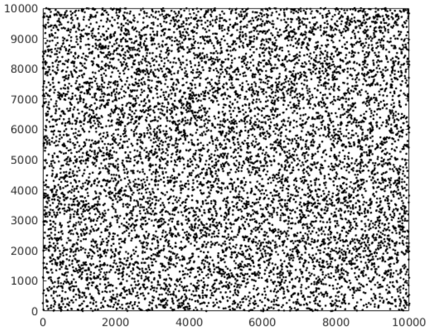
A.



B.



C.


10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2000
4000
6000
8000
10000

D.

Solution.

11/1. (5 points)

```
A = eye( 4,4 );
for x = 1:2:4
    A( x,x ) = 0;
end
```

What is the final value of `A`?

A. $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

B. $\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

C. $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$

D. $\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$

E. $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

Solution.

12/1. (5 points)

```
A = eye( 3,3 ) - ones( 3,3 );
for x = 1:3
    for y = 1:3
        if x <= y
            A( x,y ) = mod( x,y );
        end
    end
end
```

What is the final value of `A`?

A. $\begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$

B. $\begin{bmatrix} 0 & 1 & 1 \\ -1 & 0 & 2 \\ -1 & -1 & 0 \end{bmatrix}$

C. $\begin{bmatrix} 2 & -1 & -1 \\ 3 & 2 & -1 \\ 4 & 5 & 2 \end{bmatrix}$

D. $\begin{bmatrix} 1 & 1 & 0 \\ 2 & 0 & -1 \\ 0 & -1 & -1 \end{bmatrix}$

E. $\begin{bmatrix} -1 & 1 & 1 \\ -1 & -1 & 2 \\ -1 & -1 & -1 \end{bmatrix}$

Solution.

Zone 2

The following 18 questions involve Python.

13/1. (5 points) Consider the following incomplete Python program:

```
a = 'BUSTER'
b = 'KEATON'
d = { }
for x,y in zip( a,b ):
    ???
s = ''
for c in a:
    s += d[ c ]
```

What should replace the three question marks to cause this program to yield a final value for `s` of `'KEATON'`?

A. `d[ x ] = y`

B. `d[ y ] = x`

C. `d[ a ] = b`

D. `d[ b ] = a`

E. `d[ a ] = x`

Solution.

14/1. (5 points) Consider the following Python program:

```
d = { 0:0,1:0,2:0,3:0 }
for i in range( -7,-2 ):
    d[ i%4 ] += i
x = d[ 0 ]
```

What is the final *value* of `x`?

A. `-2`

B. `-3`

C. `-4`

D. `-5`

E. `-6`

Solution.

15/1. (5 points) Consider the following Python program:

```
d = { "M":1,"A":1,"R":2,"X":1 }
for c in "HARPO":
    print( d[ c ] + '-' )
```

What kind of exception will this program throw?

A. `KeyError: 'H'`

B. `TypeError: list indices must be integers, not str`

C. `SyntaxError: invalid syntax`

D. `TypeError: unsupported operand type(s) for +: 'int' and 'str'`

Solution.

16/1. (5 points) Consider the following Python program:

```
e = list( range( 0,10,2 ) )
d = [ '0','0','0','0' ]
for i in range( 0,len(e) ):
    d[ i%4 ] += str( e[ i ] )
x = d[ 1 ]
```

What is the final *type* of `x`?

A. `str`

B. `list`

C. `int`

D. `dict`

Solution.

17/1. (5 points) Consider the following incomplete Python program:

```
sum = 0
???:
    sum += i + 1
```

The program is intended to sum all of the integers between 1 and 10 (inclusive). What should replace the three question marks to complete the program?

A. `for i in range( 0,10 )`

B. `while i <= 10`

C. `for i in range( 1, 11 )`

D. `while i in range( 10 )`

Solution.

18/1. (5 points)

```
x = np.array( [ 4,2 ] * 2 )
```

What is the final *value* of `x`?

A. $\begin{bmatrix} 4 & 4 \\ 2 & 2 \end{bmatrix}$

B. $\begin{bmatrix} 4 \\ 2 \\ 4 \\ 2 \end{bmatrix}$

C. $\begin{bmatrix} 4 & 2 & 4 & 2 \end{bmatrix}$

D. $\begin{bmatrix} 8 & 4 \end{bmatrix}$

Solution.

19/1. (5 points)

```
import itertools
x = 'hardy'
???
    print( x )
```

Replacing the three question marks with which of the following will result in `'hardy'` being printed exactly ten times?

A. `for a in itertools.combinations(x,5):`

B. `for a in itertools.combinations(x,2):`

C. `for a in itertools.combinations(x,3):`

D. `for a in itertools.combinations(x,4):`

Solution.

20/1. (5 points) Consider the following incomplete Python program:

```
y = 1.0   # initial position, m
v = 0.0   # initial velocity, m/s
g = -9.8  # acceleration due to gravity, m/s^2
t = 5.0   # initial time, s
dt = ???  # time increment, s

while y > 0.0:
    t += dt
    v += g * dt
    y += v * dt
```

Which of the following values for `dt` will yield the most accurate solution?

A. `dt = 1e4`

B. `dt = 0.1`

C. `dt = 1e-4`

D. `dt = 10`

Solution.

21/1. (5 points)

```
s = 'STOOGE'
x = ''
for i in range( 0,len( s ) ):
    if ( i>1 ) and ( i<4 ):
        x = s[ i:i+2 ] + x
```

What is the *value* of `x` after this program is executed?

A. 'OGOO'

B. 'OOTO'

C. 'OO'

D. 'TO'

E. None of the other answers are correct.

Solution.

22/1. (5 points)

```
def prod_pairs( A ):
    total = 0
    ???
    return total
```

The function prod_pairs accepts a list of floats named A. prod_pairs should return the product of each pair of values in A (without repeats). For example, given the list [1,2,3], prod_pairs should return 11 from $(1*2)+(1*3)+(2*3) = 11$. What should replace the three question marks to complete the function? (Assume any necessary imports to have taken place already.)

A.
```
for i in range( len( A ) ):
    for j in range( i+1,len( A ) ):
        total += A[ i ] * A[ j ]
```

B.
```
for i in range( len( A ) ):
    for j in range( len( A ) ):
        total *= A[ i ] * A[ j ]
```

C.
```
for i,j in enumerate( A ):
        total += A[ i ] * A[ j ]
```

D.
```
for i in itertools.permutations( A ):
        total += i[ 0 ] * i[ 1 ]
```

Solution.

23/1. (5 points) What do we call the optimization heuristic that involves choosing the best from a stochastically sampled subset of the domain?

A. Brute-force search

B. Local optimum

C. Hill climbing

D. Random search

Solution.

24/1. (5 points)

```
def most_sessions( datafile ):
    d = { }
    for line in open( datafile ):
        ???
    return d
```

The function `most_sessions` should compute the greatest number of events per session of each user in the database by reading a comma-separated value input file of session data. The result should be returned from the function as a dictionary. The first column of each line in the input file is expected to contain the user's name represented as a string. The second column is expected to contain an integer representing the events in a session. Here is an example input file:

```
Groucho,10
Beppo,12
Harpo,25
Your program should ignore a non-conforming line like this one.
Beppo,3
Chico,6
Chico,14
```

The resulting return value for this file should be the following dictionary:

```
{ 'Beppo':12, 'Harpo':25, 'Groucho':10, 'Chico':14 }
```

What should replace the three question marks to complete the function?

A.
```
try:
    s,f = line.split( "," )
    if s not in d:
        d[ s ] = 0
    if int( f ) > d[ s ]:
        d[ s ] = int( f )
except:
    continue
```

B.
```
if line not in d:
    d[ line ] = 0
try:
    s,f = line.split( "," )
except:
    d[ s ] = int( f )
    continue
```

C.
```
try:
    s,f = line.split( "," )
except:
    continue
if f not in d:
    d[ f ] = 0
d[ f ] = max( int( s ), d[ f ] )
```

D.
```
  try:
      s,f = line.split()
```

```
        d[ s ] = int( f )
    except:
        break
```

Solution.

25/1. (5 points)

```
s = ''.join( [ "3","3","2","2" ] )
x = 0
for i in range( len( s )-1 ):
    x += int( ??? )
```

What should replace the three question marks so the resulting value of x is 7?

A. `s[ i:i+2:i ]`

B. `s[ i+1:i:-1 ]`

C. `s[ i+3:i:-1 ]`

D. `s[ i+1:i+2 ]`

Solution.

26/1. (5 points)

```
x = [ ]
for i in range( 1,11 ):
    for j in range( i+1,11 ):
        t = i,j
        x.append( t )
```

After the program runs, which of the following is an element of `x`?

A. `(9,10)`

B. `(9,3)`

C. `(4,1)`

D. `(8,7)`

E. `(10,4)`

Solution.

27/1. (5 points)

```
e = [ 5,4,3,2,1,10,9,8,7,6 ]
d = { 0:0,1:0,2:0,3:0 }
for a,b in enumerate( e ):
    d[ a%4 ] += b
x = d[ 1 ]
```

After it is run, what is the final *value* of `x`?

A. `4`

B. `20`

C. `14`

D. `26`

E. `8`

Solution.

28/1. (5 points)

```
x = "2,2,a".split(',')
x.reverse()
try:
    print( x[-1] )
except:
    print( type( len( x ) ) )
```

After it is run, what is printed by this program?

A. `TypeError`

B. `3`

C. `2`

D. `NoneType` (the type of `None`)

Solution.

Zone 3

29/1. (25 points)

Your friend Vanessa can't remember her Facebook password and wants your help figuring it out. She remembers the password is exactly 8 characters long. She also remembers that her username is either "vanessa" or "VanessaC" or "Vanessa95". Assume someone else has already written a function `login` that takes a two string arguments representing a username and password combination. `login` returns `True` if the input username and password are valid credentials for Facebook and `False` otherwise. Your function `guess_password` should perform a brute force search and return the correct username and password for Vanessa's account as a tuple of two strings.

We set up the alphabet string for you. Assume all of the possible password characters are contained in this string. You may `import itertools` in your solution if you prefer, but no other libraries are allowed.

```
def guess_password():
    alphabet="ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz"
    alphabet+="0123456789!@#$%^&*()-_=+,<.>/?~`"
```

Solution.

Zone 4

30/1. (25 points) Write a Python program to simulate a population of rabbits for 50 years. Your simulation should update annually (i.e. $\Delta t = 1$ year). The initial population of rabbits is 15. Each year, 5% of the population of the previous year dies off, and each year exactly 5 new rabbits are born. In your simulation, it should be impossible for "partial rabbits" to exist. For example, the population should never be 13.7—we're not interested in 70% of a rabbit. You should always round the population *down* to a whole number.

You may `import numpy` in your solution if you prefer, but no other libraries are allowed.

Solution.

Zone 5

31/1. (25 points) Consider the Taylor series definition of the exponential function:

$$\exp(x) = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \frac{x^5}{5!} + \frac{x^6}{6!} + \frac{x^7}{7!} + ...$$

The series converges for all real x, so to calculate $\exp(x)$ to within a few decimal places of accuracy one just needs to include sufficient terms in the calculation.

The following MATLAB function `expp` was written in order to calculate the value of $\exp(x)$ for all x to three decimal places of accuracy (`atol` in the code). Translate this function into a Python function—also called `expp`—which yields identical output from the function as the MATLAB function for given input. You may `import numpy as np` in your solution if you prefer, but no other libraries are allowed. (Assume a valid NumPy-compatible function `factorial` is also available. Also recall that $0! = 1! = 1$.)

```
function [ y ] = expp( x )
    y = 0;
    yold = 1;
    n = 0;
    atol = 1e-3;  % tolerance
    while ( abs( y-yold ) > atol )
        yold = y;
        term = ( x .^ n ) / factorial( n );
        if (mod(n,2) == 1)
            term = -term;
        end
        y = y + term;
        n = n + 1;
    end
end
```

Solution.