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.
Consider the following MATLAB program:

\[
x = \begin{bmatrix} 1 & 2 \end{bmatrix}; \\
y = \begin{bmatrix} 3 & 4 \end{bmatrix}; \\
z = [x' [y ; y] ]';
\]

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:

```matlab
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:

```matlab
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 \(i, j, k\),

\[
\varepsilon_{ijk} = \begin{cases} 
+1 & (1, 2, 3), (2, 3, 1), (3, 1, 2); \\
-1 & (3, 2, 1), (2, 1, 3), (1, 3, 2); \\
0 & \text{if } i = j, j = k, \text{ or } k = i.
\end{cases}
\]

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

```matlab
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
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)

\[
x = \text{eye}(2,2);
\]
\[
y = [x(:,1) x(:,2)];
\]
\[
A = [x y; y x];
\]

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)

\[
x = \text{linspace}(-1,1,101);
\]

\[
y_1 = \text{exp}(x);
\]

\[
y_2 = \text{tan}(x);
\]

\[
y_3 = \text{rand}(1,\text{numel}(x));
\]

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

A. \text{plot}(x, y_1,'r.', x,y_2,'g.', x,y_3,'b.');

B. \text{plot}(x, y_1,'r.', y_2,'g.', y_3,'b.');

C. \text{hold on;}
   \text{plot}(x, y_1);
   \text{plot}(x, y_2);
   \text{plot}(x, y_3);

D. \text{plot}(x,y_1, x,y_2, x,y_3);

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

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

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

Solution.
11/1. (5 points)

\[ A = \text{eye}(4,4); \]
\[ \text{for } x = 1:2:4 \]
\[ \quad A(x,x) = 0; \]
\[ \text{end} \]

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)

\[ A = \text{eye}(3,3) - \text{ones}(3,3); \]

\[
\text{for } x = 1:3 \\
\quad \text{for } y = 1:3 \\
\quad \quad \text{if } x \leq y \\
\quad \quad \quad A(x,y) = \text{mod}(x,y); \\
\quad \quad \text{end} \\
\quad \text{end} \\
\text{end}
\]

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.

\[
16
\]
Zone 2
The following 18 questions involve Python.
13/1. (5 points) Consider the following incomplete Python program:

```python
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:

```python
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:

```python
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:

```python
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)

\[
x = \text{np.array}(\begin{bmatrix} 4 & 2 \\ 4 & 2 \end{bmatrix} * 2)
\]

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)

```python
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:

```python
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)

```python
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.**
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.
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)

```python
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)

```python
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)

```python
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.

```python
def guess_password():
    alphabet="ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz" + "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:

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

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 $0! = 1! = 1$.)

```matlab
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.**