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:

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

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:

\[
A = \text{ones}(4,4) + 2 * \text{eye}(4,4);
A = A - 2;
A(:,3:4) = A(:,3:4) + 2;
\]

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.**
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. \(\star [ 0 1 1 1 ] + [ 1 1 0 -1 ]\)
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 function [ s ] = epsilon( ind )
2
3 s = 0;
4 s = -1;
5 s = +1;
6 if ind(1) == ind(2) | ind(2) == ind(3) | ind(3) == ind(1)
7 elseif ind(1) == 1 & ind(2) == 2 & ind(3) == 3
8 elseif ind(1) == 2 & ind(2) == 3 & ind(3) == 1
9 elseif ind(1) == 3 & ind(2) == 1 & ind(3) == 2
10 elseif ind(1) < ind(2) & ind(2) < ind(3) & ind(3) < ind(1)
11 function [ s ] = epsilon( ind )
12 function epsilon( ind )
13 else
14 if ind(1) == 1 & ind(2) == 2 & ind(3) == 3
15     A. 10, 5, 2, 6, 3, 7, 3, 8, 3, 12, 4, 1
16     B. ⋆ 10, 5, 2, 6, 4, 7, 4, 8, 4, 12, 3, 1
17     C. 10, 2, 13, 4, 12, 3, 1, 1
18     D. 11, 5, 2, 6, 4, 7, 4, 8, 4, 12, 3, 1
19     Solution.
```
7/1. (5 points) Consider the following MATLAB program:

\[ s = (2 < 3) \& \& ((2 > 3) \mid (1 \sim 0)) \]

What is the final value of \( s \)?

A. True
B. \( \star \) 1
C. 0
D. false

Solution.
8/1. (5 points)

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

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

A. \[ \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \]
B. \[ \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} \]
C. \[ \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \]
D. ★ \[ \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \]

Solution.
9/1. (5 points)

\[ x = \text{linspace}(-1,1,101); \]
\[ y1 = \exp(x); \]
\[ y2 = \tan(x); \]
\[ y3 = \text{rand}(1,\text{numel}(x)); \]

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

A. ★

\[ \text{plot}(x,y1,'r.', x,y2,'g.', x,y3,'b.' ); \]

B. \text{plot}(x,y1,'r.', y2,'g.', y3,'b.' );

C. \text{hold on;}
\[ \text{plot}(x,y1); \]
\[ \text{plot}(x,y2); \]
\[ \text{plot}(x,y3); \]

D. \text{plot}(x,y1, x,y2, x,y3 );

\text{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?

A. ![Histogram](image1)

B. ![Scatter Plot](image2)

C. ![Random Distribution](image3)
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)

```matlab
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. $egin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$

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

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

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

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

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

```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:

```python
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)

\[
x = \text{np.array}([4, 2]) * 2
\]

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)

```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.**
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 $(1 \times 2) + (1 \times 3) + (2 \times 3) = 11$. What should replace the three question marks to complete the function? (Assume any necessary imports to have taken place already.)

A. ★

```python
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 ) ):

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

C. for i,j in enumerate( A ):

```python
    total += A[ i ] * A[ j ]
```

D. for i in itertools.permutations( A ):

```python
    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.
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.

---

32
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"
    alphabet+="0123456789!@#$%^&*()-_=+,<.>/?~`"

    Solution.
```

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

```python
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.
```