CS 101 Practice Final Exam

- Be sure to enter your NetID and the code below on your Scantron.
- Do not turn this page until instructed to.
- This is a 120-minute exam.
- There are 32 questions:
  - 12 MATLAB multiple-choice questions worth 5 points each;
  - 18 Python multiple-choice questions worth 5 points each; and
  - 2 coding questions worth 25 points each
for a total of 200 possible points.

- 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 during the exam.

1. Fill in your information:

   Full Name: ____________________________

   UIN (Student Number): __________________

   NetID: ________________________________

   Lab Section: __________________________

2. Fill in the following answers on the Scantron form:
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:

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

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.
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. \texttt{A(2,1 )}
B. \texttt{A(3,2 )}
C. \texttt{A(2,3 )}
D. \texttt{A[2,1 ]}
E. \texttt{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
function \texttt{s} = \texttt{epsilon} ( \texttt{ind} )
end
\texttt{s} = 0;
\texttt{s} = -1;
\texttt{s} = +1;
if \texttt{ind(1)} == \texttt{ind(2)} | \texttt{ind(2)} == \texttt{ind(3)} | \texttt{ind(3)} == \texttt{ind(1)}
elseif \texttt{ind(1)} == 1 & \texttt{ind(2)} == 2 & \texttt{ind(3)} == 3
elseif \texttt{ind(1)} == 2 & \texttt{ind(2)} == 3 & \texttt{ind(3)} == 1
elseif \texttt{ind(1)} == 3 & \texttt{ind(2)} == 1 & \texttt{ind(3)} == 2
elseif \texttt{ind(1)} < \texttt{ind(2)} & \texttt{ind(2)} < \texttt{ind(3)} & \texttt{ind(3)} < \texttt{ind(1)}
function [ \texttt{s} ] = \texttt{epsilon} ( \texttt{ind} )
function \texttt{epsilon} ( \texttt{ind} )
else
if \texttt{ind(1)} == 1 & \texttt{ind(2)} == 2 & \texttt{ind(3)} == 3
A. 10, 5, 2, 6, 3, 7, 3, 8, 3, 12, 4, 1
B. \text{★} 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:

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

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

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

Solution.
8/1. (5 points)

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

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)

```matlab
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. ★

```matlab
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:

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

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

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

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

```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 'BUSTER'?

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( -3,7 ):
    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:

```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.**
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.
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 ] )
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"
    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
Consider the Taylor series definition of the exponential function:

\[
\exp(x) = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \frac{x^5}{5!} + \frac{x^6}{6!} + \frac{x^7}{7!} + \cdots
\]

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 (\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 import \texttt{numpy} as \texttt{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.