

- 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 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 eachfor 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 = [ y x ; x y ]';
```

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

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

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

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

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

E. None of the other answers are correct

Solution.

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

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

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

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

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

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

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

E. None of the other answers are correct

Solution.

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

```
A = ones( 3,3 ) - eye( 3,3 );  
A = A * 2;  
A( 1:2,: ) += 3;
```

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

A. ★ $\begin{bmatrix} 3 & 5 & 5 \\ 5 & 3 & 5 \\ 2 & 2 & 0 \end{bmatrix}$

B. $\begin{bmatrix} 3 & 5 & 2 \\ 5 & 3 & 2 \\ 5 & 5 & 0 \end{bmatrix}$

C. $\begin{bmatrix} 0 & 2 & 2 \\ 5 & 3 & 5 \\ 5 & 5 & 3 \end{bmatrix}$

D. $\begin{bmatrix} 0 & 5 & 5 \\ 2 & 3 & 5 \\ 2 & 5 & 3 \end{bmatrix}$

E. None of the other answers are correct

Solution.

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

```
A = ones( 3,3 ) - eye( 3,3 );  
A = A * 3;  
A( :,1:2 ) = A( :,1:2 ) + 3;
```

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

A. $\begin{bmatrix} 3 & 6 & 6 \\ 6 & 3 & 6 \\ 3 & 3 & 0 \end{bmatrix}$

B. ★ $\begin{bmatrix} 3 & 6 & 3 \\ 6 & 3 & 3 \\ 6 & 6 & 0 \end{bmatrix}$

C. $\begin{bmatrix} 0 & 3 & 3 \\ 6 & 3 & 6 \\ 6 & 6 & 3 \end{bmatrix}$

D. $\begin{bmatrix} 0 & 6 & 6 \\ 3 & 3 & 6 \\ 3 & 6 & 3 \end{bmatrix}$

E. None of the other answers are correct

Solution.

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

```
function [ a b ] = squrge( x,y )
    a = x .^ 2;
    b = a .* 3 + y;
end
```

Which of the following correctly assigns the results of a call to `squrge` `a` to `A` and `b` to `B`, respectively?

- A. `A,B = squrge(5,4);`
- B. `[A B] = squrge([5 4]);`
- C. `[A B] = squrge(5 4);`
- D. `[A B] = squrge [5 4];`
- E. ★ `[A B] = squrge(5,4);`

Solution.

3/2. (5 points) Consider the following MATLAB function stored in `splink.m`:

```
function [ a b ] = splink( x,y )
    a = x .^ 3 - y .^ 2;
    b = y / 2 + a;
end
```

Which of the following correctly assigns the results of a call to `splink` `a` to `A` and `b` to `B`, respectively?

- A. `A,B = splink(5,4);`
- B. `[A B] = splink([5 4]);`
- C. `[A B] = splink(5 4);`
- D. `[A B] = splink [5 4];`
- E. ★ `[A B] = splink(5,4);`

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,

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

is written as the array `[3 2 1]`.

How would we represent the summation of the two polynomials

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

and

$$2x^3 + 4x - 1$$

as a MATLAB polynomial array?

- A. `[-1 3 1] + [2 4 -1]`
- B. `[-1 3 1] + [2 0 4 -1]`
- C. ★ `[0 -1 3 1] + [2 0 4 -1]`
- D. `[1 3 -1 0] + [-1 4 0 2]`
- E. `[1 3 -1] + [-1 4 2]`

Solution.

4/2. (5 points) Recollect that MATLAB represents polynomials as an array of coefficients from the highest-order coefficient to the lowest. For instance,

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

is written as the array `[3 2 1]`.

How would we represent the difference of the two polynomials

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

and

$$x^3 + 4x^2 + 2$$

as a MATLAB polynomial array?

- A. ★ `[0 -1 3 1] - [1 4 0 2]`
- B. `[-1 3 1] - [2 0 4 1]`
- C. `[0 -1 3 1] - [2 0 4 1]`
- D. `[1 3 -1 0] - [1 4 0 2]`
- E. `[1 3 -1] - [1 4 2]`

Solution.

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

$$\begin{bmatrix} 1 & 16 & 256 \\ 2 & 32 & 512 \\ 4 & 64 & 1024 \\ 8 & 128 & 2048 \end{bmatrix}$$

How can we index and retrieve the value 128 from this array?

- A. **A(2,4)**
- B. ★ **A(4,2)**
- C. **A(1,3)**
- D. **A[2,4]**
- E. **A[3,1]**

Solution.

5/2. (5 points) Consider the following two-dimensional MATLAB array, stored in the variable **A**:

$$\begin{bmatrix} 1 & 16 & 256 \\ 2 & 32 & 512 \\ 4 & 64 & 1024 \\ 8 & 128 & 2048 \end{bmatrix}$$

How can we index and retrieve the value 512 from this array?

- A. **A(3,2)**
- B. ★ **A(2,3)**
- C. **A(6)**
- D. **A[2,3]**
- E. **A[1,2]**

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.*

Compose a function `cross_prod` which accepts two column vectors `a` and `b` and returns a column vector including the value of the cross product,

$$\vec{c} = \vec{a} \times \vec{b} = [a_2b_3 - a_3b_2, a_3b_1 - a_1b_3, a_1b_2 - a_2b_1].$$

```

1 end
2 c(1) = a(2)*b(3) - a(3)*b(2);
3 function [ c ] = cross_prod( a,b )
4 c(2) = a(3)*b(1) - a(1)*b(3);
5 c = zeros( 3,1 );
6 c(3) = a(1)*b(2) - a(2)*b(1);
7 c = zeros( 1,3 );
8 c = a .* b - b .* a;
9 function cross_prod( a,b )

```

- A. 3, 7, 2, 4, 6, 1
- B. ★ 3, 5, 2, 4, 6, 1
- C. 9, 5, 8, 1
- D. 9, 7, 2, 4, 6, 1
- E. 3, 7, 8, 1

Solution.

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

```
s = (3 < 5) | ((2 > 3) & (1 ~= 0))
```

What is the final value of `s`?

A. `True`

B. ★ 1

C. 0

D. `false`

Solution.

7/2. (5 points) Consider the following MATLAB program:

```
s = (5 < 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(2,:) ; x(1,:) ];  
A = [ x y ; y x ];
```

What is the final value of $A(2:3,2:3)$?

- 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.

8/2. (5 points)

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

What is the final value of $A(2:3,2:3)$?

- 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 = linspace( -10,10,201 );  
y1 = sin( x );  
y2 = cos( x );  
y3 = randn( 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.', y2, 'g.', y3, 'b.');`

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

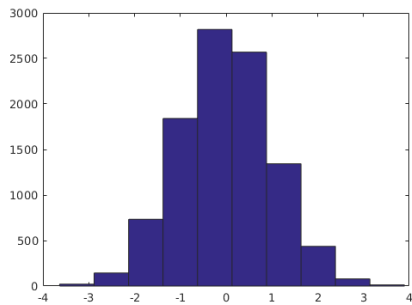
C. ★

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

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

Solution.

10/1. (5 points) Consider the following plot, produced from 10,000 random numbers selected from an as-yet-undetermined distribution.



Which of the following MATLAB programs could produce this plot? Assume that all programs work as written.

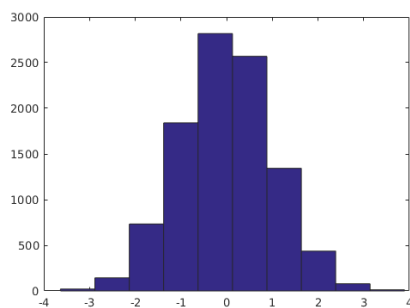
- A. `x = rand(10000,1);`
`plot(x);`
- B. ★
`x = randn(10000,1);`
`hist(x);`
- C. `x = rand(10000,1);`
`hist(x);`
- D. `x = randn(10000,1);`
`plot(x);`

Solution.

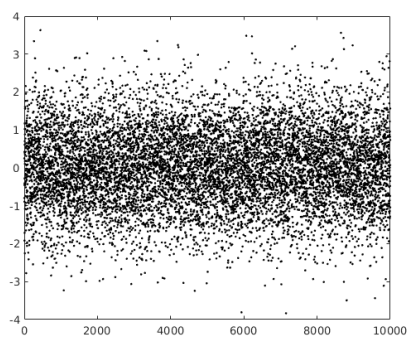
10/2. (5 points) Consider the following program, which produces 10,000 random numbers selected from a certain distribution and plots them:

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

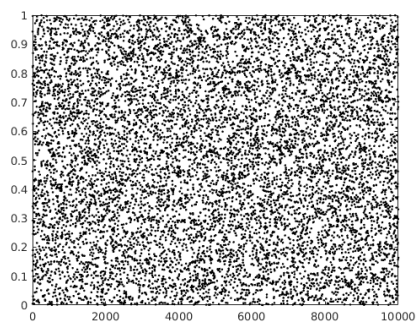
Which of the following plots could result from executing this program?



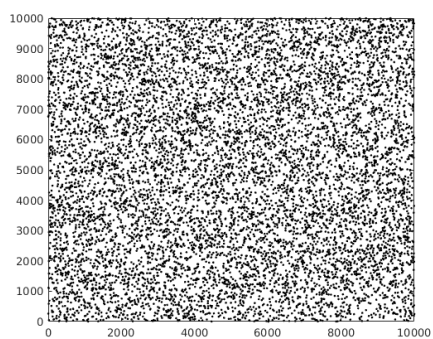
A.



B.



C. ★



D.

Solution.

11/1. (5 points)

```
A = eye( 3,3 );  
for x = 1:2:3  
    A( x,x ) = 0;  
end
```

What is the final value of A?

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

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

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

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

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

Solution.

11/2. (5 points)

```
A = eye( 3,3 );  
for x = 2:1:3  
    A( x,x ) = 0;  
end
```

What is the final value of A?

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

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

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

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

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

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 ) = x + y;  
        end  
    end  
end
```

What is the final value of A?

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

B. ★ $\begin{bmatrix} 2 & 3 & 4 \\ -1 & 4 & 5 \\ -1 & -1 & 6 \end{bmatrix}$

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

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

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

Solution.

12/2. (5 points)

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

What is the final value of A?

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

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

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

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

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

Solution.

12/3. (5 points)

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

What is the final value of A?

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

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

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

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

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

Solution.

Zone 2

The following 16 questions involve Python.

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

```
a = 'DWALIN'
b = 'THORIN'
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 'THORIN'?

- A. ★ `d[x] = y`
- B. `d[y] = x`
- C. `d[a] = b`
- D. `d[b] = a`
- E. `d[a] = x`

Solution.

13/2. (5 points) Consider the following incomplete Python program:

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

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

- 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 }  
for i in range( 10,15 ):  
    d[ i%3 ] += i  
x = d[ 1 ]
```

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

- A. 12
- B. ★ 23
- C. 11
- D. 25
- E. 1

Solution.

14/2. (5 points) Consider the following Python program:

```
d = { 0:0,1:0,2:0 }  
for i in range( 11,18 ):  
    d[ i%3 ] += i  
x = d[ 1 ]
```

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

- A. 40
- B. 42
- C. 45
- D. 29
- E. ★ 27

Solution.

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

```
d = { "B":1,"A":1,"G":2,"I":1,"N":1,"S":1 }  
for c in "BILBO":  
    print( d[ c ] + '-' )
```

What kind of exception will this program throw?

- A. `KeyError: 'L'`
- B. `TypeError: list indices must be integers, not str`
- C. `SyntaxError: invalid syntax`
- D. ★ `TypeError: unsupported operand type(s) for +: 'int' and 'str'`

Solution.

15/2. (5 points) Consider the following Python program:

```
d = { "B":1,"A":1,"G":2,"I":1,"N" 1,"S":1 }  
for c in "BILBO":  
    print( d[ c ] + '-' )
```

What kind of exception will this program throw?

- A. `KeyError: 'L'`
- 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 ] += e[ i ]
x = d[ 1 ]
```

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

- A. 0
- B. 8
- C. 10
- D. ★ 2
- E. 14

Solution.

16/2. (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 ] += e[ i ]
x = d[ 2 ]
```

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

- A. 0
- B. 8
- C. 10
- D. 2
- E. ★ 4

Solution.

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

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

The program is intended to sum all of the integers between 1 and 100 (inclusive). What should replace the three question marks to complete the program?

- A. `for i in range(0,100)`
- B. `while i <= 100`
- C. ★ `for i in range(1, 101)`
- D. `while i in range(100)`

Solution.

17/2. (5 points) Consider the following incomplete Python program:

```
sum = 0
for i in range( 0,100 ):
    ???
```

The program is intended to sum all of the integers between 1 and 100 (inclusive). What should replace the three question marks to complete the program?

- A. `sum += 1`
- B. `sum + 1 = sum`
- C. ★ `sum += i + 1`
- D. `sum += i`

Solution.

18/1. (5 points)

```
x = np.array( [ [ 2 ] , [ 3 ] ] * 2 )
```

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

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

B. ★ $\begin{bmatrix} 2 \\ 3 \\ 2 \\ 3 \end{bmatrix}$

C. $[2 \ 3 \ 2 \ 3]$

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

Solution.

18/2. (5 points)

```
x = np.array( [ [ 2 ] , [ 3 ] ] * 3 )
```

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

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

B. ★ $\begin{bmatrix} 2 \\ 3 \\ 2 \\ 3 \\ 2 \\ 3 \end{bmatrix}$

C. $[2 \ 3 \ 2 \ 3 \ 2 \ 3]$

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

Solution.

19/1. (5 points)

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

Replacing the three question marks with which of the following will result in 'beorn' being printed exactly five 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.

19/2. (5 points)

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

Replacing the three question marks with which of the following will result in 'smaug' being printed exactly one time?

- 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 = ??? # initial time, s
nt = ??? # number of time intervals, -
dt = t/nt # time increment, s
```

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

Which of the following values for `t` and `nt` will yield the most accurate solution?

- A. ★ `t, nt = 1.0, 1e5`
- B. `t, nt = 10.0, 1e3`
- C. `t, nt = 10.0, 1e4`
- D. `t, nt = 1.0, 10`

Solution.

21/1. (5 points)

```
s = 'THRANDUIL'
x = ''
for i in range( 0,len( s ) ):
    if ( i>3 ) and ( i<6 ):
        x += s[ i:i+2 ]
```

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

- A. ★ 'NDDU'
- B. 'ANND'
- C. 'AN'
- D. 'ND'
- E. None of the other answers are correct.

Solution.

21/2. (5 points)

```
s = 'ELROND'
x = ''
for i in range( 0,len( s ) ):
    if ( i>2 ) and ( i<5 ):
        x += s[ i:i+2 ]
```

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

- A. ★ 'ONND'
- B. 'ROON'
- C. 'RO'
- D. 'ND'
- E. None of the other answers are correct.

Solution.

22/1. (5 points)

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

The function `sum_pairs` accepts a list of floats named `A`. `sum_pairs` should return the sum of all pairs of values in the list (without repeats). For example, given the list `[1,2,3]`, `sum_pairs` should return 12 from $(1 + 2) + (1 + 3) + (2 + 3) = 12$. 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 iteratively checking to see if neighboring solutions improve upon the current solution?

- A. Conjugate gradient
- B. Local optimum
- C. ★ Hill-climbing
- D. Random search

Solution.

23/2. (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. Gradient descent
- D. ★ Random search

Solution.

23/3. (5 points) What do we call the optimization heuristic that involves taking *any* available improvement on the current solution?

- A. ★ Brute-force search
- B. Conjugate gradient
- C. Gradient descent
- D. Random search

Solution.

24/1. (5 points)

```
def total_sales( sales_file ):
    d = { }
    for line in open( sales_file ):
        ???
    return d
```

The function `total_sales` should compute the total sales of each employee working for a company by reading a comma-separated value input file of employee sale 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 employee's name represented as a string. The second column is expected to contain a floating point number representing the total for that sale. Here is an example input file:

```
Tom,10.0
Bill,10.55
Bill,115.50
Your program should ignore a non-conforming line like this one.
Bert,30.25
```

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

```
{ 'Bert':30.25, 'Bill':126.05, 'Tom':10.0 }
```

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

A. ★

```
try:
    s,f = line.split( "," )
    if s not in d:
        d[ s ] = 0.0
    d[ s ] += float( f )
except:
    continue
```

B. if line not in d:
 d[line] = 0.0

```
try:
    s,f = line.split( "," )
except:
    d[ s ] += float( f )
    continue
```

C. try:
 s,f = line.split(",")
except:
 continue
if f not in d:
 d[f] = 0.0
d[f] += float(s)

D. try:
 s,f = line.split()
 d[s] += float(f)
except:
 break

Solution.

25/1. (5 points)

```
s = ''.join( [ "0","1","2","1" ] )
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 34?

- A. `s[i:i+2:i]`
- B. `s[i:i+1]`
- C. ★ `s[i+2:i:-1]`
- D. `s[i+1:i+2]`

Solution.

25/2. (5 points)

```
s = ''.join( [ "2","2","0","1" ] )
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 13?

- A. `s[i:i+2:i]`
- B. `s[i:i+1]`
- C. ★ `s[i+2:i:-1]`
- D. `s[i+1:i+2]`

Solution.

25/3. (5 points)

```
s = ''.join( [ "1","1","0","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 23?

- A. `s[i:i+2:i]`
- B. `s[i:i+1]`

C. ★ `s[i+2:i:-1]`

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

Solution.

26/1. (5 points)

```
x = [ ]
for i in range( 1,101 ):
    for j in range( i+1,101 ):
        t = i,j
        x.append( t )
```

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

- A. ★ (10,52)
- B. (0,33)
- C. (42,15)
- D. (78,78)
- E. (11,4)

Solution.

26/2. (5 points)

```
x = [ ]
for i in range( 1,101 ):
    for j in range( i+1,101 ):
        t = i,j
        x.append( t )
```

After the program runs, which of the following is *not* an element of **x**?

- A. ★ (55,55)
- B. (4,33)
- C. (19,32)
- D. (78,100)
- E. (1,20)

Solution.

27/1. (5 points)

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

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

- A. 3
- B. 10
- C. 12
- D. 22
- E. ★ 8

Solution.

27/2. (5 points)

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

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

- A. 3
- B. 10
- C. 12
- D. 22
- E. ★ 8

Solution.

28/1. (5 points)

```
x = "5 4 1".split()
x = x.sort()
try:
    print( len( x ) )
except:
    print( type( x ) )
```

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

- A. TypeError
- B. 3
- C. list
- D. ★ NoneType

Solution.

28/2. (5 points)

```
x = "1 2 3".split()
x = ','.join( x )
try:
    print( x.append( 4 ) )
except:
    print( type( x ) )
```

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

- A. TypeError
- B. [1,2,3,4]
- C. list
- D. ★ str

Solution.

Zone 3

29/1. (25 points)

You have been hired by a private investigation firm to crack an smartphone of indeterminate provenance (and a process of questionable legality). The default password is exactly five characters long, with possible characters selected from the upper- and lower-case alphabets and the ten digits 0 to 9. Assume that you have available a function `test_password` which returns `True` if the password is correct and `False` otherwise.

Compose a Python function `crack_phone` which accepts no arguments and returns a string representing the correct password which unlocks the smartphone. You may `import itertools` in your solution if you prefer, but no other libraries are allowed.

```
alphabet = 'ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789'
```

Solution.

Zone 4

30/1. (25 points) Consider the Taylor series definition of the sine function:

$$\sin(x) = x + \frac{x^3}{3!} + \frac{x^5}{5!} + \frac{x^7}{7!} + \dots$$

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

The following MATLAB function `sine` was written in order to calculate the value of $\sin(x)$ for all x to three decimal places of accuracy (`atol` in the code). Translate this function into a Python function—also called `sine`—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.)

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

Solution.
