This exam has 59 questions and 15 pages.

You may use one single-sided 8.5x11” piece of paper with whatever you want written on it. Apart from that, this exam is closed book. No notes, books, calculators or electronic devices, or other assistance may be used.

Mark your answers on the supplied answer sheet.

If you think there are multiple correct answers to a question, select the best answer.
Part 1

1. What shape does the following code draw?

```python
import turtle
t1 = turtle.Turtle()
t2 = turtle.Turtle()
for i in range(2):
    t2.rt(90)
t2.bk(50)
for i in range(2):
    t1.fd(50)
t1.rt(90)
```

(A) No shape listed here
(B) There is an error when this code is run
(C) Square
(D) Rectangle

2. George R. R. Martin’s book *A Game of Thrones (A Song of Ice and Fire, Book 1)* has 704 pages. Spoiler alert: everyone dies in it. To represent any given page number from this book, how many bits would you need?

(A) 704
(B) 703
(C) 10
(D) 9
(E) 8

3. How high can you count using the fingers on one hand?

(A) Greater than 30
(B) 5
(C) 6
(D) 10
(E) 20

4. How many nibbles are in 1 kilobyte?

(A) 2048
(B) 2000
(C) 1000
(D) 1024
(E) 4096

5. One technique for string representation keeps one 32-bit string length for the string, along with the ASCII value of each individual character in the string. Given the string "abcde", how many bytes of memory would be required to store the string using this representation?

(A) 9 bytes
(B) 37 bytes
(C) 5 bytes
(D) 32 bytes
(E) 24 bytes
6. 13 is a base ten number. What is it represented as a 6-bit binary two’s complement number?
   (A) 001101
   (B) 101101
   (C) 110100
   (D) 110101
   (E) 001110

7. -18 is a base ten number. What is it represented as a 7-bit binary number using sign/magnitude representation?
   (A) 1010010
   (B) 0010010
   (C) 1001001
   (D) 1001000
   (E) 1010011

8. 1101 is a 4-bit binary two’s complement number. What is it in base 10?
   (A) -3
   (B) -2
   (C) 2
   (D) 3
   (E) 13

9. 7 is a base ten number. What is it represented as a 3-bit binary number in unsigned representation?
   (A) 111
   (B) 0111
   (C) It is too large to represent in three bits
   (D) 1110
   (E) 110

10. 1100 is a 4-bit binary number in sign/magnitude representation. What is it in base 10?
    (A) -4
    (B) 12
    (C) -12
    (D) 4
    (E) 6

11. 67 is a base eight number. What is it in base ten?
    (A) 55
    (B) 155
    (C) 83
    (D) 38
    (E) 54

12. AC is a base sixteen number. What is it in base ten?
    (A) 172
    (B) 1012
    (C) It cannot be represented in base ten
    (D) 92
    (E) -172
13. 53 is a base six number. What is it in base four?
   (A) 201
   (B) 102
   (C) 311
   (D) 113
   (E) 33

14. 29 is a base ten number. What is it in binary?
   (A) 11011
   (B) 10111
   (C) 1011
   (D) 1101
   (E) 01011

15. 17 is a base ten number. What is it in octal?
   (A) 21
   (B) 12
   (C) 15
   (D) 51
   (E) 22

16. What does this code print when it is run?
    ```python
    x = 42
    def foo():
        global x
        x = 123
    print(x)
    foo()
    print(x)
    ```
    (A) 42, then 123
    (B) 42, then 42
    (C) 123, then 42
    (D) 123, then 123
    (E) There is an error when this code is run

17. How many of the following statements evaluate to True?
    ```python
    not True
    True and (not False)
    2 ** 3 != 6
    1 + 2 * 3 >= 8
    ```
    (A) 0
    (B) 1
    (C) 2
    (D) 3
    (E) 4
Part 2

Use the following code to answer the questions in this section.

class A:
    def print(self):
        print('A says:', self.m())
    def m(self):
        return 'foo'
class B(A):
    def m(self):
        return 'bar'
class C(B):
    def m(self):
        return 'baz'
class D(A):
    def m(self):
        return 'blarg'

18. What is printed when the following code is run?

```python
o = A()
o.print()
```

(A) A says: foo
(B) A says: bar
(C) A says: baz
(D) A says: blarg
(E) More than one of these is printed

19. What is printed when the following code is run?

```python
o = B()
o.print()
```

(A) A says: foo
(B) A says: bar
(C) A says: baz
(D) A says: blarg
(E) More than one of these is printed

20. What is printed when the following code is run?

```python
o = C()
o.print()
```

(A) A says: foo
(B) A says: bar
(C) A says: baz
(D) A says: blarg
(E) More than one of these is printed
21. What is printed when the following code is run?

```python
o = D()
o.print()
```

(A) A says: foo
(B) A says: bar
(C) A says: baz
(D) A says: blarg
(E) More than one of these is printed

**Part 3**

Use the code below to answer the questions in this section. The code is located in files named `p1.py` and `p2.py`, as noted.

```python
# p1.py
x = int(input())
print(x * 3)

# p2.py
x = int(input())
print(x + 3)
```

22. The programs are run using `python3 p1.py` and the user gives the input 5 on the keyboard. What is the output?

(A) 15
(B) 18
(C) 11
(D) 24
(E) 8

23. The programs are run using `python3 p1.py | python3 p2.py` and the user gives the input 5 on the keyboard. What is the output?

(A) 15
(B) 18
(C) 11
(D) 24
(E) 8

24. The programs are run using `python3 p2.py | python3 p2.py` and the user gives the input 5 on the keyboard. What is the output?

(A) 15
(B) 18
(C) 11
(D) 24
(E) 8
25. The programs are run using

```python
python3 p2.py | python3 p1.py
```

and the user gives the input 5 on the keyboard. What is the output?

(A) 15  
(B) 18  
(C) 11  
(D) 24  
(E) 8

26. The programs are run using

```python
python3 p2.py p1.py
```

and the user gives the input 5 on the keyboard. What is the output?

(A) 15  
(B) 18  
(C) 11  
(D) 24  
(E) 8

**Part 4**

Use the code below to answer the questions in this section.

```python
def f(x):
    if x < 2:
        return 3
    elif x < 10:
        return f(x - 2) + 10
    else:
        return f(x - 10) + f(x - 11)
```

27. What is the base case?

(A) x < 2  
(B) x < 10  
(C) x >= 2  
(D) x >= 10  
(E) x < 2 and x < 10

28. What is f(-1)?

(A) 3  
(B) 13  
(C) 23  
(D) 6  
(E) f will recurse infinitely
29. What is \( f(3) \)?
   (A) 3
   (B) 13
   (C) 23
   (D) 6
   (E) \( f \) will recurse infinitely

30. What is \( f(5) \)?
   (A) 3
   (B) 13
   (C) 23
   (D) 6
   (E) \( f \) will recurse infinitely

31. Which call to \( f \) would result in every line of its code being executed at least once?
   (A) \( f(2) \)
   (B) \( f(10) \)
   (C) \( f(11) \)
   (D) \( f(15) \)

32. Running each line of the code at least once is a form of
   (A) white box testing
   (B) black box testing
   (C) unit testing
   (D) fuzzing
   (E) regression testing

**Part 5**

In this section, you will be writing a Monte Carlo simulation. This simulation will compute the probability of rolling a 2, 3, and 6 (in any order) on three six-sided dice. In other words, if you roll three six-sided dice, what’s the probability that you will get 2, 3, and 6? Starting with the following:

```python
import random
N = AAA
ofinterest = BBB
want = [2, 3, 6]
for i in range(N):
    L = []
    for j in range(3):
        CCC
    L.sort()
    if DDD:
        ofinterest = EEE
print('probability is', FFF)
```
33. This will produce an exact answer to the stated problem.
   (A) True
   (B) False

34. What should AAA be replaced with?
   (A) 100
   (B) 1000
   (C) 10000
   (D) 100000
   (E) 1000000

35. What should BBB be replaced with?
   (A) 0
   (B) 1
   (C) N
   (D) N-1

36. What should CCC be replaced with?
   (A) L.append(random.randint(1, 6))
   (B) L = random.randint(1, 6)
   (C) L.append(randint(1, 6))
   (D) L = randint(1, 6)

37. What should DDD be replaced with?
   (A) L == want
   (B) L = want
   (C) L != want
   (D) L <= want
   (E) L <> want

38. What should EEE be replaced with?
   (A) ofinterest + 1
   (B) 1
   (C) N
   (D) True
   (E) ofinterest - 1

39. What should FFF be replaced with?
   (A) ofinterest / N
   (B) ofinterest // N
   (C) N
   (D) ofinterest
   (E) ofinterest / 100

40. Consider the line L.sort() in the program. If it were removed, would the program still work?
   (A) No, it would give the wrong result
   (B) Yes
   (C) No, there would be a run-time error
   (D) No, it would compute 1 minus the probability instead
Part 6

In Python, you can force exceptions to occur using Python’s `raise` statement, which allows you to throw an instance of an exception class that you create. The superclass of an exception class must be the built-in `BaseException` class, otherwise an exception class is the same as a normal class. The code below should print `foo` when it is run:

```python
try:
    raise MyException('foo')
except MyException as e:
    print(e.reason)
```

Given this, how should the exception class be defined? Starting with the following:

```python
class AAA:
    def BBB:
        CCC
```

41. What should `AAA` be replaced with?
   - (A) `MyException(BaseException)`
   - (B) `BaseException`
   - (C) `MyException`
   - (D) `MyException()`
   - (E) `BaseException(MyException)`

42. What should `BBB` be replaced with?
   - (A) `__init__(self, s)`
   - (B) `__init__(self)`
   - (C) `__init__(s)`
   - (D) `__init__()`
   - (E) `MyException(s)`

43. What should `CCC` be replaced with?
   - (A) `self.reason = s`
   - (B) `reason = s`
   - (C) `self = s`
   - (D) `self.reason(s)`
   - (E) `reason(s)`

Part 7

In this section you are writing a program that takes zero or more filenames of input files on the command line. Each input file contains a black-and-white bitmap in PBM format (as seen in lecture). Each bitmap is rotated counter-clockwise 90° and written to a filename that has `.out` appended to its input filename. For example, say that the input file `bitmap.pbm` contains

```
P1
3 2
1 1 0
1 0 1
```

Running the program as

```
python3 main.py bitmap.pbm
```

would result in the output file `bitmap.pbm.out` being created with the contents
The code is split into two modules. Starting with the following:

```
# m1.py

import sys

def error(filename, s):
    AAA

def readpbm(filename):
    try:
        BBB
    except IOError as e:
        error(filename, e.strerror)

    magic = f.readline()
    if magic != 'P1
      
    line = f.readline()
    wh = line.split()
    width = int(wh[0])
    height = int(wh[1])

    BM = []
    for i in range(height):
        CCC
        BM.append(cols)
    DDD

def writepbm(filename, BM):
    try:
        EEE
    except IOError as e:
        error(filename, e.strerror)

    print('P1', file=f)
    height = len(BM)
    width = len(BM[0])

    FFF
    for row in BM:
        for col in row:
            GGG
            print(file=f)
    HHHH
```

```
# main.py

import m1
import sys

def rotateccw(BM):
    rv = []
    height = len(BM)
    width = len(BM[0])

    for colno in III:
        rv.append( [] )
        for rowno in range(height):
            rv[-1].append(BM[rowno][colno])

    return rv

if __name__ == '__main__':
    for file in JJJ:
        BM = m1.readpbm(file)
        BM = rotateccw(BM)
        m1.writepbm(KKK, BM)
```
44. What should AAA be replaced with?

(A) print(filename, ':', s, file=sys.stderr)
    sys.exit()
(B) print(filename, ':', s)
    sys.exit()
(C) print(filename, ':', s, file=sys.stderr)
(D) print(filename, ':', s)
(E) print('error in', filename, file=sys.stderr)

45. What should BBB be replaced with?

(A) f = open(filename, 'r')
(B) f.open(filename, 'r')
(C) f.open(filename)
(D) filename.open('r')
(E) f = open('bitmap.pbm', 'r')

46. What should CCC be replaced with?

(A) line = f.readline()
    cols = line.split()
(B) line = input()
    cols = line.split()
(C) f.readline()
    cols = line.split()
(D) line = f.readline()
    cols = line.split('|\t')
(E) cols = f.readline()

47. What should DDD be replaced with?

(A) f.close()
    return BM
(B) f.close()
(C) close(f)
    return BM
(D) close(f)
(E) f.close()
    return f

48. What should EEE be replaced with?

(A) f = open(filename, 'w')
(B) f.open(filename, 'w')
(C) f.open(filename)
(D) filename.open('w')
(E) f = open('bitmap.pbm.out', 'w')
49. What should FFF be replaced with?
(A) print(width, height, file=f)
(B) print(width, height)
(C) print(height, width)
(D) print(height, width, file=f)
(E) print(width, height, file=filename)

50. What should GGG be replaced with?
(A) print(col, end=’ ’, file=f)
(B) print(col, end=’ ’)
(C) print(col, file=f)
(D) print(col)

51. What should HHH be replaced with?
(A) f.close()
(B) close(f)
(C) Nothing
(D) close(filename)

52. What should III be replaced with?
(A) range(width-1, -1, -1)
(B) range(width)
(C) range(width, -1, -1)
(D) range(width-1)
(E) range(-1, width)

53. What should JJJ be replaced with?
(A) sys.argv[1:]
(B) sys.argv[1]
(C) sys.argv[0]
(D) sys.argv[0:]

54. What should KKK be replaced with?
(A) file + '.out'
(B) file
(C) 'bitmap.pbm.out'
(D) 'bitmap.pbm'
(E) sys.argv[1] + 'out'

55. Does the m1 module have a good design?
(A) Yes, because it has high cohesion of PBM I/O functions, and low coupling
(B) Yes, because it has low cohesion of PBM I/O functions, and high coupling
(C) No, because it has high cohesion of PBM I/O functions, and low coupling
(D) No, because it has low cohesion of PBM I/O functions, and high coupling
Part 8

Use the definitions below to answer the questions in this section.

\[ D = \{ 2: 4, 6: 8, 4: 6, 8: 8 \} \]
\[ L = [1, 3, 5, 7, 9] \]
\[ T = (1, 3, 5, 7, 9) \]
\[ DD = \{ 'foo': \{ 0: 1, 1: 2 \}, 'bar': \{ 1: 1, 2: 1 \} \} \]

56. What is \( \text{len}(DD) \)?
   (A) 2
   (B) 6
   (C) 10
   (D) 5
   (E) 4

57. What is printed when this code is run?
   ```python
   p = 2
   sum = L[p]
   for i in range(4):
       sum = sum + p
       p = D[p]
   print(sum)
   ```
   (A) 25
   (B) 23
   (C) 27
   (D) 31
   (E) 29

58. What is \( T[2:4] \)?
   (A) (5, 7)
   (B) (5, 7, 9)
   (C) (3, 5, 7, 9)
   (D) (3, 5, 7)
   (E) An error

59. What does this code print when run?
   ```python
   for i in range(len(L) // 2):
       t = L[i]
       L[i] = L[-i-1]
       L[-i-1] = t
   print(L)
   ```
   (A) [9, 7, 5, 3, 1]
   (B) [1, 3, 5, 3, 1]
   (C) [1, 3, 5, 7, 9]
   (D) [1, 1, 1, 1, 1]
   (E) [1, 1, 5, 1, 1]
Answer Key

Q1: A; Q2: C; Q3: A; Q4: A; Q5: A; Q6: A; Q7: A; Q8: A; Q9: A; Q10: A; Q11: A; Q12: A; Q13: A; Q14: A; Q15: A; Q16: A; Q17: C; Q18: A; Q19: B; Q20: C; Q21: D; Q22: A; Q23: B; Q24: C; Q25: D; Q26: E; Q27: A; Q28: A; Q29: B; Q30: C; Q31: D; Q32: A; Q33: B; Q34: E; Q35: A; Q36: A; Q37: A; Q38: A; Q39: A; Q40: A; Q41: A; Q42: A; Q43: A; Q44: A; Q45: A; Q46: A; Q47: A; Q48: A; Q49: A; Q50: A; Q51: A; Q52: A; Q53: A; Q54: A; Q55: A; Q56: A; Q57: A; Q58: A; Q59: A.

End of questions.