COMP SCI 2ME3 and SFWR ENG 2AA4 Midterm
McMaster University

Answer Key: Large arrow ($\Longleftarrow$) for correct

Day Class 01 **Version 1** Dr. S. Smith

DURATION: 1.5 hours February 28, 2018

Please CLEARLY print:

NAME:

Student ID: | | | | | | | | | |

This examination paper includes 19 pages and 30 questions. You are responsible for ensuring that your copy of the examination paper is complete. Bring any discrepancy to the attention of your invigilator.

Special Instructions:

1. It is your responsibility to ensure that the answer sheet is properly completed. Your examination result depends upon proper attention to these instructions:
   - A heavy mark must be made, completely filling the circular bubble, with an HB pencil.
   - Print your name, student number, course name, course number and the date in the space provided on the top of Side 1 and fill in the corresponding bubbles underneath.
   - **Fill in the bubble corresponding to your version number.**
   - Mark only **ONE** choice from the alternatives (1, 2, 3, 4, 5 or A, B, C, D, E) provided for each question. If there is a True/False question, mark 1 (or A) for True, and 2 (or B) for False. The question number is to the left of the bubbles. Make sure that the number of the question on the scan sheet is the same as the number on the examination paper.
   - Pay particular attention to the "Marking Directions" given on the scan sheet.
   - Begin answering the questions using the first set of bubbles, marked "1." Answer all questions.
2. Any notes or textbook are permitted.
3. Calculators, computers, cell phones, and all other electronic devices are **not** to be utilized.
4. Read each question carefully.
5. Try to allocate your time sensibly and divide it appropriately between the questions.
6. Select the **best** answer for each question.
7. The set $\mathbb{N}$ is assumed to include 0.

Question 1 [1 mark]
Figure 1 shows a map that could potentially be used for a Geographic Information System (GIS). The map consists of cells where each cell identifies the type of land use for that cell. The options include R for Residential, C for Commercial, S for Street, P for Park land and U for Undefined. A portion of one of the specification for one of the modules in this system follows.

Exported Types

cellT = { R, C, S, P, U }

Exported Access Programs

Routine name	In	Out	Exceptions
init	integer, integer		InvalidSizeException
set_cell	integer, integer, cellT		OutOfBoundsException
get_cell	integer, integer	cellT	OutOfBoundsException
get_size_x		integer	
get_size_y		integer	
count	cellT	integer	
percentage	cellT	real	
is_valid_streets		boolean	

Semantics

State Variables

m: sequence of sequence of cellT
$size\_x$: integer
$size\_y$: integer

State Invariant

count(R) + count(C) + count(S) + count(P) + count(U) = $size\_x \times size\_y$

In natural language, the count is the total number of cells of the given land type, c. How would this be written with a descriptive specification?

A. $\wedge(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y : m[i][j] = c)$

B. $\cup(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y \wedge m[i][j] = c : \{m[i][j]\})$

C. $+(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y \wedge m[i][j] = c : 1)$ $\Longleftarrow$

D. $+(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y \wedge m[i][j] = c : i + j)$

ANSWER:
Specification: Meets.

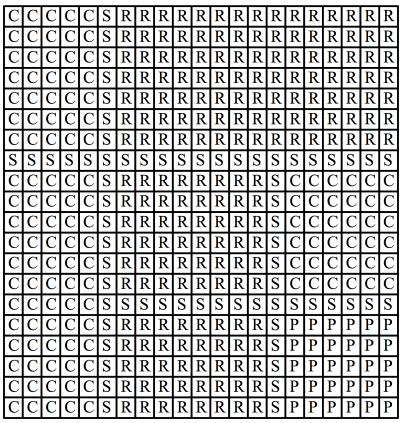


Figure 1: Example map

Question 2 [1 mark]
For Question 1 the function is_valid_streets() returns True if every street cell in the map is adjacent to at least one other street cell. Cells are considered adjacent if the squares that define each cell share an edge or a vertex. (Each corner of each square is a vertex.) In other words, a street that is only one cell long is considered to be an invalid street. How would the specification of this access program be written formally?

A. $\exists(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y : m[i][j] = \text{S})$

B. $\exists(c : \text{cellT} | c \in m : c = \text{S})$

C.

$$\forall(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y \wedge m[i][j] = \text{S} :$$
$$\exists(k, l : \mathbb{N} | i - 1 \leq k \leq i + 1 \wedge j - 1 \leq l \leq j + 1 : m[k][l] = \text{S})$$

D.

$$\forall(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y \wedge m[i][j] = \text{S} :$$
$$\exists(k, l : \mathbb{N} | 0 \leq k < size\_x \wedge 0 \leq l < size\_y$$
$$\wedge i - 1 \leq k \leq i + 1 \wedge j - 1 \leq l \leq j + 1 \wedge k \neq i \wedge l \neq j : m[k][l] = \text{S})$$

$\Longleftarrow$

This answer is actually incorrect, since the spec is wrong. The cells that share only a vertex will be considered adjacent, but the cells that share an edge will be missed. To see this draw a 3 by 3 grid, with k = i and l = j in the middle. The entire row where l = j will be left out, as will the entire column where k = i. The goal of the spec was only to leave out the middle cell. The spec could be fixed by replacing $k \neq i \wedge l \neq j$ by $\neg(k = i \wedge l = j)$.

E.

$$\forall(i, j : \mathbb{N} | 0 \leq i < size\_x \wedge 0 \leq j < size\_y \wedge m[i][j] = \text{S} :$$

Question 3 [1 mark]
Assume you have the following available within your Python code:

- A list, called `Street`, that contains all of the index pairs in the map that correspond to street cells.
- A function, called `adjacent` that takes an index pair and returns True if a street cell is adjacent, and False otherwise.

Which of the following lines of code will calculate is_valid_streets(), as described in Question 2?

A. `reduce(lambda x,y:x and y, map(adjacent, Street))` ⟸

B. `reduce(lambda x,y:x or y, map(adjacent, Street))`

C. `map(adjacent, Street)`

D. `reduce(adjacent, Street)`

ANSWER:
Functional programming: Exceeds

Question 4 [1 mark]
Consider the following conditional rule:

$$f(x) = (C_1 \Rightarrow E_1 | C_2 \Rightarrow E_2 | ... | C_m \Rightarrow E_m)$$

If we know that the type of x is T, what has to be true about the type for the values of expressions C_i and E_i, where $i \in [1..m]$?

A. C_i is Boolean and E_i is of type T

B. C_i is of type T and E_i is of type T

C. C_i can have any type and E_i is of type T

D. C_i is Boolean and E_i can have any type ⟸

E. C_i is of type T and E_i is Boolean

ANSWER:
Competence in Mathematics, Specification Mathematics, 1.a
The expressions in conditional rules do not have to have the same type as the function argument.

Question 5 [1 mark]
What is the output of the following Python statement?

```
[m+n for (m, n) in [(2,3), (2,1), (7, 8)] if m < n]
```

A. `[True, False, True]`

B. `[5, 3, 15]`

C. `[5, 15]` ⟸

D. `[(2,3), (7, 8)]`

E. `[]`

ANSWER:
Functional programming: Level.

Question 6 [1 mark]
Dividing a complex system into simpler pieces is an example of using formality in software design. Is this statement true or false?

A. True.

B. False. ⟸

ANSWER:
Software design principles: Marginal

Question 7 [1 mark]
The typical chain of commands when pushing changes to a git repo are as follows (you can assume that the state of the local repository is up to date with the remote repository):

A. `git push`; `git add`; `git commit`

B. `git push`; `git commit`; `git add`

C. `git commit`; `git add`; `git push`

D. `git add`; `git push`; `git commit`

E. `git add`; `git commit`; `git push` ⟸

ANSWER:
Engineering tools, 1.

Question 8 [1 mark]
The following table summarizes the access programs for an Abstract Data Type called `FractionT`. An element of this type consists of two integers, with one interpreted as the numerator and the other as the denominator.

Routine name	**In**	**Out**	**Exceptions**
new FractionT	integer, integer	FractionT	DenominatorOfZero
denom		integer	
numer		integer	
add	FractionT		
multiply	FractionT		
divide	FractionT		
reciprocal			
equal	FractionT	boolean	
is_simplifiable		boolean	

Which of the following statements is true about whether the interface is minimal (access routines do not offer two or more independent services) and/or essential (same service is not available more than one way)?

A. Minimal – Yes, Essential – Yes

B. Minimal – Yes, Essential – No $\Longleftarrow$

C. Minimal – No, Essential – Yes

D. Minimal – No, Essential – No

E. Unclear either way

ANSWER:
Soft Des Principles, 4.2, quality of interface

Question 9 [1 mark]
For the specification of the module for `FractionT` (Question 8), the two state variables are:
$n : \mathbb{Z}$ //numerator
$d : \mathbb{Z}$ //denominator
What should the state invariant be?

A. $n \neq d$

B. $n \neq 0$

C. $d \neq 0$ $\Longleftarrow$

D. $n \leq d$

E. None

ANSWER:
Specification: Level.

Question 10 [1 mark]
In Question 8, how could divide(f) be specified?

A. transition: $n, d := n \times \text{f.denom}(), d \times \text{f.numer(f)}$ $\Longleftarrow$

B. transition: self.multiply(f.reciprocal())

C. output: out := new FractionT($n \times$ f.denom(), $d \times$ f.numer())

D. A or B

E. All of the above

ANSWER:
Specification: Meets.

Question 11 [1 mark]
In general, a design should strive for high cohesion within modules and low coupling between modules.

A. True. $\Longleftarrow$

B. False.

ANSWER:
Relations between modules, 1.

Question 12 [1 mark]
For Assignment A2 the specification for the ADT CurveT has the curve represented by the state variable $f : \mathbb{R} \to \mathbb{R}$. In the Python implementation of CurveT class, this curve information can be captured by which of the following field types:

A. A function from float to float

B. Two sequences of floats (one for X and one for Y)

C. A sequence of pairs of floats (the pairs are tuples representing the coordinates of each data point)

D. A and B

E. All of the above $\Longleftarrow$

ANSWER:
Specification, 1.

Question 13 [1 mark]
We need to calculate the average assignment grade (out of 100) for all assignments and all students in our class. Assume that you have a list (g), where g[i] is the sum of the ith students grades on their assignments. You can assume that each student has completed all 4 assignments (worth 400 points total), unless they have an MSAF, in which case they will have completed 3 assignments (worth 300 points total). The parallel lists MSAF will have MSAF[i] = True if student i has an MSAF, and False otherwise.
The following code will calculate the average.

```
add = lambda x, y: x + y
dv4 = lambda x: x/4.0
dv3 = lambda x: x/3.0
n = len(g)
avg = reduce(add, missing code)/n
```

Which option describes the Python code that could be substituted in place of the *missing code*?

A. `[dv3(g[i]) if MSAF[i] else dv4(g[i]) for i in range(n)]`

B. `[dv3(g[i]) for i in range(n) if MSAF[i]] + [dv4(g[i]) for i in range(n) if not(MSAF[i])]`

C. `map(lambda p: p[1](p[0]), [[g[i], dv3 if MSAF[i] else dv4] for i in range(n)])`

D. A and B

E. All of the above ⟸

ANSWER:
Functional Programming: Exceeds.

Question 14 [1 mark]
Consider the following mathematical expression:

$$+(x : \mathbb{R} | x \in xs \wedge mn \leq x < mx : 1)$$

Which of the following Python expressions implements the above?

A. `sum([1 for x in xs if mn <= x < mx])`

B. `sum([1 if x < mx else 0 for x in xs if mn <= x])`

C. `[1 for x in xs if mn <= x < mx]`

D. A and B ⟸

E. A and C

ANSWER:
Functional Programming, 1.

Question 15 [1 mark]
What is the output of the following Python code?

```
a = [1, 2, 3, 4, 5]
b = [2, 2, 9, 0, 9]

def zipper(a, b):
    return [(a[i], b[i]) for i in range(len(a))]

print(list(map(lambda pair: max(pair), zipper(a, b))))
```

A. `[2, 2, 9, 4, 9]` ⟸

B. `[(5, 9)]`

C. `[(2,1), (2,2), (9,3), (4,0), (9,5)]`

D. `[1, 2, 3, 4, 5, 9]`

E. `[9, 5, 4, 3, 2, 1]`

ANSWER:
Functional Programming, 1.

Question 16 [1 mark]
The goal of this question is to turn a list of integers into a single integer. As an example, `[2, 4, 3, 6, 7]` should become `24367`. What should the value of `func` be for this to work with the following code?

```
reduce(func, [2, 4, 3, 6, 7], 0)
```

A. `lambda a, d: a+10*d`

B. `lambda a, d: 10*(a+d)`

C. `lambda a, d: 10*a+d` ⟸

D. `lambda a, d: a+d`

ANSWER:
Functional Programming, 1.

Question 17 [1 mark]
Improving the quality of Maintainability can potentially improve, or reduce, other qualities. Fill in the following table with + when the quality reinforces Maintainability and a – when the qualities have conflicting goals.

Correctness	Reliability	Efficiency
?	?	?

A. +, +, +

B. +, +, – ⟸

C. +, –, +

D. +, –, –

E. –, –, –

ANSWER:
Software Quality, 1.

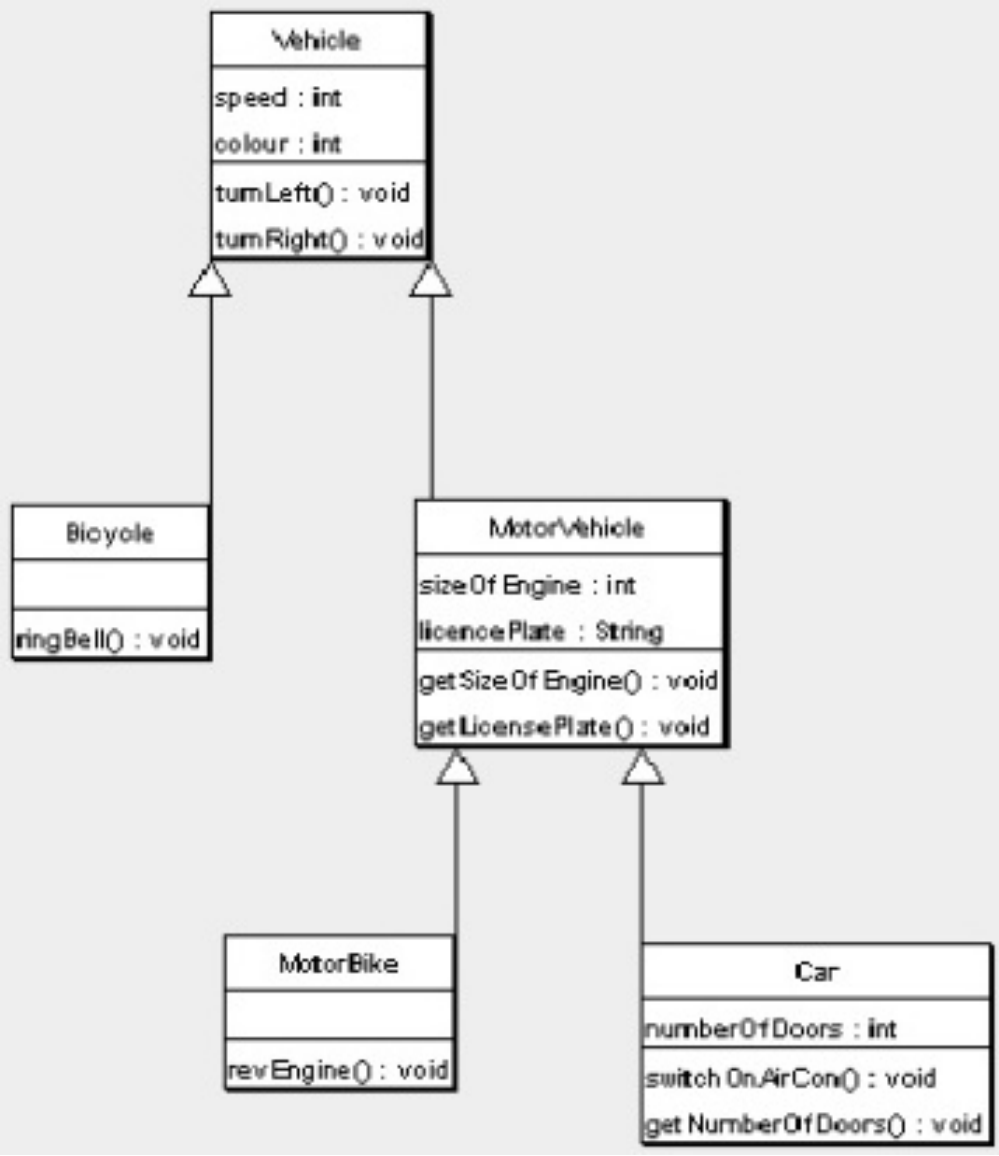
Question 18 [1 mark]
Designing by secret (that is using the principle of information hiding) does NOT automatically leads to a use relation between modules that is a hierarchy. Is this statement true or false?

A. True. $\Longleftarrow$

B. False.

ANSWER:
Software design principles: Meets
Information hiding is independent of a hierarchical uses relation. As a counter example, think about association relations in a UML diagram.

Question 19 [1 mark]
The following UML diagram was copied from the Internet (found by googling uml class diagram inheritance example vehicle).



Which of the following statements are true?

A. The MotorVehicle class specializes the Vehicle class

B. A variable of type Car can refer to an object of type Vehicle

C. A variable of type Vehicle can refer to an object of type Bicycle

D. A and C $\Longleftarrow$

E. All of the above

ANSWER:
Object Oriented Programming, 1.

Question 20 [**1 mark**]
An inheritance relation is a special case of Parnas's the more general concept of a uses relation.

A. True. ⟸

B. False.

ANSWER:
Object Oriented Programming, 1.

Question 21 [**1 mark**]

```
class PointT:
    def __init__(self, x, y):
        self.__xc = x
        self.__yc = y

p1 = PointT(1, 2)
p2 = PointT(1, 2)
```

What is the value of `p1 == p2`?

A. True.

B. False. ⟸

ANSWER:
Object Oriented Programming, 1.

Question 22 [**1 mark**]
When requirements are poorly understood, the best software development model to follow is the Waterfall model. Is this statement true or false?

A. True.

B. False. ⟸

ANSWER:
Recognizes and follows an engineering design process: Meets

Question 23 [1 mark]
The full range of software engineering tools, methods, techniques, and principles are necessary for the success of any software development project, no matter how small.

A. True.

B. False. ⟸

ANSWER:
Role of Eng, 1.
Software engineering is necessary for multi-person construction of multi-version software. Smaller scope projects may not justify the full gamut of software engineering tools, techniques, methods and principles.

Question 24 [1 mark]
Standardization of user interfaces between similar applications will potentially improve which of the following system qualities?

A. Usability

B. Performance

C. Reliability

D. A and C ⟸

E. All of the above

ANSWER:
Software quality:
Reliability is improved because improving usability generally improves reliability, since users are more likely to provide proper input for a longer time period. For instance, the reliability of the Therac 25 was reduced because of usability issues.

Question 25 [1 mark]
To be useful, an object must have mutators. Is this statement true or false?

A. True.

B. False. ⟸

ANSWER:
Modularization and interface design: Meets

Question 26 [1 mark]
You have the following function implemented to test whether an input `x` is less than another input `mx`. For the purpose of this question, assume that `x` and `mx` are integers.

```
is_below = lambda x, mx: x < mx
```

However, for increased reusability, you want to implement something more general. The more general version will be able to reproduce the behaviour of the above function, but also be usable in other situations. The more potential situations that are covered, the more general the function. Which of the following options is the most general? For the purpose of this question, you can assume that a lower bound exists for the integers as `-sys.maxsize`. Hint: Determine whether `is_below` can be implemented using the other functions.

A. `is_inBounds = lambda x, mn, mx: mn < x < mx`

B. `is_contained = lambda x, S: x in S` ⟸

C. Both options are equally general.

D. Neither option is more general than the original.

ANSWER:
Soft design principle (1.g), generality
is_contained is the most general because the others could be implemented using it. For instance, `is_below2 = lambda x, mx: is_contained(x, range(-sys.maxsize, mx))` and `is_inBounds2 = lambda x, mn, mx: is_contained(x, range(mn, mx))`. The is_contained options also allows for discontinuous sets of integers, like S = [1, 2, 3] + [-4, 5, 9]. It could also be used for types that are not numbers.

Question 27 [1 mark]
Consider the following syntax for access programs for a generic Queue ADT.

Routine name	In	Out	Exceptions
new QueueT		QueueT	
add	T		queue_full
pop			queue_empty
front		T	queue_empty

What should be the type of the state variable?

A. set of T

B. sequence of T $\Longleftarrow$

C. tuple of T

D. set of integer

E. T

ANSWER:
Modularization and interface design, 1.

Question 28 [1 mark]
To improve any of the quality critera listed in Hoffman and Strooper (consistent, essential etc.) of the generic Queue ADT in Question 27 what access programs should be added?

A. isempty - takes no arguments and returns a Boolean $\Longleftarrow$

B. isinit - takes no arguments and returns a Boolean

C. push - takes a T as input and changes the state of the queue to add to the back of the queue, has a queue_full exception

D. A and B

E. All of the above

ANSWER:
Modularization and interface design, 1.
There are not init related exceptions, so isinit is not necessary. push provides the same services as add.

Question 29 [1 mark]
Considering the Solar Water Heating Tank example from class, the following is a poor secrete for one of the modules: "The value of the height of the tank."

A. True. $\Longleftarrow$

B. False.

ANSWER:
Modularization and interface design, 1.
The values of the input variables are run-time bound. They are not design time likely changes. The likely change is the format of the input data.

Question 30 [1 mark]
According to the engineering code of ethics, engineers have a duty to which of the following groups?

A. Society.

B. Employer.

C. Profession.

D. All of the above. $\Longleftarrow$

ANSWER:
PEO, 1.
Soft Eng Profession Lecture, Slide 9

Please make sure your **version number** is clearly marked on your scan sheet!