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

DAY CLASS Dr. S. Smith
DURATION OF EXAMINATION: 3 hours
MCMASTER UNIVERSITY MIDTERM EXAMINATION March 4, 2021

NAME: [Enter your name here —SS]

Student ID: [Enter your student number here —SS]

This examination paper includes 15 pages and 4 questions. You are responsible for ensuring that your copy of the examination paper is complete. Bring any discrepancy to the attention of your instructor.

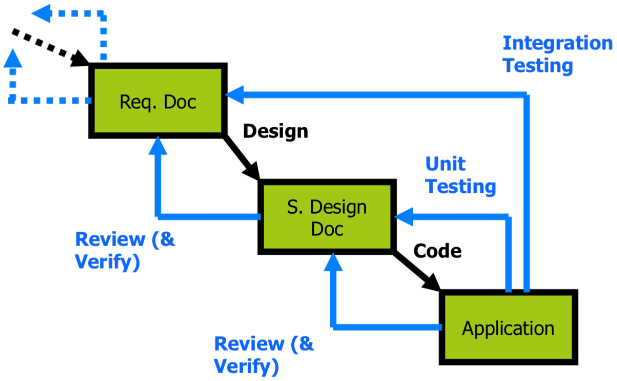
By submitting this work, I certify that the work represents solely my own independent efforts. I confirm that I am expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. I confirm that it is my responsibility to understand what constitutes academic dishonesty under the Academic Integrity Policy.

Special Instructions:

1. For taking tests remotely:
   - Turn off all unnecessary programs, especially Netflix, YouTube, games like Xbox or PS4, anything that might be downloading or streaming.
   - If your house is shared, ask others to refrain from doing those activities during the test.
   - If you can, connect to the internet via a wired connection.
   - Move close to the Wi-Fi hub in your house.
   - Restart your computer, 1-2 hours before the exam. A restart can be very helpful for several computer hiccups.
   - Commit and push your tex file, compiled pdf file, and code files frequently.
   - Ensure that you push your solution (tex file, pdf file and code files) before time expires on the test. The solution that is in the repo at the deadline is the solution that will be graded.
2. It is your responsibility to ensure that the answer sheet is properly completed. Your examination result depends upon proper attention to the instructions.
3. All physical external resources are permitted, including textbooks, calculators, computers, compilers, and the internet.
4. The work has to be completed individually. Discussion with others is strictly prohibited.

5. Read each question carefully.
6. Try to allocate your time sensibly and divide it appropriately between the questions.
7. The set $\mathbb{N}$ is assumed to include 0.

Question 1 [6 marks] Parnas advocates faking a rational design process as depicted in the figure below. The faked documentation follows these steps: Requirements (SRS) → Design (MG and MIS) → Application Implementation (code) → Verification and Validation (Unit Testing, Integration Testing, Review). How are the principles of a) abstraction and b) separation of concerns applied in a rational design process? In your answer you can refer to any aspects of the process, documentation, and/or Parnas's principles.



[Fill in your answer below —SS]

a) Abstraction

- The listing of requirements allows us to prioritize, focus on what is important, and ignore everything irrelavent.
- The faked rational design process means thinking of the requirements and then implementing a code so that the requirements are fulfilled. The design specification tells you what you want fulfilled, but not how it has to be fulfilled. It tells you want it wants the code to do, but not how the code should do it.
- The implementation of the code is based off of the design specification. You are given more degrees of freedom since you can choose the most efficient way to implement the design yourself.

b) Separation of Concerns

- The requirements, design specification, and application/implementation of the code are all separated from each other. They are done separately, not all at once.
- The requirements themselves are a way to focus on different concerns at different times. You are breaking down the problem into individual requirements.
- Multiple requirements usually mean there will be multiple modules. Each requirement will be dealt with separately. The design will specify a system decomposed into a set of modules.

Consider the specification for two modules: SeqServices and SetOfInt.

Sequence Services Library

Module

SeqServicesLibrary

Uses

None

Syntax

Exported Constants

None

Exported Types

None

Exported Access Programs

Routine name	**In**	**Out**	**Exceptions**
max_val	seq of $\mathbb{Z}$	$\mathbb{N}$	ValueError
count	$\mathbb{Z}$, seq of $\mathbb{Z}$	$\mathbb{N}$	ValueError
spices	seq of $\mathbb{Z}$	seq of string	ValueError
new_max_val	seq of $\mathbb{Z}$, $\mathbb{Z} \rightarrow \mathbb{B}$	$\mathbb{N}$	ValueError

Semantics

State Variables

None

State Invariant

None

Assumptions

- All access programs will have inputs provided that match the types given in the specification.

Access Routine Semantics

max_val(s)

- output: $out := |m| : \mathbb{N}$ such that $(m \in s) \wedge \forall (x : \mathbb{Z} | x \in s : |m| \geq |x|)$
- exception: $(|s| = 0 \Rightarrow \text{ValueError})$

count(t, s)

- output: $out := +(x : \mathbb{Z} | x \in s \wedge x = t : 1)$
- exception: $(|s| = 0 \Rightarrow \text{ValueError})$

spices(s)

- output: $out := \langle x : \mathbb{Z} | x \in s : (x \leq 0 \Rightarrow \text{“nutmeg”} | \text{True} \Rightarrow \text{“ginger”}) \rangle$
- exception: $(|s| = 0 \Rightarrow \text{ValueError})$

new_max_val(s, f)

- output: $out := \text{max\_val}(\langle x : \mathbb{Z} | x \in s \wedge f(x) : x \rangle)$
- exception: $(|s| = 0 \Rightarrow \text{ValueError})$

Set of Integers Abstract Data Type

Template Module

SetOfInt

Uses

None

Syntax

Exported Types

SetOfInt = ?

Exported Constants

None

Exported Access Programs

Routine name	In	Out	Exceptions
new SetOfInt	seq of $\mathbb{Z}$	SetOfInt	
is_member	$\mathbb{Z}$	$\mathbb{B}$	
to_seq		seq of $\mathbb{Z}$	
union	SetOfInt	SetOfInt	
diff	SetOfInt	SetOfInt	
size		$\mathbb{N}$	
empty		$\mathbb{B}$	
equals	SetOfInt	$\mathbb{B}$	

Semantics

State Variables

s: set of $\mathbb{Z}$

State Invariant

None

Assumptions

- The SetOfInt constructor is called for each object instance before any other access routine is called for that object. The constructor can only be called once. All access programs will have inputs provided that match the types given in the specification.

Access Routine Semantics

new SetOfInt(x_s):

- transition: $s := \cup(x : \mathbb{Z} | x \in x_s : \{x\})$
- output: $out := self$
- exception: none

is_member(x):

- output: $x \in s$
- exception: none

to_seq():

- output: $out :=$ set_to_seq(s)
- exception: none

union(t):

- output: SetOfInt(set_to_seq(s)$||t$.to_seq())
  # in case it is clearer, an alternate version of output is:
  SetOfInt(set_to_seq($s \cup \{x : \mathbb{Z} | x \in t$.to_seq() $: x\}$))
- exception: none

diff(t):

- output: SetOfInt(set_to_seq($s \cap$ complement(t.to_seq())))
- exception: none

size():

- output: $|s|$
- exception: none

empty():

- output: $s = \varnothing$
- exception: none

equals(t):

- output: $\forall(x : \mathbb{Z} | x \in \mathbb{Z} : x \in t$.to_seq() $\leftrightarrow x \in s)$ *# this means:* t.to_seq() $= s$
- exception: none

Local Functions

set_to_seq : set of $\mathbb{Z} \rightarrow$ seq of $\mathbb{Z}$
set_to_seq(s) $\equiv \langle x : \mathbb{Z} | x \in s : x \rangle$ # *Return a seq of all of the elems in the set s, order does not matter*

complement : seq of $\mathbb{Z} \rightarrow$ set of $\mathbb{Z}$
complement(A) $\equiv \{x : \mathbb{Z} | x \notin A : x\}$

Question 2 [15 marks]

[Complete Python code to match the above specification. —SS] The files you need to complete are: `SeqServicesLibrary.py` and `SetOfInt.py`. Two testing files are also provided: `expt.py` and `test_driver.py`. The file `expt.py` is pre-populated with some simple experiments to help you see the interface in use, and do some initial test. You are free to add to this file to experiment with your work, but the file itself isn't graded. The `test_driver.py` is also not graded. However, you may want to create test cases to improve your confidence in your solution. The stubs of the necessary files are already available in your `src` folder. The code will automatically be imported into this document when the `tex` file is compiled. You should use the provided Makefile to test your code. You will NOT need to modify the Makefile. The given Makefile will work for `make test`, without errors, from the initial state of your repo. The `make expt` rule will also work, because all lines of code have been commented out. Uncomment lines as you complete work on each part of the modules relevant to those lines in `expt.py` file. The required imports are already given in the code. You should not make any modifications in the provided import statements. You should not delete the ones that are already there. Although you can solve the problem without adding any imports, if your solution requires additional imports, you can add them. As usual, the final test is whether the code runs on mills.

Any exceptions in the specification have names identical to the expected Python exceptions; your code should use exactly the exception names as given in the spec.

You do not need to worry about doxygen comments. However, you should include regular comments in the code where it would benefit from an explanation.

You do not need to worry about PEP8. Adherence to PEP8 will not be part of the grading.

Remember, your code needs to implement the given specification so that the interface behaves as specified. This does NOT mean that the local functions need to all be implemented, or that the types used internally to the spec need to be implemented exactly as given. If you do implement any local functions, please make them private by preceding the name with double underscores.

Code for SeqServicesLibrary.py

```
## @file SeqServicesLibrary.py
#  @author Aamina Hussain
#  @brief Library module that provides functions for working with
   sequences
#  @details This library assumes that all functions will be provided
   with arguments of the expected types
#  @date 03/04/2021

def max_val(s):
        if len(s) == 0:
                raise ValueError
        for i in range(len(s)):
                s[i] = abs(s[i])
        return max(s)

def count(t, s):
        if len(s) == 0:
                raise ValueError
        counter = 0
        for i in range(len(s)):
                if s[i] == t:
                        counter+=1
        return counter

def spices(s):
        if len(s) == 0:
                raise ValueError
        spice = []
        for i in range(len(s)):
                if s[i] <= 0:
                        spice.append("nutmeg")
                else:
                        spice.append("ginger")
        return spice

def new_max_val(s, f):
        if len(s) == 0:
                raise ValueError
        new = []
        for i in range(len(s)):
                new.append(f(s[i]))
        return max_val(new)
```

Code for SetOfInt.py

```
## @file SetOfInt.py
#  @author Aamina Hussain
#  @brief Set of integers
#  @date 03/04/2021

class SetOfInt:

        def __init__(self, x_s):
                self.s = set(x_s)

        def is_member(self, x):
                if x in self.s:
                        return True
                return False

        def to_seq(self):
                return list(self.s)

        def union(self, t):
                new = self.to_seq() + t.to_seq()
                return SetOfInt(new)

        def diff(self, t):
                t_seq = t.to_seq()
                s_seq = self.to_seq()
                new = []
                for i in range(len(s_seq)):
                        if s_seq[i] not in t_seq:
                                new.append(s_seq[i])
                return SetOfInt(new)

        def size(self):
                return len(self.s)

        def empty(self):
                return len(self.s) == 0

        def equals(self, t):
                return self.s == t.s
```

Code for expt.py

```
## @file expt.py
#  @author Spencer Smith
#  @brief This file is intended to help test that your interface
   matches the specified interface
#  @date 03/04/2021

from SeqServicesLibrary import *
from SetOfInt import *

# Exercising Sequence Services Library
#print()
#print("SeqServicesLibrary, max_val expt:", max_val([1, 2, -3]))
#print("SeqServicesLibrary, count expt:", count(1, [1, 1, 1, 1]))
#print("SeqServicesLibrary, spices expt:", spices([-5, 0, 23]))
#print("SeqServicesLibrary, new_max_val expt:", new_max_val([-5, 0,
   23], lambda x: x >10))
#print()

# Exercising Set of Integers
#xs = [-9, 6, 23, 21, -5]
#ys = list(xs)
#ys.append(99)
#S = SetOfInt(xs)
#print("SetOfInt, is_member expt:", S.is_member(21))
#print("SetOfInt, to_seq expt:", S.to_seq())
#S2 = SetOfInt(ys)
#S3 = S.union(S2)
#print("SetOfInt, union expt:", S3.to_seq())
#S4 = S2.diff(S)
#print("SetOfInt, diff expt:", S4.to_seq())
#print("SetOfInt, size expt:", S4.size())
#print("SetOfInt, size expt:", S4.empty())
#S5 = SetOfInt([-9, 6, 23, -5, 21])
#print("SetOfInt, equals expt:", S.equals(S5))
#print()
```

Code for test_driver.py

```
## @file test_driver.py
#  @author Your Name
#  @brief Tests implementation of SeqServicesLibrary and SetOfInt ADT
#  @date 03/04/2021

from SeqServicesLibrary import *
from SetOfInt import *

from pytest import *

## @brief Tests functions from SeqServicesLibrary.py
class TestSeqServices:

    # Sample test
    def test_sample_test1(self):
        assert True

## @brief Tests functions from SetOfInt.py
class TestSetOfInt:

    # Sample test
    def test_sample_test2(self):
        assert True
```

Question 3 [5 marks]
Critique the design of the interface for the SetOfInt module. Specifically, review the interface with respect to its consistency, essentiality, generality and minimality. Please be specific in your answer.
[Put your answer for each quality below. —SS]

- **consistency**: The interface is consistent. The naming convention is all lowercase with underscores between words if there are multiple words. The parameters are also consistent. Whenever the input is of type SetofInt, then the input parameter is 't'.
- **essentiality**: The interface was not essential. This is because you can implement some methods using a combination of the other methods. empty() is not needed because you can check if it's empty by using size(). If the size is zero then you know it is empty.
- **generality**: The interface is not general, in the sense that it cannot be used in other contexts. For example, the interface has specified everything to be of type integer. This means it cannot be used for sets of other types, such as strings, floats, other objects, etc.
- **minimality**: The interface was minimal, meaning every access program only did one thing. This is important because we want to design for likely changes. If every method only does one thing, it can be easier to change the individual method if needed.

Question 4 [4 marks]
The module SetOfInt is for a set of integers. Please answer the following questions related to making that module generic.

a. How would you change the specification to make it generic? (Specifically what changes would you make to the given specification. You don't need to redo the spec, just summarize what changes you would need to make.)

b. What changes would you need to make to the Python implementation to make it generic for type T? (Again, you can describe and characterize the changes; you don't actually have to make them.)

c. What relational operator needs to be defined for type T to be a valid choice?

d. BONUS (1 mark) How would you specify (in the MIS) the relational operator constraint (from the previous question) on the generic type T?

[Put your answer below. —SS]

a. To make the specification generic, I would specify a type T instead of type integer, where type T is any type you choose. This includes integers, strings, etc.

b. To make the Python implementation generic for type T, I would not need to make any changes. This is because Python is a dynamically typed language and uses Duck typing. We do not specify the type of inputs or outputs for each function in Python, unlike in Java where we do specify input and output types and are forced to strictly adhere to them.

c. A rational operator that needs to be defined is an equals operator.

d. (BONUS) I would specify a new routine __eq__ which takes in a parameter which is another object of the class. Then I would define what it means for the two objects to be equal. It would output a boolean value.

THE END.