

Assignment 3 CSSE3100/7100 Reasoning about Programs

Due: 4pm on 7 May, 2021

The aim of this assignment is to provide you with experience specifying, verifying and deriving programs using arrays.

Instructions: CSSE3100 students submit a single Dafny file with your solution to question (a) to Blackboard by the due date and time.

CSSE7100 students submit a single Dafny file with your solutions to questions (a) and (b) to Blackboard by the due date and time.

Let the integer array r of length M represent a set of distinct circles in the (x,y) -plane. Circle i (for $0 \leq i < M$) has centre $(0, 0)$ and radius $r[i]$. Let the integer array x of length N represent a set of distinct vertical lines. Line i (for $0 \leq i < N$) has equation $x = x[i]$ where $x[i] \geq 0$.

(a) Assuming the values of x increase as we move from position 0 to $x.Length - 1$, write a specification and implementation of a Dafny method `Tangent` that, given r and x as parameters, returns a boolean value indicating whether or not there exists a line in x that is tangent to a circle in r . The implementation should not iterate over either array once a tangent has been found, and for a given circle in r , should not iterate over array x once it can be deduced that no tangent will be found for that circle. Also, it must not use return or break statements.

Verify your implementation using the Dafny verifier. The following lemma may be necessary depending on your approach to the specification and implementation. There is no requirement to use it.

```
lemma IncreasingArray(a: array<int>, n: int)
  requires forall i :: 1 <= i < a.Length ==> a[i-1] < a[i]
  requires 0 <= n < a.Length
  ensures forall i :: n < i < a.Length ==> a[n] < a[i]
  decreases a.Length - n;
{
  if n == a.Length - 1 {}
  else {
    IncreasingArray(a, n + 1);
  }
}
```

(b) **(CSSE7100 students only)** Define a Dafny function `IntersectionPoints` that, given r and x as parameters, returns the total number of intersection points between circles in r and lines in x . A line that is tangent to a circle has one intersection point, and a line that passes through a circle has two intersection points. Your function may call helper functions if required.

Marking

A breakdown of the marks is given below.

(a)	Pre and postconditions	1.5 marks
	Loop invariants	4.5 marks
	Termination metrics	1.5 marks
	Code	2.5 marks
(b) (CSSE7100 students only)	Function definition	4 marks

CSSE7100 students' marks will be divided by 1.4 to get a total mark out of 10. Fractional marks will be rounded to the nearest 0.5 marks.

School Policy on Student Misconduct

This assignment is to be completed individually. You are required to read and understand the School Statement on Misconduct, available on the Schools website at: <http://www.itee.uq.edu.au/itee-student-misconduct-including-plagiarism>