

CSCI 135 Software Design and Analysis I

Homework 4

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Problem 1: Intervals

We would like to create a new type to provide the ability to manipulate inexact quantities. Such quantities can be represented by intervals of the form $[a, b]$ with $a \leq b$.

(a) Define a class `Interval` that contains the necessary member data to represent the low and high ends of an interval, in addition to a constructor to construct interval objects. The class should allow you to write the following program:

```
int main() {  
    Interval r=Interval(6.12,7.48); //construct the interval [6.12,7.48];  
}
```

(b) Define two functions outside the class to extract the low and high ends of an interval. Note that the member data of class `Interval` must be public for this to work. Your functions must allow you to write the following program:

```
int main() {  
    Interval r=Interval(6.12,7.48);  
    cout<<' '[ '<<low(r)<<', '<<high(r)<<' ] '<<' \n' ;  
}
```

(c) Move the above two functions inside the class. Make any changes that are necessary, including making the member data of class `Interval` private. Write a small program to illustrate how your class works.

(d) Add a default constructor that constructs the interval $[0,1]$.

(e) Add a member function to set the low and high ends of an interval.

(f) Add a member function to check whether a number is contained in an interval. For instance, if your member function is called `contains(...)`, then you should be able to use it as follows:

```
int main() {  
    Interval r=Interval(6.12,7.48);  
    if (r.contains(6.5)) {  
        //do something  
    }  
}
```

(g) Consider the following operator overloading (outside the class):

```
Interval operator+(Interval r1, Interval r2) {  
    return Interval(r1.low()+r2.low(), r1.high()+r2.high());  
}
```

assuming that `low()` and `high()` are the member functions of part (c).

Define analogous functions to subtract two intervals, multiply two intervals, and divide two intervals.

$$[a, b] - [c, d] = [a - d, b - c]$$

$$[a, b] \cdot [c, d] = [\min(ac, ad, bc, bd), \max(ac, ad, bc, bd)]$$

$$[a, b]/[c, d] = [a, b] \cdot [1/d, 1/c] \text{ if } 0 \notin [c, d]$$

Problem 2: Arrays and shifts

(a) Write a function that accepts an array a and reverses it.

(b) Write a function that accepts an array a and an integer s , and performs a right circular shift by s on the array. For instance, if the array is an array of characters representing the string "ababaca", a circular shift by 5 makes it "abacaab". Assume s is less than the length of the array. Do this with the following strategies:

- Use extra space: While copying elements from one part of the array to another, some elements will be stepped over and deleted. Use an extra array of size s as a scratch space to save those elements as you move things around.
- Use extra time: Perform a circular shift of 1, thus requiring extra space independent of s . But repeat the operation s times.
- No extra space or time: In part (a), we need extra space dependent on s . In part (b), we need to spend a time dependent on ns , where n is the length of the array, because we perform a circular shift s times. Try to perform the circular shift with both space and time independent of s . *Hint:* think in terms of part (a).