# CptS 223 Homework #1

Please complete the homework problems on the following page. Note that this is an individual assignment and all work must be your own. Be sure to show your work when appropriate. This assignment must be turned in by the due date via Blackboard in *PDF* format. You may use any editor you like (or even print it out, *legibly* write in answers, and scan it in), but convert it to *PDF* for submission. I have provided MS Word (doc) and LibreOffice (ODF) versions for your platform of choice.

**1. [5] Order the following set of functions by their growth rate:**

1. N
2. √N
3. N^1.5
4. N^2
5. N log N
6. N log(log(N))
7. N log^2 N
8. 2/N
9. 2^N
10. 2^(N/2)
11. 37
12. N^2 log(N)
13. N^4

2/N < 37 < sqrt(N) < N < N log(log(N)) < N log N < Nlog^2 N < N^1.5 < N^2

< N^2 log(N) < N^4 < 2^(N/2) < 2^N

**2. [5] A program takes 35 seconds for input size 20 (i.e., n=20). Ignoring the effect of constants, approximately how much time can the same program be expected to take if the input size is increased to 100 given the following run-time complexities?**

1. O(N) linear, 100 = 20 \* 5 so T = T\_orig \* 5 = 175s
2. O(N + log N) same as #1 except log(100 = 2, so 177s
3. O(N^3) cubed, so 5x the input size = 5^3 = 125x the time

time = 35s \* 125 = 4375s = 1.2 hours

1. O(2^N)[[1]](#footnote-2) equivalent to 2^(5N) = (2^N)^5 meaning the original time raised to the fifth = 35s^5 = about 5.25 \* 10^7 s = 1.67 years

**4. [8] Given the following two functions:**

|  |  |
| --- | --- |
| int g(int n)  {  if(n <= 0)  {  return 0;  }  return 1 + g(n - 1);  } | int f(int n)  {  int sum = 0;  for(int i = 0; i < n; i++)  {  sum += 1;  }  return sum;  } |

1. [2] State the runtime complexity of both f() and g()

g: O(N) (N recursions)

f: O(N) (N iterations of loop)

1. [2] State the memory (space) complexity for both f() and g()

g: O(N) (N stack frames)

f: O(1) (one variable being constantly updated

1. [4] Write another function called "int h(int n)" that does the same thing, but is significantly faster.

int h(int n) {

if(n <= 0) {

return 0;

}

return n;

}

**5. [5] State g(n)'s runtime complexity:**

|  |
| --- |
| int f(int n){  if(n <= 1){  return 1;  }  return 1 + f(n/2);  }  int g(int n){  for(int i = 1; i < n; i \*= 2){  f(i);  }  } |

g iterates on the order of log(N) times, and f recurs on the order of log(N) times

total runtime complexity for g: O(log^2(N))

**7. [5] What is the runtime complexity of Adam's famous string splitter code? Hint: Make sure to look into the source code for string.find() in the C++ std library. I’ve included that code (downloaded from GNU).**

|  |
| --- |
| static vector<string> split(string text, string delimiter)  {  vector<string> pieces;  int location = text.find(delimiter);  int start = 0;  //while we find something interesting  while (location != string::npos){    //build substring  string piece = text.substr(start, location - start);  pieces.push\_back(piece);  start = location + 1;  //find again  location = text.find(delimiter, start);  }  string piece = text.substr(start, location - start);  pieces.push\_back(piece);  return pieces;  } |

**GCC/G++ source downloaded from:** [**http://mirrors.concertpass.com/gcc/releases/gcc-6.3.0/**](http://mirrors.concertpass.com/gcc/releases/gcc-6.3.0/) **Source file: gcc-6.3.0/libstdc++-v3/include/ext/vstring.tcc**

|  |
| --- |
| template<typename \_CharT, typename \_Traits, typename \_Alloc,  template <typename, typename, typename> class \_Base>  typename \_\_versa\_string<\_CharT, \_Traits, \_Alloc, \_Base>::size\_type  \_\_versa\_string<\_CharT, \_Traits, \_Alloc, \_Base>::  find(const \_CharT\* \_\_s, size\_type \_\_pos, size\_type \_\_n) const  {  \_\_glibcxx\_requires\_string\_len(\_\_s, \_\_n);  const size\_type \_\_size = this->size();  const \_CharT\* \_\_data = this->\_M\_data();  if (\_\_n == 0)  return \_\_pos <= \_\_size ? \_\_pos : npos;  if (\_\_n <= \_\_size)  {  for (; \_\_pos <= \_\_size - \_\_n; ++\_\_pos)  if (traits\_type::eq(\_\_data[\_\_pos], \_\_s[0])  && traits\_type::compare(\_\_data + \_\_pos + 1,  \_\_s + 1, \_\_n - 1) == 0)  return \_\_pos;  }  return npos;  } |

**6. [10] (adapted from the 2012 ICPC programming competition) Write an algorithm to solve the following problem and specify its runtime complexity using the most relevant terms:**

Given a nonnegative integer, what is the smallest value, k, such that

*n, 2n, 3n, …, kn*

contains all 10 decimal numbers (0 through 9) at least once? For example, given an input of "1", our sequence would be:

and thus k would be 10. Other examples:

|  |  |
| --- | --- |
| Integer Value | K value |
| 10 | 9 |
| 123456789 | 3 |
| 3141592 | 5 |

**7. [18] Provide the algorithmic efficiency for the following tasks. Justify your answer, often with a small piece of pseudocode or a drawing to help with your analysis.**

1. [3] Determining whether a provided number is odd or even

O(1)

bool isOdd(n) { return n & 1; }

bitwise AND is a O(1) operation

1. [3] Determining whether or not a number exists in a list

O(n)

check first element, if match, return true

while(!eoList && !match) {

check next element, if match, return true

}

return false

needs to run through list once, or on average on the order of running through the list once, so O(n)

1. [3] Finding the smallest number in a list

O(n)

set "current smallest" to first number in list

while(!eoList) {

check next number, if it's smaller, update current smallest

}

return current smallest

needs to run through list once, so O(n)

1. [3] Determining whether or not two **unsorted** lists of the same length contain all of the same values (assume no duplicate values)

1. [3] Determining whether or not two **sorted** lists contain all of the same values (assume no duplicate values)

1. [3] Determining whether a number is in a BST

**8. [6] Fill in what these Linux commands do.**

**For example:**

ls

cp

rm

mkdir

ssh

g++

scp

**9. [4] How do these variables get set and what do they get set with?**

int main(int argc, char\* argv[]) {

return(0);

}

1. You might need an online calculator with arbitrarily large numbers for this one. Scientific notation and 8 significant figures is just fine. [↑](#footnote-ref-2)