ACMS 20210, Sample Exam #2

Justify your responses and show all work, unless indicated otherwise.

- You do not have to account for checking whether inputs are correct (i.e. always assume the user enters a reasonable value).
- You may assume that all vectors passed to your functions have length at least 1.
- For writing functions, you may assume that the program contains the appropriate includes, declarations, and using statements before the definition of your function.

1.
   - Write a short C++ function to compute the mathematical function $f(x, y) = x^2 + e^x \cos y$. Use appropriate types for the parameters and return value of your function.

   - Write a C++ function that accepts a vector of integers (passed by constant reference) and returns a vector of integers consisting only of those entries in the original vector that were even numbers (in the same order). For example, if the user passed a vector that had been initialized by $\{1, 3, 2, 6, 3, 4, 7, 10, 3, 10\}$, the program would return a vector whose entries are $\{2, 6, 4, 10, 10\}$.

2. For both part of this problem, show a reasonable amount of work (i.e. tables of values or diagrams).

   - At the end of execution of the following code, what is the value of a?

```
int a = 4;
int b[6] = {1, 3, 4, 2, 6, 0};

int *p = nullptr;

p = &a;
*p = *p + b[2];

p = b;
a = a + p[2] - b[0];
p = &a;
*p = *p + b[3];
```

   - At the end of execution of the following code, what is the value of c?

```
int a = 1;
int b = 2;
int c = 3;

int *p = &a;
int *q = &b;

*q = c + *p;
*p = a + *p + *q;

p = q;

*q = a + *p;

q = &c;

*q = a + b + c + (*p);
```

3. • Write a C++ function that accepts as an input two vectors of doubles of the same length, both passed by constant reference, and returns a double that is computed from the sums of the absolute values of the differences of corresponding entries in the two vectors.

   For example, if the vectors passed in to your function had been initialized by $\{1.0, 3.0, 1.0, 7.0\}$ and $\{-2.0, 4.0, 6.0, 2.0\}$, the value returned would be 14.0, as computed by $|1.0 - (-2.0)| + |3.0 - 4.0| + |1.0 - 6.0| + |7.0 - 2.0|$.

- Write a C++ function of void return type that accepts a vector of integers, passed by reference (**not constant reference**), and an integer representing a lower allowed threshold for values in the vector. The function then replaces any values in the vector that are below the threshold with the threshold.

  For example, if the vector passed to your function was initialized by $\{1, 8, 4, 5, 6, 3, 2\}$ and the lower threshold was 4, after the function was called, the vector would be replaced by $\{4, 8, 4, 5, 6, 4, 4\}$.

4. • What are good reasons for using (or being able to use) functions? Give at least two.

• What is the difference between pass by value and pass by reference?

• What are the advantages of pass by constant reference, and when can it be a good idea to pass by constant reference?

• Explain what a memory leak is, and how to avoid a memory leak when using dynamically allocated memory.

5. Write a C++ function that computes the p-norm of a vector in $\mathbb{R}^n$. For a vector $\mathbf{x} = (x_1, \ldots, x_n)$ and a real number $p \geq 1$, the p-norm of the vector $\mathbf{x}$ is the quantity

$$||\mathbf{x}||_p = \left(\sum_{i=1}^{n} |x_i|^p \right)^{1/p}$$

Your C++ function should take two parameters: a vector of doubles, passed by constant reference, and a real number p (which you can assume is at least 1), and return a double representing the p-norm of the vector parameter.

6. Write a C++ function that takes two vectors of doubles x and y (of the same length) and calculates their inner product.

   For vectors $\mathbf{x} = (x_1, \ldots, x_n)$ and $\mathbf{y} = (y_1, \ldots, y_n)$, the inner product of $\mathbf{x}$ and $\mathbf{y}$ is

$$\langle \mathbf{x}, \mathbf{y} \rangle = \sum_{i=1}^{n} x_i y_i$$

7. Write a C++ function that takes a vector of doubles (passed by constant reference) and returns the difference between its maximum and minimum values.

8. Write a C++ function that takes a vector of doubles (passed by constant reference) and returns the sum of all the positive entries in the vector.

9. Write a C++ function that takes two vectors of integers (passed by constant reference) and returns the sum of all the integers in the first vector which are not divisible by any of the integers in the second vector. You may assume that all integers in the second vector are non-zero. You might want to write this using two functions, with one calling the other.