

CS302 - Programming Assignment 1: Multiplication

Motivation

You likely learned how to multiply large numbers by hand in elementary school. While the approach you learned is convenient for small numbers, it is actually not the most efficient approach. A divide and conquer algorithm called Karatsuba Multiplication is actually faster. In this assignment, you will write a program to implement Karatsuba multiplication. You can learn about Karatsuba multiplication in several of the course textbooks, or using an internet search. (Part of the purpose of this assignment is for you to use these resources to figure out how the algorithm works.)

Guidelines

Please read and abide by the [honor code guidelines](#) in the syllabus.

Please read the [rubric](#) so you know how you will be graded. For example, turning in a program that compiles and runs without errors but does nothing will earn you more points than a program that is close to working but does not compile or contains errors on running.

There are two options for this assignment: Standard and Challenge. (You must turn in only one of the two options.) You will be graded using [this rubric](#). Since the rubric is out of 30 points, if you earn X points, then your grade will be $X/30 \times .85$ for a Standard assignment and $X/30 \times .95$ for Challenge. Thus a poorly done Challenge program could give you a worse score than a well executed Standard program.

For this assignment, you should not have to use any external packages or methods. For timing, you may find, e.g. `System.currentTimeMillis` helpful.

Put a multi-line comment at the beginning of your program. It should contain:

- Your name
- “Programming Assignment 1”
- “Challenge” or “Standard”
- The name of anyone you worked with and the nature of your collaboration
- Sample multiplication from your program
- The amount of time (approximately) that you spent on this assignment

Standard Assignment

Write a program in Java that takes as input two positive integers, formatted as strings. You may assume that the two strings contain the same number of digits, and that the number of digits in each number is a power of 2. The program should output the product of the two numbers. Your program should implement Karatsuba multiplication for the multiplication, and internally, you should only use the built-in multiplication function to multiply single digits. For example, you

can evaluate $8 * 6$ using the built-in Java multiplication function, but not $84 * 29$, which should be evaluated using Karatsuba.

Challenge Assignment

First complete the standard assignment, except your program should work for two inputs with differing, arbitrary lengths. Next, write a program that implements the standard approach for multiplication that you learned in elementary school. This program should take in any two positive integers of any length and output the product. This second program should also only use the built-in multiplication function to multiply single digits. Finally, compare the time that your two programs take to run on similar inputs. You should find that for small inputs, your elementary school algorithm is faster, but for very large inputs, your Karatsuba algorithm is faster. At approximately what size input does this cross over happen? (Put this answer in your multi-line comment.)