Program Structures and Algorithms
Spring 2023(Section - 1)

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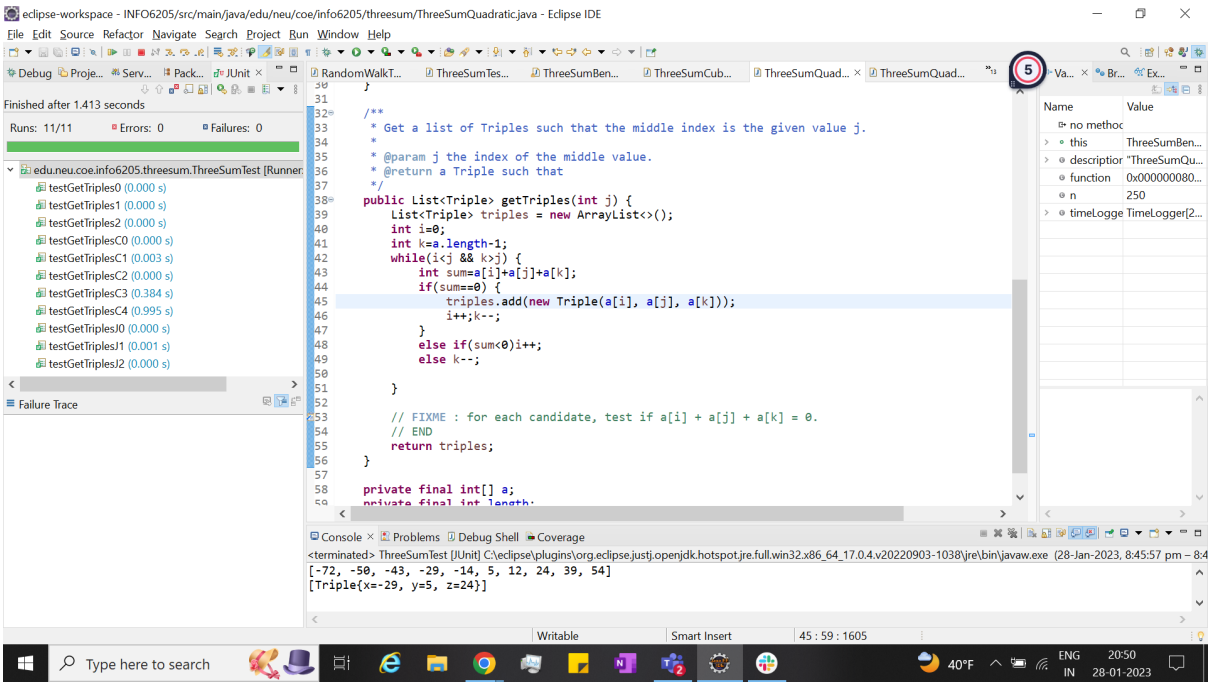
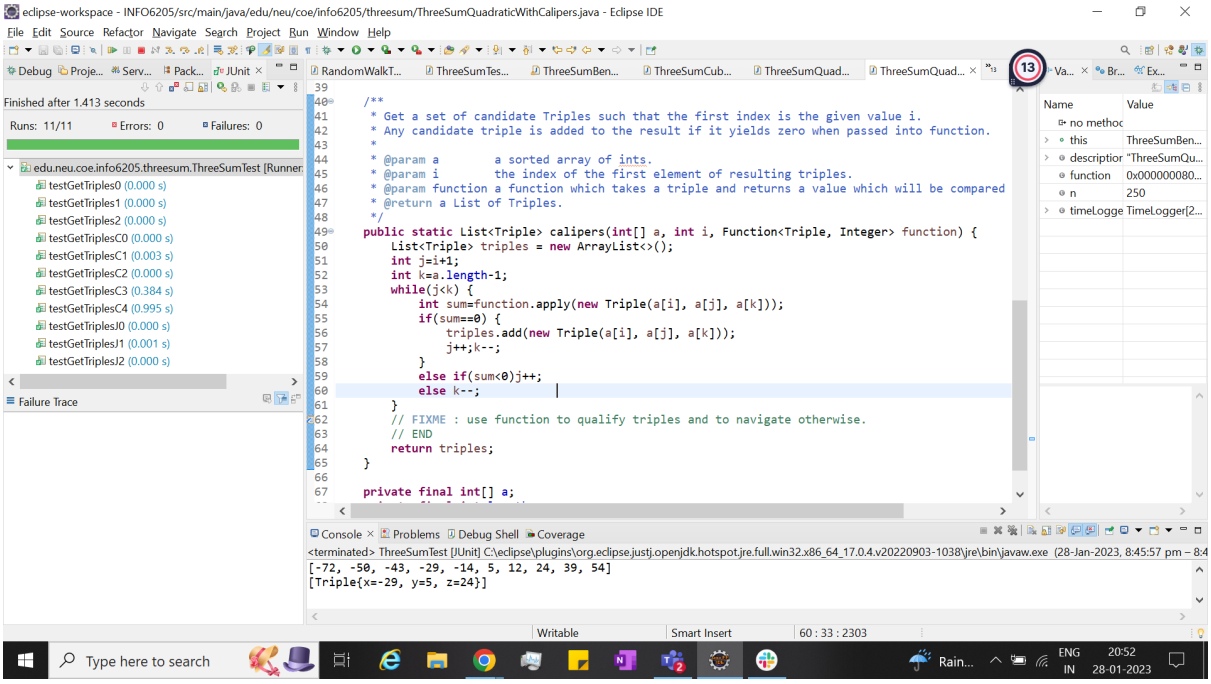
Task:
Solve 3-SUM using the *Quadrithmic*, *Quadratic*, and (bonus point) *quadraticWithCalipers* approaches, as shown in skeleton code in the repository.

Code to solve 3-SUM using Quadratic approach:

3Sum Quadratic

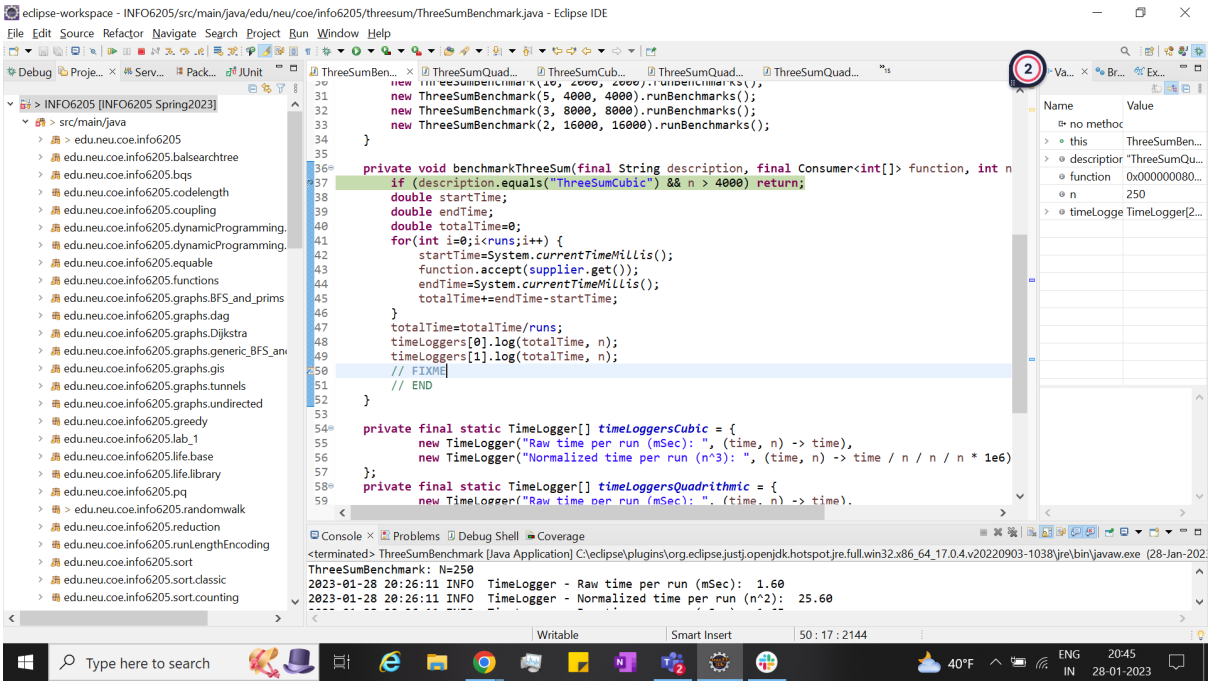


3 Sum Quadratic with Calipers

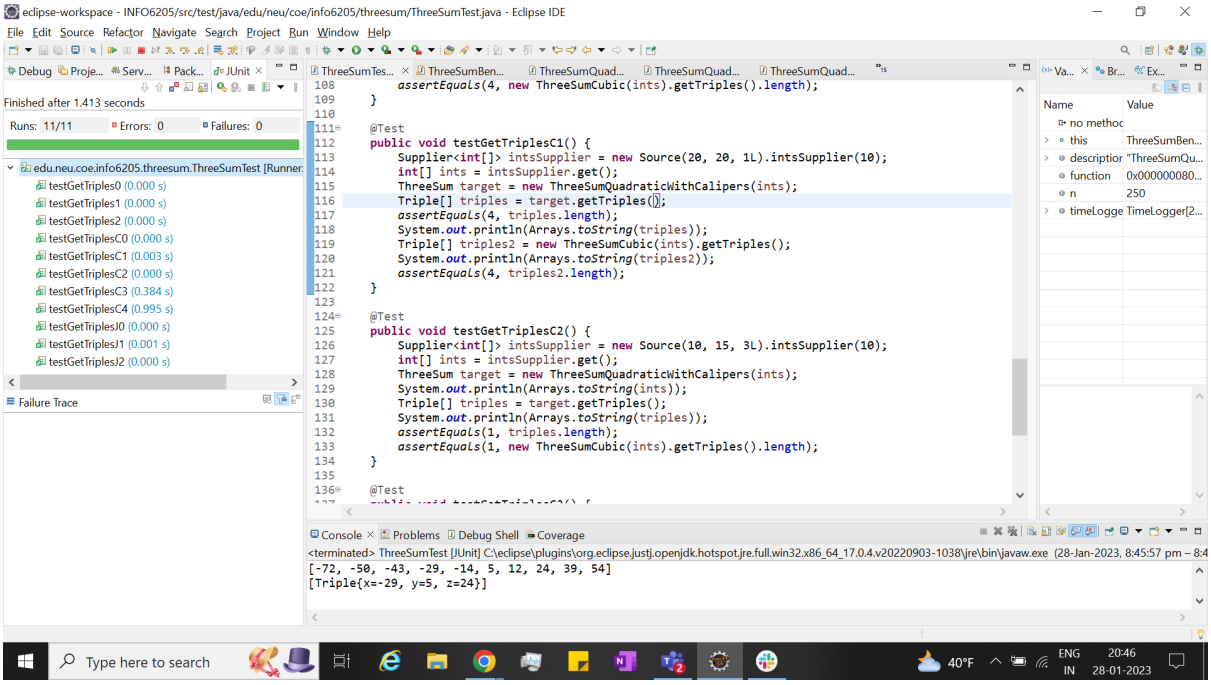


Program Structures and Algorithms
Spring 2023(Section - 1)

3 Sum Benchmark:



(a)Unit Test Screenshot:

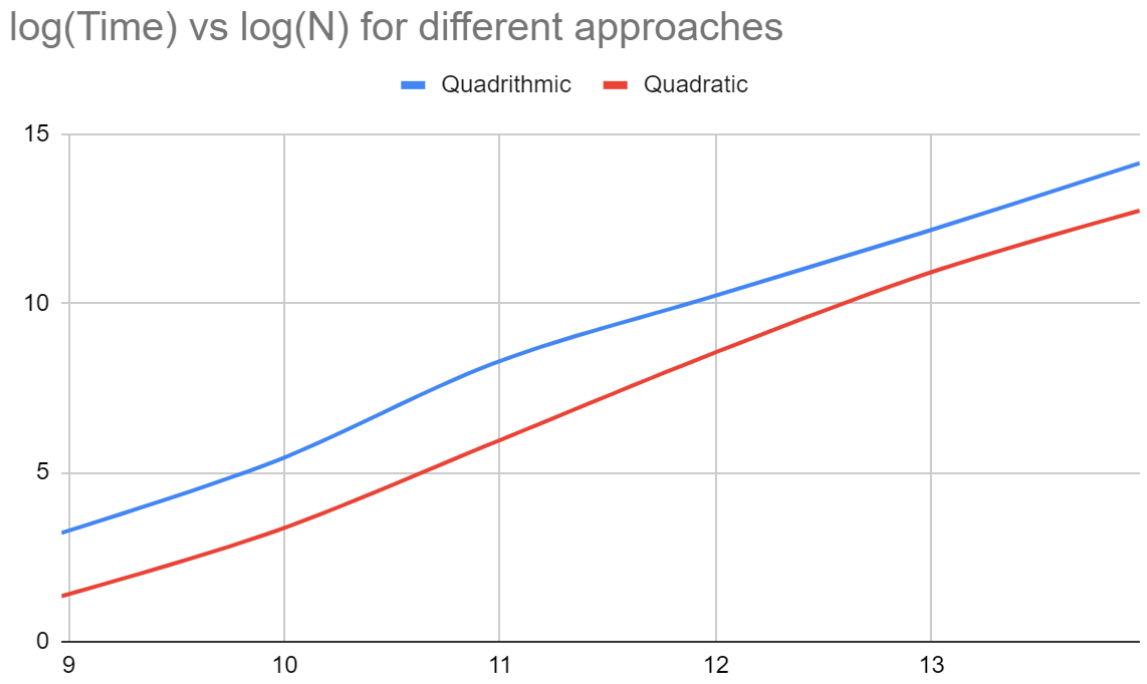


Program Structures and Algorithms
Spring 2023(Section - 1)

(b)Validating by using doubling benchmarkGraphical Representation:
Here, I used 3Sum Benchmark to time the observations and used the doubling method from n=250 until n=16000

N		Quadratic		Quadrithmic		Cubic	
		(millisec)	lg ratio	(millisec)	lg ration	(seconds)	lg ratio
250	Raw Time	1.6		2.86		0.01547	
	Normalized	25.6		5.74		0.00099	
500	Raw Time	2.54	0.67	9.3	1.7	0.1037	2.74
	Normalized	10.16		4.15		0.00083	
1000	Raw Time	9.75	1.94	41	2.14	0.8893	3.1
	Normalized	9.75		4.11		0.00089	
2000	Raw Time	58.5	2.58	297	2.86	11.9446	3.75
	Normalized	14.63		6.77		0.00149	
4000	Raw Time	353.4	2.59	1147.4	1.95	70.6222	2.56
	Normalized	22.09		5.99		0.0011	
8000	Raw Time	1841.33	2.38	4388.33	1.94		
	Normalized	28.77		5.29			
16000	Raw Time	6824	1.89	18053	2.04		
	Normalized	26.66		5.05			

Here's the plot of log(N) vs log(Time) for Quadratic and Quadrithmic approaches



(c)Explanation:

The optimization of Quadratic over Quadrithmic approach is that instead of running through 2 for loops on a sorted array for finding all possible pairs of sums of 2 numbers and then trying to do a binary search to find the complement of the sum, we can simply fix one value and iterate left pointer from one step ahead and iterate right pointer from the end and just simply check whether the sum is zero or less than zero or greater than zero and depending on that move the appropriate pointers by increasing the left or decreasing the right. This way, we can improve the time complexity by looping through the array only twice and save the time required to do a binary search.