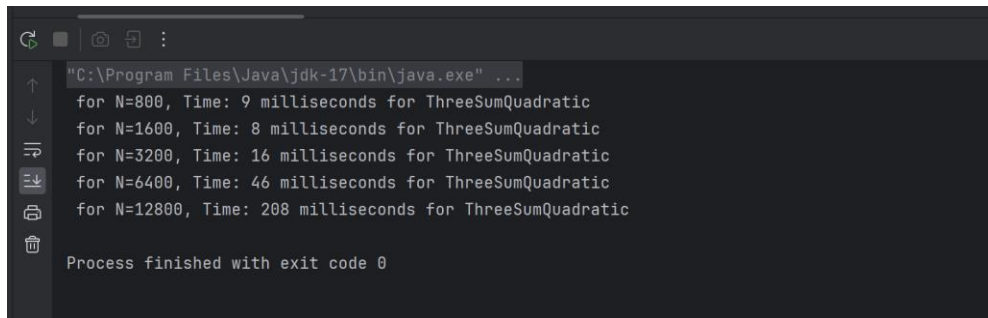
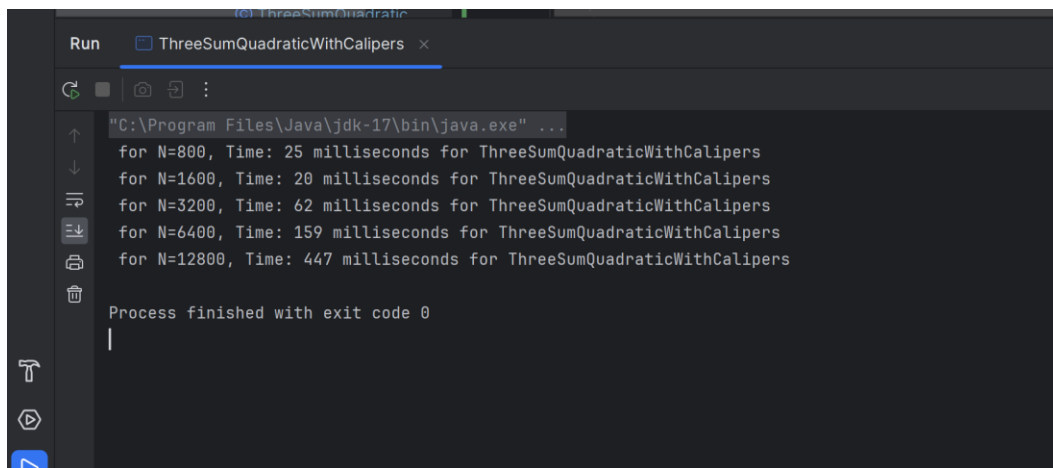


Three Sum Quadratic:



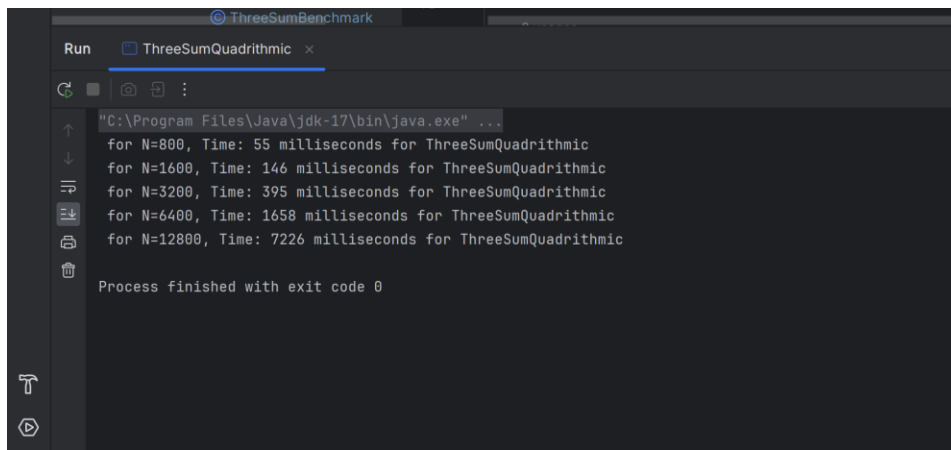
```
"C:\Program Files\Java\jdk-17\bin\java.exe" ...  
for N=800, Time: 9 milliseconds for ThreeSumQuadratic  
for N=1600, Time: 8 milliseconds for ThreeSumQuadratic  
for N=3200, Time: 16 milliseconds for ThreeSumQuadratic  
for N=6400, Time: 46 milliseconds for ThreeSumQuadratic  
for N=12800, Time: 208 milliseconds for ThreeSumQuadratic  
  
Process finished with exit code 0
```

ThreeSumQuadraticWithCalipers:



```
Run ThreeSumQuadraticWithCalipers x  
"C:\Program Files\Java\jdk-17\bin\java.exe" ...  
for N=800, Time: 25 milliseconds for ThreeSumQuadraticWithCalipers  
for N=1600, Time: 20 milliseconds for ThreeSumQuadraticWithCalipers  
for N=3200, Time: 62 milliseconds for ThreeSumQuadraticWithCalipers  
for N=6400, Time: 159 milliseconds for ThreeSumQuadraticWithCalipers  
for N=12800, Time: 447 milliseconds for ThreeSumQuadraticWithCalipers  
  
Process finished with exit code 0
```

ThreeSumQuadrithmic:



```
Run ThreeSumQuadrithmic x  
"C:\Program Files\Java\jdk-17\bin\java.exe" ...  
for N=800, Time: 55 milliseconds for ThreeSumQuadrithmic  
for N=1600, Time: 146 milliseconds for ThreeSumQuadrithmic  
for N=3200, Time: 395 milliseconds for ThreeSumQuadrithmic  
for N=6400, Time: 1658 milliseconds for ThreeSumQuadrithmic  
for N=12800, Time: 7226 milliseconds for ThreeSumQuadrithmic  
  
Process finished with exit code 0
```

ThreeSumCubic:

```
Run ThreeSumCubic x

"C:\Program Files\Java\jdk-17\bin\java.exe" ...
for N=100, Time: 19 milliseconds for ThreeSumCubic
for N=200, Time: 40 milliseconds for ThreeSumCubic
for N=400, Time: 171 milliseconds for ThreeSumCubic
for N=800, Time: 1002 milliseconds for ThreeSumCubic
for N=1600, Time: 6029 milliseconds for ThreeSumCubic

Process finished with exit code 0
```

a) UNIT TEST CASES PASSED:

```
Project ThreeSumQuadratic.java ThreeSumTest.java ThreeSumQuadraticWithCalipers.java ThreeSumQuadratic.java

> bqs
> dynamicProgramming
> functions
> graphs
> greedy
> lab_1
> life
> madhava
> pq
> randomwalk
> reduction
> sort

Run ThreeSumTest x

Tests passed: 11 of 11 tests - 1 sec 919 ms

testGetTriples0 32 ms
testGetTriples1 10 ms
testGetTriples2 2 ms
testGetTriplesC0 1 ms
testGetTriplesC1 3 ms
testGetTriplesC2 1 ms
testGetTriplesC3 424 ms
testGetTriplesC4 1 sec 446 ms
testGetTriplesJ0 0 ms
testGetTriplesJ1 0 ms
testGetTriplesJ2 0 ms

"C:\Program Files\Java\jdk-17\bin\java.exe" ...
ints: [-40, -20, -10, 0, 5, 10, 30, 40]
triples: [Triple{x=-40, y=0, z=40}, Triple{x=-40, y=10, z=30}, Triple{x=-20, y=-10, z=30}, Triple{x=-10, y=0, z=10}]
[Triple{x=-51, y=2, z=49}, Triple{x=-51, y=9, z=42}, Triple{x=-44, y=2, z=42}, Triple{x=-11, y=2, z=9}]
[Triple{x=-51, y=2, z=49}, Triple{x=-51, y=9, z=42}, Triple{x=-44, y=2, z=42}, Triple{x=-11, y=2, z=9}]
[-72, -50, -43, -29, -14, 5, 12, 24, 39, 54]
[Triple{x=-29, y=5, z=24}]
ints: [-40, -20, -10, 0, 5, 10, 30, 40]
triples: [Triple{x=-40, y=0, z=40}, Triple{x=-40, y=10, z=30}, Triple{x=-20, y=-10, z=30}, Triple{x=-10, y=0, z=10}]
[Triple{x=-51, y=2, z=49}, Triple{x=-51, y=9, z=42}, Triple{x=-44, y=2, z=42}, Triple{x=-11, y=2, z=9}]
[Triple{x=-51, y=2, z=49}, Triple{x=-51, y=9, z=42}, Triple{x=-44, y=2, z=42}, Triple{x=-11, y=2, z=9}]
[-72, -50, -43, -29, -14, 5, 12, 24, 39, 54]
[Triple{x=-29, y=5, z=24}]

Process finished with exit code 0
```

b) SPREAD SHEET

	A	B	C	D
1	N	QUADRATIC(milliseconds)	QUADRITHMIC(milli)	
2	400	9	55	
3	800	8	146	
4	1600	16	395	
5	3200	46	1658	
6	6400	208	7226	
7				
8				
9				
10				
11	N	CUBIC(milliseconds)		
12	100	19		
13	200	40		
14	400	171		
15	800	1002		
16	1600	6029		
17				
18				

c) Why Quadratic Methods Work?

The quadratic method(s) work for solving the 3-SUM problem because the algorithm examines every possible pair of elements in the input array, resulting in a time complexity of $O(N^2)$. This approach ensures that every combination of three elements is considered, allowing for the identification of triplets whose sum equals zero.