

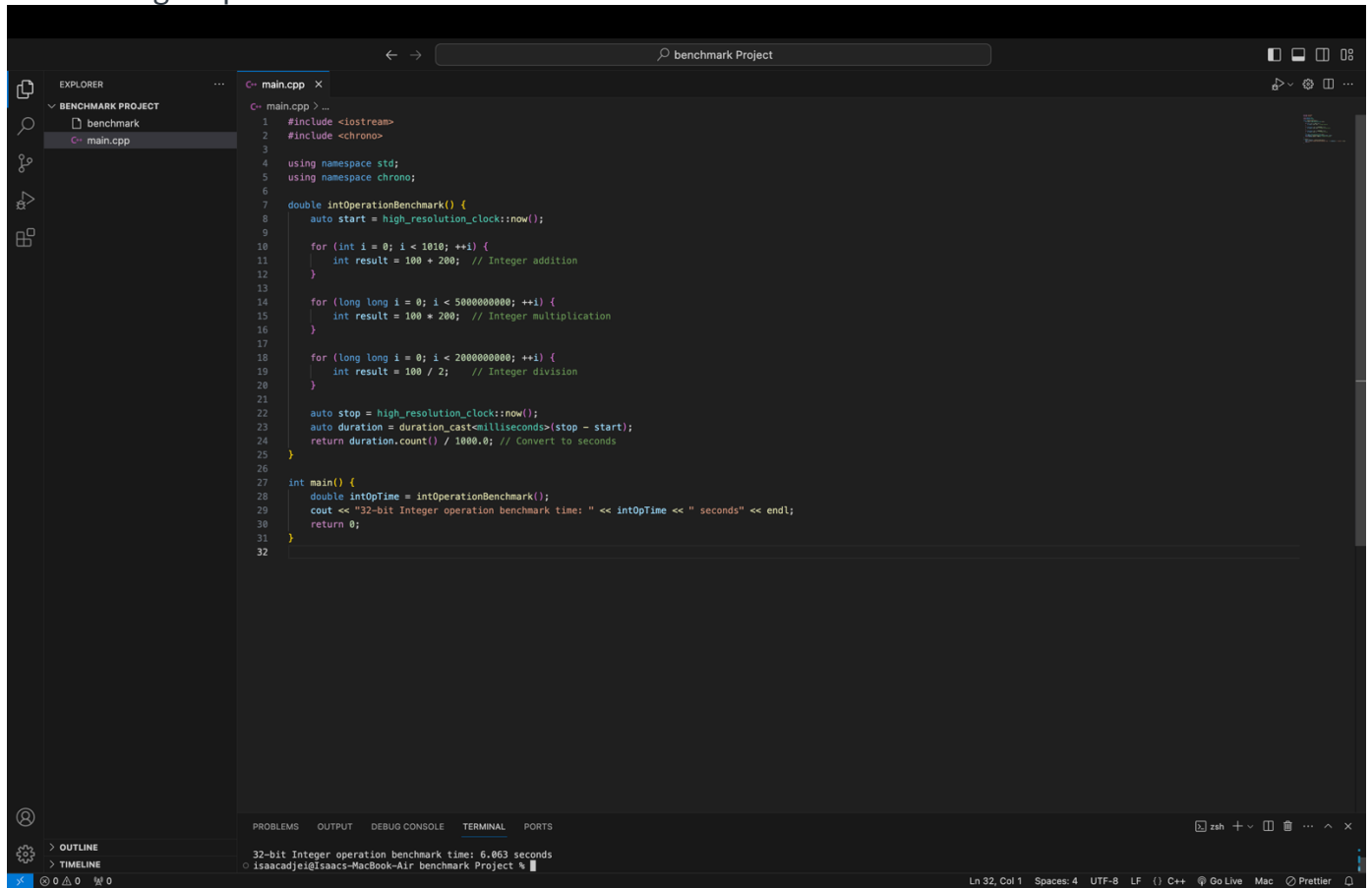
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Computer Organization II – Benchmark Project
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Brand of CPU: Apple
Model of CPU: Apple M2
Number of Cores on CPU: 8 (4 performance and 4 efficiency)
Clock Rate of CPU in GHz: High-performance "Avalanche" cores at 3.49 GHz, energy-efficient
Amount of Memory in GB: 24 GB
Type of Hard Drive: SSD
Speed of Memory: With a 128-bit memory bus and 100 GB/s bandwidth for the M2 chip
Max Sequential Write Speed: 2.8 GB/s
Max Sequential Read Speed: 3.5 GB/s
Max Random Read Speed: 1 GB/s
Max Random Write Speed: 800MB/s

	Reference Time (s)	Execution time(s)	Ratio
32-bit Integer operation benchmark	100	6.188	16.160
64-bit Floating point operation benchmark	100	6.202	16.124
Memory benchmark	100	23.12	4.324
Hard drive benchmark 1	250	0.303	825.0
Hard drive benchmark 2	10	0.209	47.8

Geometric mean = $\sqrt[5]{16.160 \times 16.124 \times 4.324 \times 825.0 \times 47.8}$
= 33.824

32-bit Integer operation benchmark

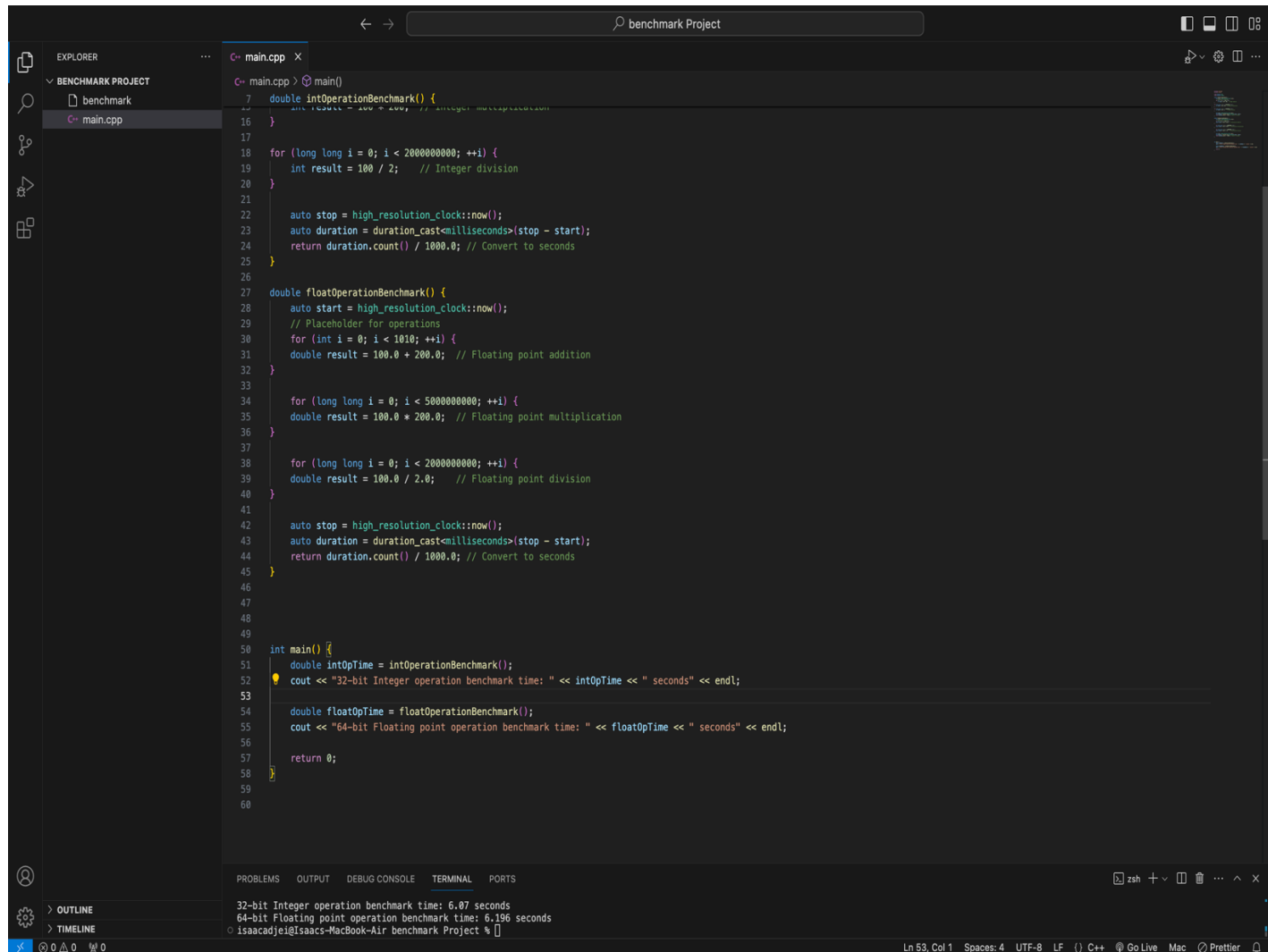


```
1 #include <iostream>
2 #include <chrono>
3
4 using namespace std;
5 using namespace chrono;
6
7 double intOperationBenchmark() {
8     auto start = high_resolution_clock::now();
9
10    for (int i = 0; i < 1010; ++i) {
11        int result = 100 + 200; // Integer addition
12    }
13
14    for (long long i = 0; i < 5000000000; ++i) {
15        int result = 100 * 200; // Integer multiplication
16    }
17
18    for (long long i = 0; i < 2000000000; ++i) {
19        int result = 100 / 2; // Integer division
20    }
21
22    auto stop = high_resolution_clock::now();
23    auto duration = duration_cast<milliseconds>(stop - start);
24    return duration.count() / 1000.0; // Convert to seconds
25 }
26
27 int main() {
28     double intOpTime = intOperationBenchmark();
29     cout << "32-bit Integer operation benchmark time: " << intOpTime << " seconds" << endl;
30     return 0;
31 }
32
```

32-bit Integer operation benchmark time: 6.063 seconds

isaacadjel@isaacs-MacBook-Air benchmark Project %

64-bit Floating point operation benchmark



The screenshot shows a C++ benchmark program in a Visual Studio Code editor. The file is named `main.cpp` and is part of a project named `benchmark Project`. The code defines two benchmark functions: `intOperationBenchmark()` and `floatOperationBenchmark()`, and a `main()` function that calls them and prints the results.

```
1  double intOperationBenchmark() {  
2      // Placeholder for operations  
3      for (long long i = 0; i < 2000000000; ++i) {  
4          int result = 100 / 2; // Integer division  
5      }  
6  
7      auto stop = high_resolution_clock::now();  
8      auto duration = duration_cast<milliseconds>(stop - start);  
9      return duration.count() / 1000.0; // Convert to seconds  
10 }  
11  
12 double floatOperationBenchmark() {  
13     auto start = high_resolution_clock::now();  
14     // Placeholder for operations  
15     for (int i = 0; i < 1010; ++i) {  
16         double result = 100.0 + 200.0; // Floating point addition  
17     }  
18  
19     for (long long i = 0; i < 5000000000; ++i) {  
20         double result = 100.0 * 200.0; // Floating point multiplication  
21     }  
22  
23     for (long long i = 0; i < 2000000000; ++i) {  
24         double result = 100.0 / 2.0; // Floating point division  
25     }  
26  
27     auto stop = high_resolution_clock::now();  
28     auto duration = duration_cast<milliseconds>(stop - start);  
29     return duration.count() / 1000.0; // Convert to seconds  
30 }  
31  
32 int main() {  
33     double intOpTime = intOperationBenchmark();  
34     cout << "32-bit Integer operation benchmark time: " << intOpTime << " seconds" << endl;  
35  
36     double floatOpTime = floatOperationBenchmark();  
37     cout << "64-bit Floating point operation benchmark time: " << floatOpTime << " seconds" << endl;  
38  
39     return 0;  
40 }
```

The output of the program, shown in the terminal, is:

```
32-bit Integer operation benchmark time: 6.07 seconds  
64-bit Floating point operation benchmark time: 6.196 seconds
```

Memory benchmark

The screenshot displays a Visual Studio Code editor window with a project named "benchmark Project". The Explorer sidebar on the left shows the project structure with a "benchmark" folder containing "main.cpp". The main editor pane shows the code for "main.cpp", which includes a memory benchmark function and a main function that runs several benchmarks.

```
46 }
47
48
49 double memoryBenchmark() {
50     auto start = high_resolution_clock::now();
51     constexpr long long arraySize = 5000000000;
52     vector<int> array(arraySize);
53     // Placeholder for read and write operations
54
55     // Read benchmark
56     for (long long i = 0; i < arraySize; ++i) {
57         volatile int value = array[i];
58     }
59
60     // Write benchmark
61     for (long long i = 0; i < arraySize; ++i) {
62         array[i] = 1;
63     }
64
65     auto stop = high_resolution_clock::now();
66     auto duration = duration_cast<milliseconds>(stop - start);
67     return duration.count() / 1000.0; // Convert to seconds
68 }
69
70
71
72
73
74 int main() {
75     double intOpTime = intOperationBenchmark();
76     cout << "32-bit Integer operation benchmark time: " << intOpTime << " seconds" << endl;
77
78     double floatOpTime = floatOperationBenchmark();
79     cout << "64-bit Floating point operation benchmark time: " << floatOpTime << " seconds" << endl;
80
81     double memoryTime = memoryBenchmark();
82     cout << "Memory benchmark time: " << memoryTime << " seconds" << endl;
83
84
85     return 0;
86 }
87
```

The terminal at the bottom shows the execution of the program. The commands used are:

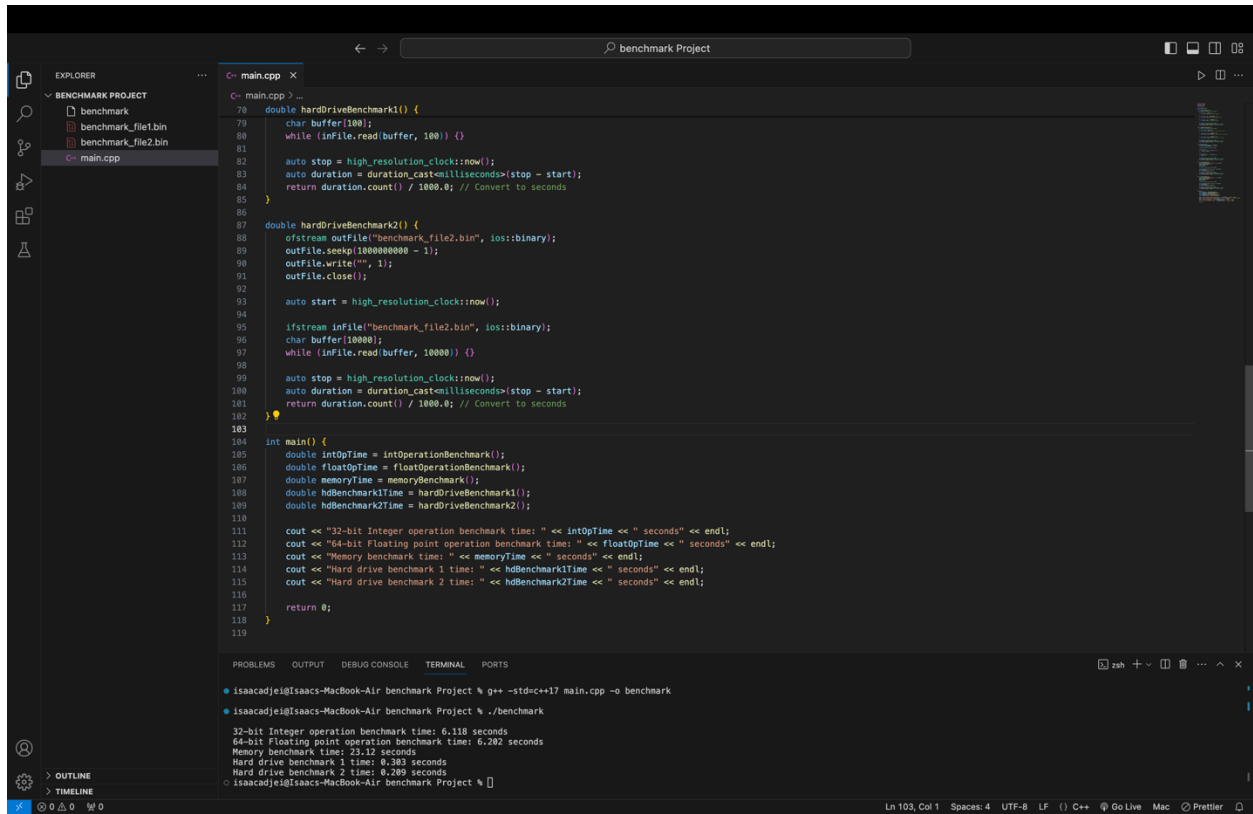
```
isaacadjei@Isaacs-MacBook-Air benchmark Project % g++ -std=c++17 main.cpp -o benchmark
isaacadjei@Isaacs-MacBook-Air benchmark Project % ./benchmark
```

The output of the program is:

```
32-bit Integer operation benchmark time: 6.08 seconds
64-bit Floating point operation benchmark time: 6.193 seconds
Memory benchmark time: 52.584 seconds
```

The status bar at the bottom indicates the current position is Line 88, Column 1, with 4 spaces, UTF-8 encoding, LF line endings, C++ language, and various extensions like Go Live, Mac, and Prettier are active.

Hard drive benchmark 1 and Hard drive benchmark 2



```
78 double hardDriveBenchmark1() {
79     char buffer[100];
80     while (inFile.read(buffer, 100)) {}
81
82     auto stop = high_resolution_clock::now();
83     auto duration = duration_cast<milliseconds>(stop - start);
84     return duration.count() / 1000.0; // Convert to seconds
85 }
86
87 double hardDriveBenchmark2() {
88     ofstream outFile("benchmark_file2.bin", ios::binary);
89     outFile.seekp(1000000000 - 1);
90     outFile.write("", 1);
91     outFile.close();
92
93     auto start = high_resolution_clock::now();
94
95     ifstream inFile("benchmark_file2.bin", ios::binary);
96     char buffer[10000];
97     while (inFile.read(buffer, 10000)) {}
98
99     auto stop = high_resolution_clock::now();
100    auto duration = duration_cast<milliseconds>(stop - start);
101    return duration.count() / 1000.0; // Convert to seconds
102 }
103
104 int main() {
105     double intOpTime = intOperationBenchmark();
106     double floatOpTime = floatOperationBenchmark();
107     double memoryTime = memoryBenchmark();
108     double hdBenchmark1Time = hardDriveBenchmark1();
109     double hdBenchmark2Time = hardDriveBenchmark2();
110
111     cout << "32-bit Integer operation benchmark time: " << intOpTime << " seconds" << endl;
112     cout << "64-bit Floating point operation benchmark time: " << floatOpTime << " seconds" << endl;
113     cout << "Memory benchmark time: " << memoryTime << " seconds" << endl;
114     cout << "Hard drive benchmark 1 time: " << hdBenchmark1Time << " seconds" << endl;
115     cout << "Hard drive benchmark 2 time: " << hdBenchmark2Time << " seconds" << endl;
116
117     return 0;
118 }
119
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

```
isaacadjei@isaacs-MacBook-Air benchmark Project % g++ -std=c++17 main.cpp -o benchmark
isaacadjei@isaacs-MacBook-Air benchmark Project % ./benchmark

32-bit Integer operation benchmark time: 6.118 seconds
64-bit Floating point operation benchmark time: 6.202 seconds
Memory benchmark time: 23.12 seconds
Hard drive benchmark 1 time: 0.383 seconds
Hard drive benchmark 2 time: 0.209 seconds
isaacadjei@isaacs-MacBook-Air benchmark Project %
```

Ln 103, Col 1 Spaces: 4 UTF-8 LF C++ Go Live Mac Prettier