

Завдання №1

Програма демонструє race conditions, оскільки кілька потоків одночасно читають і змінюють глобальну змінну `shared_variable`. Відсутність синхронізації (наприклад, через mutex) призводить до некоректного фінального значення змінної. Поведінка програми змінюється залежно від:

- Кількості пар потоків: Чим більше потоків, тим вища ймовірність помилки.
- Кількості операцій: Зростання кількості операцій збільшує ймовірність конфліктів.

Запуск програми з різними параметрами демонструє випадкові результати, характерні для race conditions.

```
mint@asus-mint:~/git/op-course/lab7/task1$ ./bin/main 2 10
Starting program with 2 pairs of threads, each performing 10 operations.
Initial value of shared variable: 0
Thread 0 completed.
Thread 1 completed.
Thread 3 completed.
Thread 2 completed.
Final value of shared variable: 0
mint@asus-mint:~/git/op-course/lab7/task1$ █

mint@asus-mint:~/git/op-course/lab7/task1$ ./bin/main 2 10000
Starting program with 2 pairs of threads, each performing 10000 operations.
Initial value of shared variable: 0
Thread 1 completed.
Thread 0 completed.
Thread 2 completed.
Thread 3 completed.
Final value of shared variable: 451
mint@asus-mint:~/git/op-course/lab7/task1$ ./bin/main 2 1000000
Starting program with 2 pairs of threads, each performing 1000000 operations.
Initial value of shared variable: 0
Thread 2 completed.
Thread 3 completed.
Thread 0 completed.
Thread 1 completed.
Final value of shared variable: -233461
mint@asus-mint:~/git/op-course/lab7/task1$ ./bin/main 2 1000000
Starting program with 2 pairs of threads, each performing 1000000 operations.
Initial value of shared variable: 0
Thread 3 completed.
Thread 2 completed.
Thread 1 completed.
Thread 0 completed.
Final value of shared variable: 448609
mint@asus-mint:~/git/op-course/lab7/task1$ █
```

Завдання №2

Програма забезпечує коректний доступ до спільної змінної `shared_result` за допомогою м'ютекса, що усуває `race conditions`.

```
mint@asus-mint:~/git/op-course/lab7/task2$ ./bin/main 4 0 2
Thread 0: calculated partial integral = 1.95833
Thread 1: calculated partial integral = 1.70833
Thread 3: calculated partial integral = 0.45833
Thread 2: calculated partial integral = 1.20833
Final result of integration: 5.33334
```

Завдання №3

У програмі використано блокування для синхронізованого доступу до масиву, де потоки-письменники записують псевдовипадкові числа, а потоки-читачі зчитують їх. Для синхронізації доступу до масиву використовується механізм блокувань для читання та запису, що дозволяє забезпечити безпечну взаємодію між потоками, зберігаючи цілісність даних. Програма працює протягом заданого часу та виводить стан масиву через певний проміжок часу.

```
mint@asus-mint:~/git/op-course/lab7/task3$ ./bin/main 20 3 6
Reader 3 read 0 from index 6
Reader 4 read 0 from index 8
Reader 4 read 0 from index 7
Writer 2 wrote 36 at index 14
Reader 4 read 0 from index 19
Writer 0 wrote 25 at index 12
Reader 1 read 0 from index 11
Reader 1 read 0 from index 1
Reader 0 read 0 from index 5
Writer 0 wrote 60 at index 12
Reader 2 read 0 from index 3
Writer 2 wrote 95 at index 10
Reader 5 read 0 from index 7
Reader 2 read 0 from index 2
Writer 1 wrote 82 at index 12
Reader 3 read 0 from index 11
Reader 4 read 0 from index 9
Reader 4 read 0 from index 8
Reader 1 read 0 from index 2
Writer 0 wrote 48 at index 5
Reader 4 read 0 from index 4
```

Reader 2 read 0 from index 3
Writer 1 wrote 35 at index 15
Writer 1 wrote 98 at index 11
Reader 0 read 0 from index 2
Reader 2 read 0 from index 3
Reader 4 read 0 from index 18
Writer 1 wrote 50 at index 6
Reader 5 read 0 from index 0
Reader 2 read 82 from index 12
Writer 2 wrote 60 at index 2
Reader 3 read 0 from index 4
Reader 1 read 35 from index 15
Array state: 0 0 60 0 0 48 50 0 0 0 95 98 82 0 36 35 0 0 0 0
Writer 0 wrote 52 at index 15
Reader 1 read 0 from index 19
Reader 5 read 60 from index 2
Reader 2 read 0 from index 8
Reader 0 read 0 from index 17
Writer 1 wrote 51 at index 8
Writer 2 wrote 29 at index 1
Reader 4 read 0 from index 7
Writer 0 wrote 7 at index 13
Reader 0 read 48 from index 5
Reader 3 read 51 from index 8
Writer 1 wrote 12 at index 19
Reader 5 read 36 from index 14
Reader 2 read 0 from index 18
Writer 2 wrote 29 at index 16
Reader 1 read 98 from index 11
Writer 0 wrote 57 at index 12
Reader 2 read 0 from index 3
Writer 2 wrote 50 at index 15
Reader 4 read 0 from index 17
Reader 0 read 48 from index 5
Reader 3 read 50 from index 15
Reader 5 read 0 from index 7
Writer 1 wrote 87 at index 13
Writer 2 wrote 51 at index 12
Reader 1 read 12 from index 19
Reader 5 read 12 from index 19
Writer 1 wrote 88 at index 9
Writer 1 wrote 76 at index 0
Writer 0 wrote 20 at index 17
Reader 3 read 36 from index 14
Reader 0 read 51 from index 8

Array state: 76 29 60 0 0 48 50 0 51 88 95 98 51 87 36 50 29 20 0 12

Reader 0 read 20 from index 17

Reader 2 read 88 from index 9

Writer 0 wrote 6 at index 6

Reader 0 read 12 from index 19

Writer 1 wrote 78 at index 4

Reader 4 read 0 from index 7

Reader 1 read 0 from index 3

Writer 0 wrote 60 at index 11

Reader 0 read 60 from index 11

Reader 2 read 95 from index 10

Writer 1 wrote 88 at index 5

Reader 1 read 0 from index 3

Reader 5 read 76 from index 0

Writer 0 wrote 97 at index 11

Writer 2 wrote 55 at index 12

Reader 3 read 0 from index 18

Reader 1 read 0 from index 18

Reader 4 read 51 from index 8

Reader 0 read 6 from index 6

Writer 2 wrote 41 at index 8

Reader 2 read 12 from index 19

Writer 2 wrote 70 at index 6

Reader 4 read 29 from index 16

Reader 5 read 88 from index 9

Reader 5 read 60 from index 2

Writer 1 wrote 62 at index 3

Reader 1 read 36 from index 14

Writer 1 wrote 86 at index 16

Writer 2 wrote 37 at index 8

Writer 0 wrote 47 at index 6

Writer 1 wrote 25 at index 15

Reader 5 read 62 from index 3

Reader 3 read 88 from index 9

Writer 2 wrote 15 at index 19

Reader 5 read 62 from index 3

Array state: 76 29 60 62 78 88 47 0 37 88 95 97 55 87 36 25 86 20 0 15

Reader 0 read 47 from index 6

Reader 2 read 76 from index 0

Reader 4 read 86 from index 16

Reader 1 read 95 from index 10

Reader 3 read 88 from index 9

Reader 2 read 37 from index 8

Writer 0 wrote 16 at index 15

Reader 5 read 88 from index 5

Writer 2 wrote 91 at index 12
Reader 5 read 20 from index 17
Writer 1 wrote 95 at index 4
Reader 1 read 0 from index 18
Reader 3 read 36 from index 14
Reader 4 read 0 from index 18
Reader 0 read 29 from index 1
Writer 2 wrote 70 at index 10
Reader 2 read 47 from index 6
Writer 2 wrote 55 at index 10
Writer 1 wrote 23 at index 10
Reader 5 read 0 from index 18
Writer 0 wrote 73 at index 7
Reader 5 read 23 from index 10
Reader 4 read 29 from index 1
Reader 0 read 15 from index 19
Reader 5 read 36 from index 14
Reader 1 read 97 from index 11
Writer 2 wrote 1 at index 4
Reader 1 read 47 from index 6
Writer 1 wrote 28 at index 8
Reader 5 read 36 from index 14
Reader 0 read 88 from index 5
Reader 3 read 36 from index 14
Reader 4 read 88 from index 5
Reader 1 read 47 from index 6
Reader 2 read 16 from index 15
Array state: 76 29 60 62 1 88 47 73 28 88 23 97 91 87 36 16 86 20 0 15
Reader 0 read 23 from index 10
Writer 1 wrote 32 at index 5
Writer 2 wrote 40 at index 4
Writer 1 wrote 63 at index 14
Reader 5 read 0 from index 18
Writer 0 wrote 16 at index 9
Reader 3 read 20 from index 17
Reader 2 read 60 from index 2
Reader 4 read 32 from index 5
Reader 1 read 63 from index 14
Reader 5 read 73 from index 7
Writer 2 wrote 25 at index 19
Reader 1 read 47 from index 6
Reader 3 read 76 from index 0
Writer 1 wrote 84 at index 1
Writer 0 wrote 24 at index 18
Reader 5 read 91 from index 12

Reader 0 read 16 from index 15
Reader 2 read 91 from index 12
Writer 1 wrote 92 at index 19
Writer 1 wrote 27 at index 3
Reader 0 read 76 from index 0
Reader 2 read 92 from index 19
Reader 0 read 32 from index 5
Reader 4 read 27 from index 3
Writer 0 wrote 82 at index 12
Writer 1 wrote 38 at index 12
Writer 0 wrote 51 at index 16
Reader 4 read 87 from index 13
Reader 4 read 60 from index 2
Writer 2 wrote 4 at index 10
Reader 2 read 63 from index 14
Reader 5 read 4 from index 10
Reader 1 read 92 from index 19
Reader 2 read 87 from index 13
Reader 3 read 73 from index 7
Reader 3 read 27 from index 3
Reader 0 read 73 from index 7
Reader 4 read 73 from index 7
Array state: 76 84 60 27 40 32 47 73 28 16 4 97 38 87 63 16 51 20 24 92
Reader 5 read 87 from index 13
Writer 2 wrote 31 at index 4
Reader 0 read 87 from index 13
Writer 1 wrote 18 at index 16
Reader 0 read 24 from index 18
Reader 1 read 92 from index 19
Writer 1 wrote 65 at index 16
Reader 2 read 47 from index 6
Writer 0 wrote 7 at index 9
Writer 1 wrote 75 at index 8
Writer 0 wrote 0 at index 4
Writer 1 wrote 7 at index 3
Reader 3 read 65 from index 16
Reader 2 read 24 from index 18
Reader 0 read 7 from index 3
Reader 2 read 87 from index 13
Writer 2 wrote 14 at index 1
Reader 4 read 76 from index 0
Reader 4 read 38 from index 12
Reader 0 read 24 from index 18
Writer 2 wrote 2 at index 7
Reader 0 read 63 from index 14

Reader 0 read 97 from index 11
Reader 3 read 4 from index 10
Writer 1 wrote 11 at index 1
Reader 5 read 11 from index 1
Reader 3 read 47 from index 6
Reader 3 read 7 from index 3
Writer 0 wrote 94 at index 10
Reader 2 read 11 from index 1
Reader 5 read 0 from index 4
Reader 3 read 2 from index 7
Reader 1 read 7 from index 3
Reader 3 read 2 from index 7
Writer 2 wrote 82 at index 14
Reader 0 read 11 from index 1
Reader 2 read 92 from index 19
Reader 2 read 38 from index 12
Writer 0 wrote 63 at index 4
Writer 0 wrote 8 at index 17
Writer 0 wrote 51 at index 3
Writer 2 wrote 97 at index 5
Writer 1 wrote 64 at index 19
Reader 4 read 94 from index 10
Reader 5 read 47 from index 6
Reader 2 read 97 from index 11
Reader 1 read 60 from index 2
Writer 0 wrote 42 at index 7
Reader 1 read 7 from index 9
Array state: 76 11 60 51 63 97 47 42 75 7 94 97 38 87 82 16 65 8 24 64
Reader 3 read 87 from index 13
Reader 0 read 75 from index 8
Writer 2 wrote 34 at index 17
Reader 5 read 34 from index 17
Writer 0 wrote 21 at index 9
Writer 1 wrote 70 at index 7
Reader 4 read 47 from index 6
Reader 2 read 65 from index 16
Reader 5 read 94 from index 10
Reader 5 read 87 from index 13
Writer 1 wrote 7 at index 7
Reader 2 read 16 from index 15
Reader 1 read 87 from index 13
Writer 0 wrote 26 at index 10
Reader 3 read 97 from index 11
Reader 5 read 7 from index 7
Writer 2 wrote 96 at index 1

Reader 0 read 97 from index 11
Writer 1 wrote 70 at index 14
Reader 5 read 47 from index 6
Writer 1 wrote 74 at index 15
Reader 5 read 97 from index 5
Reader 4 read 21 from index 9
Writer 1 wrote 56 at index 15
Reader 1 read 60 from index 2
Reader 4 read 7 from index 7
Writer 0 wrote 26 at index 19
Reader 1 read 26 from index 10
Reader 3 read 75 from index 8
Writer 2 wrote 4 at index 3
Reader 0 read 47 from index 6
Reader 1 read 96 from index 1
Reader 2 read 70 from index 14
Reader 5 read 63 from index 4
Reader 3 read 96 from index 1
Array state: 76 96 60 4 63 97 47 7 75 21 26 97 38 87 70 56 65 34 24 26
Writer 1 wrote 29 at index 6
Writer 0 wrote 76 at index 9
Writer 0 wrote 11 at index 3
Reader 0 read 11 from index 3
Reader 2 read 34 from index 17
Reader 0 read 97 from index 11
Writer 0 wrote 11 at index 10
Reader 5 read 87 from index 13
Reader 2 read 60 from index 2
Reader 0 read 96 from index 1
Reader 1 read 7 from index 7
Reader 4 read 60 from index 2
Reader 4 read 65 from index 16
Writer 2 wrote 75 at index 15
Reader 0 read 75 from index 8
Reader 3 read 38 from index 12
Writer 0 wrote 35 at index 8
Reader 5 read 11 from index 3
Reader 1 read 87 from index 13
Writer 1 wrote 33 at index 8
Reader 2 read 26 from index 19
Writer 1 wrote 87 at index 0
Reader 4 read 97 from index 11
Writer 1 wrote 79 at index 17
Writer 2 wrote 22 at index 19
Reader 0 read 29 from index 6

Reader 3 read 22 from index 19
Reader 3 read 24 from index 18
Writer 1 wrote 68 at index 7
Reader 1 read 60 from index 2
Writer 0 wrote 20 at index 19
Writer 2 wrote 28 at index 11
Writer 1 wrote 0 at index 5
Reader 4 read 79 from index 17
Reader 5 read 33 from index 8
Reader 2 read 20 from index 19
Reader 3 read 33 from index 8
Reader 1 read 79 from index 17
Array state: 87 96 60 11 63 0 29 68 33 76 11 28 38 87 70 75 65 79 24 20
Reader 4 read 38 from index 12
Writer 0 wrote 3 at index 12
Reader 5 read 28 from index 11
Reader 1 read 0 from index 5
Reader 3 read 75 from index 15
Reader 0 read 70 from index 14
Reader 1 read 33 from index 8
Reader 3 read 79 from index 17
Writer 1 wrote 95 at index 0
Writer 2 wrote 92 at index 14
Reader 5 read 75 from index 15
Reader 4 read 20 from index 19
Reader 0 read 96 from index 1
Writer 0 wrote 16 at index 10
Reader 2 read 92 from index 14
Writer 2 wrote 93 at index 18
Reader 3 read 79 from index 17
Writer 0 wrote 85 at index 14
Reader 3 read 96 from index 1
Reader 1 read 29 from index 6
Writer 2 wrote 15 at index 1
Reader 3 read 33 from index 8
Reader 2 read 75 from index 15
Reader 0 read 75 from index 15
Reader 5 read 29 from index 6
Writer 1 wrote 19 at index 3
Reader 4 read 87 from index 13
Reader 3 read 20 from index 19
Writer 0 wrote 49 at index 8
Reader 2 read 19 from index 3
Reader 0 read 75 from index 15
Array state: 95 15 60 19 63 0 29 68 49 76 16 28 3 87 85 75 65 79 93 20

Reader 2 read 19 from index 3
Writer 1 wrote 7 at index 11
Writer 2 wrote 80 at index 19
Reader 1 read 80 from index 19
Reader 1 read 19 from index 3
Reader 4 read 95 from index 0
Reader 5 read 65 from index 16
Writer 0 wrote 71 at index 16
Reader 0 read 3 from index 12
Writer 1 wrote 43 at index 5
Reader 3 read 43 from index 5
Reader 2 read 60 from index 2
Reader 2 read 7 from index 11
Reader 4 read 80 from index 19
Writer 2 wrote 82 at index 3
Reader 3 read 63 from index 4
Reader 5 read 87 from index 13
Reader 5 read 3 from index 12
Reader 3 read 85 from index 14
Writer 0 wrote 24 at index 14
Reader 4 read 3 from index 12
Reader 2 read 7 from index 11
Reader 1 read 87 from index 13
Reader 0 read 49 from index 8
Writer 2 wrote 45 at index 17
Writer 1 wrote 46 at index 11
Writer 0 wrote 85 at index 0
Writer 0 wrote 67 at index 4
Reader 1 read 49 from index 8
Writer 1 wrote 91 at index 13
Reader 0 read 68 from index 7
Time is up. Terminating program.
mint@asus-mint:~/git/op-course/lab7/task3\$