

Basic performance analysis

Binary search

```
cd ./generator, \
echo "10000 1000 0.5" | cargo run > ../inp_low; \
echo "1000000 100000 0.5" | cargo run > ../inp_mid; \
echo "10000000 1000000 0.5" | cargo run > ../inp_hi; \
```

MINGW64:/d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$ ..\common\compare_performance.sh
Averaging performance of 10 runs...
./main_cpp:
  test inp_low: runtime 0.17671 sec, core 0.00040 sec
  test inp_mid: runtime 0.93241 sec, core 0.01466 sec
  test inp_hi: runtime 8.65214 sec, core 0.37673 sec

./main_rust:
  test inp_low: runtime 0.03502 sec, core 0.00017 sec
  test inp_mid: runtime 0.12013 sec, core 0.02494 sec
  test inp_hi: runtime 1.30274 sec, core 0.66416 sec
```

DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
\$ |

```
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "100 10 0.5" | cargo run > ../inp_low
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s
    Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "100000 10000 0.5" | cargo run > ../inp_mid
  Finished dev [unoptimized + debuginfo] target(s) in 0.03s
    Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "10000000 1000000 0.5" | cargo run > ../inp_hi
  Finished dev [unoptimized + debuginfo] target(s) in 0.03s
    Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> cd ..
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$ ./common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.09879 sec, core 0.00000 sec
  test inp_mid: runtime 0.19679 sec, core 0.00139 sec
  test inp_hi: runtime 9.29229 sec, core 0.40703 sec

./main_rust:
  test inp_low: runtime 0.03241 sec, core 0.00000 sec
  test inp_mid: runtime 0.03070 sec, core 0.00259 sec
  test inp_hi: runtime 1.78433 sec, core 0.89658 sec

DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$ PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search> cd .\generator\
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "500 50 0.5"      | cargo run > ../inp_low
  Finished dev [unoptimized + debuginfo] target(s) in 0.04s
    Running `target\debug\generator.exe`
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "500000 50000 0.5"    | cargo run > ../inp_mid
  Finished dev [unoptimized + debuginfo] target(s) in 0.04s
    Running `target\debug\generator.exe`
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "50000000 5000000 0.5"   | cargo run > ../inp_hi
  Finished dev [unoptimized + debuginfo] target(s) in 0.02s
    Running `target\debug\generator.exe`

DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$ ./common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.03486 sec, core 0.00010 sec
  test inp_mid: runtime 0.66117 sec, core 0.00806 sec
  test inp_hi: runtime 51.94723 sec, core 2.77775 sec

./main_rust:
  test inp_low: runtime 0.25771 sec, core 0.00000 sec
  test inp_mid: runtime 0.08867 sec, core 0.00876 sec
  test inp_hi: runtime 9.29431 sec, core 5.19443 sec

DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$ |
```

Merge Sort

```
MINGW64:/d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
$ ./common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.05564 sec, core 0.00370 sec
  test inp_mid: runtime 1.02332 sec, core 0.20230 sec
  test inp_hi: runtime 9.73628 sec, core 2.25293 sec

./main_rust:
  test inp_low: runtime 0.03692 sec, core 0.00387 sec
  test inp_mid: runtime 0.30885 sec, core 0.21809 sec
  test inp_hi: runtime 2.77279 sec, core 2.20561 sec
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
$ |
```

```
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort> cd ..\generator\
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 100    | cargo run > ../inp_low
  Finished dev [unoptimized + debuginfo] target(s) in 2.08s
      Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 3000000    | cargo run > ../inp_mid
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s
      Running `target\debug\generator.exe`
④ PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 10000000 | cargo run > ../inp_hi\
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s
      Running `target\debug\generator.exe`
: The term '\` is not recognized as a name of a cmdlet, function, script file, or executable program.
Check the spelling of the name, or if a path was included, verify that the path is correct and try again.
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 30000000 | cargo run > ../inp_hi
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s
      Running `target\debug\generator.exe`
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
$ ./common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.03641 sec, core 0.00010 sec
  test inp_mid: runtime 2.66057 sec, core 0.64745 sec
  test inp_hi: runtime 26.87381 sec, core 7.19119 sec

./main_rust:
  test inp_low: runtime 0.10522 sec, core 0.00002 sec
  test inp_mid: runtime 0.80033 sec, core 0.62884 sec
  test inp_hi: runtime 8.69833 sec, core 7.06314 sec
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
$ |
```

```
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort> cd ..\generator\  
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 1000 | cargo run > ../inp_low  
  Finished dev [unoptimized + debuginfo] target(s) in 0.04s  
    Running `target\debug\generator.exe`  
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 6000000 | cargo run > ../inp_mid  
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s  
    Running `target\debug\generator.exe`  
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 60000000 | cargo run > ../inp_hi  
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s  
    Running `target\debug\generator.exe`  
PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator>  
  
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort  
$ ./common/compare_performance.sh  
Averaging performance of 10 runs..  
.main_cpp:  
  test inp_low: runtime 0.07458 sec, core 0.00041 sec  
  test inp_mid: runtime 5.29366 sec, core 1.28019 sec  
  test inp_hi: runtime 90.58684 sec, core 15.80502 sec  
  
.main_rust:  
  test inp_low: runtime 0.53825 sec, core 0.00017 sec  
  test inp_mid: runtime 1.61679 sec, core 1.25265 sec  
  test inp_hi: runtime 17.09453 sec, core 14.01823 sec  
  
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort  
$
```

QUICKSORT

No. of threads =12

Data size 100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000630388 seconds
Parallel execution time: 0.010689 seconds
Speedup: 0.0589754
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.035] ms
[sort parallel]:          [0.024] ms
++++                  (1.46x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size =1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.00125862 seconds
Parallel execution time: 0.0468141 seconds
Speedup: 0.0268856
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.351] ms
[sort parallel]:          [0.369] ms
++++                  (0.95x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

th=12 Data size =10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.219147 seconds
Parallel execution time: 0.37155 seconds
Speedup: 0.589818
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
        Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0
[sort rust serial]:      [3.509] ms
[sort parallel]:          [2.057] ms
++++                  (1.71x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size =100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 28.957 seconds
Parallel execution time: 8.21565 seconds
Speedup: 3.52462
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 1.09s
        Running `target\debug\rust.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0
[sort rust serial]:      [40.31] ms
[sort parallel]:          [14.153] ms
++++                  (2.85x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

No. of threads = 8

Data size =100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 4.3363e-05 seconds
Parallel execution time: 0.000683119 seconds
Speedup: 0.063478
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Compiling rust v0.1.0 (C:\Users\deept\Desktop\quicksort\rust)
      Finished dev [unoptimized + debuginfo] target(s) in 1.62s
        Running `target\debug\rust.exe`

Configuration:
num_elements: 100, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.069] ms
[sort parallel]:          [0.025] ms
++++                  (2.76x speedup from 8 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size =1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000572228 seconds
Parallel execution time: 0.00230012 seconds
Speedup: 0.248782
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
        Running `target\debug\rust.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.389] ms
[sort parallel]:          [0.334] ms
++++                  (1.16x speedup from 8 threads)
```

th=8 Data size =10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.0962031 seconds
Parallel execution time: 0.0486788 seconds
Speedup: 1.97629
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [4.074] ms
[sort parallel]:          [1.937] ms
++++                  (2.10x speedup from 8 threads)

PS C:\Users\deept\Desktop\quicksort\rust> cargo run
```

Data size =100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 29.725 seconds
Parallel execution time: 7.83191 seconds
Speedup: 3.79537
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [46.637] ms
[sort parallel]:          [18.904] ms
++++                  (2.47x speedup from 8 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

No. of threads = 4

Data size 100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 6.9205e-05 seconds
Parallel execution time: 0.000800861 seconds
Speedup: 0.0864132
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.047] ms
[sort parallel]:          [0.029] ms
++++                  (1.62x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size 1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000967046 seconds
Parallel execution time: 0.0100446 seconds
Speedup: 0.0962749
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```



```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.429] ms
[sort parallel]:          [0.341] ms
++++                  (1.26x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

th=4 Data size 10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.224818 seconds
Parallel execution time: 0.0711804 seconds
Speedup: 3.15842
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [3.228] ms
[sort parallel]:          [2.417] ms
++++                  (1.34x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

Data size 100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 29.7136 seconds
Parallel execution time: 6.04085 seconds
Speedup: 4.91878
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [44.303] ms
[sort parallel]:          [18.51] ms
++++                  (2.39x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

No. of threads = 2

Data size 100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 6.838e-05 seconds
Parallel execution time: 0.000543729 seconds
Speedup: 0.125761
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.042] ms
[sort parallel]:          [0.025] ms
++++                  (1.68x speedup from 2 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size 1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000988244 seconds
Parallel execution time: 0.00316973 seconds
Speedup: 0.311775
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.438] ms
[sort parallel]:          [0.355] ms
++++                  (1.23x speedup from 2 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

Th = 2 Data size 10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.23298 seconds
Parallel execution time: 0.0783256 seconds
Speedup: 2.9745
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort rust serial]:      [3.611] ms
[sort parallel]:          [2.78] ms
++++                  (1.30x speedup from 2 threads)
```

Data size 100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 30.9935 seconds
Parallel execution time: 7.72338 seconds
Speedup: 4.01294
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Compiling rust v0.1.0 (C:\Users\deept\Desktop\quicksort\rust)
    Finished dev [unoptimized + debuginfo] target(s) in 1.64s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort rust serial]:      [48.667] ms
[sort parallel]:          [36.344] ms
++++                  (1.34x speedup from 2 threads)
```

MATRIX MULTIPLICATION RESULTS:

12 threads, 16 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 8.1e-05 seconds.
Parallel execution time: 0.00445274 seconds.
Speedup: 0.0181911
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0003911 seconds.
Parallel execution time: 0.0029192 seconds.
Speedup: 0.13397506166072898
PS C:\Users\deept\Desktop\matmul_rust> |
```

12 threads, 32 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.003682 seconds.
Parallel execution time: 0.00491974 seconds.
Speedup: 0.748414
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.17s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0031391 seconds.
Parallel execution time: 0.0028358 seconds.
Speedup: 1.1069539459764441
```

12 threads, 64 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.035867 seconds.
Parallel execution time: 0.0220278 seconds.
Speedup: 1.62826
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.06s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0280424 seconds.
Parallel execution time: 0.0067919 seconds.
Speedup: 4.1288004829281935
PS C:\Users\deept\Desktop\matmul_rust> |
```

12 threads, 128 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.382459 seconds.
Parallel execution time: 0.108847 seconds.
Speedup: 3.51372
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.222809 seconds.
Parallel execution time: 0.0456788 seconds.
Speedup: 4.877733215408461
PS C:\Users\deept\Desktop\matmul_rust> |
```

12 threads, 256 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 1.82582 seconds.
Parallel execution time: 0.356328 seconds.
Speedup: 5.124
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.06s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 1.8259158 seconds.
Parallel execution time: 0.2380793 seconds.
Speedup: 7.669359746941461
PS C:\Users\deept\Desktop\matmul_rust> |
```

12 threads, 512 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 15.6312 seconds.
Parallel execution time: 2.65851 seconds.
Speedup: 5.87968
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 15.0239844 seconds.
Parallel execution time: 1.4314876 seconds.
Speedup: 10.495364682166999
PS C:\Users\deept\Desktop\matmul_rust>
```

12 threads, 1024 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 124.391 seconds.
Parallel execution time: 22.6706 seconds.
Speedup: 5.48691
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```



```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 122.9293364 seconds.
Parallel execution time: 12.5387495 seconds.
Speedup: 9.80395504352328
PS C:\Users\deept\Desktop\matmul_rust> |
```

8 threads, 16 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 8.1e-05 seconds.
Parallel execution time: 0.00199841 seconds.
Speedup: 0.0405322
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0004109 seconds.
Parallel execution time: 0.0016239 seconds.
Speedup: 0.2530328222181169
PS C:\Users\deept\Desktop\matmul_rust>
```

8 threads, 32 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.004658 seconds.
Parallel execution time: 0.00656732 seconds.
Speedup: 0.70927
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.06s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0041423 seconds.
Parallel execution time: 0.0020848 seconds.
Speedup: 1.9869052187260168
PS C:\Users\deept\Desktop\matmul_rust>
```

8 threads, 64 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.041965 seconds.
Parallel execution time: 0.0216636 seconds.
Speedup: 1.93712
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0348912 seconds.
Parallel execution time: 0.0052821 seconds.
Speedup: 6.605554608962344
PS C:\Users\deept\Desktop\matmul_rust> |
```

8 threads, 128 data size

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.2419166 seconds.
Parallel execution time: 0.0468069 seconds.
Speedup: 5.1683961125389635
PS C:\Users\deept\Desktop\matmul_rust> |
```

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.254586 seconds.
Parallel execution time: 0.0535394 seconds.
Speedup: 4.75511
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```

8 threads, 256 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 2.02053 seconds.
Parallel execution time: 0.456634 seconds.
Speedup: 4.42483
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 1.8544451 seconds.
Parallel execution time: 0.2391707 seconds.
Speedup: 7.75364666324094
PS C:\Users\deept\Desktop\matmul_rust> |
```

8 threads, 512 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 15.671 seconds.
Parallel execution time: 2.80953 seconds.
Speedup: 5.57782
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.04s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 15.1080247 seconds.
Parallel execution time: 1.7907864999999998 seconds.
Speedup: 8.436530373665427
PS C:\Users\deept\Desktop\matmul_rust> |
```

8 threads, 1024 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 160.788 seconds.
Parallel execution time: 30.0977 seconds.
Speedup: 5.34221
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 152.2318764 seconds.
Parallel execution time: 22.2702012 seconds.
Speedup: 6.8356758447247445
PS C:\Users\deept\Desktop\matmul_rust> |
```

4 threads, 16 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 8.1e-05 seconds.
Parallel execution time: 0.00213906 seconds.
Speedup: 0.0378672
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0005656 seconds.
Parallel execution time: 0.0027867 seconds.
Speedup: 0.20296407937704095
PS C:\Users\deept\Desktop\matmul_rust> |
```

4 threads, 32 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.003516 seconds.
Parallel execution time: 0.00309325 seconds.
Speedup: 1.13667
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.04s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0036483 seconds.
Parallel execution time: 0.001742 seconds.
Speedup: 2.094316877152698
PS C:\Users\deept\Desktop\matmul_rust>
```

4 threads, 64 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.036392 seconds.
Parallel execution time: 0.0101711 seconds.
Speedup: 3.578
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0271798 seconds.
Parallel execution time: 0.0066022 seconds.
Speedup: 4.116779255399716
PS C:\Users\deept\Desktop\matmul_rust>
```

4 threads, 128 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.214041 seconds.
Parallel execution time: 0.0740821 seconds.
Speedup: 2.88924
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.2306754 seconds.
Parallel execution time: 0.0497609 seconds.
Speedup: 4.635675801683652
PS C:\Users\deept\Desktop\matmul_rust>
```

4 threads, 256 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 1.91951 seconds.
Parallel execution time: 0.664444 seconds.
Speedup: 2.8889
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.04s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 1.8177458 seconds.
Parallel execution time: 0.4063939 seconds.
Speedup: 4.4728668417513155
PS C:\Users\deept\Desktop\matmul_rust> |
```

4 threads, 512 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 14.2698 seconds.
Parallel execution time: 4.15823 seconds.
Speedup: 3.43169
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.04s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 19.3991665 seconds.
Parallel execution time: 3.4339934 seconds.
Speedup: 5.6491566058338964
PS C:\Users\deept\Desktop\matmul_rust>
```

4 threads, 1024 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 123.985 seconds.
Parallel execution time: 39.8417 seconds.
Speedup: 3.11193
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.04s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 120.7661157 seconds.
Parallel execution time: 29.9517813 seconds.
Speedup: 4.032017811908903
PS C:\Users\deept\Desktop\matmul_rust>
```

2 threads, 16 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 8.1e-05 seconds.
Parallel execution time: 0.000663541 seconds.
Speedup: 0.122072
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ |
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0003946 seconds.
Parallel execution time: 0.0009746 seconds.
Speedup: 0.40488405499692176
PS C:\Users\deept\Desktop\matmul_rust> |
```

2 threads, 32 data size

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0038188 seconds.
Parallel execution time: 0.0021121 seconds.
Speedup: 1.808058330571469
PS C:\Users\deept\Desktop\matmul_rust>
```

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.004182 seconds.
Parallel execution time: 0.0022817 seconds.
Speedup: 1.83285
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

2 threads, 64 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.032615 seconds.
Parallel execution time: 0.0208075 seconds.
Speedup: 1.56746
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.0253578 seconds.
Parallel execution time: 0.0123672 seconds.
Speedup: 2.050407529594411
PS C:\Users\deept\Desktop\matmul_rust>
```

2 threads, 128 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 0.242263 seconds.
Parallel execution time: 0.126868 seconds.
Speedup: 1.90956
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 0.2106853 seconds.
Parallel execution time: 0.0972466 seconds.
Speedup: 2.166505564204815
PS C:\Users\deept\Desktop\matmul_rust>
```

2 threads, 256 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 1.94043 seconds.
Parallel execution time: 1.15263 seconds.
Speedup: 1.68348
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 1.862886 seconds.
Parallel execution time: 0.7535196 seconds.
Speedup: 2.47224624283164
PS C:\Users\deept\Desktop\matmul_rust>
```

2 threads, 512 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 15.5872 seconds.
Parallel execution time: 9.32583 seconds.
Speedup: 1.6714
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 14.9361866 seconds.
Parallel execution time: 6.1232643 seconds.
Speedup: 2.4392523118755465
PS C:\Users\deept\Desktop\matmul_rust> |
```

2 threads, 1024 data size

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$ ./a.out
Serial execution time: 131.905 seconds.
Parallel execution time: 73.4204 seconds.
Speedup: 1.79657
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/matrixmultiply_cpp/sample$
```

```
PS C:\Users\deept\Desktop\matmul_rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.05s
        Running `target\debug\matmul_rust.exe`
Serial execution time: 123.1039377 seconds.
Parallel execution time: 54.9460872 seconds.
Speedup: 2.240449574724222
PS C:\Users\deept\Desktop\matmul_rust> |
```

QUICKSORT RESULTS

No. of threads =12

Data size 100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000630388 seconds
Parallel execution time: 0.010689 seconds
Speedup: 0.0589754
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```



```
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.035] ms
[sort parallel]:          [0.024] ms
++++                  (1.46x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size =1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.00125862 seconds
Parallel execution time: 0.0468141 seconds
Speedup: 0.0268856
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```



```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.351] ms
[sort parallel]:          [0.369] ms
++++                  (0.95x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

Data size =10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.219147 seconds
Parallel execution time: 0.37155 seconds
Speedup: 0.589818
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
        Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0

[sort rust serial]:      [3.509] ms
[sort parallel]:          [2.057] ms
++++                  (1.71x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size =100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 28.957 seconds
Parallel execution time: 8.21565 seconds
Speedup: 3.52462
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 1.03s
        Running `target\debug\rust.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 12, num_of_runs: 1, code_config: 0

[sort rust serial]:      [40.31] ms
[sort parallel]:          [14.153] ms
++++                  (2.85x speedup from 12 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

No. of threads = 8

Data size =100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 4.3363e-05 seconds
Parallel execution time: 0.000683119 seconds
Speedup: 0.063478
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Compiling rust v0.1.0 (C:\Users\deept\Desktop\quicksort\rust)
      Finished dev [unoptimized + debuginfo] target(s) in 1.62s
        Running `target\debug\rust.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.069] ms
[sort parallel]:          [0.025] ms
++++                  (2.76x speedup from 8 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size =1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000572228 seconds
Parallel execution time: 0.00230012 seconds
Speedup: 0.248782
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
        Running `target\debug\rust.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.389] ms
[sort parallel]:          [0.334] ms
++++                  (1.16x speedup from 8 threads)
```

Data size =10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.0962031 seconds
Parallel execution time: 0.0486788 seconds
Speedup: 1.97629
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [4.074] ms
[sort parallel]:          [1.937] ms
++++                  (2.10x speedup from 8 threads)

PS C:\Users\deept\Desktop\quicksort\rust> cargo run
```

Data size =100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 29.725 seconds
Parallel execution time: 7.83191 seconds
Speedup: 3.79537
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 8, num_of_runs: 1, code_config: 0

[sort rust serial]:      [46.637] ms
[sort parallel]:          [18.904] ms
++++                  (2.47x speedup from 8 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

No. of threads = 4

Data size 100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 6.9205e-05 seconds
Parallel execution time: 0.000800861 seconds
Speedup: 0.0864132
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.047] ms
[sort parallel]:          [0.029] ms
++++                  (1.62x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size 1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000967046 seconds
Parallel execution time: 0.0100446 seconds
Speedup: 0.0962749
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```



```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.429] ms
[sort parallel]:          [0.341] ms
++++                  (1.26x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size 10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.224818 seconds
Parallel execution time: 0.0711804 seconds
Speedup: 3.15842
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [3.228] ms
[sort parallel]:          [2.417] ms
++++                  (1.34x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

Data size 100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 29.7136 seconds
Parallel execution time: 6.04085 seconds
Speedup: 4.91878
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.09s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort rust serial]:      [44.303] ms
[sort parallel]:          [18.51] ms
++++                  (2.39x speedup from 4 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

No. of threads = 2

Data size 100

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 6.838e-05 seconds
Parallel execution time: 0.000543729 seconds
Speedup: 0.125761
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.042] ms
[sort parallel]:          [0.025] ms
++++                  (1.68x speedup from 2 threads)

PS C:\Users\deept\Desktop\quicksort\rust>
```

Data size 1000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.000988244 seconds
Parallel execution time: 0.00316973 seconds
Speedup: 0.311775
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort rust serial]:      [0.438] ms
[sort parallel]:          [0.355] ms
++++                  (1.23x speedup from 2 threads)

PS C:\Users\deept\Desktop\quicksort\rust> |
```

Data size 10000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 0.23298 seconds
Parallel execution time: 0.0783256 seconds
Speedup: 2.9745
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$
```

```
PS C:\Users\deept\Desktop\quicksort\rust> cargo run
>>
    Finished dev [unoptimized + debuginfo] target(s) in 0.10s
      Running `target\debug\rust.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort rust serial]:      [3.611] ms
[sort parallel]:          [2.78] ms
++++                  (1.30x speedup from 2 threads)
```

Data size 100000

```
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ ./a.out
Serial execution time: 30.9935 seconds
Parallel execution time: 7.72338 seconds
Speedup: 4.01294
deeptanshu@DESKTOP-BBS6LAK:/mnt/c/Users/deept/Desktop/quicksort/C++$ |
```

Quick Sort

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.40s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 100, sort_order: 0, num_threads: 1, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]:      [0.053] ms
[sort-unstable-rust serial]:     [0.071] ms
[sort-stable par]:              [0.118] ms
++++                  (0.45x speedup from 1 threads)

[sort-unstable par]:            [0.11] ms
++++                  (0.65x speedup from 1 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> |
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.46s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 100, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.035] ms
[sort-unstable-rust serial]:    [0.046] ms
[sort-stable par]:             [0.067] ms
++++                  (0.52x speedup from 2 threads)

[sort-unstable par]:           [0.03] ms
++++                  (1.53x speedup from 2 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.53s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 100, sort_order: 0, num_threads: 3, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.053] ms
[sort-unstable-rust serial]:    [0.119] ms
[sort-stable par]:              [0.118] ms
++++                  (0.45x speedup from 3 threads)

[sort-unstable par]:            [0.075] ms
++++                  (1.59x speedup from 3 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

In 86.0s

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.57s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 100, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.025] ms
[sort-unstable-rust serial]:    [0.028] ms
[sort-stable par]:              [0.034] ms
++++                  (0.74x speedup from 4 threads)

[sort-unstable par]:            [0.027] ms
++++                  (1.04x speedup from 4 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.31s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 100, sort_order: 0, num_threads: 5, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.065] ms
[sort-unstable-rust serial]:    [0.067] ms
[sort-stable par]:              [0.087] ms
++++                  (0.75x speedup from 5 threads)

[sort-unstable par]:            [0.033] ms
++++                  (2.03x speedup from 5 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.52s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 100, sort_order: 0, num_threads: 6, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.07] ms
[sort-unstable-rust serial]:    [0.071] ms
[sort-stable par]:             [0.138] ms
++++                         (0.51x speedup from 6 threads)

[sort-unstable par]:           [0.035] ms
++++                         (2.03x speedup from 6 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

Ln 86, □

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.51s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 1000, sort_order: 0, num_threads: 1, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.232] ms
[sort-unstable-rust serial]:    [0.256] ms
[sort-stable par]:              [0.336] ms
++++                         (0.69x speedup from 1 threads)

[sort-unstable par]:           [0.274] ms
++++                         (0.93x speedup from 1 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.62s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 1000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.232] ms
[sort-unstable-rust serial]:    [0.237] ms
[sort-stable par]:              [0.374] ms
++++                         (0.62x speedup from 2 threads)

[sort-unstable par]:           [0.256] ms
++++                         (0.93x speedup from 2 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.45s
      Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 1000, sort_order: 0, num_threads: 3, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]:      [0.401] ms
[sort-unstable-rust serial]:    [0.396] ms
[sort-stable par]:              [0.959] ms
++++                         (0.42x speedup from 3 threads)

[sort-unstable par]:           [0.516] ms
++++                         (0.77x speedup from 3 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.56s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [0.396] ms
[sort-unstable-rust serial]: [0.478] ms
[sort-stable par]: [0.617] ms
++++ (0.64x speedup from 4 threads)

[sort-unstable par]: [0.537] ms
++++ (0.89x speedup from 4 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.32s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 5, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [0.718] ms
[sort-unstable-rust serial]: [0.644] ms
[sort-stable par]: [0.808] ms
++++ (0.89x speedup from 5 threads)

[sort-unstable par]: [1.471] ms
++++ (0.44x speedup from 5 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.26s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 6, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [0.47] ms
[sort-unstable-rust serial]: [0.302] ms
[sort-stable par]: [0.351] ms
++++ (1.34x speedup from 6 threads)

[sort-unstable par]: [0.424] ms
++++ (0.71x speedup from 6 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.42s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 10000, sort_order: 0, num_threads: 1, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [3.668] ms
[sort-unstable-rust serial]: [3.042] ms
[sort-stable par]: [16.187] ms
++++ (0.23x speedup from 1 threads)

[sort-unstable par]: [12.337] ms
++++ (0.25x speedup from 1 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.50s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [4.979] ms
[sort-unstable-rust serial]: [2.187] ms
[sort-stable par]: [4.31] ms
++++ (1.16x speedup from 2 threads)

[sort-unstable par]: [2.913] ms
++++ (0.75x speedup from 2 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

Ln

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.53s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 3, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [4.264] ms
[sort-unstable-rust serial]: [4.537] ms
[sort-stable par]: [3.863] ms
++++ (1.10x speedup from 3 threads)

[sort-unstable par]: [4.155] ms
++++ (1.09x speedup from 3 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.40s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [4.717] ms
[sort-unstable-rust serial]: [3.834] ms
[sort-stable par]: [3.833] ms
++++ (1.23x speedup from 4 threads)

[sort-unstable par]: [4.048] ms
++++ (0.95x speedup from 4 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 9.40s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 5, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [4.639] ms
[sort-unstable-rust serial]: [4.022] ms
[sort-stable par]: [3.615] ms
++++ (1.28x speedup from 5 threads)

[sort-unstable par]: [3.0] ms
++++ (1.34x speedup from 5 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.60s
      Running `target\debug\quick_sort.exe`  
Configuration:  
num_elements: 10000, sort_order: 0, num_threads: 6, num_of_runs: 1, code_config: 0  
[sort-stable-rust serial]: [4.139] ms  
[sort-unstable-rust serial]: [3.88] ms  
[sort-stable par]: [3.221] ms  
++++ (1.29x speedup from 6 threads)  
[sort-unstable par]: [3.166] ms  
++++ (1.23x speedup from 6 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.53s
      Running `target\debug\quick_sort.exe`  
Configuration:  
num_elements: 10000, sort_order: 0, num_threads: 1, num_of_runs: 1, code_config: 0  
[sort-stable-rust serial]: [51.523] ms  
[sort-unstable-rust serial]: [29.637] ms  
[sort-stable par]: [48.696] ms  
++++ (1.06x speedup from 1 threads)  
[sort-unstable par]: [41.25] ms  
++++ (0.72x speedup from 1 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.46s
      Running `target\debug\quick_sort.exe`  
Configuration:  
num_elements: 10000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0  
[sort-stable-rust serial]: [46.98] ms  
[sort-unstable-rust serial]: [41.024] ms  
[sort-stable par]: [26.929] ms  
++++ (1.74x speedup from 2 threads)  
[sort-unstable par]: [19.321] ms  
++++ (2.12x speedup from 2 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.59s
      Running `target\debug\quick_sort.exe`  
Configuration:  
num_elements: 10000, sort_order: 0, num_threads: 3, num_of_runs: 1, code_config: 0  
[sort-stable-rust serial]: [46.176] ms  
[sort-unstable-rust serial]: [38.189] ms  
[sort-stable par]: [11.599] ms  
++++ (3.98x speedup from 3 threads)  
[sort-unstable par]: [15.236] ms  
++++ (2.51x speedup from 3 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.64s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [43.945] ms
[sort-unstable-rust serial]: [37.285] ms
[sort-stable par]: [23.373] ms
++++ (1.88x speedup from 4 threads)

[sort-unstable par]: [14.439] ms
++++ (2.58x speedup from 4 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

Ln 86

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.56s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 5, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [36.0] ms
[sort-unstable-rust serial]: [29.548] ms
[sort-stable par]: [14.139] ms
++++ (2.55x speedup from 5 threads)

[sort-unstable par]: [20.155] ms
++++ (1.47x speedup from 5 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

Ln 87

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 4.02s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 100000, sort_order: 0, num_threads: 6, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [31.585] ms
[sort-unstable-rust serial]: [44.219] ms
[sort-stable par]: [15.552] ms
++++ (2.03x speedup from 6 threads)

[sort-unstable par]: [15.476] ms
++++ (2.86x speedup from 6 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

Ln 88

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.66s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 1000000, sort_order: 0, num_threads: 1, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [238.092] ms
[sort-unstable-rust serial]: [215.052] ms
[sort-stable par]: [361.561] ms
++++ (0.66x speedup from 1 threads)

[sort-unstable par]: [366.599] ms
++++ (0.59x speedup from 1 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.48s
      Running `target\debug\quick_sort.exe`

Configuration:
```

```
num_elements: 1000000, sort_order: 0, num_threads: 2, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]: [239.295] ms
[sort-unstable-rust serial]: [210.037] ms
[sort-stable par]: [196.589] ms
++++ (1.22x speedup from 2 threads)
```

```
[sort-unstable par]: [243.758] ms
++++ (0.86x speedup from 2 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.54s
      Running `target\debug\quick_sort.exe`

Configuration:
```

```
num_elements: 1000000, sort_order: 0, num_threads: 3, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]: [231.287] ms
[sort-unstable-rust serial]: [228.055] ms
[sort-stable par]: [127.52] ms
++++ (1.81x speedup from 3 threads)
```

```
[sort-unstable par]: [169.371] ms
++++ (1.35x speedup from 3 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.54s
      Running `target\debug\quick_sort.exe`

Configuration:
```

```
num_elements: 1000000, sort_order: 0, num_threads: 4, num_of_runs: 1, code_config: 0
```

```
[sort-stable-rust serial]: [234.913] ms
[sort-unstable-rust serial]: [244.727] ms
[sort-stable par]: [111.75] ms
++++ (2.10x speedup from 4 threads)
```

```
[sort-unstable par]: [115.833] ms
++++ (2.11x speedup from 4 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.59s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 1000000, sort_order: 0, num_threads: 5, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [259.711] ms
[sort-unstable-rust serial]: [205.858] ms
[sort-stable par]: [93.459] ms
++++ (2.78x speedup from 5 threads)

[sort-unstable par]: [104.847] ms
++++ (1.96x speedup from 5 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.41s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 1000000, sort_order: 0, num_threads: 6, num_of_runs: 1, code_config: 0

[sort-stable-rust serial]: [237.432] ms
[sort-unstable-rust serial]: [276.803] ms
[sort-stable par]: [95.962] ms
++++ (2.47x speedup from 6 threads)

[sort-unstable par]: [95.273] ms
++++ (2.91x speedup from 6 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

||||||||||||||||||||||||||||||||||||||||||||

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Finished dev [unoptimized + debuginfo] target(s) in 0.05s
      Running `target\debug\quick_sort.exe`
Configuration:
num_elements: 1000, sort_order: 0, num_threads: 8, num_of_runs: 3, code_config: 0

[sort-stable-rust serial]: [0.143] ms
[sort-unstable-rust serial]: [0.135] ms
[sort-stable par]: [0.179] ms
++++ (0.80x speedup from 8 threads)

[sort-unstable par]: [0.151] ms
++++ (0.89x speedup from 8 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 25.46s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 8, num_of_runs: 5, code_config: 0

[sort-stable-rust serial]: [0.305] ms
[sort-unstable-rust serial]: [0.277] ms
[sort-stable par]: [0.353] ms
++++ (0.86x speedup from 8 threads)

[sort-unstable par]: [0.359] ms
++++ (0.77x speedup from 8 threads)
```

```
PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 8.86s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 5, num_of_runs: 3, code_config: 0

[sort-stable-rust serial]: [0.301] ms
[sort-unstable-rust serial]: [0.305] ms
[sort-stable par]: [0.411] ms
++++ (0.73x speedup from 5 threads)

[sort-unstable par]: [0.385] ms
++++ (0.79x speedup from 5 threads)
```

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █

```
PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.53s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 6, num_of_runs: 3, code_config: 0

[sort-stable-rust serial]: [0.137] ms
[sort-unstable-rust serial]: [0.137] ms
[sort-stable par]: [0.281] ms
++++ (0.49x speedup from 6 threads)

[sort-unstable par]: [0.249] ms
++++ (0.55x speedup from 6 threads)
```

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █

```
PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.60s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 1000, sort_order: 0, num_threads: 10, num_of_runs: 3, code_config: 0

[sort-stable-rust serial]: [0.123] ms
[sort-unstable-rust serial]: [0.157] ms
[sort-stable par]: [0.196] ms
++++ (0.63x speedup from 10 threads)

[sort-unstable par]: [0.145] ms
++++ (1.08x speedup from 10 threads)
```

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.67s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 10000, sort_order: 0, num_threads: 5, num_of_runs: 3, code_config: 0
```

```
[sort-stable-rust serial]: [2.824] ms
[sort-unstable-rust serial]: [3.204] ms
[sort-stable par]: [2.496] ms
++++ (1.13x speedup from 5 threads)

[sort-unstable par]: [2.051] ms
++++ (1.56x speedup from 5 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 1.40s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 10000, sort_order: 0, num_threads: 7, num_of_runs: 3, code_config: 0
```

```
[sort-stable-rust serial]: [3.852] ms
[sort-unstable-rust serial]: [2.558] ms
[sort-stable par]: [1.41] ms
++++ (2.73x speedup from 7 threads)

[sort-unstable par]: [1.431] ms
++++ (1.79x speedup from 7 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Finished dev [unoptimized + debuginfo] target(s) in 0.06s
      Running `target\debug\quick_sort.exe`
```

```
Configuration:
num_elements: 10000, sort_order: 0, num_threads: 7, num_of_runs: 3, code_config: 0
```

```
[sort-stable-rust serial]: [2.834] ms
[sort-unstable-rust serial]: [2.405] ms
[sort-stable par]: [2.205] ms
++++ (1.29x speedup from 7 threads)

[sort-unstable par]: [1.827] ms
++++ (1.32x speedup from 7 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Finished dev [unoptimized + debuginfo] target(s) in 0.06s
    Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 10000, sort_order: 0, num_threads: 7, num_of_runs: 3, code_config: 0
```

```
[sort-stable-rust serial]:      [2.298] ms
[sort-unstable-rust serial]:    [2.723] ms
[sort-stable par]:              [1.958] ms
++++                         (1.17x speedup from 7 threads)
```

```
[sort-unstable par]:           [2.475] ms
++++                         (1.10x speedup from 7 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
  Finished dev [unoptimized + debuginfo] target(s) in 1.83s
    Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 10000, sort_order: 0, num_threads: 9, num_of_runs: 3, code_config: 0
```

```
[sort-stable-rust serial]:      [3.776] ms
[sort-unstable-rust serial]:    [3.294] ms
[sort-stable par]:              [1.273] ms
++++                         (2.97x speedup from 9 threads)
```

```
[sort-unstable par]:           [1.241] ms
++++                         (2.65x speedup from 9 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
  Finished dev [unoptimized + debuginfo] target(s) in 1.79s
    Running `target\debug\quick_sort.exe`
```

Configuration:

```
num_elements: 10000, sort_order: 0, num_threads: 11, num_of_runs: 3, code_config: 0
```

```
[sort-stable-rust serial]:      [1.849] ms
[sort-unstable-rust serial]:    [2.232] ms
[sort-stable par]:              [1.845] ms
++++                         (1.00x speedup from 11 threads)
```

```
[sort-unstable par]:           [2.216] ms
++++                         (1.01x speedup from 11 threads)
```

```
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> █
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort> cargo run
  Compiling quick_sort v0.1.0 (D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort)
    Finished dev [unoptimized + debuginfo] target(s) in 2.22s
      Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 100000, sort_order: 0, num_threads: 8, num_of_runs: 3, code_config: 0

[sort-stable-rust serial]: [36.343] ms
[sort-unstable-rust serial]: [17.697] ms
[sort-stable par]: [7.204] ms
++++ (5.04x speedup from 8 threads)

[sort-unstable par]: [7.807] ms
++++ (2.27x speedup from 8 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

```
  Finished dev [unoptimized + debuginfo] target(s) in 2.74s
    Running `target\debug\quick_sort.exe`

Configuration:
num_elements: 100000, sort_order: 0, num_threads: 5, num_of_runs: 3, code_config: 0

[sort-stable-rust serial]: [27.52] ms
[sort-unstable-rust serial]: [18.521] ms
[sort-stable par]: [8.726] ms
++++ (3.15x speedup from 5 threads)

[sort-unstable par]: [9.272] ms
++++ (2.00x speedup from 5 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\quick_sort>
```

Matrix Multiplication

```
  Finished dev [unoptimized + debuginfo] target(s) in 1.54s
    Running `target\debug\matrixmultiply.exe`

Configuration:
size=10 num_threads: 1, num_of_runs: 1
[matmul-rust serial]: [0.027] ms
[matmul-rust par_row]: [0.119] ms
++++ (0.23x speedup from 1 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
  Finished dev [unoptimized + debuginfo] target(s) in 1.61s
    Running `target\debug\matrixmultiply.exe`

Configuration:
size=10 num_threads: 2, num_of_runs: 1
[matmul-rust serial]: [0.066] ms
[matmul-rust par_row]: [0.224] ms
++++ (0.29x speedup from 2 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
Finished dev [unoptimized + debuginfo] target(s) in 1.35s
Running `target\debug\matrixmultiply.exe`
Configuration:
size=10 num_threads: 3, num_of_runs: 1
[matmul-rust serial]: [0.051] ms
[matmul-rust par_row]: [0.103] ms
++++ (0.50x speedup from 3 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>

Finished dev [unoptimized + debuginfo] target(s) in 1.66s
Running `target\debug\matrixmultiply.exe`
Configuration:
size=10 num_threads: 4, num_of_runs: 1
[matmul-rust serial]: [0.028] ms
[matmul-rust par_row]: [0.207] ms
++++ (0.14x speedup from 4 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>

Finished dev [unoptimized + debuginfo] target(s) in 1.55s
Running `target\debug\matrixmultiply.exe`
Configuration:
size=10 num_threads: 5, num_of_runs: 1
[matmul-rust serial]: [0.049] ms
[matmul-rust par_row]: [0.151] ms
++++ (0.32x speedup from 5 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>

Finished dev [unoptimized + debuginfo] target(s) in 1.52s
Running `target\debug\matrixmultiply.exe`
Configuration:
size=10 num_threads: 6, num_of_runs: 1
[matmul-rust serial]: [0.128] ms
[matmul-rust par_row]: [0.221] ms
++++ (0.58x speedup from 6 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>

Finished dev [unoptimized + debuginfo] target(s) in 1.95s
Running `target\debug\matrixmultiply.exe`
Configuration:
size=100 num_threads: 1, num_of_runs: 1
[matmul-rust serial]: [44.685] ms
[matmul-rust par_row]: [44.43] ms
++++ (1.01x speedup from 1 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
Finished dev [unoptimized + debuginfo] target(s) in 1.42s
Running `target\debug\matrixmultiply.exe`

Configuration:
size=100 num_threads: 2, num_of_runs: 1
[matmul-rust serial]: [40.06] ms
[matmul-rust par_row]: [21.157] ms
++++ (1.89x speedup from 2 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
Finished dev [unoptimized + debuginfo] target(s) in 1.61s
Running `target\debug\matrixmultiply.exe`

Configuration:
size=100 num_threads: 3, num_of_runs: 1
[matmul-rust serial]: [41.433] ms
[matmul-rust par_row]: [14.569] ms
++++ (2.84x speedup from 3 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
Finished dev [unoptimized + debuginfo] target(s) in 3.11s
Running `target\debug\matrixmultiply.exe`

Configuration:
size=100 num_threads: 4, num_of_runs: 1
[matmul-rust serial]: [41.231] ms
[matmul-rust par_row]: [16.061] ms
++++ (2.57x speedup from 4 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
Finished dev [unoptimized + debuginfo] target(s) in 1.55s
Running `target\debug\matrixmultiply.exe`

Configuration:
size=100 num_threads: 5, num_of_runs: 1
[matmul-rust serial]: [41.245] ms
[matmul-rust par_row]: [15.702] ms
++++ (2.63x speedup from 5 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
Finished dev [unoptimized + debuginfo] target(s) in 1.27s
Running `target\debug\matrixmultiply.exe`

Configuration:
size=100 num_threads: 6, num_of_runs: 1
[matmul-rust serial]: [39.043] ms
[matmul-rust par_row]: [13.026] ms
++++ (3.00x speedup from 6 threads)

○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```
matrixmultiply (main) generated 3 warnings (run --cargo-lint)
  Finished dev [unoptimized + debuginfo] target(s) in 1.41s
    Running `target\debug\matrixmultiply.exe`  
Configuration:  
size=1000 num_threads: 1, num_of_runs: 1  
[matmul-rust serial]: [18688.612] ms  
[matmul-rust par_row]: [19133.992] ms  
++++ (0.98x speedup from 1 threads)  
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>  
  
  Finished dev [unoptimized + debuginfo] target(s) in 1.37s
    Running `target\debug\matrixmultiply.exe`  
Configuration:  
size=1000 num_threads: 2, num_of_runs: 1  
[matmul-rust serial]: [18505.132] ms  
[matmul-rust par_row]: [9684.847] ms  
++++ (1.91x speedup from 2 threads)  
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>  
  
  Finished dev [unoptimized + debuginfo] target(s) in 1.27s
    Running `target\debug\matrixmultiply.exe`  
Configuration:  
size=1000 num_threads: 3, num_of_runs: 1  
[matmul-rust serial]: [18662.879] ms  
[matmul-rust par_row]: [7863.76] ms  
++++ (2.37x speedup from 3 threads)  
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>  
  
  Finished dev [unoptimized + debuginfo] target(s) in 1.61s
    Running `target\debug\matrixmultiply.exe`  
Configuration:  
size=1000 num_threads: 4, num_of_runs: 1  
[matmul-rust serial]: [18706.741] ms  
[matmul-rust par_row]: [6391.445] ms  
++++ (2.93x speedup from 4 threads)  
○ PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>  
  
  Finished dev [unoptimized + debuginfo] target(s) in 1.47s
    Running `target\debug\matrixmultiply.exe`  
Configuration:  
size=1000 num_threads: 5, num_of_runs: 1  
[matmul-rust serial]: [20422.479] ms  
[matmul-rust par_row]: [6576.057] ms  
++++ (3.11x speedup from 5 threads)  
PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply>
```

```

Finished dev [unoptimized + debuginfo] target(s) in 1.36s
Running `target\debug\matrixmultiply.exe`  

Configuration:  

size=1000 num_threads: 6, num_of_runs: 1  

[matmul-rust serial]: [33200.326] ms  

[matmul-rust par_row]: [20252.484] ms  

++++ (1.64x speedup from 6 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply> █

Finished dev [unoptimized + debuginfo] target(s) in 4.82s
Running `target\debug\matrixmultiply.exe`  

Configuration:  

size=50 num_threads: 4, num_of_runs: 1  

[matmul-rust serial]: [2.28] ms  

[matmul-rust par_row]: [0.929] ms  

++++ (2.45x speedup from 4 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply> █

Finished dev [unoptimized + debuginfo] target(s) in 7.71s
Running `target\debug\matrixmultiply.exe`  

Configuration:  

size=500 num_threads: 4, num_of_runs: 1  

[matmul-rust serial]: [2592.857] ms  

[matmul-rust par_row]: [870.691] ms  

++++ (2.98x speedup from 4 threads)

PS D:\C DATA\Desktop\BITS Course\4-1\popl\15618-project-master\rust\matrixmultiply> █

```

Basic performance analysis

Binary search

```

cd ./generator, \
echo "10000 1000 0.5" | cargo run > ../inp_low; \
echo "1000000 100000 0.5" | cargo run > ../inp_mid; \
echo "10000000 1000000 0.5" | cargo run > ../inp_hi; \

```

```
◆ MINGW64:/d/C DATA/Desktop/BITS Course/4-1/pop1/rust-vs-cpp-bench-master/binary_search
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/pop1/rust-vs-cpp-bench-master/binary_search
$ ./common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.17671 sec, core 0.00040 sec
  test inp_mid: runtime 0.93241 sec, core 0.01466 sec
  test inp_hi: runtime 8.65214 sec, core 0.37673 sec

./main_rust:
  test inp_low: runtime 0.03502 sec, core 0.00017 sec
  test inp_mid: runtime 0.12013 sec, core 0.02494 sec
  test inp_hi: runtime 1.30274 sec, core 0.66416 sec
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/pop1/rust-vs-cpp-bench-master/binary_search
$ |
```

```
PS D:\C DATA\Desktop\BITS Course\4-1\pop1\rust-vs-cpp-bench-master\binary_search\generator> cargo run > ..\inp_low
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s
    Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\pop1\rust-vs-cpp-bench-master\binary_search\generator> echo "100 10 0.5"      | cargo run > ..\inp_low
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s
    Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\pop1\rust-vs-cpp-bench-master\binary_search\generator> echo "100000 10000 0.5"    | cargo run > ..\inp_mid
  Finished dev [unoptimized + debuginfo] target(s) in 0.03s
    Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\pop1\rust-vs-cpp-bench-master\binary_search\generator> echo "10000000 1000000 0.5"   | cargo run > ..\inp_hi
  Finished dev [unoptimized + debuginfo] target(s) in 0.03s
    Running `target\debug\generator.exe`
PS D:\C DATA\Desktop\BITS Course\4-1\pop1\rust-vs-cpp-bench-master\binary_search\generator> cd ..
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/pop1/rust-vs-cpp-bench-master/binary_search
$ ./common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.09879 sec, core 0.00000 sec
  test inp_mid: runtime 0.19679 sec, core 0.00139 sec
  test inp_hi: runtime 9.29229 sec, core 0.40703 sec

./main_rust:
  test inp_low: runtime 0.03241 sec, core 0.00000 sec
  test inp_mid: runtime 0.03070 sec, core 0.00259 sec
  test inp_hi: runtime 1.78433 sec, core 0.89658 sec
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/pop1/rust-vs-cpp-bench-master/binary_search
$
```

```
z:\common\110\minishell
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search> cd ..\generator\
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "500 50 0.5"      | cargo run > ../inp_low
  Finished dev [unoptimized + debugInfo] target(s) in 0.04s
    Running `target\debug\generator.exe`
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "500000 50000 0.5"     | cargo run > ../inp_mid
  Finished dev [unoptimized + debugInfo] target(s) in 0.04s
    Running `target\debug\generator.exe`
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\binary_search\generator> echo "50000000 5000000 0.5"   | cargo run > ../inp_hi
  Finished dev [unoptimized + debugInfo] target(s) in 0.02s
    Running `target\debug\generator.exe`
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$ .../common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.03486 sec, core 0.00010 sec
  test inp_mid: runtime 0.66117 sec, core 0.00806 sec
  test inp_hi: runtime 51.94723 sec, core 2.77775 sec

./main_rust:
  test inp_low: runtime 0.25771 sec, core 0.00000 sec
  test inp_mid: runtime 0.08867 sec, core 0.00876 sec
  test inp_hi: runtime 9.29431 sec, core 5.19443 sec

DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/binary_search
$ |
```

Merge Sort

```
MINGW64:/d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
$ .../common/compare_performance.sh
Averaging performance of 10 runs..
./main_cpp:
  test inp_low: runtime 0.05564 sec, core 0.00370 sec
  test inp_mid: runtime 1.02332 sec, core 0.20230 sec
  test inp_hi: runtime 9.73628 sec, core 2.25293 sec

./main_rust:
  test inp_low: runtime 0.03692 sec, core 0.00387 sec
  test inp_mid: runtime 0.30885 sec, core 0.21809 sec
  test inp_hi: runtime 2.77279 sec, core 2.20561 sec

DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort
$ |
```

```
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort> cd ..\generator\  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 1000 | cargo run > ../inp_low  
  Finished dev [unoptimized + debuginfo] target(s) in 2.08s  
    Running `target\debug\generator.exe`  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 3000000 | cargo run > ../inp_mid  
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s  
    Running `target\debug\generator.exe`  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 10000000 | cargo run > ../inp_hi;\  
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s  
    Running `target\debug\generator.exe`  
  \: The term '\` is not recognized as a name of a cmdlet, function, script file, or executable program.  
  Check the spelling of the name, or if a path was included, verify that the path is correct and try again.  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 3000000 | cargo run > ../inp_hi  
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s  
    Running `target\debug\generator.exe`
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort  
$ ./common/compare_performance.sh  
Averaging performance of 10 runs..  
.main_cpp:  
  test inp_low: runtime 0.03641 sec, core 0.00010 sec  
  test inp_mid: runtime 2.66057 sec, core 0.64745 sec  
  test inp_hi: runtime 26.87381 sec, core 7.19119 sec  
  
.main_rust:  
  test inp_low: runtime 0.10522 sec, core 0.00002 sec  
  test inp_mid: runtime 0.80033 sec, core 0.62884 sec  
  test inp_hi: runtime 8.69833 sec, core 7.06314 sec
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort  
$ |  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort> cd ..\generator\  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 1000 | cargo run > ../inp_low  
  Finished dev [unoptimized + debuginfo] target(s) in 0.04s  
    Running `target\debug\generator.exe`  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 6000000 | cargo run > ../inp_mid  
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s  
    Running `target\debug\generator.exe`  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator> echo 60000000 | cargo run > ../inp_hi  
  Finished dev [unoptimized + debuginfo] target(s) in 0.01s  
    Running `target\debug\generator.exe`  
● PS D:\C DATA\Desktop\BITS Course\4-1\popl\rust-vs-cpp-bench-master\mergesort\generator>
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort  
$ ./common/compare_performance.sh  
Averaging performance of 10 runs..  
.main_cpp:  
  test inp_low: runtime 0.07458 sec, core 0.00041 sec  
  test inp_mid: runtime 5.29366 sec, core 1.28019 sec  
  test inp_hi: runtime 90.58684 sec, core 15.80502 sec  
  
.main_rust:  
  test inp_low: runtime 0.53825 sec, core 0.00017 sec  
  test inp_mid: runtime 1.61679 sec, core 1.25265 sec  
  test inp_hi: runtime 17.09453 sec, core 14.01823 sec
```

```
DELL@DESKTOP-KNONJFA MINGW64 /d/C DATA/Desktop/BITS Course/4-1/popl/rust-vs-cpp-bench-master/mergesort  
$
```

