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KHOA KHOA HỌC VÀ KỸ THUẬT MÁY TÍNH

Kiến Trúc Máy Tính - CO2008

Bài tập lớn

SẮP XẾP CHUỖI SỐ THỰC BẰNG GIẢI THUẬT MERGE SORT

Lớp: L12 Nhóm 6: Đề 5

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1 Lời Cảm Ơn

Đầu tiên, nhóm chúng em xin được gửi lời cảm ơn đến các giảng viên là thầy Trần Thanh Bình và thầy Huỳnh Phúc Nghị đã giúp nhóm chúng em thực hiện bài tập lớn này. Nhờ sự giúp đỡ tận tình của quý thầy, chúng em đã vượt qua những khúc mắc, khó khăn trong suốt quá trình thực hiện bài tập, từ đó hoàn thành đúng tiến độ môn học và cho ra sản phẩm chất lượng.

Ngoài ra, không thể không nhắc đến sự quan tâm giúp đỡ của các anh chị, các bạn sinh viên trong cộng đồng sinh viên trường Đại học Bách Khoa nói riêng và ĐHQG-HCM nói chung, những đóng góp to lớn của các anh chị và các bạn đã giúp chúng em nắm chắc hơn cách sử dụng kiến trúc tập lệnh MIPS mà nhóm chỉ mới gần đây được tiếp cận trong quá trình theo học ở môi trường Đại Học.

Cuối cùng nhóm em xin gửi lời cảm ơn một lần nữa đến các tập thể cá nhân đã giúp đỡ và truyền cảm hứng cho nhóm trong suốt quá trình thực hiện dự án bài tập lớn này.

2 Kiến trúc tập lệnh MIPS

2.1 Giới thiệu về MIPS

MIPS - Microprocessor without Interlocked Pipeline Stages - là kiến trúc bộ tập lệnh RISC phát triển bởi MIPS Technologies. Ban đầu kiến trúc MIPS là 32 bit, và sau đó là phiên bản 64 bit. Nhiều sửa đổi của MIPS, bao gồm MIPS I, MIPS II, MIPS III, MIPS IV, MIPS V, MIPS32, MIPS64. Phiên bản hiện tại là MIPS32 và MIPS64.

2.2 Một số lệnh MIPS

Sau đây là một số lệnh MIPS mà nhóm sẽ sử dụng để thực hiện giải thuật Merge Sort.

1. add $t0, $t1, $t2: thanh ghi $t0 chứa kết quả của phép cộng 2 thanh ghi $t1, $t2.
2. addi $t0, $t1, 1: thanh ghi $t0 chứa kết quả của phép cộng thanh ghi $t1 và hằng số 1.
3. li $v0, 1: thanh ghi $v0 được load vào hằng số 1.
4. bge $t0, $t1, label: Nếu giá trị thanh ghi $t0 lớn hơn hoặc bằng giá trị tại thanh ghi $t1, nhảy đến label.
5. bne $t0, $t1, label: Nếu giá trị thanh ghi $t0 không bằng giá trị tại thanh ghi $t1, nhảy đến label.
6. beq $t0, $t1, label: Nếu giá trị thanh ghi $t0 bằng giá trị tại thanh ghi $t1, nhảy đến label.
7. jal label: nhảy đến label.
8. jr $ra: Nhảy đến địa chỉ chứa trong thanh ghi $ra, với $ra là thanh ghi chưa địa chỉ của câu lệnh kế tiếp được thực thi.
9. la $a0, my_arr: lưu địa chỉ của my_arr vào thanh ghi $a0.
10. lw $t0, 0($a0): lấy giá trị 4 byte ở vị trí 0 từ $a0.
11. sw $t0, 0($a0): lưu giá trị 4 byte ở vị trí 0 từ $a0.
12. move $a2, $a3: lưu thanh ghi $a3 vào thanh ghi $a2.
13. lwc1 $t0, 0($a0): lấy giá trị 4 byte số thực ở vị trí 0 từ $a0.
14. swc1 $t0, 0($a0): lưu giá trị 4 byte số thực ở vị trí 0 từ $a0.
15. c.lt.s $f10, $f8: so sánh $f10 và $f8 nếu $f10 bé hơn $f8 thì trả về 1 ngược lại là 0.
16. bc1t Store_2_come_in: rẽ nhánh nếu giá trị trả về là 1.
17. Lệnh gọi hệ thống: Syscall.

3 Thuật toán Merge Sort

3.1 Giới thiệu thuật toán Merge Sort

Thuật toán Merge Sort (hay còn gọi là thuật toán Sắp xếp trộn) là một trong những thuật toán dùng để sắp xếp danh sách (hoặc cấu trúc dữ liệu tương tự) theo một thứ tự định trước. Giải thuật có độ phức tạp ở mức trung bình và sử dụng phương pháp Divide an Conquer (chia để trị) để hiện thực. Ưu điểm của thuật toán này so với các thuật toán sắp xếp hiện hành khác là độ phức tạp thời gian thấp **O(nlogn)**, và chạy ổn định. Tuy nhiên nhược điểm của thuật toán Merge Sort nằm ở độ phức tạp không gian cao **O(n)**, vì cần tạo ra một dãy tạm thời để lưu mảng giữa các bước sắp xếp.

3.2 Độ phức tạp

Độ phức tạp của thuật toán:

- Tốt nhất: **O(nlogn)**
- Trung bình: **O(nlogn)**
- Tệ nhất: **O(nlogn)**

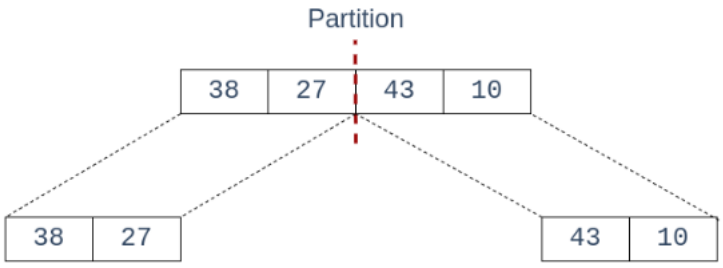
Độ phức tạp về không gian:

- Tốt nhất: **O(n)**
- Trung bình: **O(n)**
- Tệ nhất: **O(n)**

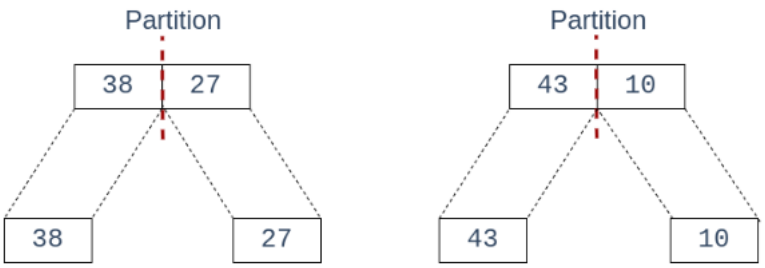
3.3 Ý tưởng hiện thực

Thuật toán Merge Sort có thể được mô hình thành 2 thao tác: split (chia) và merge (trộn).

- Thao tác split: Phân chia danh sách hiện tại thành hai nửa (danh sách con) có số lượng phần tử chênh lệch nhau tối đa là 1.

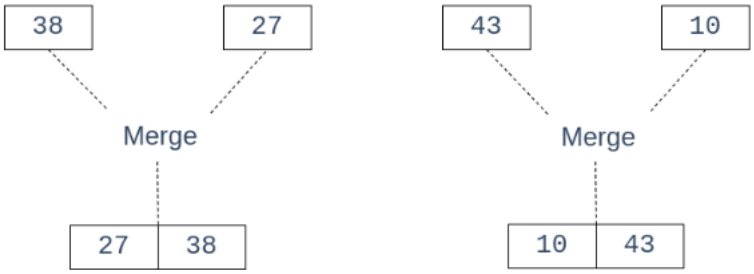


Hình 1: *Thao tác chia (Divide)*

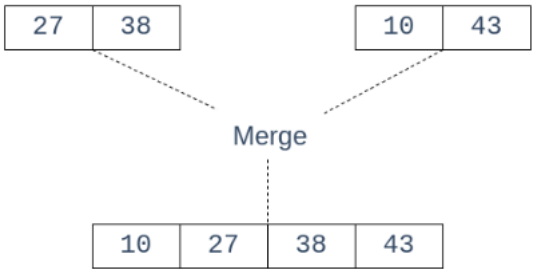


Hình 2: *Chia đến khi không thể chia được nữa*

- Thao tác Merge: Trộn hay danh sách đã được sắp xếp thành một danh sách mới bao gồm toàn bộ phần tử của cả hai danh sách cũ mà vẫn giữ nguyên được tính chất sắp xếp theo thứ tự cho trước.



Hình 3: *Thao tác trộn (Merge)*



Hình 4: *Thao tác trộn (Merge) đến khi mảng được sắp xếp xong*

Với việc kết hợp với Recursion (đệ quy), ta có thể thực hiện giải thuật sắp xếp Merge Sort theo đoạn mã giả sau đây.

```
mergeSort(arr[], l, r):
    if r > l
        1. Tìm vị trí middle của array để chia đôi thành hai array.
            middle = (l + r) >> 1
        2. Gọi lại hàm merSort ở nửa array đầu tiên.
            mergeSort(arr, l, m)
        3. Gọi lại hàm merSort ở nửa array thứ hai.
            mergeSort(arr, m + 1, r)
        4. Đệ quy để trộn  của hai nửa array.
            merge(arr, l , m , r)
merge(arr[], l, m, r):
    x = l, y = m + 1
    nArr = []
1. Trộn cho đến khi hết các phần tử trong mảng.
    while x <= m và y <= r:
        if arr[x] < arr[y]:
            nối arr[x] đến nArr
            x += 1
        else
            nối arr[y] đến nArr
            y += 1
2. Nối thêm phần còn lại của nửa đầu nếu tồn tại
    while x <= m:
        nối arr[x] đến nArr
        x += 1
3. Nối thêm phần còn lại của nửa thứ hai nếu tồn tại
    while y <= r
        nối arr[y] to nArr
```

```
            b += 1
    4. Copy nArr trên Arr[l:r]
```

Dễ thấy việc chia danh sách sẽ lặp lại liên tục từ danh sách lớn hơn thành các danh sách nhỏ hơn. Khi đó, bằng việc thực hiện gộp đệ quy các danh sách vẫn lại giữ nguyên tính chất sắp xếp có thứ tự như đã đề cập ở trên, ta thu được danh sách mới có thứ tự sắp xếp theo ý muốn.

4 Sử dụng MIPS để hiện thực thuật toán Merge Sort

Dưới đây là giải thuật Merge Sort được viết bằng kiến trúc tập lệnh MIPS

```
.data
Float_Format:        .asciiz        "%f"
Float_Space:        .asciiz        ", "
Closing_Bracket:        .asciiz        "]\n"
Line:  .asciiz        "-----------------------------------------\n"

Print_Unsorted_Array:        .asciiz        "Unsorted Array: ["
Print_Sorted_Array:        .asciiz        "Sorted Array:   ["
Print_Current_Array:        .asciiz        "Current array:  ["

From:                        .asciiz "\nFrom "
To:                        .asciiz        " to "
eol:                        .asciiz        "\n"

#---------------------------------------------------------------------------
array_length:                .word 50
my_array:                .float -962.858, 9818.01, -6477.765, -9240.773, 6011.937,
↪  -2761.61, 2715.285, -7458.972, 9994.299, 8655.005, 4596.247, 1883.858, -9528.377,
↪  -9118.649, 7176.856, 3151.494, -281.062, 2559.125, -119.249, -4376.422, 9385.195,
↪  -1931.018, 9503.287, -2837.743, 7717.346, 521.422, 435.957, -4769.552, -7383.0,
↪  4017.666, -5787.8, -6366.994, 43.75, 6323.169, -6442.651, -9324.26, -6760.675,
↪  -6339.054, 7000.495, -4636.416, 4248.967, -4317.137, 9780.658, 4698.3, 9573.222,
↪  5397.591, -6001.695, -9052.361, 701.68, -2462.871
#---------------------------------------------------------------------------
arr_store_1:                .space 200
arr_store_2:                .space 200

#---------------------------------------------------------------------------
.text
main:

        jal        print_unsorted_array        # in ra mang chua duoc sap xep

        li          $v0, 4
        la          $a0, Line        # Prints ------------------------------
        syscall

        #-------------------------------------------------
        # chuan bi cac tham so
        la        $a0, my_array                # a0 luu mang
        addi        $a1, $a1, 0                # a1 la index 0

        lw        $a2, array_length
        subi        $a2, $a2, 1                # a2 la index cuoi cung

        addi        $s1, $a1, 0                # s1 s2 se duoc su dung de in current array
        addi        $s2, $a2, 0

```

```
        #-------------------------------------------------
        jal         Merge_sort                  # Merge sort

        #-------------------------------------------------
        jal          print_sorted_array         # in mang da duoc sap xep

        #-------------------------------------------------
        li           $v0, 10                        # ket thuc chuong trinh!
        syscall
#-----------------------------------------------------------------------------------------
# Ham sap xep tron (merge sort)
#
# a0 la mang
# a1 chua low index
# a2 chua high index
Merge_sort:
        beq         $a1, $a2, Stop_sorting         # low = high
                                        # stop sorting

        # tinh middle index
        add         $a3, $a1, $a2
        div         $a3, $a3, 2                 # a3 = middle index

        #        STACKS
        #   --------------
        #   |        ra        |
        #   |        middle        |
        #   |        high        |
        #   |        low        |
        addi        $sp, $sp, -16         # tao 4 empty trog stack
        sw         $a1, 0($sp)          # luu low vao stack
        sw         $a2, 4($sp)          # luu high vao stack
        sw         $a3, 8($sp)          # luu middle vao stack
        sw         $ra, 12($sp)          # luu return address vao stack

        move        $a2, $a3         # (low, mid)
                                # new high = current mid

        # goi ham de quy mersort cho khoi dau tien
        jal         Merge_sort

        # sau khi hoan thanh merge sort cho khoi dau tien thi return o day

        lw         $a1, 0($sp)          # lay low truoc do ra
        lw         $a2, 4($sp)          # lay high truoc do ra
        lw         $a3, 8($sp)          # lay middle truoc do ra

        addi          $a3, $a3, 1         # middle + 1
        move        $a1, $a3         # (middle + 1, high)

        # goi ham de quy mersort cho khoi thu hai
        jal         Merge_sort

        # sau khi hoan thanh merge sort cho khoi thu hai thi return o day

        lw         $a1, 0($sp)          # lay low truoc do ra
        lw         $a2, 4($sp)          # lay high truoc do ra
        lw         $a3, 8($sp)          # lay middle truoc do ra

        # lets merge the array
        jal         Merge_array
```

```
104
105         lw        $a1, 0($sp)         # lay low truoc do ra
106         lw        $a2, 4($sp)         # lay high truoc do ra
107         lw        $a3, 8($sp)         # lay middle truoc do ra
108         lw        $ra, 12($sp)         # lay return address truoc do ra
109         addi        $sp, $sp, 16         # xoa 4 empty da them vao khoi stack
110
111         Stop_sorting:
112                 jr        $ra
113
114 # Ghep 2 mang da duoc sap xep lai voi nhau
115 # sap xep chung va ghep lai voi nhau
116 #
117 # a0 = mang
118 # a1 = low
119 # a2 = high
120 # a3 = middle
121 Merge_array:
122         sw        $a0, 0($sp)         # luu array vao stack de thuc hien viec in current
        ↪  array
123
124         # in ra vị trí hiện tại
125         li        $v0, 4
126         la        $a0, From         # From
127         syscall
128
129         li        $v0, 1
130         move        $a0, $a1         # low
131         syscall
132
133         li        $v0, 4
134         la        $a0, To                 # to
135         syscall
136
137         li        $v0, 1
138         move        $a0, $a2         # high
139         syscall
140
141         li        $v0, 4
142         la        $a0, eol         # \n
143         syscall
144
145
146
147         # in vi tri hien tai
148         li        $v0, 4
149         la        $a0, Print_Current_Array         # Print : "Current Array: ["
150         syscall
151
152         # lay lai mang de tien hanh merge
153         lw        $a0, 0($sp)
154
155         # t0 = N1 = middle - low + 1
156         sub         $t0, $a3, $a1
157         addi         $t0, $t0, 1
158
159         # t1 = N2 = high - mid
160         sub         $t1, $a2, $a3
161
162         # t2 = first store array
163         # t3 = second store array
```

```
164         la        $t2, arr_store_1
165         la        $t3, arr_store_2
166
167         # Tao ra 2 temp array de ho tro viec sap xep
168         mul        $t4, $a1, 4
169         add        $t4, $a0, $t4        # dia chi cua first_array[ low ]
170
171         mul        $t5, $a3, 4
172         add        $t5, $a0, $t5        # dia chi cua first_array[ mid ]
173
174         Copy_first_array_to_store_1:
175                 slt        $s7, $t5, $t4        # s7 = 0 khi low < mid
176                                                 # s7 = 1 khi low >= mid (da copy het mang)
177                 bnez        $s7, First_copy_end
178
179                 lwc1        $f8, 0($t4)         # lay dia chi first_array[ current ]
180                 swc1        $f8, 0($t2)        # luu vao first_store[ current ]
181
182                 addi        $t4, $t4, 4        # tang ca hai len index ke tiep
183                 addi        $t2, $t2, 4
184
185                 j        Copy_first_array_to_store_1
186
187                 First_copy_end:
188                         # chuan bi copy mang thu hai
189                         addi        $s5, $a3, 1        # mid + 1
190
191                         mul        $s5, $s5, 4
192                         add        $t4, $a0, $s5        # dia chi cua second_array[ mid + 1
                            ↪  ]
193
194                         mul        $s5, $a2, 4
195                         add        $t5, $a0, $s5        # dia chi cua second_array[ high ]
196
197         Copy_second_array_to_store_2:
198                 slt        $s7, $t5, $t4        # s7 = 0 khi low < mid
199                                                 # s7 = 1 khi low >= mid (da copy het mang)
200                 bnez        $s7, Second_copy_end
201
202                 lwc1        $f8, 0($t4)        # lay dia chi second_array[ current ]
203                 swc1        $f8, 0($t3)        # luu vao second_store[ current ]
204
205                 addi        $t4, $t4, 4        # tang ca hai len index ke tiep
206                 addi        $t3, $t3, 4
207
208                 j        Copy_second_array_to_store_2
209
210                 Second_copy_end:
211
212         Compare_and_merge:
213                 # t2 = first store array
214                 # t3 = second store array
215                 la        $t2, arr_store_1
216                 la        $t3, arr_store_2
217
218                 # t0 = N1
219                 # t1 = N2
220
221                 # luu a0 = array vao trong stack
222                 sw        $a0, -4($sp)
223
```

```
224                 # khoi tao cho t4 = i = 0
225                 # va t5 = j = 0
226                 move        $t4, $0
227                 move        $t5, $0
228
229                 # thiet lap cho a0 = array[ low ]
230                 mul         $t6, $a1, 4
231                 add         $a0, $a0, $t6
232
233                 # t0 = N1         t4 = i
234                 # t1 = N2         t5 = j
235                 # while (i < N1 && j < N2)
236                 First_loop_compare_and_insert:
237                         beq         $t0, $t4, first_loop_end
238                         beq         $t1, $t5, first_loop_end
239
240                         lwc1        $f8, 0($t2)         # f8 = arr_store_1[ i ]
241                         lwc1        $f10, 0($t3)         # f10 = arr_store_2[ j ]
242
243                         c.lt.s        $f10, $f8         # f10 < f8
244                         bc1t        Store_2_come_in         # cap nhat array neu phia truoc
                            ↪  > phia sau (sai)
245
246                         # IMPORTANT, CORE
                            ↪  CODE-------------------------------------------------------------
247                         swc1        $f8, 0($a0)         # Dua phan tu dung truoc (so be hon)
                            ↪  vao array
248                                                 # my_array[ current ] = store_1[ i ]
249
250                         addi        $t2, $t2, 4         # store_1 -> next
251                         addi        $t4, $t4, 1         # i -> next
252                                                 # tien toi phan tu tiep theo cua mang dau
                                                    ↪  tien (dung truoc)
253
254                         j         go_next_without_j_increase
255
256                         Store_2_come_in:
257                                 swc1        $f10, 0($a0)         # Dua phan tu dung sau (o
                                    ↪  array 2nd va < store_1[ current ]) vao array
258                                 addi        $t3, $t3, 4         # store_2 -> next
259                                 addi        $t5, $t5, 1         # j -> next
260                                                     # tien toi phan tu tiep theo cua
                                                        ↪  mang thu hai (dung sau)
261
262                         go_next_without_j_increase:
263                                 addi        $a0, $a0, 4         # my_array[ current ] ->
                                    ↪  next
264                                 j         First_loop_compare_and_insert
265
266                         first_loop_end:
267         #-------------------------------------------------------------------------------
268                 # while (i < N1)
269                 Second_loop_insert_lef_over_in_store_1:
270                         beq         $t4, $t0, Second_loop_end
271
272                         lwc1        $f8, 0($t2)         # lay ra store_1[ current ]
273                         swc1        $f8, 0($a0)         # dua vao my_array
274
275                         addi        $t2, $t2, 4         # store_1 -> next
276                         addi        $a0, $a0, 4         # my_array -> next
277                         addi        $t4, $t4, 1         # i++
```

```
278
279                         j       Second_loop_insert_lef_over_in_store_1
280
281                         Second_loop_end:
282 #-------------------------------------------------------------------------------
283                 # while (j < N2)
284                 Third_loop_insert_left_over_in_store_2:
285                         beq       $t1, $t5, Third_loop_end
286
287                         lwc1        $f8, 0($t3)         # lay ra store_2[ current ]
288                         swc1        $f8, 0($a0)         # dua vao my_array
289
290                         addi        $t3, $t3, 4         # store_2 -> next
291                         addi        $a0, $a0, 4         # my_array -> next
292                         addi        $t5, $t5, 1         # j++
293
294                         j         Third_loop_insert_left_over_in_store_2
295
296                         Third_loop_end:
297                                 lw        $a0, -4($sp)
298
299                                 addi        $sp, $sp, -12
300                                 sw        $ra, 0($sp)
301                                 sw        $a1, 4($sp)
302                                 sw        $a2, 8($sp)
303                                 add        $a1, $0, $s1
304                                 add        $a2, $0, $s2
305
306                                 jal        print_current_array
307
308                                 lw        $ra, 0($sp)
309
310                                 lw        $a1, 4($sp)
311                                 lw        $a2, 8($sp)
312                                 addi        $sp, $sp, 12
313
314                                 jr        $ra
315
316 #-------------------------------------------------------------------------------
317 # SUPPORT FUNCTIONS
318 #-------------------------------------------------------------------------------
319 print_current_array:
320         # a0 -> mang
321         # a1 -> low
322         # a2 -> high
323
324         # luu mang vao stack
325         sw        $a0, -4($sp)
326
327         # t7 = low
328         addi        $t7, $a1, 0
329
330         # t6 = my_array[ current ]
331         mul        $t6, $a1, 4
332         add        $t6, $t6, $a0
333
334         #li          $v0, 4
335         #la          $a0, Line                       # Prints
          ↪  -----------------------------
336         #syscall
337
```

```
        #li          $v0, 4
        #la          $a0, Print_Current_Array        # Print : "Current Array: ["
        #syscall

print_current_array_loop:
        slt         $s4, $a2, $t7
        bne         $s4, $0, print_current_array_loop_end

        lwc1         $f12, 0($t6)         # load real number to f12
        li          $v0, 2                # syscall to print float
        syscall

        beq         $a2, $t7, next_loop

        li          $v0, 4                # syscall to print ", "
        la          $a0, Float_Space
        syscall

        next_loop:
                addi        $t6, $t6, 4         # my_array -> next
                addi        $t7, $t7, 1         # low ++

        j         print_current_array_loop

print_current_array_loop_end:
        li          $v0, 4
        la          $a0, Closing_Bracket         # Prints the closing bracket
        syscall

        # lay lai mang va tiep tuc
        lw          $a0, -4($sp)
        jr          $ra
#-------------------------------------------------------------------------------------------
print_unsorted_array:
    li          $v0, 4
    la          $a0, Print_Unsorted_Array        # Print : "Unsorted Array: ["
    syscall

    lw         $t8, array_length
    subi         $t8, $t8, 1                      # t8 = length   19
    subi         $s4, $t8, 1                      # 18

    li          $t0, -1                            # counter
    la         $t1, my_array

    print_array_loop:
        # thoat neu in ra het tat ca
        bge         $t0, $t8, exit_print_unsorted

        lwc1         $f12, 0($t1)         # load float number to f12
        li          $v0, 2                # syscall to print float
        syscall

        # bo qua dau space cuoi cung
        bge         $t0, $s4, skip_last_unsorted

        # in ra space
        li          $v0, 4
        la          $a0, Float_Space
        syscall

```

```
399     skip_last_unsorted:
400         # tang bien dem
401         addi    $t0, $t0, 1
402         addi    $t1, $t1, 4
403         j       print_array_loop
404 
405     exit_print_unsorted:
406         li          $v0, 4
407         la          $a0, Closing_Bracket        # in dau ngoac dong "]"
408         syscall
409 
410         jr         $ra
411 
412 #-------------------------------------------------------------------------------------
413 #-------------------------------------------------------------------------------------
414 print_sorted_array:
415     li          $v0, 4
416     la          $a0, Line                       # Prints -------------------------------
417     syscall
418 
419     li          $v0, 4
420     la          $a0, Print_Sorted_Array                # Print : "Sorted Array: ["
421     syscall
422 
423     lw        $t8, array_length
424     subi        $t8, $t8, 1
425     subi        $s4, $t8, 1
426 
427     li         $t0, -1                                 # bien dem
428     la        $t1, my_array                # su dung array de luu
429 
430 print_sorted_array_loop:
431     # thoat neu in ra het
432     bge $t0, $t8, exit_print_sorted
433 
434     # lay dia chi cua array[ index ]
435     lwc1        $f12, 0($t1)        # load so thuc vao $f12
436     li        $v0, 2                # syscall de in float
437     syscall
438 
439     # bo qua space cuoi cung (beautify purpose)
440     bge        $t0, $s4, skip_last_sorted
441 
442     # in ra space
443     li          $v0, 4
444     la          $a0, Float_Space
445     syscall
446 
447 skip_last_sorted:
448     # tang bien dem
449     addi    $t0, $t0, 1
450     addi    $t1, $t1, 4
451     j             print_sorted_array_loop
452 
453 exit_print_sorted:
454     li          $v0, 4
455     la          $a0, Closing_Bracket                # in dau ngoac dong "]"
456     syscall
457 
458     jr         $ra
459 
```

5 Kiểm tra tính đúng đắn của giải thuật

Để kiểm tra tính đúng đắn của giải thuật nhóm đã sử dụng một đoạn code viết bằng ngôn ngữ Python để tạo ra testcase.

```
import random

min_range = 0   # minimum of range
max_range = 100 # maximum of range
num_float_point = 3

random_numbers = [round(random.uniform(min_range, max_range), num_float_point) for _ in
↪  range(50)]

print(random_numbers)
```

Trong đó hàm **random.uniform(min_range, max_range)** dùng để sinh ngẫu nhiên số thực từ khoảng min_range đến khoảng max_range. Còn num_float_point chỉ số chữ số sau phần thập phân của giá trị sinh ngẫu nhiên.
Trong bài báo cáo này, nhóm sẽ sử dụng miền min_range và max_range và num_float_point theo như bảng sau:

Testcase	1 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30
min_range	0	-50	-100	-500	-1000	-10000
max_range	50	50	100	500	1000	10000
max_range	5	5	3	3	3	3

6 Xử lý các testcase

6.1 Các testcase cơ bản

Ở phần này các testcase nhỏ nên để kiểm tra khả năng compile và execute của giải thuật.
Testcase 1: Merge Sort với 3 phần tử

```
Testcase 1: 3.5, 2.1, 1.6
Expected Result: 1.6, 2.1, 3.5

Got:
Unsorted Array: [3.5, 2.1, 1.6]
-------------------------------------------

From 0 to 1
Current array:  [2.1, 3.5, 1.6]

From 0 to 2
Current array:  [1.6, 2.1, 3.5]
-------------------------------------------
Sorted Array:   [1.6, 2.1, 3.5]
```

Testcase 2: Merge Sort với 6 phần tử

```
Testcase 2: 5.4312, 7.43312, -6.12312, 8.12123, 1.1286, -1.2345
Expected Result: -6.12312, -1.2345, 1.1286, 5.4312, 7.43312, 8.12123

Got:
Unsorted Array: [5.4312, 7.43312, -6.12312, 8.12123, 1.1286, -1.2345]
-------------------------------------------
```

```
From 0 to 1
Current array:  [5.4312, 7.43312, -6.12312, 8.12123, 1.1286, -1.2345]

From 0 to 2
Current array:  [-6.12312, 5.4312, 7.43312, 8.12123, 1.1286, -1.2345]

From 3 to 4
Current array:  [-6.12312, 5.4312, 7.43312, 1.1286, 8.12123, -1.2345]

From 3 to 5
Current array:  [-6.12312, 5.4312, 7.43312, -1.2345, 1.1286, 8.12123]

From 0 to 5
Current array:  [-6.12312, -1.2345, 1.1286, 5.4312, 7.43312, 8.12123]
-------------------------------------------
Sorted Array:   [-6.12312, -1.2345, 1.1286, 5.4312, 7.43312, 8.12123]
```

Testcase 3: Merge Sort với 9 phần tử

```
    Testcase 3: 1901.2111, -0.00001, 2000, -354.12312, -4543.1212, 1.121231, 5.12312,
    ↪  -12312.54, 21,121
    Expected Result: -12312.54, -4543.121, -354.1231, -1.0E-5, 1.121231, 5.12312, 21.0,
    ↪  1901.211, 2000.0

    Got:
   Unsorted Array: [1901.211, -1.0E-5, 2000.0, -354.1231, -4543.121, 1.121231, 5.12312,
   ↪  -12312.54, 21.0]
-------------------------------------------

From 0 to 1
Current array:  [-1.0E-5, 1901.211, 2000.0, -354.1231, -4543.121, 1.121231, 5.12312,
↪  -12312.54, 21.0]

From 0 to 2
Current array:  [-1.0E-5, 1901.211, 2000.0, -354.1231, -4543.121, 1.121231, 5.12312,
↪  -12312.54, 21.0]

From 3 to 4
Current array:  [-1.0E-5, 1901.211, 2000.0, -4543.121, -354.1231, 1.121231, 5.12312,
↪  -12312.54, 21.0]

From 0 to 4
Current array:  [-4543.121, -354.1231, -1.0E-5, 1901.211, 2000.0, 1.121231, 5.12312,
↪  -12312.54, 21.0]

From 5 to 6
Current array:  [-4543.121, -354.1231, -1.0E-5, 1901.211, 2000.0, 1.121231, 5.12312,
↪  -12312.54, 21.0]

From 7 to 8
Current array:  [-4543.121, -354.1231, -1.0E-5, 1901.211, 2000.0, 1.121231, 5.12312,
↪  -12312.54, 21.0]

From 5 to 8
Current array:  [-4543.121, -354.1231, -1.0E-5, 1901.211, 2000.0, -12312.54, 1.121231,
↪  5.12312, 21.0]

From 0 to 8
Current array:  [-12312.54, -4543.121, -354.1231, -1.0E-5, 1.121231, 5.12312, 21.0,
↪  1901.211, 2000.0]
```

```
31 ---------------------------------------------
32 Sorted Array:   [-12312.54, -4543.121, -354.1231, -1.0E-5, 1.121231, 5.12312, 21.0,
   ↪  1901.211, 2000.0]
```

6.2 Các testcase theo yêu cầu của đề tài

Ở phần này các testcase theo yêu cầu của đề tài để kiểm tra tính đúng đắn của giải thuật, cùng với thống kê số lượng lệnh và thời gian thực thi của mỗi testcase. Cùng với dữ liệu cho trước là tần số có giá trị bằng 3.4 GHz và có độ dài mảng là 50 và sau đây là phần xử lý các testcase của chương trình.
Testcase 1: Range [0,50]

```
1  Testcase 1: 23.18453, 29.68527, 2.61612, 44.63207, 22.59021, 47.02046, 41.5606, 27.41478,
   ↪  39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011, 23.62394,
   ↪  20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
   ↪  39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296,
   ↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
   ↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028
2  Expected Result: 2.61612, 6.03336, 6.67903, 9.91662, 10.91356, 13.77181, 14.15296,
   ↪  16.77894, 20.18345, 20.37747, 20.38083, 20.54836, 21.91005, 22.28941, 22.59021,
   ↪  23.18453, 23.62394, 23.85558, 24.19028, 24.69623, 25.50375, 25.88564, 26.33365,
   ↪  27.26726, 27.41478, 29.68527, 32.83011, 33.65523, 34.17373, 34.56091, 34.86247,
   ↪  36.3928, 37.98149, 38.37856, 39.84028, 39.8511, 39.87978, 40.42393, 41.5606, 42.05233,
   ↪  42.6256, 42.76902, 43.1465, 44.63207, 45.61486, 45.96829, 46.34581, 46.65152, 47.02046,
   ↪  49.93229
3  Got:
4      Unsorted Array: [23.18453, 29.68527, 2.61612, 44.63207, 22.59021, 47.02046, 41.5606,
       ↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
       ↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
       ↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083,
       ↪  6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336,
       ↪  45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181,
       ↪  37.98149, 22.28941, 39.84028]
5  ---------------------------------------------
6  From 0 to 1
7  Current array:  [23.18453, 29.68527, 2.61612, 44.63207, 22.59021, 47.02046, 41.5606,
   ↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
   ↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
   ↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
   ↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
   ↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
   ↪  39.84028]
8  From 2 to 3
9  Current array:  [23.18453, 29.68527, 2.61612, 44.63207, 22.59021, 47.02046, 41.5606,
   ↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
   ↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
   ↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
   ↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
   ↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
   ↪  39.84028]
10 From 0 to 3
11 Current array:  [2.61612, 23.18453, 29.68527, 44.63207, 22.59021, 47.02046, 41.5606,
   ↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
   ↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
   ↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
   ↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
   ↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
   ↪  39.84028]
12 From 4 to 5
```

```
Current array:  [2.61612, 23.18453, 29.68527, 44.63207, 22.59021, 47.02046, 41.5606,
↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 4 to 6
Current array:  [2.61612, 23.18453, 29.68527, 44.63207, 22.59021, 41.5606, 47.02046,
↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 0 to 6
Current array:  [2.61612, 22.59021, 23.18453, 29.68527, 41.5606, 44.63207, 47.02046,
↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 7 to 8
Current array:  [2.61612, 22.59021, 23.18453, 29.68527, 41.5606, 44.63207, 47.02046,
↪  27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 7 to 9
Current array:  [2.61612, 22.59021, 23.18453, 29.68527, 41.5606, 44.63207, 47.02046,
↪  23.85558, 27.41478, 39.87978, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 10 to 11
Current array:  [2.61612, 22.59021, 23.18453, 29.68527, 41.5606, 44.63207, 47.02046,
↪  23.85558, 27.41478, 39.87978, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 10 to 12
Current array:  [2.61612, 22.59021, 23.18453, 29.68527, 41.5606, 44.63207, 47.02046,
↪  23.85558, 27.41478, 39.87978, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011,
↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 7 to 12
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Current array:  [2.61612, 22.59021, 23.18453, 29.68527, 41.5606, 44.63207, 47.02046,
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↪  23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581,
↪  33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903,
↪  14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233,
↪  46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941,
↪  39.84028]
From 0 to 12
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527,
↪  39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 40.42393, 32.83011, 23.62394,
↪  20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
↪  39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 13 to 14
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↪  20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
↪  39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 13 to 15
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↪  20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
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↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 16 to 17
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527,
↪  39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 23.62394, 32.83011, 40.42393,
↪  20.18345, 20.54836, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
↪  39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 16 to 18
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527,
↪  39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 23.62394, 32.83011, 40.42393,
↪  16.77894, 20.18345, 20.54836, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
↪  39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 13 to 18
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527,
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↪  23.62394, 32.83011, 40.42393, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
↪  39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 19 to 20
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527,
↪  39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 16.77894, 20.18345, 20.54836,
↪  23.62394, 32.83011, 40.42393, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523,
↪  39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 19 to 21
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Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527, 39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 16.77894, 20.18345, 20.54836, 23.62394, 32.83011, 40.42393, 24.19028, 24.69623, 42.76902, 46.34581, 33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 22 to 23
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527, 39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 16.77894, 20.18345, 20.54836, 23.62394, 32.83011, 40.42393, 24.19028, 24.69623, 42.76902, 33.65523, 46.34581, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 22 to 24
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From 19 to 24
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527, 39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 16.77894, 20.18345, 20.54836, 23.62394, 32.83011, 40.42393, 24.19028, 24.69623, 33.65523, 39.8511, 42.76902, 46.34581, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 13 to 24
Current array:  [2.61612, 22.59021, 23.18453, 23.85558, 26.33365, 27.41478, 29.68527, 39.87978, 41.5606, 42.6256, 44.63207, 45.96829, 47.02046, 16.77894, 20.18345, 20.54836, 23.62394, 24.19028, 24.69623, 32.83011, 33.65523, 39.8511, 40.42393, 42.76902, 46.34581, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 0 to 24
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394, 23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523, 39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581, 47.02046, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 25 to 26
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394, 23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523, 39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581, 47.02046, 27.26726, 49.93229, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 27 to 28
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394, 23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523, 39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581, 47.02046, 27.26726, 49.93229, 9.91662, 20.37747, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 25 to 28
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↪  47.02046, 9.91662, 20.37747, 27.26726, 49.93229, 21.91005, 20.38083, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 29 to 30
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↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 9.91662, 20.37747, 27.26726, 49.93229, 20.38083, 21.91005, 6.67903, 14.15296,
↪  25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 29 to 31
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↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 25 to 31
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
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↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 20.37747, 20.38083, 21.91005, 27.26726, 49.93229, 14.15296,
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↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 32 to 33
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
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↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 32 to 34
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↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
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↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 35 to 36
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From 35 to 37
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
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↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 32 to 37
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Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
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↪  47.02046, 6.67903, 9.91662, 20.37747, 20.38083, 21.91005, 27.26726, 49.93229, 14.15296,
↪  25.50375, 25.88564, 34.86247, 36.3928, 38.37856, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 25 to 37
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
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↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 45.61486, 42.05233, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 38 to 39
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
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↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 45.61486, 42.05233, 46.65152,
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From 38 to 40
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↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 42.05233, 45.61486, 46.65152,
↪  34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 41 to 42
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 42.05233, 45.61486, 34.17373,
↪  46.65152, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 41 to 43
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 42.05233, 45.61486, 34.17373,
↪  43.1465, 46.65152, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 38 to 43
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 34.17373, 42.05233, 43.1465,
↪  45.61486, 46.65152, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 44 to 45
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 34.17373, 42.05233, 43.1465,
↪  45.61486, 46.65152, 10.91356, 34.56091, 13.77181, 37.98149, 22.28941, 39.84028]
From 44 to 46
```

```
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 34.17373, 42.05233, 43.1465,
↪  45.61486, 46.65152, 10.91356, 13.77181, 34.56091, 37.98149, 22.28941, 39.84028]
From 47 to 48
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 34.17373, 42.05233, 43.1465,
↪  45.61486, 46.65152, 10.91356, 13.77181, 34.56091, 22.28941, 37.98149, 39.84028]
From 47 to 49
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 34.17373, 42.05233, 43.1465,
↪  45.61486, 46.65152, 10.91356, 13.77181, 34.56091, 22.28941, 37.98149, 39.84028]
From 44 to 49
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 34.17373, 42.05233, 43.1465,
↪  45.61486, 46.65152, 10.91356, 13.77181, 22.28941, 34.56091, 37.98149, 39.84028]
From 38 to 49
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.67903, 9.91662, 14.15296, 20.37747, 20.38083, 21.91005, 25.50375, 25.88564,
↪  27.26726, 34.86247, 36.3928, 38.37856, 49.93229, 6.03336, 10.91356, 13.77181, 22.28941,
↪  34.17373, 34.56091, 37.98149, 39.84028, 42.05233, 43.1465, 45.61486, 46.65152]
From 25 to 49
Current array:  [2.61612, 16.77894, 20.18345, 20.54836, 22.59021, 23.18453, 23.62394,
↪  23.85558, 24.19028, 24.69623, 26.33365, 27.41478, 29.68527, 32.83011, 33.65523,
↪  39.8511, 39.87978, 40.42393, 41.5606, 42.6256, 42.76902, 44.63207, 45.96829, 46.34581,
↪  47.02046, 6.03336, 6.67903, 9.91662, 10.91356, 13.77181, 14.15296, 20.37747, 20.38083,
↪  21.91005, 22.28941, 25.50375, 25.88564, 27.26726, 34.17373, 34.56091, 34.86247,
↪  36.3928, 37.98149, 38.37856, 39.84028, 42.05233, 43.1465, 45.61486, 46.65152, 49.93229]
From 0 to 49
Current array:  [2.61612, 6.03336, 6.67903, 9.91662, 10.91356, 13.77181, 14.15296,
↪  16.77894, 20.18345, 20.37747, 20.38083, 20.54836, 21.91005, 22.28941, 22.59021,
↪  23.18453, 23.62394, 23.85558, 24.19028, 24.69623, 25.50375, 25.88564, 26.33365,
↪  27.26726, 27.41478, 29.68527, 32.83011, 33.65523, 34.17373, 34.56091, 34.86247,
↪  36.3928, 37.98149, 38.37856, 39.84028, 39.8511, 39.87978, 40.42393, 41.5606, 42.05233,
↪  42.6256, 42.76902, 43.1465, 44.63207, 45.61486, 45.96829, 46.34581, 46.65152, 47.02046,
↪  49.93229]
---------------------------------------------
Sorted Array:   [2.61612, 6.03336, 6.67903, 9.91662, 10.91356, 13.77181, 14.15296,
↪  16.77894, 20.18345, 20.37747, 20.38083, 20.54836, 21.91005, 22.28941, 22.59021,
↪  23.18453, 23.62394, 23.85558, 24.19028, 24.69623, 25.50375, 25.88564, 26.33365,
↪  27.26726, 27.41478, 29.68527, 32.83011, 33.65523, 34.17373, 34.56091, 34.86247,
↪  36.3928, 37.98149, 38.37856, 39.84028, 39.8511, 39.87978, 40.42393, 41.5606, 42.05233,
↪  42.6256, 42.76902, 43.1465, 44.63207, 45.61486, 45.96829, 46.34581, 46.65152, 47.02046,
↪  49.93229]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30305	3433	43872

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43872}{3.4 * 10^9} = 1.290 * 10^{-5} \ (s)$$

Testcase 2: Range [0,50]

```
Testcase 2: 35.48539, 34.41756, 39.08564, 25.71059, 48.92365, 49.79362, 39.25007, 46.65382, 24.64545, 29.93266, 19.55947, 15.68617, 40.5616, 16.63911, 11.68793, 33.91588, 37.08301, 32.81227, 31.00747, 24.60012, 32.31996, 47.52016, 23.60699, 33.18372, 45.38873, 4.29172, 44.61571, 3.01743, 0.7056, 33.01827, 26.71807, 45.23475, 1.67649, 3.25748, 3.69056, 1.74636, 24.71375, 17.98044, 3.70875, 21.24752, 45.04675, 30.89906, 42.14745, 34.50544, 15.02136, 15.86153, 29.50264, 19.36043, 3.23624, 4.76868
Expected Result: 0.7056, 1.67649, 1.74636, 3.01743, 3.23624, 3.25748, 3.69056, 3.70875, 4.29172, 4.76868, 11.68793, 15.02136, 15.68617, 15.86153, 16.63911, 17.98044, 19.36043, 19.55947, 21.24752, 23.60699, 24.60012, 24.64545, 24.71375, 25.71059, 26.71807, 29.50264, 29.93266, 30.89906, 31.00747, 32.31996, 32.81227, 33.01827, 33.18372, 33.91588, 34.41756, 34.50544, 35.48539, 37.08301, 39.08564, 39.25007, 40.5616, 42.14745, 44.61571, 45.04675, 45.23475, 45.38873, 46.65382, 47.52016, 48.92365, 49.79362
Got:
Unsorted Array: [35.48539, 34.41756, 39.08564, 25.71059, 48.92365, 49.79362, 39.25007, 46.65382, 24.64545, 29.93266, 19.55947, 15.68617, 40.5616, 16.63911, 11.68793, 33.91588, 37.08301, 32.81227, 31.00747, 24.60012, 32.31996, 47.52016, 23.60699, 33.18372, 45.38873, 4.29172, 44.61571, 3.01743, 0.7056, 33.01827, 26.71807, 45.23475, 1.67649, 3.25748, 3.69056, 1.74636, 24.71375, 17.98044, 3.70875, 21.24752, 45.04675, 30.89906, 42.14745, 34.50544, 15.02136, 15.86153, 29.50264, 19.36043, 3.23624, 4.76868]
---------------------------------------------
From 0 to 1
Current array:  [34.41756, 35.48539, 39.08564, 25.71059, 48.92365, 49.79362, 39.25007, 46.65382, 24.64545, 29.93266, 19.55947, 15.68617, 40.5616, 16.63911, 11.68793, 33.91588, 37.08301, 32.81227, 31.00747, 24.60012, 32.31996, 47.52016, 23.60699, 33.18372, 45.38873, 4.29172, 44.61571, 3.01743, 0.7056, 33.01827, 26.71807, 45.23475, 1.67649, 3.25748, 3.69056, 1.74636, 24.71375, 17.98044, 3.70875, 21.24752, 45.04675, 30.89906, 42.14745, 34.50544, 15.02136, 15.86153, 29.50264, 19.36043, 3.23624, 4.76868]
From 2 to 3
Current array:  [34.41756, 35.48539, 25.71059, 39.08564, 48.92365, 49.79362, 39.25007, 46.65382, 24.64545, 29.93266, 19.55947, 15.68617, 40.5616, 16.63911, 11.68793, 33.91588, 37.08301, 32.81227, 31.00747, 24.60012, 32.31996, 47.52016, 23.60699, 33.18372, 45.38873, 4.29172, 44.61571, 3.01743, 0.7056, 33.01827, 26.71807, 45.23475, 1.67649, 3.25748, 3.69056, 1.74636, 24.71375, 17.98044, 3.70875, 21.24752, 45.04675, 30.89906, 42.14745, 34.50544, 15.02136, 15.86153, 29.50264, 19.36043, 3.23624, 4.76868]
[...]
From 0 to 49
Current array:  [0.7056, 1.67649, 1.74636, 3.01743, 3.23624, 3.25748, 3.69056, 3.70875, 4.29172, 4.76868, 11.68793, 15.02136, 15.68617, 15.86153, 16.63911, 17.98044, 19.36043, 19.55947, 21.24752, 23.60699, 24.60012, 24.64545, 24.71375, 25.71059, 26.71807, 29.50264, 29.93266, 30.89906, 31.00747, 32.31996, 32.81227, 33.01827, 33.18372, 33.91588, 34.41756, 34.50544, 35.48539, 37.08301, 39.08564, 39.25007, 40.5616, 42.14745, 44.61571, 45.04675, 45.23475, 45.38873, 46.65382, 47.52016, 48.92365, 49.79362]
---------------------------------------------
Sorted Array:   [0.7056, 1.67649, 1.74636, 3.01743, 3.23624, 3.25748, 3.69056, 3.70875, 4.29172, 4.76868, 11.68793, 15.02136, 15.68617, 15.86153, 16.63911, 17.98044, 19.36043, 19.55947, 21.24752, 23.60699, 24.60012, 24.64545, 24.71375, 25.71059, 26.71807, 29.50264, 29.93266, 30.89906, 31.00747, 32.31996, 32.81227, 33.01827, 33.18372, 33.91588, 34.41756, 34.50544, 35.48539, 37.08301, 39.08564, 39.25007, 40.5616, 42.14745, 44.61571, 45.04675, 45.23475, 45.38873, 46.65382, 47.52016, 48.92365, 49.79362]
```

Lệnh R	Lệnh I	Lệnh J	IC
10131	30293	3433	43857

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43857}{3.4 * 10^9} = 1.289 * 10^{-5} \ (s)$$

Testcase 3: Range [0,50]

```
Testcase 3: [13.99276, 28.04074, 5.79055, 39.03372, 41.71303, 49.1464, 39.97108, 5.08661, 39.7825, 42.87429, 39.20532, 49.61727, 28.94537, 2.94409, 21.18124, 16.72143, 3.32985, 2.26167, 40.37296, 22.81542, 11.70602, 7.50666, 38.50242, 41.2645, 31.64901, 16.22299, 30.75663, 21.19037, 30.98768, 33.64744, 11.93162, 34.70245, 47.09475, 18.23906, 39.63019, 19.6473, 7.03564, 0.91096, 48.86326, 2.18727, 29.16499, 1.9634, 45.64394, 22.59205, 29.27404, 4.59003, 44.72793, 38.29071, 47.04545, 11.11774]
Expected Result: [0.91096, 1.9634, 2.18727, 2.26167, 2.94409, 3.32985, 4.59003, 5.08661, 5.79055, 7.03564, 7.50666, 11.11774, 11.70602, 11.93162, 13.99276, 16.22299, 16.72143, 18.23906, 19.6473, 21.18124, 21.19037, 22.59205, 22.81542, 28.04074, 28.94537, 29.16499, 29.27404, 30.75663, 30.98768, 31.64901, 33.64744, 34.70245, 38.29071, 38.50242, 39.03372, 39.20532, 39.63019, 39.7825, 39.97108, 40.37296, 41.2645, 41.71303, 42.87429, 44.72793, 45.64394, 47.04545, 47.09475, 48.86326, 49.1464, 49.61727]
Got:
Unsorted Array: [23.18453, 29.68527, 2.61612, 44.63207, 22.59021, 47.02046, 41.5606, 27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011, 23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
-------------------------------------------
From 0 to 1
Current array:  [23.18453, 29.68527, 2.61612, 44.63207, 22.59021, 47.02046, 41.5606, 27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011, 23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
From 2 to 3
Current array:  [23.18453, 29.68527, 2.61612, 44.63207, 22.59021, 47.02046, 41.5606, 27.41478, 39.87978, 23.85558, 26.33365, 42.6256, 45.96829, 40.42393, 32.83011, 23.62394, 20.54836, 20.18345, 16.77894, 24.69623, 42.76902, 24.19028, 46.34581, 33.65523, 39.8511, 49.93229, 27.26726, 20.37747, 9.91662, 21.91005, 20.38083, 6.67903, 14.15296, 25.50375, 34.86247, 38.37856, 25.88564, 36.3928, 6.03336, 45.61486, 42.05233, 46.65152, 34.17373, 43.1465, 34.56091, 10.91356, 13.77181, 37.98149, 22.28941, 39.84028]
[...]
From 0 to 49
Current array:  [0.91096, 1.9634, 2.18727, 2.26167, 2.94409, 3.32985, 4.59003, 5.08661, 5.79055, 7.03564, 7.50666, 11.11774, 11.70602, 11.93162, 13.99276, 16.22299, 16.72143, 18.23906, 19.6473, 21.18124, 21.19037, 22.59205, 22.81542, 28.04074, 28.94537, 29.16499, 29.27404, 30.75663, 30.98768, 31.64901, 33.64744, 34.70245, 38.29071, 38.50242, 39.03372, 39.20532, 39.63019, 39.7825, 39.97108, 40.37296, 41.2645, 41.71303, 42.87429, 44.72793, 45.64394, 47.04545, 47.09475, 48.86326, 49.1464, 49.61727]
-------------------------------------------
Sorted Array:   [0.91096, 1.9634, 2.18727, 2.26167, 2.94409, 3.32985, 4.59003, 5.08661, 5.79055, 7.03564, 7.50666, 11.11774, 11.70602, 11.93162, 13.99276, 16.22299, 16.72143, 18.23906, 19.6473, 21.18124, 21.19037, 22.59205, 22.81542, 28.04074, 28.94537, 29.16499, 29.27404, 30.75663, 30.98768, 31.64901, 33.64744, 34.70245, 38.29071, 38.50242, 39.03372, 39.20532, 39.63019, 39.7825, 39.97108, 40.37296, 41.2645, 41.71303, 42.87429, 44.72793, 45.64394, 47.04545, 47.09475, 48.86326, 49.1464, 49.61727]
```

Lệnh R	Lệnh I	Lệnh J	IC
10133	30295	3441	43896

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43896}{3.4 * 10^9} = 1.291 * 10^{-5} \ (s)$$

Testcase 4: Range [0,50]

```
Testcase 4: [47.35274, 20.96511, 36.11337, 35.21949, 49.24212, 40.80097, 7.16648, 0.51045, 21.32688, 44.83189, 31.83069, 19.2043, 47.56273, 26.52431, 26.09275, 21.9057, 16.34736, 20.35512, 20.21503, 36.20446, 21.5167, 15.11288, 22.06566, 7.80171, 25.01642, 42.46622, 37.89431, 5.89674, 24.83084, 36.7083, 38.69827, 29.04027, 34.01683, 39.61975, 43.60407, 25.01532, 38.2817, 49.49998, 6.5682, 38.3801, 10.27585, 20.40269, 14.14534, 35.52045, 30.8295, 23.92683, 39.38022, 32.37546, 29.45457, 34.01524]
Expected Result: [0.51045, 5.89674, 6.5682, 7.16648, 7.80171, 10.27585, 14.14534, 15.11288, 16.34736, 19.2043, 20.21503, 20.35512, 20.40269, 20.96511, 21.32688, 21.5167, 21.9057, 22.06566, 23.92683, 24.83084, 25.01532, 25.01642, 26.09275, 26.52431, 29.04027, 29.45457, 30.8295, 31.83069, 32.37546, 34.01524, 34.01683, 35.21949, 35.52045, 36.11337, 36.20446, 36.7083, 37.89431, 38.2817, 38.3801, 38.69827, 39.38022, 39.61975, 40.80097, 42.46622, 43.60407, 44.83189, 47.35274, 47.56273, 49.24212, 49.49998]
Got:
Unsorted Array: [47.35274, 20.96511, 36.11337, 35.21949, 49.24212, 40.80097, 7.16648, 0.51045, 21.32688, 44.83189, 31.83069, 19.2043, 47.56273, 26.52431, 26.09275, 21.9057, 16.34736, 20.35512, 20.21503, 36.20446, 21.5167, 15.11288, 22.06566, 7.80171, 25.01642, 42.46622, 37.89431, 5.89674, 24.83084, 36.7083, 38.69827, 29.04027, 34.01683, 39.61975, 43.60407, 25.01532, 38.2817, 49.49998, 6.5682, 38.3801, 10.27585, 20.40269, 14.14534, 35.52045, 30.8295, 23.92683, 39.38022, 32.37546, 29.45457, 34.01524]
---------------------------------------------

From 0 to 1
Current array:  [20.96511, 47.35274, 36.11337, 35.21949, 49.24212, 40.80097, 7.16648, 0.51045, 21.32688, 44.83189, 31.83069, 19.2043, 47.56273, 26.52431, 26.09275, 21.9057, 16.34736, 20.35512, 20.21503, 36.20446, 21.5167, 15.11288, 22.06566, 7.80171, 25.01642, 42.46622, 37.89431, 5.89674, 24.83084, 36.7083, 38.69827, 29.04027, 34.01683, 39.61975, 43.60407, 25.01532, 38.2817, 49.49998, 6.5682, 38.3801, 10.27585, 20.40269, 14.14534, 35.52045, 30.8295, 23.92683, 39.38022, 32.37546, 29.45457, 34.01524]

From 2 to 3
Current array:  [20.96511, 47.35274, 35.21949, 36.11337, 49.24212, 40.80097, 7.16648, 0.51045, 21.32688, 44.83189, 31.83069, 19.2043, 47.56273, 26.52431, 26.09275, 21.9057, 16.34736, 20.35512, 20.21503, 36.20446, 21.5167, 15.11288, 22.06566, 7.80171, 25.01642, 42.46622, 37.89431, 5.89674, 24.83084, 36.7083, 38.69827, 29.04027, 34.01683, 39.61975, 43.60407, 25.01532, 38.2817, 49.49998, 6.5682, 38.3801, 10.27585, 20.40269, 14.14534, 35.52045, 30.8295, 23.92683, 39.38022, 32.37546, 29.45457, 34.01524]
[...]
From 0 to 49
Current array:  [0.51045, 5.89674, 6.5682, 7.16648, 7.80171, 10.27585, 14.14534, 15.11288, 16.34736, 19.2043, 20.21503, 20.35512, 20.40269, 20.96511, 21.32688, 21.5167, 21.9057, 22.06566, 23.92683, 24.83084, 25.01532, 25.01642, 26.09275, 26.52431, 29.04027, 29.45457, 30.8295, 31.83069, 32.37546, 34.01524, 34.01683, 35.21949, 35.52045, 36.11337, 36.20446, 36.7083, 37.89431, 38.2817, 38.3801, 38.69827, 39.38022, 39.61975, 40.80097, 42.46622, 43.60407, 44.83189, 47.35274, 47.56273, 49.24212, 49.49998]
---------------------------------------------
Sorted Array:   [0.51045, 5.89674, 6.5682, 7.16648, 7.80171, 10.27585, 14.14534, 15.11288, 16.34736, 19.2043, 20.21503, 20.35512, 20.40269, 20.96511, 21.32688, 21.5167, 21.9057, 22.06566, 23.92683, 24.83084, 25.01532, 25.01642, 26.09275, 26.52431, 29.04027, 29.45457, 30.8295, 31.83069, 32.37546, 34.01524, 34.01683, 35.21949, 35.52045, 36.11337, 36.20446, 36.7083, 37.89431, 38.2817, 38.3801, 38.69827, 39.38022, 39.61975, 40.80097, 42.46622, 43.60407, 44.83189, 47.35274, 47.56273, 49.24212, 49.49998]
```

Lệnh R	Lệnh I	Lệnh J	IC
10135	30306	3433	43874

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43874}{3.4 * 10^9} = 1.290 * 10^{-5} \ (s)$$

Testcase 5: Range [0,50]

```
Testcase 5: [48.5766, 9.57959, 37.55198, 40.09039, 27.38069, 21.60299, 15.52209, 47.07426, 0.0838, 6.36298, 13.67122, 30.87243, 29.9525, 26.04363, 46.84559, 19.86617, 32.97964, 23.87946, 23.40043, 27.97693, 10.16293, 33.49739, 5.91454, 39.59695, 19.14496, 39.57212, 47.21317, 47.45831, 0.77521, 35.29028, 20.95546, 32.5285, 47.13668, 28.92012, 31.56447, 21.20507, 6.08905, 29.15422, 40.9019, 24.54896, 29.39174, 8.44068, 31.21645, 41.69891, 8.42231, 7.19608, 39.58397, 17.09455, 4.09895, 39.02363]
Expected Result: [0.0838, 0.77521, 4.09895, 5.91454, 6.08905, 6.36298, 7.19608, 8.42231, 8.44068, 9.57959, 10.16293, 13.67122, 15.52209, 17.09455, 19.14496, 19.86617, 20.95546, 21.20507, 21.60299, 23.40043, 23.87946, 24.54896, 26.04363, 27.38069, 27.97693, 28.92012, 29.15422, 29.39174, 29.9525, 30.87243, 31.21645, 31.56447, 32.5285, 32.97964, 33.49739, 35.29028, 37.55198, 39.02363, 39.57212, 39.58397, 39.59695, 40.09039, 40.9019, 41.69891, 46.84559, 47.07426, 47.13668, 47.21317, 47.45831, 48.5766]
Got:
Unsorted Array: [48.5766, 9.57959, 37.55198, 40.09039, 27.38069, 21.60299, 15.52209, 47.07426, 0.0838, 6.36298, 13.67122, 30.87243, 29.9525, 26.04363, 46.84559, 19.86617, 32.97964, 23.87946, 23.40043, 27.97693, 10.16293, 33.49739, 5.91454, 39.59695, 19.14496, 39.57212, 47.21317, 47.45831, 0.77521, 35.29028, 20.95546, 32.5285, 47.13668, 28.92012, 31.56447, 21.20507, 6.08905, 29.15422, 40.9019, 24.54896, 29.39174, 8.44068, 31.21645, 41.69891, 8.42231, 7.19608, 39.58397, 17.09455, 4.09895, 39.02363]
-------------------------------------------
From 0 to 1
Current array:  [9.57959, 48.5766, 37.55198, 40.09039, 27.38069, 21.60299, 15.52209, 47.07426, 0.0838, 6.36298, 13.67122, 30.87243, 29.9525, 26.04363, 46.84559, 19.86617, 32.97964, 23.87946, 23.40043, 27.97693, 10.16293, 33.49739, 5.91454, 39.59695, 19.14496, 39.57212, 47.21317, 47.45831, 0.77521, 35.29028, 20.95546, 32.5285, 47.13668, 28.92012, 31.56447, 21.20507, 6.08905, 29.15422, 40.9019, 24.54896, 29.39174, 8.44068, 31.21645, 41.69891, 8.42231, 7.19608, 39.58397, 17.09455, 4.09895, 39.02363]
From 2 to 3
Current array:  [9.57959, 48.5766, 37.55198, 40.09039, 27.38069, 21.60299, 15.52209, 47.07426, 0.0838, 6.36298, 13.67122, 30.87243, 29.9525, 26.04363, 46.84559, 19.86617, 32.97964, 23.87946, 23.40043, 27.97693, 10.16293, 33.49739, 5.91454, 39.59695, 19.14496, 39.57212, 47.21317, 47.45831, 0.77521, 35.29028, 20.95546, 32.5285, 47.13668, 28.92012, 31.56447, 21.20507, 6.08905, 29.15422, 40.9019, 24.54896, 29.39174, 8.44068, 31.21645, 41.69891, 8.42231, 7.19608, 39.58397, 17.09455, 4.09895, 39.02363]
[...]
From 0 to 49
Current array:  [0.0838, 0.77521, 4.09895, 5.91454, 6.08905, 6.36298, 7.19608, 8.42231, 8.44068, 9.57959, 10.16293, 13.67122, 15.52209, 17.09455, 19.14496, 19.86617, 20.95546, 21.20507, 21.60299, 23.40043, 23.87946, 24.54896, 26.04363, 27.38069, 27.97693, 28.92012, 29.15422, 29.39174, 29.9525, 30.87243, 31.21645, 31.56447, 32.5285, 32.97964, 33.49739, 35.29028, 37.55198, 39.02363, 39.57212, 39.58397, 39.59695, 40.09039, 40.9019, 41.69891, 46.84559, 47.07426, 47.13668, 47.21317, 47.45831, 48.5766]
-------------------------------------------
Sorted Array:   [0.0838, 0.77521, 4.09895, 5.91454, 6.08905, 6.36298, 7.19608, 8.42231, 8.44068, 9.57959, 10.16293, 13.67122, 15.52209, 17.09455, 19.14496, 19.86617, 20.95546, 21.20507, 21.60299, 23.40043, 23.87946, 24.54896, 26.04363, 27.38069, 27.97693, 28.92012, 29.15422, 29.39174, 29.9525, 30.87243, 31.21645, 31.56447, 32.5285, 32.97964, 33.49739, 35.29028, 37.55198, 39.02363, 39.57212, 39.58397, 39.59695, 40.09039, 40.9019, 41.69891, 46.84559, 47.07426, 47.13668, 47.21317, 47.45831, 48.5766]
```

Lệnh R	Lệnh I	Lệnh J	IC
10137	30320	3426	43883

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43883}{3.4 * 10^9} = 1.291 * 10^{-5} \ (s)$$

Testcase 6: Range [-50,50]

```
Testcase 6: [0.1801, -19.69797, 2.2505, 9.74237, 45.51398, -5.05004, 40.05896, 7.33191,
↪  -6.53971, -19.42939, -2.3284, 0.81955, 41.4408, -49.94342, -11.06674, 38.89954,
↪  47.75531, -21.68667, -32.66299, 14.49391, 15.13531, -30.7437, -0.98071, 1.03548,
↪  30.85876, 5.81442, -32.91468, -47.41518, -3.66882, -15.30999, -19.81223, 6.60616,
↪  -17.0274, -33.00275, 4.32444, 13.58604, 13.52292, 40.1278, -39.04982, -44.47601,
↪  34.94582, 36.48551, 30.01589, -24.72845, -2.91659, -15.14369, -13.357, 37.6937,
↪  15.99343, 1.03108]
Expected Result: [-49.94342, -47.41518, -44.47601, -39.04982, -33.00275, -32.91468,
↪  -32.66299, -30.7437, -24.72845, -21.68667, -19.81223, -19.69797, -19.42939, -17.0274,
↪  -15.30999, -15.14369, -13.357, -11.06674, -6.53971, -5.05004, -3.66882, -2.91659,
↪  -2.3284, -0.98071, 0.1801, 0.81955, 1.03108, 1.03548, 2.2505, 4.32444, 5.81442,
↪  6.60616, 7.33191, 9.74237, 13.52292, 13.58604, 14.49391, 15.13531, 15.99343, 30.01589,
↪  30.85876, 34.94582, 36.48551, 37.6937, 38.89954, 40.05896, 40.1278, 41.4408, 45.51398,
↪  47.75531]
Got:
Unsorted Array: [0.1801, -19.69797, 2.2505, 9.74237, 45.51398, -5.05004, 40.05896, 7.33191,
↪  -6.53971, -19.42939, -2.3284, 0.81955, 41.4408, -49.94342, -11.06674, 38.89954,
↪  47.75531, -21.68667, -32.66299, 14.49391, 15.13531, -30.7437, -0.98071, 1.03548,
↪  30.85876, 5.81442, -32.91468, -47.41518, -3.66882, -15.30999, -19.81223, 6.60616,
↪  -17.0274, -33.00275, 4.32444, 13.58604, 13.52292, 40.1278, -39.04982, -44.47601,
↪  34.94582, 36.48551, 30.01589, -24.72845, -2.91659, -15.14369, -13.357, 37.6937,
↪  15.99343, 1.03108]
-------------------------------------------
From 0 to 1
Current array:  [-19.69797, 0.1801, 2.2505, 9.74237, 45.51398, -5.05004, 40.05896, 7.33191,
↪  -6.53971, -19.42939, -2.3284, 0.81955, 41.4408, -49.94342, -11.06674, 38.89954,
↪  47.75531, -21.68667, -32.66299, 14.49391, 15.13531, -30.7437, -0.98071, 1.03548,
↪  30.85876, 5.81442, -32.91468, -47.41518, -3.66882, -15.30999, -19.81223, 6.60616,
↪  -17.0274, -33.00275, 4.32444, 13.58604, 13.52292, 40.1278, -39.04982, -44.47601,
↪  34.94582, 36.48551, 30.01589, -24.72845, -2.91659, -15.14369, -13.357, 37.6937,
↪  15.99343, 1.03108]
From 2 to 3
Current array:  [-19.69797, 0.1801, 2.2505, 9.74237, 45.51398, -5.05004, 40.05896, 7.33191,
↪  -6.53971, -19.42939, -2.3284, 0.81955, 41.4408, -49.94342, -11.06674, 38.89954,
↪  47.75531, -21.68667, -32.66299, 14.49391, 15.13531, -30.7437, -0.98071, 1.03548,
↪  30.85876, 5.81442, -32.91468, -47.41518, -3.66882, -15.30999, -19.81223, 6.60616,
↪  -17.0274, -33.00275, 4.32444, 13.58604, 13.52292, 40.1278, -39.04982, -44.47601,
↪  34.94582, 36.48551, 30.01589, -24.72845, -2.91659, -15.14369, -13.357, 37.6937,
↪  15.99343, 1.03108]
[...]
From 0 to 49
Current array:  [-49.94342, -47.41518, -44.47601, -39.04982, -33.00275, -32.91468,
↪  -32.66299, -30.7437, -24.72845, -21.68667, -19.81223, -19.69797, -19.42939, -17.0274,
↪  -15.30999, -15.14369, -13.357, -11.06674, -6.53971, -5.05004, -3.66882, -2.91659,
↪  -2.3284, -0.98071, 0.1801, 0.81955, 1.03108, 1.03548, 2.2505, 4.32444, 5.81442,
↪  6.60616, 7.33191, 9.74237, 13.52292, 13.58604, 14.49391, 15.13531, 15.99343, 30.01589,
↪  30.85876, 34.94582, 36.48551, 37.6937, 38.89954, 40.05896, 40.1278, 41.4408, 45.51398,
↪  47.75531]
-------------------------------------------
Sorted Array:   [-49.94342, -47.41518, -44.47601, -39.04982, -33.00275, -32.91468,
↪  -32.66299, -30.7437, -24.72845, -21.68667, -19.81223, -19.69797, -19.42939, -17.0274,
↪  -15.30999, -15.14369, -13.357, -11.06674, -6.53971, -5.05004, -3.66882, -2.91659,
↪  -2.3284, -0.98071, 0.1801, 0.81955, 1.03108, 1.03548, 2.2505, 4.32444, 5.81442,
↪  6.60616, 7.33191, 9.74237, 13.52292, 13.58604, 14.49391, 15.13531, 15.99343, 30.01589,
↪  30.85876, 34.94582, 36.48551, 37.6937, 38.89954, 40.05896, 40.1278, 41.4408, 45.51398,
↪  47.75531]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30300	3442	43876

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43876}{3.4 * 10^9} = 1.290 * 10^{-5} \ (s)$$

Testcase 7: Range [-50,50]

```
Testcase 7: [-40.44804, 25.71607, 18.16486, 21.78897, -14.51953, 44.53007, 21.01126,
↪  -25.56119, -9.615, -28.14137, 0.51476, 33.26727, 16.45855, -17.5741, -33.56368, 4.7977,
↪  -46.19637, 49.70528, -49.86714, 28.45928, 30.7908, 24.14811, -14.42392, -6.81544,
↪  -34.08756, 27.64191, 45.65396, 36.85757, -8.45132, -25.22858, 21.32218, -14.3264,
↪  -6.24478, -16.96269, 32.25121, -20.19697, 22.65542, 29.50256, 15.66246, -35.73621,
↪  -4.9693, 17.31065, 0.86704, 4.9185, -24.81432, -25.15511, -15.46138, 31.40912,
↪  -17.58271, 27.26863]
Expected Result: [-49.86714, -46.19637, -40.44804, -35.73621, -34.08756, -33.56368,
↪  -28.14137, -25.56119, -25.22858, -25.15511, -24.81432, -20.19697, -17.58271, -17.5741,
↪  -16.96269, -15.46138, -14.51953, -14.42392, -14.3264, -9.615, -8.45132, -6.81544,
↪  -6.24478, -4.9693, 0.51476, 0.86704, 4.7977, 4.9185, 15.66246, 16.45855, 17.31065,
↪  18.16486, 21.01126, 21.32218, 21.78897, 22.65542, 24.14811, 25.71607, 27.26863,
↪  27.64191, 28.45928, 29.50256, 30.7908, 31.40912, 32.25121, 33.26727, 36.85757,
↪  44.53007, 45.65396, 49.70528]
Got:
Unsorted Array: [-40.44804, 25.71607, 18.16486, 21.78897, -14.51953, 44.53007, 21.01126,
↪  -25.56119, -9.615, -28.14137, 0.51476, 33.26727, 16.45855, -17.5741, -33.56368, 4.7977,
↪  -46.19637, 49.70528, -49.86714, 28.45928, 30.7908, 24.14811, -14.42392, -6.81544,
↪  -34.08756, 27.64191, 45.65396, 36.85757, -8.45132, -25.22858, 21.32218, -14.3264,
↪  -6.24478, -16.96269, 32.25121, -20.19697, 22.65542, 29.50256, 15.66246, -35.73621,
↪  -4.9693, 17.31065, 0.86704, 4.9185, -24.81432, -25.15511, -15.46138, 31.40912,
↪  -17.58271, 27.26863]
-------------------------------------------
From 0 to 1
Current array:  [-40.44804, 25.71607, 18.16486, 21.78897, -14.51953, 44.53007, 21.01126,
↪  -25.56119, -9.615, -28.14137, 0.51476, 33.26727, 16.45855, -17.5741, -33.56368, 4.7977,
↪  -46.19637, 49.70528, -49.86714, 28.45928, 30.7908, 24.14811, -14.42392, -6.81544,
↪  -34.08756, 27.64191, 45.65396, 36.85757, -8.45132, -25.22858, 21.32218, -14.3264,
↪  -6.24478, -16.96269, 32.25121, -20.19697, 22.65542, 29.50256, 15.66246, -35.73621,
↪  -4.9693, 17.31065, 0.86704, 4.9185, -24.81432, -25.15511, -15.46138, 31.40912,
↪  -17.58271, 27.26863]
From 2 to 3
Current array:  [-40.44804, 25.71607, 18.16486, 21.78897, -14.51953, 44.53007, 21.01126,
↪  -25.56119, -9.615, -28.14137, 0.51476, 33.26727, 16.45855, -17.5741, -33.56368, 4.7977,
↪  -46.19637, 49.70528, -49.86714, 28.45928, 30.7908, 24.14811, -14.42392, -6.81544,
↪  -34.08756, 27.64191, 45.65396, 36.85757, -8.45132, -25.22858, 21.32218, -14.3264,
↪  -6.24478, -16.96269, 32.25121, -20.19697, 22.65542, 29.50256, 15.66246, -35.73621,
↪  -4.9693, 17.31065, 0.86704, 4.9185, -24.81432, -25.15511, -15.46138, 31.40912,
↪  -17.58271, 27.26863]
[...]
From 0 to 49
Current array:  [-49.86714, -46.19637, -40.44804, -35.73621, -34.08756, -33.56368,
↪  -28.14137, -25.56119, -25.22858, -25.15511, -24.81432, -20.19697, -17.58271, -17.5741,
↪  -16.96269, -15.46138, -14.51953, -14.42392, -14.3264, -9.615, -8.45132, -6.81544,
↪  -6.24478, -4.9693, 0.51476, 0.86704, 4.7977, 4.9185, 15.66246, 16.45855, 17.31065,
↪  18.16486, 21.01126, 21.32218, 21.78897, 22.65542, 24.14811, 25.71607, 27.26863,
↪  27.64191, 28.45928, 29.50256, 30.7908, 31.40912, 32.25121, 33.26727, 36.85757,
↪  44.53007, 45.65396, 49.70528]
-------------------------------------------
Sorted Array:   [-49.86714, -46.19637, -40.44804, -35.73621, -34.08756, -33.56368,
↪  -28.14137, -25.56119, -25.22858, -25.15511, -24.81432, -20.19697, -17.58271, -17.5741,
↪  -16.96269, -15.46138, -14.51953, -14.42392, -14.3264, -9.615, -8.45132, -6.81544,
↪  -6.24478, -4.9693, 0.51476, 0.86704, 4.7977, 4.9185, 15.66246, 16.45855, 17.31065,
↪  18.16486, 21.01126, 21.32218, 21.78897, 22.65542, 24.14811, 25.71607, 27.26863,
↪  27.64191, 28.45928, 29.50256, 30.7908, 31.40912, 32.25121, 33.26727, 36.85757,
↪  44.53007, 45.65396, 49.70528]
```

Lệnh R	Lệnh I	Lệnh J	IC
10135	30306	3436	43877

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43877}{3.4 * 10^9} = 1.2905 * 10^{-5} \ (s)$$

Testcase 8: Range [-50,50]

```
Testcase 8: [46.98688, -20.25828, 33.05556, -4.84202, -12.18453, 21.08121, 8.15939,
↪  49.51578, -32.41025, -32.19701, -17.7702, -2.86966, -22.0768, 6.51807, 23.34824,
↪  0.80818, -30.79809, 21.351, -21.60488, 26.07436, 19.41652, 4.22784, 43.12045, 39.50863,
↪  39.52737, -26.28795, -14.52635, -16.69035, -49.20338, 13.97164, 11.96652, 11.12781,
↪  8.32978, 26.36627, 41.68024, 16.05277, 33.32804, -34.37927, -38.89082, -13.21826,
↪  -40.18547, -20.05729, -39.04126, -24.26115, 41.7843, -33.85369, -3.26534, 48.13866,
↪  38.57494, -40.6303]
Expected Result: [-49.20338, -40.6303, -40.18547, -39.04126, -38.89082, -34.37927,
↪  -33.85369, -32.41025, -32.19701, -30.79809, -26.28795, -24.26115, -22.0768, -21.60488,
↪  -20.25828, -20.05729, -17.7702, -16.69035, -14.52635, -13.21826, -12.18453, -4.84202,
↪  -3.26534, -2.86966, 0.80818, 4.22784, 6.51807, 8.15939, 8.32978, 11.12781, 11.96652,
↪  13.97164, 16.05277, 19.41652, 21.08121, 21.351, 23.34824, 26.07436, 26.36627, 33.05556,
↪  33.32804, 38.57494, 39.50863, 39.52737, 41.68024, 41.7843, 43.12045, 46.98688,
↪  48.13866, 49.51578]
Got:
Unsorted Array: [46.98688, -20.25828, 33.05556, -4.84202, -12.18453, 21.08121, 8.15939,
↪  49.51578, -32.41025, -32.19701, -17.7702, -2.86966, -22.0768, 6.51807, 23.34824,
↪  0.80818, -30.79809, 21.351, -21.60488, 26.07436, 19.41652, 4.22784, 43.12045, 39.50863,
↪  39.52737, -26.28795, -14.52635, -16.69035, -49.20338, 13.97164, 11.96652, 11.12781,
↪  8.32978, 26.36627, 41.68024, 16.05277, 33.32804, -34.37927, -38.89082, -13.21826,
↪  -40.18547, -20.05729, -39.04126, -24.26115, 41.7843, -33.85369, -3.26534, 48.13866,
↪  38.57494, -40.6303]
-----------------------------------------------
From 0 to 1
Current array:  [-20.25828, 46.98688, 33.05556, -4.84202, -12.18453, 21.08121, 8.15939,
↪  49.51578, -32.41025, -32.19701, -17.7702, -2.86966, -22.0768, 6.51807, 23.34824,
↪  0.80818, -30.79809, 21.351, -21.60488, 26.07436, 19.41652, 4.22784, 43.12045, 39.50863,
↪  39.52737, -26.28795, -14.52635, -16.69035, -49.20338, 13.97164, 11.96652, 11.12781,
↪  8.32978, 26.36627, 41.68024, 16.05277, 33.32804, -34.37927, -38.89082, -13.21826,
↪  -40.18547, -20.05729, -39.04126, -24.26115, 41.7843, -33.85369, -3.26534, 48.13866,
↪  38.57494, -40.6303]
From 2 to 3
Current array:  [-20.25828, 46.98688, -4.84202, 33.05556, -12.18453, 21.08121, 8.15939,
↪  49.51578, -32.41025, -32.19701, -17.7702, -2.86966, -22.0768, 6.51807, 23.34824,
↪  0.80818, -30.79809, 21.351, -21.60488, 26.07436, 19.41652, 4.22784, 43.12045, 39.50863,
↪  39.52737, -26.28795, -14.52635, -16.69035, -49.20338, 13.97164, 11.96652, 11.12781,
↪  8.32978, 26.36627, 41.68024, 16.05277, 33.32804, -34.37927, -38.89082, -13.21826,
↪  -40.18547, -20.05729, -39.04126, -24.26115, 41.7843, -33.85369, -3.26534, 48.13866,
↪  38.57494, -40.6303]
[...]
From 0 to 49
Current array:  [-49.20338, -40.6303, -40.18547, -39.04126, -38.89082, -34.37927,
↪  -33.85369, -32.41025, -32.19701, -30.79809, -26.28795, -24.26115, -22.0768, -21.60488,
↪  -20.25828, -20.05729, -17.7702, -16.69035, -14.52635, -13.21826, -12.18453, -4.84202,
↪  -3.26534, -2.86966, 0.80818, 4.22784, 6.51807, 8.15939, 8.32978, 11.12781, 11.96652,
↪  13.97164, 16.05277, 19.41652, 21.08121, 21.351, 23.34824, 26.07436, 26.36627, 33.05556,
↪  33.32804, 38.57494, 39.50863, 39.52737, 41.68024, 41.7843, 43.12045, 46.98688,
↪  48.13866, 49.51578]
-----------------------------------------------
```

```
Sorted Array:   [-49.20338, -40.6303, -40.18547, -39.04126, -38.89082, -34.37927,
↪  -33.85369, -32.41025, -32.19701, -30.79809, -26.28795, -24.26115, -22.0768, -21.60488,
↪  -20.25828, -20.05729, -17.7702, -16.69035, -14.52635, -13.21826, -12.18453, -4.84202,
↪  -3.26534, -2.86966, 0.80818, 4.22784, 6.51807, 8.15939, 8.32978, 11.12781, 11.96652,
↪  13.97164, 16.05277, 19.41652, 21.08121, 21.351, 23.34824, 26.07436, 26.36627, 33.05556,
↪  33.32804, 38.57494, 39.50863, 39.52737, 41.68024, 41.7843, 43.12045, 46.98688,
↪  48.13866, 49.51578]
```

Lệnh R	Lệnh I	Lệnh J	IC
10127	30287	3433	43847

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43847}{3.4 * 10^9} = 1.2896 * 10^{-5} \ (s)$$

Testcase 9: Range [-50,50]

```
Testcase 9: [-41.93716, -8.5489, -3.18179, -22.70396, -19.39443, -42.72603, -23.46731,
↪  -23.1853, -31.89708, -38.50798, 13.67324, 7.27045, 18.03106, -49.67424, -20.04777,
↪  -28.74329, -36.5256, 39.98871, 0.47537, -45.14297, 17.46003, 42.43598, -15.77505,
↪  40.41755, -25.57807, -4.37862, 2.09586, 34.28066, -29.21475, -14.46113, 29.38167,
↪  29.19058, -19.65351, 40.22905, 41.36976, -47.0984, -13.74685, -31.16495, 34.24306,
↪  2.21679, -11.57785, -41.54224, 47.89523, 17.94894, -29.08015, -0.35139, -48.79384,
↪  46.20338, -42.55179, 36.5557]
Expected Result: [-49.67424, -48.79384, -47.0984, -45.14297, -42.72603, -42.55179,
↪  -41.93716, -41.54224, -38.50798, -36.5256, -31.89708, -31.16495, -29.21475, -29.08015,
↪  -28.74329, -25.57807, -23.46731, -23.1853, -22.70396, -20.04777, -19.65351, -19.39443,
↪  -15.77505, -14.46113, -13.74685, -11.57785, -8.5489, -4.37862, -3.18179, -0.35139,
↪  0.47537, 2.09586, 2.21679, 7.27045, 13.67324, 17.46003, 17.94894, 18.03106, 29.19058,
↪  29.38167, 34.24306, 34.28066, 36.5557, 39.98871, 40.22905, 40.41755, 41.36976,
↪  42.43598, 46.20338, 47.89523]
Got:
Unsorted Array: [-41.93716, -8.5489, -3.18179, -22.70396, -19.39443, -42.72603, -23.46731,
↪  -23.1853, -31.89708, -38.50798, 13.67324, 7.27045, 18.03106, -49.67424, -20.04777,
↪  -28.74329, -36.5256, 39.98871, 0.47537, -45.14297, 17.46003, 42.43598, -15.77505,
↪  40.41755, -25.57807, -4.37862, 2.09586, 34.28066, -29.21475, -14.46113, 29.38167,
↪  29.19058, -19.65351, 40.22905, 41.36976, -47.0984, -13.74685, -31.16495, 34.24306,
↪  2.21679, -11.57785, -41.54224, 47.89523, 17.94894, -29.08015, -0.35139, -48.79384,
↪  46.20338, -42.55179, 36.5557]
---------------------------------------------
From 0 to 1
Current array:  [-41.93716, -8.5489, -3.18179, -22.70396, -19.39443, -42.72603, -23.46731,
↪  -23.1853, -31.89708, -38.50798, 13.67324, 7.27045, 18.03106, -49.67424, -20.04777,
↪  -28.74329, -36.5256, 39.98871, 0.47537, -45.14297, 17.46003, 42.43598, -15.77505,
↪  40.41755, -25.57807, -4.37862, 2.09586, 34.28066, -29.21475, -14.46113, 29.38167,
↪  29.19058, -19.65351, 40.22905, 41.36976, -47.0984, -13.74685, -31.16495, 34.24306,
↪  2.21679, -11.57785, -41.54224, 47.89523, 17.94894, -29.08015, -0.35139, -48.79384,
↪  46.20338, -42.55179, 36.5557]
From 2 to 3
Current array:  [-41.93716, -8.5489, -22.70396, -3.18179, -19.39443, -42.72603, -23.46731,
↪  -23.1853, -31.89708, -38.50798, 13.67324, 7.27045, 18.03106, -49.67424, -20.04777,
↪  -28.74329, -36.5256, 39.98871, 0.47537, -45.14297, 17.46003, 42.43598, -15.77505,
↪  40.41755, -25.57807, -4.37862, 2.09586, 34.28066, -29.21475, -14.46113, 29.38167,
↪  29.19058, -19.65351, 40.22905, 41.36976, -47.0984, -13.74685, -31.16495, 34.24306,
↪  2.21679, -11.57785, -41.54224, 47.89523, 17.94894, -29.08015, -0.35139, -48.79384,
↪  46.20338, -42.55179, 36.5557]
[...]
From 0 to 49
```

```
Current array:  [-49.67424, -48.79384, -47.0984, -45.14297, -42.72603, -42.55179,
↪  -41.93716, -41.54224, -38.50798, -36.5256, -31.89708, -31.16495, -29.21475, -29.08015,
↪  -28.74329, -25.57807, -23.46731, -23.1853, -22.70396, -20.04777, -19.65351, -19.39443,
↪  -15.77505, -14.46113, -13.74685, -11.57785, -8.5489, -4.37862, -3.18179, -0.35139,
↪  0.47537, 2.09586, 2.21679, 7.27045, 13.67324, 17.46003, 17.94894, 18.03106, 29.19058,
↪  29.38167, 34.24306, 34.28066, 36.5557, 39.98871, 40.22905, 40.41755, 41.36976,
↪  42.43598, 46.20338, 47.89523]
---------------------------------------------
Sorted Array:   [-49.67424, -48.79384, -47.0984, -45.14297, -42.72603, -42.55179,
↪  -41.93716, -41.54224, -38.50798, -36.5256, -31.89708, -31.16495, -29.21475, -29.08015,
↪  -28.74329, -25.57807, -23.46731, -23.1853, -22.70396, -20.04777, -19.65351, -19.39443,
↪  -15.77505, -14.46113, -13.74685, -11.57785, -8.5489, -4.37862, -3.18179, -0.35139,
↪  0.47537, 2.09586, 2.21679, 7.27045, 13.67324, 17.46003, 17.94894, 18.03106, 29.19058,
↪  29.38167, 34.24306, 34.28066, 36.5557, 39.98871, 40.22905, 40.41755, 41.36976,
↪  42.43598, 46.20338, 47.89523]
```

Lệnh R	Lệnh I	Lệnh J	IC
10132	30293	3445	43870

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43870}{3.4 * 10^9} = 1.2903 * 10^{-5} \ \ (s)$$

Testcase 10: Range [-50,50]

```
Testcase 10: [24.89025, 45.61226, 36.54196, -46.15081, -23.65792, -49.98396, -10.54817,
↪  -5.28814, -39.50416, 9.29145, 8.05867, 43.42098, -18.08428, -39.82083, 13.20435,
↪  -31.06564, -0.36839, 22.99332, 22.13227, -21.53975, 3.7588, -43.85042, 26.24412,
↪  22.0212, 46.38457, -25.57836, -17.51452, 27.73021, -7.996, -8.40525, -48.25501,
↪  11.2031, 7.07243, 34.3143, 37.40999, 10.17314, -24.91575, -19.18957, -43.24097,
↪  -29.30607, -18.41471, -47.53467, -40.79804, 22.98686, 21.21904, 35.71936, -6.78829,
↪  41.91102, -9.69971, -25.20931]
Expected Result: [-49.98396, -48.25501, -47.53467, -46.15081, -43.85042, -43.24097,
↪  -40.79804, -39.82083, -39.50416, -31.06564, -29.30607, -25.57836, -25.20931, -24.91575,
↪  -23.65792, -21.53975, -19.18957, -18.41471, -18.08428, -17.51452, -10.54817, -9.69971,
↪  -8.40525, -7.996, -6.78829, -5.28814, -0.36839, 3.7588, 7.07243, 8.05867, 9.29145,
↪  10.17314, 11.2031, 13.20435, 21.21904, 22.0212, 22.13227, 22.98686, 22.99332, 24.89025,
↪  26.24412, 27.73021, 34.3143, 35.71936, 36.54196, 37.40999, 41.91102, 43.42098,
↪  45.61226, 46.38457]
Got:
Unsorted Array: [24.89025, 45.61226, 36.54196, -46.15081, -23.65792, -49.98396, -10.54817,
↪  -5.28814, -39.50416, 9.29145, 8.05867, 43.42098, -18.08428, -39.82083, 13.20435,
↪  -31.06564, -0.36839, 22.99332, 22.13227, -21.53975, 3.7588, -43.85042, 26.24412,
↪  22.0212, 46.38457, -25.57836, -17.51452, 27.73021, -7.996, -8.40525, -48.25501,
↪  11.2031, 7.07243, 34.3143, 37.40999, 10.17314, -24.91575, -19.18957, -43.24097,
↪  -29.30607, -18.41471, -47.53467, -40.79804, 22.98686, 21.21904, 35.71936, -6.78829,
↪  41.91102, -9.69971, -25.20931]
---------------------------------------------
From 0 to 1
Current array:  [24.89025, 45.61226, 36.54196, -46.15081, -23.65792, -49.98396, -10.54817,
↪  -5.28814, -39.50416, 9.29145, 8.05867, 43.42098, -18.08428, -39.82083, 13.20435,
↪  -31.06564, -0.36839, 22.99332, 22.13227, -21.53975, 3.7588, -43.85042, 26.24412,
↪  22.0212, 46.38457, -25.57836, -17.51452, 27.73021, -7.996, -8.40525, -48.25501,
↪  11.2031, 7.07243, 34.3143, 37.40999, 10.17314, -24.91575, -19.18957, -43.24097,
↪  -29.30607, -18.41471, -47.53467, -40.79804, 22.98686, 21.21904, 35.71936, -6.78829,
↪  41.91102, -9.69971, -25.20931]
From 2 to 3
```

```
Current array:  [24.89025, 45.61226, -46.15081, 36.54196, -23.65792, -49.98396, -10.54817,
↪  -5.28814, -39.50416, 9.29145, 8.05867, 43.42098, -18.08428, -39.82083, 13.20435,
↪  -31.06564, -0.36839, 22.99332, 22.13227, -21.53975, 3.7588, -43.85042, 26.24412,
↪  22.0212, 46.38457, -25.57836, -17.51452, 27.73021, -7.996, -8.40525, -48.25501,
↪  11.2031, 7.07243, 34.3143, 37.40999, 10.17314, -24.91575, -19.18957, -43.24097,
↪  -29.30607, -18.41471, -47.53467, -40.79804, 22.98686, 21.21904, 35.71936, -6.78829,
↪  41.91102, -9.69971, -25.20931]
[...]
From 0 to 49
Current array:  [-49.98396, -48.25501, -47.53467, -46.15081, -43.85042, -43.24097,
↪  -40.79804, -39.82083, -39.50416, -31.06564, -29.30607, -25.57836, -25.20931, -24.91575,
↪  -23.65792, -21.53975, -19.18957, -18.41471, -18.08428, -17.51452, -10.54817, -9.69971,
↪  -8.40525, -7.996, -6.78829, -5.28814, -0.36839, 3.7588, 7.07243, 8.05867, 9.29145,
↪  10.17314, 11.2031, 13.20435, 21.21904, 22.0212, 22.13227, 22.98686, 22.99332, 24.89025,
↪  26.24412, 27.73021, 34.3143, 35.71936, 36.54196, 37.40999, 41.91102, 43.42098,
↪  45.61226, 46.38457]
---------------------------------------------
Sorted Array:   [-49.98396, -48.25501, -47.53467, -46.15081, -43.85042, -43.24097,
↪  -40.79804, -39.82083, -39.50416, -31.06564, -29.30607, -25.57836, -25.20931, -24.91575,
↪  -23.65792, -21.53975, -19.18957, -18.41471, -18.08428, -17.51452, -10.54817, -9.69971,
↪  -8.40525, -7.996, -6.78829, -5.28814, -0.36839, 3.7588, 7.07243, 8.05867, 9.29145,
↪  10.17314, 11.2031, 13.20435, 21.21904, 22.0212, 22.13227, 22.98686, 22.99332, 24.89025,
↪  26.24412, 27.73021, 34.3143, 35.71936, 36.54196, 37.40999, 41.91102, 43.42098,
↪  45.61226, 46.38457]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30297	3444	43875

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43875}{3.4 * 10^9} = 1.2904 * 10^{-5} \ (s)$$

Testcase 11: Range [-100,100]

```
Testcase 11: [-31.764, 7.624, 97.672, 22.022, -38.224, -53.111, -14.83, 42.254, 58.023,
↪  -57.02, -49.8, -77.213, -38.359, -56.16, -48.874, 37.173, 17.557, 71.101, 24.986,
↪  -55.265, 96.004, -98.394, 9.934, -58.738, -48.882, -0.444, -25.922, 72.384, 40.925,
↪  11.335, -15.967, 6.542, 47.634, -61.965, 88.402, 17.042, -40.282, 55.287, 42.348,
↪  95.112, 45.75, 73.157, 60.509, -75.392, -14.701, 11.851, -18.908, -47.329, 25.041,
↪  86.972]
Expected Result: [-98.394, -77.213, -75.392, -61.965, -58.738, -57.02, -56.16, -55.265,
↪  -53.111, -49.8, -48.882, -48.874, -47.329, -40.282, -38.359, -38.224, -31.764, -25.922,
↪  -18.908, -15.967, -14.83, -14.701, -0.444, 6.542, 7.624, 9.934, 11.335, 11.851, 17.042,
↪  17.557, 22.022, 24.986, 25.041, 37.173, 40.925, 42.254, 42.348, 45.75, 47.634, 55.287,
↪  58.023, 60.509, 71.101, 72.384, 73.157, 86.972, 88.402, 95.112, 96.004, 97.672]
Got:
Unsorted Array: [-31.764, 7.624, 97.672, 22.022, -38.224, -53.111, -14.83, 42.254, 58.023,
↪  -57.02, -49.8, -77.213, -38.359, -56.16, -48.874, 37.173, 17.557, 71.101, 24.986,
↪  -55.265, 96.004, -98.394, 9.934, -58.738, -48.882, -0.444, -25.922, 72.384, 40.925,
↪  11.335, -15.967, 6.542, 47.634, -61.965, 88.402, 17.042, -40.282, 55.287, 42.348,
↪  95.112, 45.75, 73.157, 60.509, -75.392, -14.701, 11.851, -18.908, -47.329, 25.041,
↪  86.972]
---------------------------------------------
From 0 to 1
Current array:  [-31.764, 7.624, 97.672, 22.022, -38.224, -53.111, -14.83, 42.254, 58.023,
↪  -57.02, -49.8, -77.213, -38.359, -56.16, -48.874, 37.173, 17.557, 71.101, 24.986,
↪  -55.265, 96.004, -98.394, 9.934, -58.738, -48.882, -0.444, -25.922, 72.384, 40.925,
↪  11.335, -15.967, 6.542, 47.634, -61.965, 88.402, 17.042, -40.282, 55.287, 42.348,
↪  95.112, 45.75, 73.157, 60.509, -75.392, -14.701, 11.851, -18.908, -47.329, 25.041,
↪  86.972]
From 2 to 3
```

```
Current array:  [-31.764, 7.624, 22.022, 97.672, -38.224, -53.111, -14.83, 42.254, 58.023,
↪  -57.02, -49.8, -77.213, -38.359, -56.16, -48.874, 37.173, 17.557, 71.101, 24.986,
↪  -55.265, 96.004, -98.394, 9.934, -58.738, -48.882, -0.444, -25.922, 72.384, 40.925,
↪  11.335, -15.967, 6.542, 47.634, -61.965, 88.402, 17.042, -40.282, 55.287, 42.348,
↪  95.112, 45.75, 73.157, 60.509, -75.392, -14.701, 11.851, -18.908, -47.329, 25.041,
↪  86.972]
[...]
From 0 to 49
Current array:  [-98.394, -77.213, -75.392, -61.965, -58.738, -57.02, -56.16, -55.265,
↪  -53.111, -49.8, -48.882, -48.874, -47.329, -40.282, -38.359, -38.224, -31.764, -25.922,
↪  -18.908, -15.967, -14.83, -14.701, -0.444, 6.542, 7.624, 9.934, 11.335, 11.851, 17.042,
↪  17.557, 22.022, 24.986, 25.041, 37.173, 40.925, 42.254, 42.348, 45.75, 47.634, 55.287,
↪  58.023, 60.509, 71.101, 72.384, 73.157, 86.972, 88.402, 95.112, 96.004, 97.672]
-------------------------------------------
Sorted Array:   [-98.394, -77.213, -75.392, -61.965, -58.738, -57.02, -56.16, -55.265,
↪  -53.111, -49.8, -48.882, -48.874, -47.329, -40.282, -38.359, -38.224, -31.764, -25.922,
↪  -18.908, -15.967, -14.83, -14.701, -0.444, 6.542, 7.624, 9.934, 11.335, 11.851, 17.042,
↪  17.557, 22.022, 24.986, 25.041, 37.173, 40.925, 42.254, 42.348, 45.75, 47.634, 55.287,
↪  58.023, 60.509, 71.101, 72.384, 73.157, 86.972, 88.402, 95.112, 96.004, 97.672]
```

Lệnh R	Lệnh I	Lệnh J	IC
10138	30316	3437	43891

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43891}{3.4 * 10^9} = 1.2909 * 10^{-5} \ (s)$$

Testcase 12: Range [-100,100]

```
Testcase 12: [87.35, -91.104, 27.016, -96.99, -64.334, -45.193, 62.351, -35.325, 42.888,
↪  -95.246, 11.163, -99.388, 4.516, -63.258, -83.788, 54.468, 16.73, -20.122, -62.187,
↪  -99.699, -2.651, 13.294, -27.3, -52.355, -18.845, 76.709, -10.6, 47.539, -7.136,
↪  -74.803, 22.84, -26.076, -6.514, -94.424, 17.234, 42.814, 53.113, 78.741, -74.026,
↪  -13.075, 7.502, -37.904, -45.86, -65.921, -14.08, -31.338, 1.322, -49.668, -83.851,
↪  -18.619]
Expected Result: [-99.699, -99.388, -96.99, -95.246, -94.424, -91.104, -83.851, -83.788,
↪  -74.803, -74.026, -65.921, -64.334, -63.258, -62.187, -52.355, -49.668, -45.86,
↪  -45.193, -37.904, -35.325, -31.338, -27.3, -26.076, -20.122, -18.845, -18.619, -14.08,
↪  -13.075, -10.6, -7.136, -6.514, -2.651, 1.322, 4.516, 7.502, 11.163, 13.294, 16.73,
↪  17.234, 22.84, 27.016, 42.814, 42.888, 47.539, 53.113, 54.468, 62.351, 76.709, 78.741,
↪  87.35]
Got:
Unsorted Array: [87.35, -91.104, 27.016, -96.99, -64.334, -45.193, 62.351, -35.325, 42.888,
↪  -95.246, 11.163, -99.388, 4.516, -63.258, -83.788, 54.468, 16.73, -20.122, -62.187,
↪  -99.699, -2.651, 13.294, -27.3, -52.355, -18.845, 76.709, -10.6, 47.539, -7.136,
↪  -74.803, 22.84, -26.076, -6.514, -94.424, 17.234, 42.814, 53.113, 78.741, -74.026,
↪  -13.075, 7.502, -37.904, -45.86, -65.921, -14.08, -31.338, 1.322, -49.668, -83.851,
↪  -18.619]
-------------------------------------------
From 0 to 1
Current array:  [-91.104, 87.35, 27.016, -96.99, -64.334, -45.193, 62.351, -35.325, 42.888,
↪  -95.246, 11.163, -99.388, 4.516, -63.258, -83.788, 54.468, 16.73, -20.122, -62.187,
↪  -99.699, -2.651, 13.294, -27.3, -52.355, -18.845, 76.709, -10.6, 47.539, -7.136,
↪  -74.803, 22.84, -26.076, -6.514, -94.424, 17.234, 42.814, 53.113, 78.741, -74.026,
↪  -13.075, 7.502, -37.904, -45.86, -65.921, -14.08, -31.338, 1.322, -49.668, -83.851,
↪  -18.619]
From 2 to 3
```

```
Current array:  [-91.104, 87.35, -96.99, 27.016, -64.334, -45.193, 62.351, -35.325, 42.888,
↪  -95.246, 11.163, -99.388, 4.516, -63.258, -83.788, 54.468, 16.73, -20.122, -62.187,
↪  -99.699, -2.651, 13.294, -27.3, -52.355, -18.845, 76.709, -10.6, 47.539, -7.136,
↪  -74.803, 22.84, -26.076, -6.514, -94.424, 17.234, 42.814, 53.113, 78.741, -74.026,
↪  -13.075, 7.502, -37.904, -45.86, -65.921, -14.08, -31.338, 1.322, -49.668, -83.851,
↪  -18.619]
[...]
From 0 to 49
Current array:  [-99.699, -99.388, -96.99, -95.246, -94.424, -91.104, -83.851, -83.788,
↪  -74.803, -74.026, -65.921, -64.334, -63.258, -62.187, -52.355, -49.668, -45.86,
↪  -45.193, -37.904, -35.325, -31.338, -27.3, -26.076, -20.122, -18.845, -18.619, -14.08,
↪  -13.075, -10.6, -7.136, -6.514, -2.651, 1.322, 4.516, 7.502, 11.163, 13.294, 16.73,
↪  17.234, 22.84, 27.016, 42.814, 42.888, 47.539, 53.113, 54.468, 62.351, 76.709, 78.741,
↪  87.35]
--------------------------------------------
Sorted Array:   [-99.699, -99.388, -96.99, -95.246, -94.424, -91.104, -83.851, -83.788,
↪  -74.803, -74.026, -65.921, -64.334, -63.258, -62.187, -52.355, -49.668, -45.86,
↪  -45.193, -37.904, -35.325, -31.338, -27.3, -26.076, -20.122, -18.845, -18.619, -14.08,
↪  -13.075, -10.6, -7.136, -6.514, -2.651, 1.322, 4.516, 7.502, 11.163, 13.294, 16.73,
↪  17.234, 22.84, 27.016, 42.814, 42.888, 47.539, 53.113, 54.468, 62.351, 76.709, 78.741,
↪  87.35]
```

Lệnh R	Lệnh I	Lệnh J	IC
10132	30302	3426	43860

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43860}{3.4 * 10^9} = 1.2900 * 10^{-5} \ (s)$$

Testcase 13: Range [-100,100]

```
Testcase 13: [-95.761, 92.253, -84.825, -68.896, 13.297, 88.259, -24.036, 33.209, 2.895,
↪  -75.379, 39.673, -29.584, -8.678, 35.488, -17.315, 91.825, -15.556, -50.316, 13.868,
↪  -16.625, 6.421, 50.233, 8.543, 28.881, 29.382, -30.886, 35.795, -17.517, -2.872,
↪  -14.62, -13.499, 45.479, -67.887, -85.969, -46.687, -97.569, 96.788, 11.356, -46.013,
↪  -42.691, 27.718, -71.127, 95.471, 67.614, 75.209, -46.588, 61.418, 38.968, 66.931,
↪  25.429]
Expected Result: [-97.569, -95.761, -85.969, -84.825, -75.379, -71.127, -68.896, -67.887,
↪  -50.316, -46.687, -46.588, -46.013, -42.691, -30.886, -29.584, -24.036, -17.517,
↪  -17.315, -16.625, -15.556, -14.62, -13.499, -8.678, -2.872, 2.895, 6.421, 8.543,
↪  11.356, 13.297, 13.868, 25.429, 27.718, 28.881, 29.382, 33.209, 35.488, 35.795, 38.968,
↪  39.673, 45.479, 50.233, 61.418, 66.931, 67.614, 75.209, 88.259, 91.825, 92.253, 95.471,
↪  96.788]
Got:
Unsorted Array: [-95.761, 92.253, -84.825, -68.896, 13.297, 88.259, -24.036, 33.209, 2.895,
↪  -75.379, 39.673, -29.584, -8.678, 35.488, -17.315, 91.825, -15.556, -50.316, 13.868,
↪  -16.625, 6.421, 50.233, 8.543, 28.881, 29.382, -30.886, 35.795, -17.517, -2.872,
↪  -14.62, -13.499, 45.479, -67.887, -85.969, -46.687, -97.569, 96.788, 11.356, -46.013,
↪  -42.691, 27.718, -71.127, 95.471, 67.614, 75.209, -46.588, 61.418, 38.968, 66.931,
↪  25.429]
--------------------------------------------
From 0 to 1
Current array:  [-95.761, 92.253, -84.825, -68.896, 13.297, 88.259, -24.036, 33.209, 2.895,
↪  -75.379, 39.673, -29.584, -8.678, 35.488, -17.315, 91.825, -15.556, -50.316, 13.868,
↪  -16.625, 6.421, 50.233, 8.543, 28.881, 29.382, -30.886, 35.795, -17.517, -2.872,
↪  -14.62, -13.499, 45.479, -67.887, -85.969, -46.687, -97.569, 96.788, 11.356, -46.013,
↪  -42.691, 27.718, -71.127, 95.471, 67.614, 75.209, -46.588, 61.418, 38.968, 66.931,
↪  25.429]
From 2 to 3
```

```
Current array:  [-95.761, 92.253, -84.825, -68.896, 13.297, 88.259, -24.036, 33.209, 2.895,
↪  -75.379, 39.673, -29.584, -8.678, 35.488, -17.315, 91.825, -15.556, -50.316, 13.868,
↪  -16.625, 6.421, 50.233, 8.543, 28.881, 29.382, -30.886, 35.795, -17.517, -2.872,
↪  -14.62, -13.499, 45.479, -67.887, -85.969, -46.687, -97.569, 96.788, 11.356, -46.013,
↪  -42.691, 27.718, -71.127, 95.471, 67.614, 75.209, -46.588, 61.418, 38.968, 66.931,
↪  25.429]
[...]
From 0 to 49
Current array:  [-97.569, -95.761, -85.969, -84.825, -75.379, -71.127, -68.896, -67.887,
↪  -50.316, -46.687, -46.588, -46.013, -42.691, -30.886, -29.584, -24.036, -17.517,
↪  -17.315, -16.625, -15.556, -14.62, -13.499, -8.678, -2.872, 2.895, 6.421, 8.543,
↪  11.356, 13.297, 13.868, 25.429, 27.718, 28.881, 29.382, 33.209, 35.488, 35.795, 38.968,
↪  39.673, 45.479, 50.233, 61.418, 66.931, 67.614, 75.209, 88.259, 91.825, 92.253, 95.471,
↪  96.788]
-------------------------------------------
Sorted Array:   [-97.569, -95.761, -85.969, -84.825, -75.379, -71.127, -68.896, -67.887,
↪  -50.316, -46.687, -46.588, -46.013, -42.691, -30.886, -29.584, -24.036, -17.517,
↪  -17.315, -16.625, -15.556, -14.62, -13.499, -8.678, -2.872, 2.895, 6.421, 8.543,
↪  11.356, 13.297, 13.868, 25.429, 27.718, 28.881, 29.382, 33.209, 35.488, 35.795, 38.968,
↪  39.673, 45.479, 50.233, 61.418, 66.931, 67.614, 75.209, 88.259, 91.825, 92.253, 95.471,
↪  96.788]
```

Lệnh R	Lệnh I	Lệnh J	IC
10142	30324	3445	43911

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43860}{3.4 * 10^9} = 1.2915 * 10^{-5} \ (s)$$

Testcase 14: Range [-100,100]

```
Testcase 14: [-93.405, -8.787, 72.058, 12.223, -81.924, -84.625, 28.731, 2.789, -6.564,
↪  -36.196, -53.925, 20.737, 14.03, 71.46, 16.408, 52.811, 97.543, 73.364, 98.469, 50.127,
↪  17.797, 93.64, -81.527, 90.769, -93.032, 22.189, -69.368, -69.129, -16.06, 40.001,
↪  -79.963, -83.134, 80.238, 49.548, -26.937, 76.688, -71.962, 54.811, -54.486, -18.948,
↪  -62.428, 79.673, 56.659, -9.594, 94.852, -35.359, -25.764, 92.856, 71.283, -83.1]
Expected Result: [-93.405, -93.032, -84.625, -83.134, -83.1, -81.924, -81.527, -79.963,
↪  -71.962, -69.368, -69.129, -62.428, -54.486, -53.925, -36.196, -35.359, -26.937,
↪  -25.764, -18.948, -16.06, -9.594, -8.787, -6.564, 2.789, 12.223, 14.03, 16.408, 17.797,
↪  20.737, 22.189, 28.731, 40.001, 49.548, 50.127, 52.811, 54.811, 56.659, 71.283, 71.46,
↪  72.058, 73.364, 76.688, 79.673, 80.238, 90.769, 92.856, 93.64, 94.852, 97.543, 98.469]
Got:
Unsorted Array: [-93.405, -8.787, 72.058, 12.223, -81.924, -84.625, 28.731, 2.789, -6.564,
↪  -36.196, -53.925, 20.737, 14.03, 71.46, 16.408, 52.811, 97.543, 73.364, 98.469, 50.127,
↪  17.797, 93.64, -81.527, 90.769, -93.032, 22.189, -69.368, -69.129, -16.06, 40.001,
↪  -79.963, -83.134, 80.238, 49.548, -26.937, 76.688, -71.962, 54.811, -54.486, -18.948,
↪  -62.428, 79.673, 56.659, -9.594, 94.852, -35.359, -25.764, 92.856, 71.283, -83.1]
-------------------------------------------
From 0 to 1
Current array:  [-93.405, -8.787, 72.058, 12.223, -81.924, -84.625, 28.731, 2.789, -6.564,
↪  -36.196, -53.925, 20.737, 14.03, 71.46, 16.408, 52.811, 97.543, 73.364, 98.469, 50.127,
↪  17.797, 93.64, -81.527, 90.769, -93.032, 22.189, -69.368, -69.129, -16.06, 40.001,
↪  -79.963, -83.134, 80.238, 49.548, -26.937, 76.688, -71.962, 54.811, -54.486, -18.948,
↪  -62.428, 79.673, 56.659, -9.594, 94.852, -35.359, -25.764, 92.856, 71.283, -83.1]
From 2 to 3
Current array:  [-93.405, -8.787, 12.223, 72.058, -81.924, -84.625, 28.731, 2.789, -6.564,
↪  -36.196, -53.925, 20.737, 14.03, 71.46, 16.408, 52.811, 97.543, 73.364, 98.469, 50.127,
↪  17.797, 93.64, -81.527, 90.769, -93.032, 22.189, -69.368, -69.129, -16.06, 40.001,
↪  -79.963, -83.134, 80.238, 49.548, -26.937, 76.688, -71.962, 54.811, -54.486, -18.948,
↪  -62.428, 79.673, 56.659, -9.594, 94.852, -35.359, -25.764, 92.856, 71.283, -83.1]
[...]
From 0 to 49
```

```
Current array:  [-93.405, -93.032, -84.625, -83.134, -83.1, -81.924, -81.527, -79.963,
↪  -71.962, -69.368, -69.129, -62.428, -54.486, -53.925, -36.196, -35.359, -26.937,
↪  -25.764, -18.948, -16.06, -9.594, -8.787, -6.564, 2.789, 12.223, 14.03, 16.408, 17.797,
↪  20.737, 22.189, 28.731, 40.001, 49.548, 50.127, 52.811, 54.811, 56.659, 71.283, 71.46,
↪  72.058, 73.364, 76.688, 79.673, 80.238, 90.769, 92.856, 93.64, 94.852, 97.543, 98.469]
--------------------------------------------
Sorted Array:   [-93.405, -93.032, -84.625, -83.134, -83.1, -81.924, -81.527, -79.963,
↪  -71.962, -69.368, -69.129, -62.428, -54.486, -53.925, -36.196, -35.359, -26.937,
↪  -25.764, -18.948, -16.06, -9.594, -8.787, -6.564, 2.789, 12.223, 14.03, 16.408, 17.797,
↪  20.737, 22.189, 28.731, 40.001, 49.548, 50.127, 52.811, 54.811, 56.659, 71.283, 71.46,
↪  72.058, 73.364, 76.688, 79.673, 80.238, 90.769, 92.856, 93.64, 94.852, 97.543, 98.469]
```

Lệnh R	Lệnh I	Lệnh J	IC
10125	30281	3432	43838

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43838}{3.4 * 10^9} = 1.2894 * 10^{-5} \ \ (s)$$

Testcase 15: Range [-100,100]

```
Testcase 15: [59.773, 3.813, 56.869, -34.719, -26.865, -12.664, -92.364, 16.03, 43.978,
↪  -5.245, 77.479, 87.389, -77.262, 71.51, -19.983, 82.26, 12.431, 58.356, 69.155, 61.251,
↪  46.088, -89.724, -25.401, 81.709, -33.832, 62.651, 11.681, -57.542, -20.668, -54.794,
↪  -25.182, -90.237, 33.967, 69.109, -95.393, -84.421, -4.418, -49.725, -70.897, 17.722,
↪  86.75, 48.909, 80.77, -5.975, 37.707, 76.693, -70.531, 17.857, -46.873, 24.005]
Expected Result: [-95.393, -92.364, -90.237, -89.724, -84.421, -77.262, -70.897, -70.531,
↪  -57.542, -54.794, -49.725, -46.873, -34.719, -33.832, -26.865, -25.401, -25.182,
↪  -20.668, -19.983, -12.664, -5.975, -5.245, -4.418, 3.813, 11.681, 12.431, 16.03,
↪  17.722, 17.857, 24.005, 33.967, 37.707, 43.978, 46.088, 48.909, 56.869, 58.356, 59.773,
↪  61.251, 62.651, 69.109, 69.155, 71.51, 76.693, 77.479, 80.77, 81.709, 82.26, 86.75,
↪  87.389]
Got:
Unsorted Array: [59.773, 3.813, 56.869, -34.719, -26.865, -12.664, -92.364, 16.03, 43.978,
↪  -5.245, 77.479, 87.389, -77.262, 71.51, -19.983, 82.26, 12.431, 58.356, 69.155, 61.251,
↪  46.088, -89.724, -25.401, 81.709, -33.832, 62.651, 11.681, -57.542, -20.668, -54.794,
↪  -25.182, -90.237, 33.967, 69.109, -95.393, -84.421, -4.418, -49.725, -70.897, 17.722,
↪  86.75, 48.909, 80.77, -5.975, 37.707, 76.693, -70.531, 17.857, -46.873, 24.005]
--------------------------------------------
From 0 to 1
Current array:  [3.813, 59.773, 56.869, -34.719, -26.865, -12.664, -92.364, 16.03, 43.978,
↪  -5.245, 77.479, 87.389, -77.262, 71.51, -19.983, 82.26, 12.431, 58.356, 69.155, 61.251,
↪  46.088, -89.724, -25.401, 81.709, -33.832, 62.651, 11.681, -57.542, -20.668, -54.794,
↪  -25.182, -90.237, 33.967, 69.109, -95.393, -84.421, -4.418, -49.725, -70.897, 17.722,
↪  86.75, 48.909, 80.77, -5.975, 37.707, 76.693, -70.531, 17.857, -46.873, 24.005]
From 2 to 3
Current array:  [3.813, 59.773, -34.719, 56.869, -26.865, -12.664, -92.364, 16.03, 43.978,
↪  -5.245, 77.479, 87.389, -77.262, 71.51, -19.983, 82.26, 12.431, 58.356, 69.155, 61.251,
↪  46.088, -89.724, -25.401, 81.709, -33.832, 62.651, 11.681, -57.542, -20.668, -54.794,
↪  -25.182, -90.237, 33.967, 69.109, -95.393, -84.421, -4.418, -49.725, -70.897, 17.722,
↪  86.75, 48.909, 80.77, -5.975, 37.707, 76.693, -70.531, 17.857, -46.873, 24.005]
[...]
From 0 to 49
Current array:  [-95.393, -92.364, -90.237, -89.724, -84.421, -77.262, -70.897, -70.531,
↪  -57.542, -54.794, -49.725, -46.873, -34.719, -33.832, -26.865, -25.401, -25.182,
↪  -20.668, -19.983, -12.664, -5.975, -5.245, -4.418, 3.813, 11.681, 12.431, 16.03,
↪  17.722, 17.857, 24.005, 33.967, 37.707, 43.978, 46.088, 48.909, 56.869, 58.356, 59.773,
↪  61.251, 62.651, 69.109, 69.155, 71.51, 76.693, 77.479, 80.77, 81.709, 82.26, 86.75,
↪  87.389]
--------------------------------------------
```

```
Sorted Array:   [-95.393, -92.364, -90.237, -89.724, -84.421, -77.262, -70.897, -70.531,
↪  -57.542, -54.794, -49.725, -46.873, -34.719, -33.832, -26.865, -25.401, -25.182,
↪  -20.668, -19.983, -12.664, -5.975, -5.245, -4.418, 3.813, 11.681, 12.431, 16.03,
↪  17.722, 17.857, 24.005, 33.967, 37.707, 43.978, 46.088, 48.909, 56.869, 58.356, 59.773,
↪  61.251, 62.651, 69.109, 69.155, 71.51, 76.693, 77.479, 80.77, 81.709, 82.26, 86.75,
↪  87.389]
```

Lệnh R	Lệnh I	Lệnh J	IC
10128	30286	3428	43842

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43838}{3.4 * 10^9} = 1.2895 * 10^{-5} \ (s)$$

Testcase 16: Range [-500,500]

```
Testcase 16: [-428.001, -490.463, 291.476, -132.239, -422.145, 277.661, -354.05, -222.587,
↪  -131.976, 109.807, 8.475, 198.102, -423.838, 267.911, 328.09, 217.604, 376.318, 389.23,
↪  400.656, 80.157, 261.955, 54.862, -146.491, 184.573, 79.168, 476.931, 279.947, 487.67,
↪  -266.282, 127.123, 190.107, -260.032, 487.895, -140.477, 494.897, 107.803, 270.453,
↪  -35.501, 370.362, 23.025, -469.005, -297.826, 242.438, 399.952, -228.763, -448.727,
↪  203.916, -171.459, 380.533, -129.91]
Expected Result: [-490.463, -469.005, -448.727, -428.001, -423.838, -422.145, -354.05,
↪  -297.826, -266.282, -260.032, -228.763, -222.587, -171.459, -146.491, -140.477,
↪  -132.239, -131.976, -129.91, -35.501, 8.475, 23.025, 54.862, 79.168, 80.157, 107.803,
↪  109.807, 127.123, 184.573, 190.107, 198.102, 203.916, 217.604, 242.438, 261.955,
↪  267.911, 270.453, 277.661, 279.947, 291.476, 328.09, 370.362, 376.318, 380.533, 389.23,
↪  399.952, 400.656, 476.931, 487.67, 487.895, 494.897]
Got:
Unsorted Array: [-428.001, -490.463, 291.476, -132.239, -422.145, 277.661, -354.05,
↪  -222.587, -131.976, 109.807, 8.475, 198.102, -423.838, 267.911, 328.09, 217.604,
↪  376.318, 389.23, 400.656, 80.157, 261.955, 54.862, -146.491, 184.573, 79.168, 476.931,
↪  279.947, 487.67, -266.282, 127.123, 190.107, -260.032, 487.895, -140.477, 494.897,
↪  107.803, 270.453, -35.501, 370.362, 23.025, -469.005, -297.826, 242.438, 399.952,
↪  -228.763, -448.727, 203.916, -171.459, 380.533, -129.91]
-----------------------------------------------
From 0 to 1
Current array:  [-490.463, -428.001, 291.476, -132.239, -422.145, 277.661, -354.05,
↪  -222.587, -131.976, 109.807, 8.475, 198.102, -423.838, 267.911, 328.09, 217.604,
↪  376.318, 389.23, 400.656, 80.157, 261.955, 54.862, -146.491, 184.573, 79.168, 476.931,
↪  279.947, 487.67, -266.282, 127.123, 190.107, -260.032, 487.895, -140.477, 494.897,
↪  107.803, 270.453, -35.501, 370.362, 23.025, -469.005, -297.826, 242.438, 399.952,
↪  -228.763, -448.727, 203.916, -171.459, 380.533, -129.91]
From 2 to 3
Current array:  [-490.463, -428.001, -132.239, 291.476, -422.145, 277.661, -354.05,
↪  -222.587, -131.976, 109.807, 8.475, 198.102, -423.838, 267.911, 328.09, 217.604,
↪  376.318, 389.23, 400.656, 80.157, 261.955, 54.862, -146.491, 184.573, 79.168, 476.931,
↪  279.947, 487.67, -266.282, 127.123, 190.107, -260.032, 487.895, -140.477, 494.897,
↪  107.803, 270.453, -35.501, 370.362, 23.025, -469.005, -297.826, 242.438, 399.952,
↪  -228.763, -448.727, 203.916, -171.459, 380.533, -129.91]
[...]
From 0 to 49
Current array:  [-490.463, -469.005, -448.727, -428.001, -423.838, -422.145, -354.05,
↪  -297.826, -266.282, -260.032, -228.763, -222.587, -171.459, -146.491, -140.477,
↪  -132.239, -131.976, -129.91, -35.501, 8.475, 23.025, 54.862, 79.168, 80.157, 107.803,
↪  109.807, 127.123, 184.573, 190.107, 198.102, 203.916, 217.604, 242.438, 261.955,
↪  267.911, 270.453, 277.661, 279.947, 291.476, 328.09, 370.362, 376.318, 380.533, 389.23,
↪  399.952, 400.656, 476.931, 487.67, 487.895, 494.897]
-----------------------------------------------
```

```
Sorted Array:  [-490.463, -469.005, -448.727, -428.001, -423.838, -422.145, -354.05,
↪  -297.826, -266.282, -260.032, -228.763, -222.587, -171.459, -146.491, -140.477,
↪  -132.239, -131.976, -129.91, -35.501, 8.475, 23.025, 54.862, 79.168, 80.157, 107.803,
↪  109.807, 127.123, 184.573, 190.107, 198.102, 203.916, 217.604, 242.438, 261.955,
↪  267.911, 270.453, 277.661, 279.947, 291.476, 328.09, 370.362, 376.318, 380.533, 389.23,
↪  399.952, 400.656, 476.931, 487.67, 487.895, 494.897]
```

Lệnh R	Lệnh I	Lệnh J	IC
10123	30267	3433	43823

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43823}{3.4 * 10^9} = 1.2889 * 10^{-5} \ (s)$$

Testcase 17: Range [-500,500]

```
Testcase 17: [336.089, 265.763, -173.466, 387.399, 19.644, -385.057, 430.815, -247.345,
↪  177.173, -284.433, -246.908, 295.001, 69.083, -414.525, -428.003, 185.533, -206.298,
↪  274.749, 151.089, -146.221, -223.174, 19.156, -397.993, -204.755, 12.34, -343.71,
↪  -309.758, 497.093, 262.709, -116.911, 407.674, 404.957, -156.902, -143.517, 445.683,
↪  148.899, 268.974, -157.544, 213.776, 223.505, 249.514, 294.676, 450.178, -210.136,
↪  -61.1, 295.938, 244.853, -50.978, -256.868, -180.098]
Expected Result: [-428.003, -414.525, -397.993, -385.057, -343.71, -309.758, -284.433,
↪  -256.868, -247.345, -246.908, -223.174, -210.136, -206.298, -204.755, -180.098,
↪  -173.466, -157.544, -156.902, -146.221, -143.517, -116.911, -61.1, -50.978, 12.34,
↪  19.156, 19.644, 69.083, 148.899, 151.089, 177.173, 185.533, 213.776, 223.505, 244.853,
↪  249.514, 262.709, 265.763, 268.974, 274.749, 294.676, 295.001, 295.938, 336.089,
↪  387.399, 404.957, 407.674, 430.815, 445.683, 450.178, 497.093]
Got:
Unsorted Array: [336.089, 265.763, -173.466, 387.399, 19.644, -385.057, 430.815, -247.345,
↪  177.173, -284.433, -246.908, 295.001, 69.083, -414.525, -428.003, 185.533, -206.298,
↪  274.749, 151.089, -146.221, -223.174, 19.156, -397.993, -204.755, 12.34, -343.71,
↪  -309.758, 497.093, 262.709, -116.911, 407.674, 404.957, -156.902, -143.517, 445.683,
↪  148.899, 268.974, -157.544, 213.776, 223.505, 249.514, 294.676, 450.178, -210.136,
↪  -61.1, 295.938, 244.853, -50.978, -256.868, -180.098]
-----------------------------------------------
From 0 to 1
Current array:  [265.763, 336.089, -173.466, 387.399, 19.644, -385.057, 430.815, -247.345,
↪  177.173, -284.433, -246.908, 295.001, 69.083, -414.525, -428.003, 185.533, -206.298,
↪  274.749, 151.089, -146.221, -223.174, 19.156, -397.993, -204.755, 12.34, -343.71,
↪  -309.758, 497.093, 262.709, -116.911, 407.674, 404.957, -156.902, -143.517, 445.683,
↪  148.899, 268.974, -157.544, 213.776, 223.505, 249.514, 294.676, 450.178, -210.136,
↪  -61.1, 295.938, 244.853, -50.978, -256.868, -180.098]
From 2 to 3
Current array:  [265.763, 336.089, -173.466, 387.399, 19.644, -385.057, 430.815, -247.345,
↪  177.173, -284.433, -246.908, 295.001, 69.083, -414.525, -428.003, 185.533, -206.298,
↪  274.749, 151.089, -146.221, -223.174, 19.156, -397.993, -204.755, 12.34, -343.71,
↪  -309.758, 497.093, 262.709, -116.911, 407.674, 404.957, -156.902, -143.517, 445.683,
↪  148.899, 268.974, -157.544, 213.776, 223.505, 249.514, 294.676, 450.178, -210.136,
↪  -61.1, 295.938, 244.853, -50.978, -256.868, -180.098]
[...]
From 0 to 49
Current array:  [-428.003, -414.525, -397.993, -385.057, -343.71, -309.758, -284.433,
↪  -256.868, -247.345, -246.908, -223.174, -210.136, -206.298, -204.755, -180.098,
↪  -173.466, -157.544, -156.902, -146.221, -143.517, -116.911, -61.1, -50.978, 12.34,
↪  19.156, 19.644, 69.083, 148.899, 151.089, 177.173, 185.533, 213.776, 223.505, 244.853,
↪  249.514, 262.709, 265.763, 268.974, 274.749, 294.676, 295.001, 295.938, 336.089,
↪  387.399, 404.957, 407.674, 430.815, 445.683, 450.178, 497.093]
-----------------------------------------------
```

```
Sorted Array:  [-428.003, -414.525, -397.993, -385.057, -343.71, -309.758, -284.433,
↪  -256.868, -247.345, -246.908, -223.174, -210.136, -206.298, -204.755, -180.098,
↪  -173.466, -157.544, -156.902, -146.221, -143.517, -116.911, -61.1, -50.978, 12.34,
↪  19.156, 19.644, 69.083, 148.899, 151.089, 177.173, 185.533, 213.776, 223.505, 244.853,
↪  249.514, 262.709, 265.763, 268.974, 274.749, 294.676, 295.001, 295.938, 336.089,
↪  387.399, 404.957, 407.674, 430.815, 445.683, 450.178, 497.093]
```

Lệnh R	Lệnh I	Lệnh J	IC
10135	30303	3439	43877

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43877}{3.4 * 10^9} = 1.2905 * 10^{-5} \ (s)$$

Testcase 18: Range [-500,500]

```
Testcase 18:[345.356, 289.171, -203.387, -417.324, 132.511, 459.133, 298.785, 190.21,
↪  261.291, 408.117, 455.333, 361.75, -422.205, -393.474, -218.246, 101.704, -67.973,
↪  11.561, -390.783, -243.088, 129.322, 59.045, -119.411, 326.688, 295.379, 328.996,
↪  -15.969, 333.346, -205.112, -325.009, -472.886, 480.041, 79.023, 101.207, -349.92,
↪  -285.566, 77.692, 10.493, -80.948, 310.577, 153.116, 366.044, 275.177, -301.823,
↪  205.079, -214.763, 149.584, -26.406, 205.145, -473.158]
Expected Result: [-473.158, -472.886, -422.205, -417.324, -393.474, -390.783, -349.92,
↪  -325.009, -301.823, -285.566, -243.088, -218.246, -214.763, -205.112, -203.387,
↪  -119.411, -80.948, -67.973, -26.406, -15.969, 10.493, 11.561, 59.045, 77.692, 79.023,
↪  101.207, 101.704, 129.322, 132.511, 149.584, 153.116, 190.21, 205.079, 205.145,
↪  261.291, 275.177, 289.171, 295.379, 298.785, 310.577, 326.688, 328.996, 333.346,
↪  345.356, 361.75, 366.044, 408.117, 455.333, 459.133, 480.041]
Got:
Unsorted Array: [345.356, 289.171, -203.387, -417.324, 132.511, 459.133, 298.785, 190.21,
↪  261.291, 408.117, 455.333, 361.75, -422.205, -393.474, -218.246, 101.704, -67.973,
↪  11.561, -390.783, -243.088, 129.322, 59.045, -119.411, 326.688, 295.379, 328.996,
↪  -15.969, 333.346, -205.112, -325.009, -472.886, 480.041, 79.023, 101.207, -349.92,
↪  -285.566, 77.692, 10.493, -80.948, 310.577, 153.116, 366.044, 275.177, -301.823,
↪  205.079, -214.763, 149.584, -26.406, 205.145, -473.158]
-----------------------------------------------
From 0 to 1
Current array:  [289.171, 345.356, -203.387, -417.324, 132.511, 459.133, 298.785, 190.21,
↪  261.291, 408.117, 455.333, 361.75, -422.205, -393.474, -218.246, 101.704, -67.973,
↪  11.561, -390.783, -243.088, 129.322, 59.045, -119.411, 326.688, 295.379, 328.996,
↪  -15.969, 333.346, -205.112, -325.009, -472.886, 480.041, 79.023, 101.207, -349.92,
↪  -285.566, 77.692, 10.493, -80.948, 310.577, 153.116, 366.044, 275.177, -301.823,
↪  205.079, -214.763, 149.584, -26.406, 205.145, -473.158]
From 2 to 3
Current array:  [289.171, 345.356, -417.324, -203.387, 132.511, 459.133, 298.785, 190.21,
↪  261.291, 408.117, 455.333, 361.75, -422.205, -393.474, -218.246, 101.704, -67.973,
↪  11.561, -390.783, -243.088, 129.322, 59.045, -119.411, 326.688, 295.379, 328.996,
↪  -15.969, 333.346, -205.112, -325.009, -472.886, 480.041, 79.023, 101.207, -349.92,
↪  -285.566, 77.692, 10.493, -80.948, 310.577, 153.116, 366.044, 275.177, -301.823,
↪  205.079, -214.763, 149.584, -26.406, 205.145, -473.158]
[...]
From 0 to 49
Current array:  [-473.158, -472.886, -422.205, -417.324, -393.474, -390.783, -349.92,
↪  -325.009, -301.823, -285.566, -243.088, -218.246, -214.763, -205.112, -203.387,
↪  -119.411, -80.948, -67.973, -26.406, -15.969, 10.493, 11.561, 59.045, 77.692, 79.023,
↪  101.207, 101.704, 129.322, 132.511, 149.584, 153.116, 190.21, 205.079, 205.145,
↪  261.291, 275.177, 289.171, 295.379, 298.785, 310.577, 326.688, 328.996, 333.346,
↪  345.356, 361.75, 366.044, 408.117, 455.333, 459.133, 480.041]
-----------------------------------------------
```

```
Sorted Array:   [-473.158, -472.886, -422.205, -417.324, -393.474, -390.783, -349.92,
↪  -325.009, -301.823, -285.566, -243.088, -218.246, -214.763, -205.112, -203.387,
↪  -119.411, -80.948, -67.973, -26.406, -15.969, 10.493, 11.561, 59.045, 77.692, 79.023,
↪  101.207, 101.704, 129.322, 132.511, 149.584, 153.116, 190.21, 205.079, 205.145,
↪  261.291, 275.177, 289.171, 295.379, 298.785, 310.577, 326.688, 328.996, 333.346,
↪  345.356, 361.75, 366.044, 408.117, 455.333, 459.133, 480.041]
```

Lệnh R	Lệnh I	Lệnh J	IC
10132	30297	3432	43861

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43861}{3.4 * 10^9} = 1.2900 * 10^{-5} \ (s)$$

Testcase 19: Range [-500,500]

```
Testcase 19:[-6.241, -493.712, 263.668, 237.342, 379.975, 171.709, -490.266, 232.347,
↪  -291.63, -301.09, 14.925, -361.101, 8.632, 187.574, 61.774, 77.952, -410.67, -298.828,
↪  471.947, 328.883, 88.77, 223.621, 103.849, -279.161, 256.82, 293.646, -262.103,
↪  448.964, -440.852, 363.649, -185.243, -438.284, -445.39, -183.59, -87.602, 151.826,
↪  -291.256, -303.424, 348.426, 327.682, -401.148, -244.396, -303.449, 311.332, 414.083,
↪  411.77, 496.121, 409.285, -397.121, -319.255]
Expected Result: [-493.712, -490.266, -445.39, -440.852, -438.284, -410.67, -401.148,
↪  -397.121, -361.101, -319.255, -303.449, -303.424, -301.09, -298.828, -291.63, -291.256,
↪  -279.161, -262.103, -244.396, -185.243, -183.59, -87.602, -6.241, 8.632, 14.925,
↪  61.774, 77.952, 88.77, 103.849, 151.826, 171.709, 187.574, 223.621, 232.347, 237.342,
↪  256.82, 263.668, 293.646, 311.332, 327.682, 328.883, 348.426, 363.649, 379.975,
↪  409.285, 411.77, 414.083, 448.964, 471.947, 496.121]
Got:
Unsorted Array: [-6.241, -493.712, 263.668, 237.342, 379.975, 171.709, -490.266, 232.347,
↪  -291.63, -301.09, 14.925, -361.101, 8.632, 187.574, 61.774, 77.952, -410.67, -298.828,
↪  471.947, 328.883, 88.77, 223.621, 103.849, -279.161, 256.82, 293.646, -262.103,
↪  448.964, -440.852, 363.649, -185.243, -438.284, -445.39, -183.59, -87.602, 151.826,
↪  -291.256, -303.424, 348.426, 327.682, -401.148, -244.396, -303.449, 311.332, 414.083,
↪  411.77, 496.121, 409.285, -397.121, -319.255]
-----------------------------------------------
From 0 to 1
Current array:  [-493.712, -6.241, 263.668, 237.342, 379.975, 171.709, -490.266, 232.347,
↪  -291.63, -301.09, 14.925, -361.101, 8.632, 187.574, 61.774, 77.952, -410.67, -298.828,
↪  471.947, 328.883, 88.77, 223.621, 103.849, -279.161, 256.82, 293.646, -262.103,
↪  448.964, -440.852, 363.649, -185.243, -438.284, -445.39, -183.59, -87.602, 151.826,
↪  -291.256, -303.424, 348.426, 327.682, -401.148, -244.396, -303.449, 311.332, 414.083,
↪  411.77, 496.121, 409.285, -397.121, -319.255]
From 2 to 3
Current array:  [-493.712, -6.241, 237.342, 263.668, 379.975, 171.709, -490.266, 232.347,
↪  -291.63, -301.09, 14.925, -361.101, 8.632, 187.574, 61.774, 77.952, -410.67, -298.828,
↪  471.947, 328.883, 88.77, 223.621, 103.849, -279.161, 256.82, 293.646, -262.103,
↪  448.964, -440.852, 363.649, -185.243, -438.284, -445.39, -183.59, -87.602, 151.826,
↪  -291.256, -303.424, 348.426, 327.682, -401.148, -244.396, -303.449, 311.332, 414.083,
↪  411.77, 496.121, 409.285, -397.121, -319.255]
[...]
From 0 to 49
Current array:  [-493.712, -490.266, -445.39, -440.852, -438.284, -410.67, -401.148,
↪  -397.121, -361.101, -319.255, -303.449, -303.424, -301.09, -298.828, -291.63, -291.256,
↪  -279.161, -262.103, -244.396, -185.243, -183.59, -87.602, -6.241, 8.632, 14.925,
↪  61.774, 77.952, 88.77, 103.849, 151.826, 171.709, 187.574, 223.621, 232.347, 237.342,
↪  256.82, 263.668, 293.646, 311.332, 327.682, 328.883, 348.426, 363.649, 379.975,
↪  409.285, 411.77, 414.083, 448.964, 471.947, 496.121]
-----------------------------------------------
```

```
Sorted Array:   [-493.712, -490.266, -445.39, -440.852, -438.284, -410.67, -401.148,
↪  -397.121, -361.101, -319.255, -303.449, -303.424, -301.09, -298.828, -291.63, -291.256,
↪  -279.161, -262.103, -244.396, -185.243, -183.59, -87.602, -6.241, 8.632, 14.925,
↪  61.774, 77.952, 88.77, 103.849, 151.826, 171.709, 187.574, 223.621, 232.347, 237.342,
↪  256.82, 263.668, 293.646, 311.332, 327.682, 328.883, 348.426, 363.649, 379.975,
↪  409.285, 411.77, 414.083, 448.964, 471.947, 496.121]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30309	3429	43872

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43872}{3.4 * 10^9} = 1.2904 * 10^{-5} \ (s)$$

Testcase 20: Range [-500,500]

```
Testcase 20:[-440.456, 427.979, -239.256, -119.899, -237.39, -211.97, 126.807, 271.247,
↪  282.15, -159.058, -247.968, 385.374, -76.203, 440.831, 17.814, -418.88, 317.98,
↪  -284.016, 2.203, 95.843, -452.309, 436.258, -241.749, -365.125, 168.079, 31.28,
↪  -115.119, -427.957, -178.793, -309.183, -151.55, -185.18, -257.195, -174.362, 74.79,
↪  -165.71, -211.695, -118.111, 464.079, -210.191, -83.908, -377.784, 19.866, -70.03,
↪  246.241, 499.384, -229.404, -394.414, 217.502, 340.781]
Expected Result: [-452.309, -440.456, -427.957, -418.88, -394.414, -377.784, -365.125,
↪  -309.183, -284.016, -257.195, -247.968, -241.749, -239.256, -237.39, -229.404, -211.97,
↪  -211.695, -210.191, -185.18, -178.793, -174.362, -165.71, -159.058, -151.55, -119.899,
↪  -118.111, -115.119, -83.908, -76.203, -70.03, 2.203, 17.814, 19.866, 31.28, 74.79,
↪  95.843, 126.807, 168.079, 217.502, 246.241, 271.247, 282.15, 317.98, 340.781, 385.374,
↪  427.979, 436.258, 440.831, 464.079, 499.384]
Got:
Unsorted Array: [-440.456, 427.979, -239.256, -119.899, -237.39, -211.97, 126.807, 271.247,
↪  282.15, -159.058, -247.968, 385.374, -76.203, 440.831, 17.814, -418.88, 317.98,
↪  -284.016, 2.203, 95.843, -452.309, 436.258, -241.749, -365.125, 168.079, 31.28,
↪  -115.119, -427.957, -178.793, -309.183, -151.55, -185.18, -257.195, -174.362, 74.79,
↪  -165.71, -211.695, -118.111, 464.079, -210.191, -83.908, -377.784, 19.866, -70.03,
↪  246.241, 499.384, -229.404, -394.414, 217.502, 340.781]
-----------------------------------------------
From 0 to 1
Current array:  [-440.456, 427.979, -239.256, -119.899, -237.39, -211.97, 126.807, 271.247,
↪  282.15, -159.058, -247.968, 385.374, -76.203, 440.831, 17.814, -418.88, 317.98,
↪  -284.016, 2.203, 95.843, -452.309, 436.258, -241.749, -365.125, 168.079, 31.28,
↪  -115.119, -427.957, -178.793, -309.183, -151.55, -185.18, -257.195, -174.362, 74.79,
↪  -165.71, -211.695, -118.111, 464.079, -210.191, -83.908, -377.784, 19.866, -70.03,
↪  246.241, 499.384, -229.404, -394.414, 217.502, 340.781]
From 2 to 3
Current array:  [-440.456, 427.979, -239.256, -119.899, -237.39, -211.97, 126.807, 271.247,
↪  282.15, -159.058, -247.968, 385.374, -76.203, 440.831, 17.814, -418.88, 317.98,
↪  -284.016, 2.203, 95.843, -452.309, 436.258, -241.749, -365.125, 168.079, 31.28,
↪  -115.119, -427.957, -178.793, -309.183, -151.55, -185.18, -257.195, -174.362, 74.79,
↪  -165.71, -211.695, -118.111, 464.079, -210.191, -83.908, -377.784, 19.866, -70.03,
↪  246.241, 499.384, -229.404, -394.414, 217.502, 340.781]
[...]
From 0 to 49
Current array:  [-452.309, -440.456, -427.957, -418.88, -394.414, -377.784, -365.125,
↪  -309.183, -284.016, -257.195, -247.968, -241.749, -239.256, -237.39, -229.404, -211.97,
↪  -211.695, -210.191, -185.18, -178.793, -174.362, -165.71, -159.058, -151.55, -119.899,
↪  -118.111, -115.119, -83.908, -76.203, -70.03, 2.203, 17.814, 19.866, 31.28, 74.79,
↪  95.843, 126.807, 168.079, 217.502, 246.241, 271.247, 282.15, 317.98, 340.781, 385.374,
↪  427.979, 436.258, 440.831, 464.079, 499.384]
-----------------------------------------------
```

```
Sorted Array:  [-452.309, -440.456, -427.957, -418.88, -394.414, -377.784, -365.125,
↪  -309.183, -284.016, -257.195, -247.968, -241.749, -239.256, -237.39, -229.404, -211.97,
↪  -211.695, -210.191, -185.18, -178.793, -174.362, -165.71, -159.058, -151.55, -119.899,
↪  -118.111, -115.119, -83.908, -76.203, -70.03, 2.203, 17.814, 19.866, 31.28, 74.79,
↪  95.843, 126.807, 168.079, 217.502, 246.241, 271.247, 282.15, 317.98, 340.781, 385.374,
↪  427.979, 436.258, 440.831, 464.079, 499.384]
```

Lệnh R	Lệnh I	Lệnh J	IC
10139	30317	3443	43899

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43899}{3.4 * 10^9} = 1.2911 * 10^{-5} \ (s)$$

Testcase 21: Range [-1000,1000]

```
Testcase 21:[361.107, -818.14, -727.335, 909.724, 268.655, 471.589, 751.383, 132.268,
↪  78.694, 680.668, -685.383, -895.725, 4.178, -824.971, -77.545, -504.747, -349.501,
↪  879.128, -530.904, 100.785, 81.84, -635.781, 798.765, 623.399, 849.411, 387.748,
↪  386.32, 540.216, 824.16, 668.597, 58.057, 3.148, 561.388, 415.331, 552.324, 74.645,
↪  -567.839, -104.746, 570.046, -397.06, 216.97, 540.884, -421.095, -74.93, -147.945,
↪  -565.371, -201.378, -771.659, -980.186, -289.106]
Expected Result: [-980.186, -895.725, -824.971, -818.14, -771.659, -727.335, -685.383,
↪  -635.781, -567.839, -565.371, -530.904, -504.747, -421.095, -397.06, -349.501,
↪  -289.106, -201.378, -147.945, -104.746, -77.545, -74.93, 3.148, 4.178, 58.057, 74.645,
↪  78.694, 81.84, 100.785, 132.268, 216.97, 268.655, 361.107, 386.32, 387.748, 415.331,
↪  471.589, 540.216, 540.884, 552.324, 561.388, 570.046, 623.399, 668.597, 680.668,
↪  751.383, 798.765, 824.16, 849.411, 879.128, 909.724]
Got:
Unsorted Array: [361.107, -818.14, -727.335, 909.724, 268.655, 471.589, 751.383, 132.268,
↪  78.694, 680.668, -685.383, -895.725, 4.178, -824.971, -77.545, -504.747, -349.501,
↪  879.128, -530.904, 100.785, 81.84, -635.781, 798.765, 623.399, 849.411, 387.748,
↪  386.32, 540.216, 824.16, 668.597, 58.057, 3.148, 561.388, 415.331, 552.324, 74.645,
↪  -567.839, -104.746, 570.046, -397.06, 216.97, 540.884, -421.095, -74.93, -147.945,
↪  -565.371, -201.378, -771.659, -980.186, -289.106]
-----------------------------------------------
From 0 to 1
Current array:  [-818.14, 361.107, -727.335, 909.724, 268.655, 471.589, 751.383, 132.268,
↪  78.694, 680.668, -685.383, -895.725, 4.178, -824.971, -77.545, -504.747, -349.501,
↪  879.128, -530.904, 100.785, 81.84, -635.781, 798.765, 623.399, 849.411, 387.748,
↪  386.32, 540.216, 824.16, 668.597, 58.057, 3.148, 561.388, 415.331, 552.324, 74.645,
↪  -567.839, -104.746, 570.046, -397.06, 216.97, 540.884, -421.095, -74.93, -147.945,
↪  -565.371, -201.378, -771.659, -980.186, -289.106]
From 2 to 3
Current array:  [-818.14, 361.107, -727.335, 909.724, 268.655, 471.589, 751.383, 132.268,
↪  78.694, 680.668, -685.383, -895.725, 4.178, -824.971, -77.545, -504.747, -349.501,
↪  879.128, -530.904, 100.785, 81.84, -635.781, 798.765, 623.399, 849.411, 387.748,
↪  386.32, 540.216, 824.16, 668.597, 58.057, 3.148, 561.388, 415.331, 552.324, 74.645,
↪  -567.839, -104.746, 570.046, -397.06, 216.97, 540.884, -421.095, -74.93, -147.945,
↪  -565.371, -201.378, -771.659, -980.186, -289.106]
[...]
From 0 to 49
Current array:  [-980.186, -895.725, -824.971, -818.14, -771.659, -727.335, -685.383,
↪  -635.781, -567.839, -565.371, -530.904, -504.747, -421.095, -397.06, -349.501,
↪  -289.106, -201.378, -147.945, -104.746, -77.545, -74.93, 3.148, 4.178, 58.057, 74.645,
↪  78.694, 81.84, 100.785, 132.268, 216.97, 268.655, 361.107, 386.32, 387.748, 415.331,
↪  471.589, 540.216, 540.884, 552.324, 561.388, 570.046, 623.399, 668.597, 680.668,
↪  751.383, 798.765, 824.16, 849.411, 879.128, 909.724]
-----------------------------------------------
```

```
Sorted Array:   [-980.186, -895.725, -824.971, -818.14, -771.659, -727.335, -685.383,
↪  -635.781, -567.839, -565.371, -530.904, -504.747, -421.095, -397.06, -349.501,
↪  -289.106, -201.378, -147.945, -104.746, -77.545, -74.93, 3.148, 4.178, 58.057, 74.645,
↪  78.694, 81.84, 100.785, 132.268, 216.97, 268.655, 361.107, 386.32, 387.748, 415.331,
↪  471.589, 540.216, 540.884, 552.324, 561.388, 570.046, 623.399, 668.597, 680.668,
↪  751.383, 798.765, 824.16, 849.411, 879.128, 909.724]
```

Lệnh R	Lệnh I	Lệnh J	IC
10131	30302	3423	43856

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43856}{3.4 * 10^9} = 1.2899 * 10^{-5} \ (s)$$

Testcase 22: Range [-1000,1000]

```
Testcase 22:[-477.872, 82.676, -383.194, -276.637, -596.377, -331.298, -395.782, 808.379,
↪  890.232, 618.054, 78.786, -381.51, -645.615, 830.91, 668.014, -467.182, 787.768,
↪  103.815, -788.233, 228.656, -843.135, 697.447, -756.865, 713.751, 955.713, 410.915,
↪  396.088, 492.954, 37.312, 117.987, 119.749, 539.216, -547.728, -917.148, 561.255,
↪  798.983, 121.212, -225.631, 468.283, -11.127, 666.328, -603.904, 258.991, -79.774,
↪  -742.481, -576.042, 793.361, -631.878, -629.259, 858.993]
Expected Result: [-917.148, -843.135, -788.233, -756.865, -742.481, -645.615, -631.878,
↪  -629.259, -603.904, -596.377, -576.042, -547.728, -477.872, -467.182, -395.782,
↪  -383.194, -381.51, -331.298, -276.637, -225.631, -79.774, -11.127, 37.312, 78.786,
↪  82.676, 103.815, 117.987, 119.749, 121.212, 228.656, 258.991, 396.088, 410.915,
↪  468.283, 492.954, 539.216, 561.255, 618.054, 666.328, 668.014, 697.447, 713.751,
↪  787.768, 793.361, 798.983, 808.379, 830.91, 858.993, 890.232, 955.713]
Got:
Unsorted Array: [-477.872, 82.676, -383.194, -276.637, -596.377, -331.298, -395.782,
↪  808.379, 890.232, 618.054, 78.786, -381.51, -645.615, 830.91, 668.014, -467.182,
↪  787.768, 103.815, -788.233, 228.656, -843.135, 697.447, -756.865, 713.751, 955.713,
↪  410.915, 396.088, 492.954, 37.312, 117.987, 119.749, 539.216, -547.728, -917.148,
↪  561.255, 798.983, 121.212, -225.631, 468.283, -11.127, 666.328, -603.904, 258.991,
↪  -79.774, -742.481, -576.042, 793.361, -631.878, -629.259, 858.993]
-----------------------------------------------
From 0 to 1
Current array:  [-477.872, 82.676, -383.194, -276.637, -596.377, -331.298, -395.782,
↪  808.379, 890.232, 618.054, 78.786, -381.51, -645.615, 830.91, 668.014, -467.182,
↪  787.768, 103.815, -788.233, 228.656, -843.135, 697.447, -756.865, 713.751, 955.713,
↪  410.915, 396.088, 492.954, 37.312, 117.987, 119.749, 539.216, -547.728, -917.148,
↪  561.255, 798.983, 121.212, -225.631, 468.283, -11.127, 666.328, -603.904, 258.991,
↪  -79.774, -742.481, -576.042, 793.361, -631.878, -629.259, 858.993]
From 2 to 3
Current array:  [-477.872, 82.676, -383.194, -276.637, -596.377, -331.298, -395.782,
↪  808.379, 890.232, 618.054, 78.786, -381.51, -645.615, 830.91, 668.014, -467.182,
↪  787.768, 103.815, -788.233, 228.656, -843.135, 697.447, -756.865, 713.751, 955.713,
↪  410.915, 396.088, 492.954, 37.312, 117.987, 119.749, 539.216, -547.728, -917.148,
↪  561.255, 798.983, 121.212, -225.631, 468.283, -11.127, 666.328, -603.904, 258.991,
↪  -79.774, -742.481, -576.042, 793.361, -631.878, -629.259, 858.993]
[...]
From 0 to 49
Current array:  [-917.148, -843.135, -788.233, -756.865, -742.481, -645.615, -631.878,
↪  -629.259, -603.904, -596.377, -576.042, -547.728, -477.872, -467.182, -395.782,
↪  -383.194, -381.51, -331.298, -276.637, -225.631, -79.774, -11.127, 37.312, 78.786,
↪  82.676, 103.815, 117.987, 119.749, 121.212, 228.656, 258.991, 396.088, 410.915,
↪  468.283, 492.954, 539.216, 561.255, 618.054, 666.328, 668.014, 697.447, 713.751,
↪  787.768, 793.361, 798.983, 808.379, 830.91, 858.993, 890.232, 955.713]
-----------------------------------------------
```

```
Sorted Array:   [-917.148, -843.135, -788.233, -756.865, -742.481, -645.615, -631.878,
↪  -629.259, -603.904, -596.377, -576.042, -547.728, -477.872, -467.182, -395.782,
↪  -383.194, -381.51, -331.298, -276.637, -225.631, -79.774, -11.127, 37.312, 78.786,
↪  82.676, 103.815, 117.987, 119.749, 121.212, 228.656, 258.991, 396.088, 410.915,
↪  468.283, 492.954, 539.216, 561.255, 618.054, 666.328, 668.014, 697.447, 713.751,
↪  787.768, 793.361, 798.983, 808.379, 830.91, 858.993, 890.232, 955.713]
```

Lệnh R	Lệnh I	Lệnh J	IC
10135	30301	3442	43878

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43878}{3.4 * 10^9} = 1.2905 * 10^{-5} \ (s)$$

Testcase 23: Range [-1000,1000]

```
Testcase 23:[-48.655, 78.903, 576.981, 896.496, 752.253, 621.534, -730.839, 503.675,
↪  689.797, -940.424, -811.841, -223.566, 515.377, -838.166, 799.526, 522.477, 882.046,
↪  -59.349, -227.525, 652.196, 584.179, 624.651, -214.168, 83.229, 117.076, -271.241,
↪  579.936, -292.702, -649.549, 834.756, -603.133, 236.24, -540.068, -433.685, 968.711,
↪  566.88, 831.178, 373.764, -864.946, -430.514, -62.189, -527.147, -443.703, -919.88,
↪  427.739, -651.816, -275.463, 230.082, -276.493, 672.473]
Expected Result: [-940.424, -919.88, -864.946, -838.166, -811.841, -730.839, -651.816,
↪  -649.549, -603.133, -540.068, -527.147, -443.703, -433.685, -430.514, -292.702,
↪  -276.493, -275.463, -271.241, -227.525, -223.566, -214.168, -62.189, -59.349, -48.655,
↪  78.903, 83.229, 117.076, 230.082, 236.24, 373.764, 427.739, 503.675, 515.377, 522.477,
↪  566.88, 576.981, 579.936, 584.179, 621.534, 624.651, 652.196, 672.473, 689.797,
↪  752.253, 799.526, 831.178, 834.756, 882.046, 896.496, 968.711]
Got:
Unsorted Array: [-48.655, 78.903, 576.981, 896.496, 752.253, 621.534, -730.839, 503.675,
↪  689.797, -940.424, -811.841, -223.566, 515.377, -838.166, 799.526, 522.477, 882.046,
↪  -59.349, -227.525, 652.196, 584.179, 624.651, -214.168, 83.229, 117.076, -271.241,
↪  579.936, -292.702, -649.549, 834.756, -603.133, 236.24, -540.068, -433.685, 968.711,
↪  566.88, 831.178, 373.764, -864.946, -430.514, -62.189, -527.147, -443.703, -919.88,
↪  427.739, -651.816, -275.463, 230.082, -276.493, 672.473]
-----------------------------------------------
From 0 to 1
Current array:  [-48.655, 78.903, 576.981, 896.496, 752.253, 621.534, -730.839, 503.675,
↪  689.797, -940.424, -811.841, -223.566, 515.377, -838.166, 799.526, 522.477, 882.046,
↪  -59.349, -227.525, 652.196, 584.179, 624.651, -214.168, 83.229, 117.076, -271.241,
↪  579.936, -292.702, -649.549, 834.756, -603.133, 236.24, -540.068, -433.685, 968.711,
↪  566.88, 831.178, 373.764, -864.946, -430.514, -62.189, -527.147, -443.703, -919.88,
↪  427.739, -651.816, -275.463, 230.082, -276.493, 672.473]
From 2 to 3
Current array:  [-48.655, 78.903, 576.981, 896.496, 752.253, 621.534, -730.839, 503.675,
↪  689.797, -940.424, -811.841, -223.566, 515.377, -838.166, 799.526, 522.477, 882.046,
↪  -59.349, -227.525, 652.196, 584.179, 624.651, -214.168, 83.229, 117.076, -271.241,
↪  579.936, -292.702, -649.549, 834.756, -603.133, 236.24, -540.068, -433.685, 968.711,
↪  566.88, 831.178, 373.764, -864.946, -430.514, -62.189, -527.147, -443.703, -919.88,
↪  427.739, -651.816, -275.463, 230.082, -276.493, 672.473]
[...]
From 0 to 49
Current array:  [-940.424, -919.88, -864.946, -838.166, -811.841, -730.839, -651.816,
↪  -649.549, -603.133, -540.068, -527.147, -443.703, -433.685, -430.514, -292.702,
↪  -276.493, -275.463, -271.241, -227.525, -223.566, -214.168, -62.189, -59.349, -48.655,
↪  78.903, 83.229, 117.076, 230.082, 236.24, 373.764, 427.739, 503.675, 515.377, 522.477,
↪  566.88, 576.981, 579.936, 584.179, 621.534, 624.651, 652.196, 672.473, 689.797,
↪  752.253, 799.526, 831.178, 834.756, 882.046, 896.496, 968.711]
-----------------------------------------------
```

```
Sorted Array:   [-940.424, -919.88, -864.946, -838.166, -811.841, -730.839, -651.816,
↪  -649.549, -603.133, -540.068, -527.147, -443.703, -433.685, -430.514, -292.702,
↪  -276.493, -275.463, -271.241, -227.525, -223.566, -214.168, -62.189, -59.349, -48.655,
↪  78.903, 83.229, 117.076, 230.082, 236.24, 373.764, 427.739, 503.675, 515.377, 522.477,
↪  566.88, 576.981, 579.936, 584.179, 621.534, 624.651, 652.196, 672.473, 689.797,
↪  752.253, 799.526, 831.178, 834.756, 882.046, 896.496, 968.711]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30302	3435	43871

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43871}{3.4 * 10^9} = 1.2903 * 10^{-5} \ (s)$$

Testcase 24: Range [-1000,1000]

```
Testcase 24:[480.215, -526.76, 766.35, -511.792, 29.392, -975.113, 51.159, 50.585, 935.068,
↪  -190.398, 202.02, -588.885, -105.686, -371.922, -895.687, 60.257, 225.211, 262.542,
↪  -103.879, -750.116, -310.94, 568.55, -857.217, -913.349, -120.028, -370.13, 792.459,
↪  23.675, 223.589, 45.196, -964.359, 731.295, -268.313, -54.954, -542.005, -842.849,
↪  -104.622, 975.989, -954.723, 215.441, -974.622, 825.465, 791.845, 5.515, -911.713,
↪  -751.31, -968.161, 172.637, 596.371, 288.607]
Expected Result: [-975.113, -974.622, -968.161, -964.359, -954.723, -913.349, -911.713,
↪  -895.687, -857.217, -842.849, -751.31, -750.116, -588.885, -542.005, -526.76, -511.792,
↪  -371.922, -370.13, -310.94, -268.313, -190.398, -120.028, -105.686, -104.622, -103.879,
↪  -54.954, 5.515, 23.675, 29.392, 45.196, 50.585, 51.159, 60.257, 172.637, 202.02,
↪  215.441, 223.589, 225.211, 262.542, 288.607, 480.215, 568.55, 596.371, 731.295, 766.35,
↪  791.845, 792.459, 825.465, 935.068, 975.989]
Got:
Unsorted Array: [480.215, -526.76, 766.35, -511.792, 29.392, -975.113, 51.159, 50.585,
↪  935.068, -190.398, 202.02, -588.885, -105.686, -371.922, -895.687, 60.257, 225.211,
↪  262.542, -103.879, -750.116, -310.94, 568.55, -857.217, -913.349, -120.028, -370.13,
↪  792.459, 23.675, 223.589, 45.196, -964.359, 731.295, -268.313, -54.954, -542.005,
↪  -842.849, -104.622, 975.989, -954.723, 215.441, -974.622, 825.465, 791.845, 5.515,
↪  -911.713, -751.31, -968.161, 172.637, 596.371, 288.607]
-----------------------------------------------
From 0 to 1
Current array:  [-526.76, 480.215, 766.35, -511.792, 29.392, -975.113, 51.159, 50.585,
↪  935.068, -190.398, 202.02, -588.885, -105.686, -371.922, -895.687, 60.257, 225.211,
↪  262.542, -103.879, -750.116, -310.94, 568.55, -857.217, -913.349, -120.028, -370.13,
↪  792.459, 23.675, 223.589, 45.196, -964.359, 731.295, -268.313, -54.954, -542.005,
↪  -842.849, -104.622, 975.989, -954.723, 215.441, -974.622, 825.465, 791.845, 5.515,
↪  -911.713, -751.31, -968.161, 172.637, 596.371, 288.607]
From 2 to 3
Current array:  [-526.76, 480.215, -511.792, 766.35, 29.392, -975.113, 51.159, 50.585,
↪  935.068, -190.398, 202.02, -588.885, -105.686, -371.922, -895.687, 60.257, 225.211,
↪  262.542, -103.879, -750.116, -310.94, 568.55, -857.217, -913.349, -120.028, -370.13,
↪  792.459, 23.675, 223.589, 45.196, -964.359, 731.295, -268.313, -54.954, -542.005,
↪  -842.849, -104.622, 975.989, -954.723, 215.441, -974.622, 825.465, 791.845, 5.515,
↪  -911.713, -751.31, -968.161, 172.637, 596.371, 288.607]
[...]
From 0 to 49
Current array:  [-975.113, -974.622, -968.161, -964.359, -954.723, -913.349, -911.713,
↪  -895.687, -857.217, -842.849, -751.31, -750.116, -588.885, -542.005, -526.76, -511.792,
↪  -371.922, -370.13, -310.94, -268.313, -190.398, -120.028, -105.686, -104.622, -103.879,
↪  -54.954, 5.515, 23.675, 29.392, 45.196, 50.585, 51.159, 60.257, 172.637, 202.02,
↪  215.441, 223.589, 225.211, 262.542, 288.607, 480.215, 568.55, 596.371, 731.295, 766.35,
↪  791.845, 792.459, 825.465, 935.068, 975.989]
-----------------------------------------------
```

```
Sorted Array:   [-975.113, -974.622, -968.161, -964.359, -954.723, -913.349, -911.713,
↪  -895.687, -857.217, -842.849, -751.31, -750.116, -588.885, -542.005, -526.76, -511.792,
↪  -371.922, -370.13, -310.94, -268.313, -190.398, -120.028, -105.686, -104.622, -103.879,
↪  -54.954, 5.515, 23.675, 29.392, 45.196, 50.585, 51.159, 60.257, 172.637, 202.02,
↪  215.441, 223.589, 225.211, 262.542, 288.607, 480.215, 568.55, 596.371, 731.295, 766.35,
↪  791.845, 792.459, 825.465, 935.068, 975.989]
```

Lệnh R	Lệnh I	Lệnh J	IC
10137	30309	3441	43887

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43887}{3.4 * 10^9} = 1.2908 * 10^{-5} \ (s)$$

Testcase 25: Range [-1000,1000]

```
Testcase 25:[-339.076, 232.465, 548.887, -353.99, -334.6, -552.415, 202.005, 153.16,
↪  -323.186, 265.0, -616.457, -879.451, 125.93, -306.257, 825.693, 478.916, 110.651,
↪  -754.634, 420.799, -289.127, 290.859, 532.697, 948.783, -290.409, 492.329, 880.839,
↪  182.849, -848.467, -764.89, -349.402, -793.051, 506.988, 15.064, 193.771, 912.559,
↪  -665.278, 53.31, -991.261, 75.658, -544.119, 876.786, -250.607, 101.278, 196.537,
↪  -680.867, -797.061, -775.764, 690.607, -171.048, 392.011]
Expected Result: [-991.261, -879.451, -848.467, -797.061, -793.051, -775.764, -764.89,
↪  -754.634, -680.867, -665.278, -616.457, -552.415, -544.119, -353.99, -349.402,
↪  -339.076, -334.6, -323.186, -306.257, -290.409, -289.127, -250.607, -171.048, 15.064,
↪  53.31, 75.658, 101.278, 110.651, 125.93, 153.16, 182.849, 193.771, 196.537, 202.005,
↪  232.465, 265.0, 290.859, 392.011, 420.799, 478.916, 492.329, 506.988, 532.697, 548.887,
↪  690.607, 825.693, 876.786, 880.839, 912.559, 948.783]
Got:
Unsorted Array: [-339.076, 232.465, 548.887, -353.99, -334.6, -552.415, 202.005, 153.16,
↪  -323.186, 265.0, -616.457, -879.451, 125.93, -306.257, 825.693, 478.916, 110.651,
↪  -754.634, 420.799, -289.127, 290.859, 532.697, 948.783, -290.409, 492.329, 880.839,
↪  182.849, -848.467, -764.89, -349.402, -793.051, 506.988, 15.064, 193.771, 912.559,
↪  -665.278, 53.31, -991.261, 75.658, -544.119, 876.786, -250.607, 101.278, 196.537,
↪  -680.867, -797.061, -775.764, 690.607, -171.048, 392.011]
-----------------------------------------------
From 0 to 1
Current array:  [-339.076, 232.465, 548.887, -353.99, -334.6, -552.415, 202.005, 153.16,
↪  -323.186, 265.0, -616.457, -879.451, 125.93, -306.257, 825.693, 478.916, 110.651,
↪  -754.634, 420.799, -289.127, 290.859, 532.697, 948.783, -290.409, 492.329, 880.839,
↪  182.849, -848.467, -764.89, -349.402, -793.051, 506.988, 15.064, 193.771, 912.559,
↪  -665.278, 53.31, -991.261, 75.658, -544.119, 876.786, -250.607, 101.278, 196.537,
↪  -680.867, -797.061, -775.764, 690.607, -171.048, 392.011]
From 2 to 3
Current array:  [-339.076, 232.465, -353.99, 548.887, -334.6, -552.415, 202.005, 153.16,
↪  -323.186, 265.0, -616.457, -879.451, 125.93, -306.257, 825.693, 478.916, 110.651,
↪  -754.634, 420.799, -289.127, 290.859, 532.697, 948.783, -290.409, 492.329, 880.839,
↪  182.849, -848.467, -764.89, -349.402, -793.051, 506.988, 15.064, 193.771, 912.559,
↪  -665.278, 53.31, -991.261, 75.658, -544.119, 876.786, -250.607, 101.278, 196.537,
↪  -680.867, -797.061, -775.764, 690.607, -171.048, 392.011]
[...]
From 0 to 49
Current array:  [-991.261, -879.451, -848.467, -797.061, -793.051, -775.764, -764.89,
↪  -754.634, -680.867, -665.278, -616.457, -552.415, -544.119, -353.99, -349.402,
↪  -339.076, -334.6, -323.186, -306.257, -290.409, -289.127, -250.607, -171.048, 15.064,
↪  53.31, 75.658, 101.278, 110.651, 125.93, 153.16, 182.849, 193.771, 196.537, 202.005,
↪  232.465, 265.0, 290.859, 392.011, 420.799, 478.916, 492.329, 506.988, 532.697, 548.887,
↪  690.607, 825.693, 876.786, 880.839, 912.559, 948.783]
-----------------------------------------------
```

```
Sorted Array:   [-991.261, -879.451, -848.467, -797.061, -793.051, -775.764, -764.89,
↪  -754.634, -680.867, -665.278, -616.457, -552.415, -544.119, -353.99, -349.402,
↪  -339.076, -334.6, -323.186, -306.257, -290.409, -289.127, -250.607, -171.048, 15.064,
↪  53.31, 75.658, 101.278, 110.651, 125.93, 153.16, 182.849, 193.771, 196.537, 202.005,
↪  232.465, 265.0, 290.859, 392.011, 420.799, 478.916, 492.329, 506.988, 532.697, 548.887,
↪  690.607, 825.693, 876.786, 880.839, 912.559, 948.783]
```

Lệnh R	Lệnh I	Lệnh J	IC
10140	30321	3440	43901

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43901}{3.4 * 10^9} = 1.2912 * 10^{-5} \ (s)$$

Testcase 26: Range [-10000,10000]

```
Testcase 26:[-1527.884, -8763.781, 7124.916, -6963.593, -831.917, 1415.503, -1540.278,
↪  -7983.28, 2049.712, -1149.488, -7448.066, 5988.226, 1187.293, -7306.915, 2015.197,
↪  168.79, -6983.325, -8758.489, 310.01, 5246.415, -4718.542, 1712.145, 8887.875,
↪  -3836.371, 6916.789, 2685.851, 6589.122, 839.162, 5786.044, -9999.848, -8250.888,
↪  -7751.243, 3895.818, -847.371, 3674.345, -916.706, -8975.796, 6196.415, -8582.256,
↪  3810.492, 142.23, 2960.204, -9175.938, -1053.377, 2151.08, 8999.007, 3064.355,
↪  -3170.293, -5875.144, 8916.19]
Expected Result: [-9999.848, -9175.938, -8975.796, -8763.781, -8758.489, -8582.256,
↪  -8250.888, -7983.28, -7751.243, -7448.066, -7306.915, -6983.325, -6963.593, -5875.144,
↪  -4718.542, -3836.371, -3170.293, -1540.278, -1527.884, -1149.488, -1053.377, -916.706,
↪  -847.371, -831.917, 142.23, 168.79, 310.01, 839.162, 1187.293, 1415.503, 1712.145,
↪  2015.197, 2049.712, 2151.08, 2685.851, 2960.204, 3064.355, 3674.345, 3810.492,
↪  3895.818, 5246.415, 5786.044, 5988.226, 6196.415, 6589.122, 6916.789, 7124.916,
↪  8887.875, 8916.19, 8999.007]
Got:
Unsorted Array: [-1527.884, -8763.781, 7124.916, -6963.593, -831.917, 1415.503, -1540.278,
↪  -7983.28, 2049.712, -1149.488, -7448.066, 5988.226, 1187.293, -7306.915, 2015.197,
↪  168.79, -6983.325, -8758.489, 310.01, 5246.415, -4718.542, 1712.145, 8887.875,
↪  -3836.371, 6916.789, 2685.851, 6589.122, 839.162, 5786.044, -9999.848, -8250.888,
↪  -7751.243, 3895.818, -847.371, 3674.345, -916.706, -8975.796, 6196.415, -8582.256,
↪  3810.492, 142.23, 2960.204, -9175.938, -1053.377, 2151.08, 8999.007, 3064.355,
↪  -3170.293, -5875.144, 8916.19]
-----------------------------------------
From 0 to 1
Current array:  [-8763.781, -1527.884, 7124.916, -6963.593, -831.917, 1415.503, -1540.278,
↪  -7983.28, 2049.712, -1149.488, -7448.066, 5988.226, 1187.293, -7306.915, 2015.197,
↪  168.79, -6983.325, -8758.489, 310.01, 5246.415, -4718.542, 1712.145, 8887.875,
↪  -3836.371, 6916.789, 2685.851, 6589.122, 839.162, 5786.044, -9999.848, -8250.888,
↪  -7751.243, 3895.818, -847.371, 3674.345, -916.706, -8975.796, 6196.415, -8582.256,
↪  3810.492, 142.23, 2960.204, -9175.938, -1053.377, 2151.08, 8999.007, 3064.355,
↪  -3170.293, -5875.144, 8916.19]
From 2 to 3
Current array:  [-8763.781, -1527.884, -6963.593, 7124.916, -831.917, 1415.503, -1540.278,
↪  -7983.28, 2049.712, -1149.488, -7448.066, 5988.226, 1187.293, -7306.915, 2015.197,
↪  168.79, -6983.325, -8758.489, 310.01, 5246.415, -4718.542, 1712.145, 8887.875,
↪  -3836.371, 6916.789, 2685.851, 6589.122, 839.162, 5786.044, -9999.848, -8250.888,
↪  -7751.243, 3895.818, -847.371, 3674.345, -916.706, -8975.796, 6196.415, -8582.256,
↪  3810.492, 142.23, 2960.204, -9175.938, -1053.377, 2151.08, 8999.007, 3064.355,
↪  -3170.293, -5875.144, 8916.19]
[...]
From 0 to 49
```

```
Current array:  [-9999.848, -9175.938, -8975.796, -8763.781, -8758.489, -8582.256,
↪  -8250.888, -7983.28, -7751.243, -7448.066, -7306.915, -6983.325, -6963.593, -5875.144,
↪  -4718.542, -3836.371, -3170.293, -1540.278, -1527.884, -1149.488, -1053.377, -916.706,
↪  -847.371, -831.917, 142.23, 168.79, 310.01, 839.162, 1187.293, 1415.503, 1712.145,
↪  2015.197, 2049.712, 2151.08, 2685.851, 2960.204, 3064.355, 3674.345, 3810.492,
↪  3895.818, 5246.415, 5786.044, 5988.226, 6196.415, 6589.122, 6916.789, 7124.916,
↪  8887.875, 8916.19, 8999.007]
---------------------------------------------
Sorted Array:   [-9999.848, -9175.938, -8975.796, -8763.781, -8758.489, -8582.256,
↪  -8250.888, -7983.28, -7751.243, -7448.066, -7306.915, -6983.325, -6963.593, -5875.144,
↪  -4718.542, -3836.371, -3170.293, -1540.278, -1527.884, -1149.488, -1053.377, -916.706,
↪  -847.371, -831.917, 142.23, 168.79, 310.01, 839.162, 1187.293, 1415.503, 1712.145,
↪  2015.197, 2049.712, 2151.08, 2685.851, 2960.204, 3064.355, 3674.345, 3810.492,
↪  3895.818, 5246.415, 5786.044, 5988.226, 6196.415, 6589.122, 6916.789, 7124.916,
↪  8887.875, 8916.19, 8999.007]
```

Lệnh R	Lệnh I	Lệnh J	IC
10140	30321	3443	43904

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43904}{3.4 * 10^9} = 1.2913 * 10^{-5} \ (s)$$

Testcase 27: Range [-10000,10000]

```
Testcase 27:[2240.268, -950.556, 6629.549, -2531.274, 4082.055, 5856.022, 185.093,
↪  7384.931, -3588.646, -3035.2, 5762.768, 684.533, 7465.119, -8838.378, 1061.438,
↪  3297.421, 5526.503, 1123.997, 3287.406, -879.593, 3840.252, 3245.531, 2303.104,
↪  -2637.199, 253.261, -4349.138, -8520.107, 2630.255, -3076.147, -2561.711, -4688.838,
↪  -5426.654, -1613.056, 2365.834, 5883.815, 9265.451, 4767.544, -7777.872, -7559.812,
↪  543.455, -6629.032, 5264.207, -4671.668, -5283.648, 3106.033, 9376.562, 6958.625,
↪  -7995.951, 3136.346, -1875.621]
Expected Result: [-8838.378, -8520.107, -7995.951, -7777.872, -7559.812, -6629.032,
↪  -5426.654, -5283.648, -4688.838, -4671.668, -4349.138, -3588.646, -3076.147, -3035.2,
↪  -2637.199, -2561.711, -2531.274, -1875.621, -1613.056, -950.556, -879.593, 185.093,
↪  253.261, 543.455, 684.533, 1061.438, 1123.997, 2240.268, 2303.104, 2365.834, 2630.255,
↪  3106.033, 3136.346, 3245.531, 3287.406, 3297.421, 3840.252, 4082.055, 4767.544,
↪  5264.207, 5526.503, 5762.768, 5856.022, 5883.815, 6629.549, 6958.625, 7384.931,
↪  7465.119, 9265.451, 9376.562]
Got:
Unsorted Array: [2240.268, -950.556, 6629.549, -2531.274, 4082.055, 5856.022, 185.093,
↪  7384.931, -3588.646, -3035.2, 5762.768, 684.533, 7465.119, -8838.378, 1061.438,
↪  3297.421, 5526.503, 1123.997, 3287.406, -879.593, 3840.252, 3245.531, 2303.104,
↪  -2637.199, 253.261, -4349.138, -8520.107, 2630.255, -3076.147, -2561.711, -4688.838,
↪  -5426.654, -1613.056, 2365.834, 5883.815, 9265.451, 4767.544, -7777.872, -7559.812,
↪  543.455, -6629.032, 5264.207, -4671.668, -5283.648, 3106.033, 9376.562, 6958.625,
↪  -7995.951, 3136.346, -1875.621]
---------------------------------------------
From 0 to 1
Current array:  [-950.556, 2240.268, 6629.549, -2531.274, 4082.055, 5856.022, 185.093,
↪  7384.931, -3588.646, -3035.2, 5762.768, 684.533, 7465.119, -8838.378, 1061.438,
↪  3297.421, 5526.503, 1123.997, 3287.406, -879.593, 3840.252, 3245.531, 2303.104,
↪  -2637.199, 253.261, -4349.138, -8520.107, 2630.255, -3076.147, -2561.711, -4688.838,
↪  -5426.654, -1613.056, 2365.834, 5883.815, 9265.451, 4767.544, -7777.872, -7559.812,
↪  543.455, -6629.032, 5264.207, -4671.668, -5283.648, 3106.033, 9376.562, 6958.625,
↪  -7995.951, 3136.346, -1875.621]
From 2 to 3
```

```
Current array:  [-950.556, 2240.268, -2531.274, 6629.549, 4082.055, 5856.022, 185.093,
↪  7384.931, -3588.646, -3035.2, 5762.768, 684.533, 7465.119, -8838.378, 1061.438,
↪  3297.421, 5526.503, 1123.997, 3287.406, -879.593, 3840.252, 3245.531, 2303.104,
↪  -2637.199, 253.261, -4349.138, -8520.107, 2630.255, -3076.147, -2561.711, -4688.838,
↪  -5426.654, -1613.056, 2365.834, 5883.815, 9265.451, 4767.544, -7777.872, -7559.812,
↪  543.455, -6629.032, 5264.207, -4671.668, -5283.648, 3106.033, 9376.562, 6958.625,
↪  -7995.951, 3136.346, -1875.621]
[...]
From 0 to 49
Current array:  [-8838.378, -8520.107, -7995.951, -7777.872, -7559.812, -6629.032,
↪  -5426.654, -5283.648, -4688.838, -4671.668, -4349.138, -3588.646, -3076.147, -3035.2,
↪  -2637.199, -2561.711, -2531.274, -1875.621, -1613.056, -950.556, -879.593, 185.093,
↪  253.261, 543.455, 684.533, 1061.438, 1123.997, 2240.268, 2303.104, 2365.834, 2630.255,
↪  3106.033, 3136.346, 3245.531, 3287.406, 3297.421, 3840.252, 4082.055, 4767.544,
↪  5264.207, 5526.503, 5762.768, 5856.022, 5883.815, 6629.549, 6958.625, 7384.931,
↪  7465.119, 9265.451, 9376.562]
-----------------------------------------------
Sorted Array:   [-8838.378, -8520.107, -7995.951, -7777.872, -7559.812, -6629.032,
↪  -5426.654, -5283.648, -4688.838, -4671.668, -4349.138, -3588.646, -3076.147, -3035.2,
↪  -2637.199, -2561.711, -2531.274, -1875.621, -1613.056, -950.556, -879.593, 185.093,
↪  253.261, 543.455, 684.533, 1061.438, 1123.997, 2240.268, 2303.104, 2365.834, 2630.255,
↪  3106.033, 3136.346, 3245.531, 3287.406, 3297.421, 3840.252, 4082.055, 4767.544,
↪  5264.207, 5526.503, 5762.768, 5856.022, 5883.815, 6629.549, 6958.625, 7384.931,
↪  7465.119, 9265.451, 9376.562]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30304	3436	43874

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43874}{3.4 * 10^9} = 1.2904 * 10^{-5} \ (s)$$

Testcase 28: Range [-10000,10000]

```
Testcase 28:[-2341.192, -9507.92, -3977.586, 315.263, 2530.294, 4349.993, 9417.34,
↪  -8008.545, -8311.587, -8121.104, 7234.902, -907.667, -678.725, 9638.786, 2282.838,
↪  5480.919, -2470.519, -1443.282, 6856.364, -5779.904, -3352.91, -6442.059, 4667.425,
↪  -8996.535, -5379.087, 214.858, 2232.534, -8780.005, -8378.472, 4334.263, 6699.497,
↪  4380.901, 1474.976, 6418.878, 4219.54, -6684.353, 6361.424, 758.156, -643.671,
↪  -7011.016, -4194.512, 2772.081, 9970.833, 3269.303, 4618.173, -2523.3, 4007.419,
↪  8155.886, -6025.517, 8995.96]
Expected Result: [-9507.92, -8996.535, -8780.005, -8378.472, -8311.587, -8121.104,
↪  -8008.545, -7011.016, -6684.353, -6442.059, -6025.517, -5779.904, -5379.087, -4194.512,
↪  -3977.586, -3352.91, -2523.3, -2470.519, -2341.192, -1443.282, -907.667, -678.725,
↪  -643.671, 214.858, 315.263, 758.156, 1474.976, 2232.534, 2282.838, 2530.294, 2772.081,
↪  3269.303, 4007.419, 4219.54, 4334.263, 4349.993, 4380.901, 4618.173, 4667.425,
↪  5480.919, 6361.424, 6418.878, 6699.497, 6856.364, 7234.902, 8155.886, 8995.96, 9417.34,
↪  9638.786, 9970.833]
Got:
Unsorted Array: [-2341.192, -9507.92, -3977.586, 315.263, 2530.294, 4349.993, 9417.34,
↪  -8008.545, -8311.587, -8121.104, 7234.902, -907.667, -678.725, 9638.786, 2282.838,
↪  5480.919, -2470.519, -1443.282, 6856.364, -5779.904, -3352.91, -6442.059, 4667.425,
↪  -8996.535, -5379.087, 214.858, 2232.534, -8780.005, -8378.472, 4334.263, 6699.497,
↪  4380.901, 1474.976, 6418.878, 4219.54, -6684.353, 6361.424, 758.156, -643.671,
↪  -7011.016, -4194.512, 2772.081, 9970.833, 3269.303, 4618.173, -2523.3, 4007.419,
↪  8155.886, -6025.517, 8995.96]
-----------------------------------------------
From 0 to 1
```

```
Current array:  [-9507.92, -2341.192, -3977.586, 315.263, 2530.294, 4349.993, 9417.34,
↪  -8008.545, -8311.587, -8121.104, 7234.902, -907.667, -678.725, 9638.786, 2282.838,
↪  5480.919, -2470.519, -1443.282, 6856.364, -5779.904, -3352.91, -6442.059, 4667.425,
↪  -8996.535, -5379.087, 214.858, 2232.534, -8780.005, -8378.472, 4334.263, 6699.497,
↪  4380.901, 1474.976, 6418.878, 4219.54, -6684.353, 6361.424, 758.156, -643.671,
↪  -7011.016, -4194.512, 2772.081, 9970.833, 3269.303, 4618.173, -2523.3, 4007.419,
↪  8155.886, -6025.517, 8995.96]
From 2 to 3
Current array:  [-9507.92, -2341.192, -3977.586, 315.263, 2530.294, 4349.993, 9417.34,
↪  -8008.545, -8311.587, -8121.104, 7234.902, -907.667, -678.725, 9638.786, 2282.838,
↪  5480.919, -2470.519, -1443.282, 6856.364, -5779.904, -3352.91, -6442.059, 4667.425,
↪  -8996.535, -5379.087, 214.858, 2232.534, -8780.005, -8378.472, 4334.263, 6699.497,
↪  4380.901, 1474.976, 6418.878, 4219.54, -6684.353, 6361.424, 758.156, -643.671,
↪  -7011.016, -4194.512, 2772.081, 9970.833, 3269.303, 4618.173, -2523.3, 4007.419,
↪  8155.886, -6025.517, 8995.96]
[...]
From 0 to 49
Current array:  [-9507.92, -8996.535, -8780.005, -8378.472, -8311.587, -8121.104,
↪  -8008.545, -7011.016, -6684.353, -6442.059, -6025.517, -5779.904, -5379.087, -4194.512,
↪  -3977.586, -3352.91, -2523.3, -2470.519, -2341.192, -1443.282, -907.667, -678.725,
↪  -643.671, 214.858, 315.263, 758.156, 1474.976, 2232.534, 2282.838, 2530.294, 2772.081,
↪  3269.303, 4007.419, 4219.54, 4334.263, 4349.993, 4380.901, 4618.173, 4667.425,
↪  5480.919, 6361.424, 6418.878, 6699.497, 6856.364, 7234.902, 8155.886, 8995.96, 9417.34,
↪  9638.786, 9970.833]
--------------------------------------------
Sorted Array:   [-9507.92, -8996.535, -8780.005, -8378.472, -8311.587, -8121.104,
↪  -8008.545, -7011.016, -6684.353, -6442.059, -6025.517, -5779.904, -5379.087, -4194.512,
↪  -3977.586, -3352.91, -2523.3, -2470.519, -2341.192, -1443.282, -907.667, -678.725,
↪  -643.671, 214.858, 315.263, 758.156, 1474.976, 2232.534, 2282.838, 2530.294, 2772.081,
↪  3269.303, 4007.419, 4219.54, 4334.263, 4349.993, 4380.901, 4618.173, 4667.425,
↪  5480.919, 6361.424, 6418.878, 6699.497, 6856.364, 7234.902, 8155.886, 8995.96, 9417.34,
↪  9638.786, 9970.833]
```

Lệnh R	Lệnh I	Lệnh J	IC
10135	30305	3444	43884

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43884}{3.4 * 10^9} = 1.2907 * 10^{-5} \ (s)$$

Testcase 29: Range [-10000,10000]

```
Testcase 29:[57.768, 1566.313, -9219.717, 6616.214, 1374.255, 2970.018, 8923.016,
↪  -9791.351, 7092.371, 829.423, -5129.777, -4809.824, -7131.793, 2252.742, 5615.3,
↪  8546.447, 6600.255, -9167.704, 7753.381, -7591.077, -5875.619, 3162.322, 3309.033,
↪  281.136, -8292.797, -9832.904, -1057.056, -9280.219, -8214.81, 5357.767, 804.157,
↪  2561.555, -3415.442, 1535.837, 7008.071, -5253.854, -3621.7, 6781.979, -9869.016,
↪  -2104.788, -1339.764, -5145.406, -6027.134, -7922.143, -7904.985, -5984.033, -1952.158,
↪  8003.321, 7667.123, -5249.98]
Expected Result: [-9869.016, -9832.904, -9791.351, -9280.219, -9219.717, -9167.704,
↪  -8292.797, -8214.81, -7922.143, -7904.985, -7591.077, -7131.793, -6027.134, -5984.033,
↪  -5875.619, -5253.854, -5249.98, -5145.406, -5129.777, -4809.824, -3621.7, -3415.442,
↪  -2104.788, -1952.158, -1339.764, -1057.056, 57.768, 281.136, 804.157, 829.423,
↪  1374.255, 1535.837, 1566.313, 2252.742, 2561.555, 2970.018, 3162.322, 3309.033,
↪  5357.767, 5615.3, 6600.255, 6616.214, 6781.979, 7008.071, 7092.371, 7667.123, 7753.381,
↪  8003.321, 8546.447, 8923.016]
Got:
```

```
Unsorted Array: [57.768, 1566.313, -9219.717, 6616.214, 1374.255, 2970.018, 8923.016,
↪  -9791.351, 7092.371, 829.423, -5129.777, -4809.824, -7131.793, 2252.742, 5615.3,
↪  8546.447, 6600.255, -9167.704, 7753.381, -7591.077, -5875.619, 3162.322, 3309.033,
↪  281.136, -8292.797, -9832.904, -1057.056, -9280.219, -8214.81, 5357.767, 804.157,
↪  2561.555, -3415.442, 1535.837, 7008.071, -5253.854, -3621.7, 6781.979, -9869.016,
↪  -2104.788, -1339.764, -5145.406, -6027.134, -7922.143, -7904.985, -5984.033, -1952.158,
↪  8003.321, 7667.123, -5249.98]
--------------------------------------------
From 0 to 1
Current array:  [57.768, 1566.313, -9219.717, 6616.214, 1374.255, 2970.018, 8923.016,
↪  -9791.351, 7092.371, 829.423, -5129.777, -4809.824, -7131.793, 2252.742, 5615.3,
↪  8546.447, 6600.255, -9167.704, 7753.381, -7591.077, -5875.619, 3162.322, 3309.033,
↪  281.136, -8292.797, -9832.904, -1057.056, -9280.219, -8214.81, 5357.767, 804.157,
↪  2561.555, -3415.442, 1535.837, 7008.071, -5253.854, -3621.7, 6781.979, -9869.016,
↪  -2104.788, -1339.764, -5145.406, -6027.134, -7922.143, -7904.985, -5984.033, -1952.158,
↪  8003.321, 7667.123, -5249.98]
From 2 to 3
Current array:  [57.768, 1566.313, -9219.717, 6616.214, 1374.255, 2970.018, 8923.016,
↪  -9791.351, 7092.371, 829.423, -5129.777, -4809.824, -7131.793, 2252.742, 5615.3,
↪  8546.447, 6600.255, -9167.704, 7753.381, -7591.077, -5875.619, 3162.322, 3309.033,
↪  281.136, -8292.797, -9832.904, -1057.056, -9280.219, -8214.81, 5357.767, 804.157,
↪  2561.555, -3415.442, 1535.837, 7008.071, -5253.854, -3621.7, 6781.979, -9869.016,
↪  -2104.788, -1339.764, -5145.406, -6027.134, -7922.143, -7904.985, -5984.033, -1952.158,
↪  8003.321, 7667.123, -5249.98]
[...]
From 0 to 49
Current array:  [-9869.016, -9832.904, -9791.351, -9280.219, -9219.717, -9167.704,
↪  -8292.797, -8214.81, -7922.143, -7904.985, -7591.077, -7131.793, -6027.134, -5984.033,
↪  -5875.619, -5253.854, -5249.98, -5145.406, -5129.777, -4809.824, -3621.7, -3415.442,
↪  -2104.788, -1952.158, -1339.764, -1057.056, 57.768, 281.136, 804.157, 829.423,
↪  1374.255, 1535.837, 1566.313, 2252.742, 2561.555, 2970.018, 3162.322, 3309.033,
↪  5357.767, 5615.3, 6600.255, 6616.214, 6781.979, 7008.071, 7092.371, 7667.123, 7753.381,
↪  8003.321, 8546.447, 8923.016]
--------------------------------------------
Sorted Array:   [-9869.016, -9832.904, -9791.351, -9280.219, -9219.717, -9167.704,
↪  -8292.797, -8214.81, -7922.143, -7904.985, -7591.077, -7131.793, -6027.134, -5984.033,
↪  -5875.619, -5253.854, -5249.98, -5145.406, -5129.777, -4809.824, -3621.7, -3415.442,
↪  -2104.788, -1952.158, -1339.764, -1057.056, 57.768, 281.136, 804.157, 829.423,
↪  1374.255, 1535.837, 1566.313, 2252.742, 2561.555, 2970.018, 3162.322, 3309.033,
↪  5357.767, 5615.3, 6600.255, 6616.214, 6781.979, 7008.071, 7092.371, 7667.123, 7753.381,
↪  8003.321, 8546.447, 8923.016]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30296	3444	43874

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43874}{3.4 * 10^9} = 1.2904 * 10^{-5} \ (s)$$

Testcase 30: Range [-10000,10000]

```
Testcase 30:[-962.858, 9818.01, -6477.765, -9240.773, 6011.937, -2761.61, 2715.285,
↪  -7458.972, 9994.299, 8655.005, 4596.247, 1883.858, -9528.377, -9118.649, 7176.856,
↪  3151.494, -281.062, 2559.125, -119.249, -4376.422, 9385.195, -1931.018, 9503.287,
↪  -2837.743, 7717.346, 521.422, 435.957, -4769.552, -7383.0, 4017.666, -5787.8,
↪  -6366.994, 43.75, 6323.169, -6442.651, -9324.26, -6760.675, -6339.054, 7000.495,
↪  -4636.416, 4248.967, -4317.137, 9780.658, 4698.3, 9573.222, 5397.591, -6001.695,
↪  -9052.361, 701.68, -2462.871]
```

```
Expected Result: [-9528.377, -9324.26, -9240.773, -9118.649, -9052.361, -7458.972, -7383.0,
↪  -6760.675, -6477.765, -6442.651, -6366.994, -6339.054, -6001.695, -5787.8, -4769.552,
↪  -4636.416, -4376.422, -4317.137, -2837.743, -2761.61, -2462.871, -1931.018, -962.858,
↪  -281.062, -119.249, 43.75, 435.957, 521.422, 701.68, 1883.858, 2559.125, 2715.285,
↪  3151.494, 4017.666, 4248.967, 4596.247, 4698.3, 5397.591, 6011.937, 6323.169, 7000.495,
↪  7176.856, 7717.346, 8655.005, 9385.195, 9503.287, 9573.222, 9780.658, 9818.01,
↪  9994.299]
Got:
Unsorted Array: [-962.858, 9818.01, -6477.765, -9240.773, 6011.937, -2761.61, 2715.285,
↪  -7458.972, 9994.299, 8655.005, 4596.247, 1883.858, -9528.377, -9118.649, 7176.856,
↪  3151.494, -281.062, 2559.125, -119.249, -4376.422, 9385.195, -1931.018, 9503.287,
↪  -2837.743, 7717.346, 521.422, 435.957, -4769.552, -7383.0, 4017.666, -5787.8,
↪  -6366.994, 43.75, 6323.169, -6442.651, -9324.26, -6760.675, -6339.054, 7000.495,
↪  -4636.416, 4248.967, -4317.137, 9780.658, 4698.3, 9573.222, 5397.591, -6001.695,
↪  -9052.361, 701.68, -2462.871]
-------------------------------------------
From 0 to 1
Current array:  [-962.858, 9818.01, -6477.765, -9240.773, 6011.937, -2761.61, 2715.285,
↪  -7458.972, 9994.299, 8655.005, 4596.247, 1883.858, -9528.377, -9118.649, 7176.856,
↪  3151.494, -281.062, 2559.125, -119.249, -4376.422, 9385.195, -1931.018, 9503.287,
↪  -2837.743, 7717.346, 521.422, 435.957, -4769.552, -7383.0, 4017.666, -5787.8,
↪  -6366.994, 43.75, 6323.169, -6442.651, -9324.26, -6760.675, -6339.054, 7000.495,
↪  -4636.416, 4248.967, -4317.137, 9780.658, 4698.3, 9573.222, 5397.591, -6001.695,
↪  -9052.361, 701.68, -2462.871]
From 2 to 3
Current array:  [-962.858, 9818.01, -9240.773, -6477.765, 6011.937, -2761.61, 2715.285,
↪  -7458.972, 9994.299, 8655.005, 4596.247, 1883.858, -9528.377, -9118.649, 7176.856,
↪  3151.494, -281.062, 2559.125, -119.249, -4376.422, 9385.195, -1931.018, 9503.287,
↪  -2837.743, 7717.346, 521.422, 435.957, -4769.552, -7383.0, 4017.666, -5787.8,
↪  -6366.994, 43.75, 6323.169, -6442.651, -9324.26, -6760.675, -6339.054, 7000.495,
↪  -4636.416, 4248.967, -4317.137, 9780.658, 4698.3, 9573.222, 5397.591, -6001.695,
↪  -9052.361, 701.68, -2462.871]
[...]
From 0 to 49
Current array:  [-9528.377, -9324.26, -9240.773, -9118.649, -9052.361, -7458.972, -7383.0,
↪  -6760.675, -6477.765, -6442.651, -6366.994, -6339.054, -6001.695, -5787.8, -4769.552,
↪  -4636.416, -4376.422, -4317.137, -2837.743, -2761.61, -2462.871, -1931.018, -962.858,
↪  -281.062, -119.249, 43.75, 435.957, 521.422, 701.68, 1883.858, 2559.125, 2715.285,
↪  3151.494, 4017.666, 4248.967, 4596.247, 4698.3, 5397.591, 6011.937, 6323.169, 7000.495,
↪  7176.856, 7717.346, 8655.005, 9385.195, 9503.287, 9573.222, 9780.658, 9818.01,
↪  9994.299]
-------------------------------------------
Sorted Array:   [-9528.377, -9324.26, -9240.773, -9118.649, -9052.361, -7458.972, -7383.0,
↪  -6760.675, -6477.765, -6442.651, -6366.994, -6339.054, -6001.695, -5787.8, -4769.552,
↪  -4636.416, -4376.422, -4317.137, -2837.743, -2761.61, -2462.871, -1931.018, -962.858,
↪  -281.062, -119.249, 43.75, 435.957, 521.422, 701.68, 1883.858, 2559.125, 2715.285,
↪  3151.494, 4017.666, 4248.967, 4596.247, 4698.3, 5397.591, 6011.937, 6323.169, 7000.495,
↪  7176.856, 7717.346, 8655.005, 9385.195, 9503.287, 9573.222, 9780.658, 9818.01,
↪  9994.299]
```

Lệnh R	Lệnh I	Lệnh J	IC
10134	30308	3430	43872

$$\text{Time} = \frac{\text{CPI*IC}}{\text{CR}} = \frac{1 * 43872}{3.4 * 10^9} = 1.2903 * 10^{-5} \ (s)$$

6.3 Kết luận

Như vậy, ta có thể thấy thuật toán Merge Sort thực hiện sắp xếp tăng dần đối với một mảng gồm 50 phần tử tốn khoảng 0.0129 ms, khi thực hiện trên phần cứng có CPI = 1 và tần số 3.4 GHz.
Sử dụng chương trình mà nhóm đã viết, một mảng 50 phần tử cần 43900 lệnh MIPS để xấp xếp tăng

dần bằng thuật toán Merge Sort, trong đó 25% là lệnh kiểu R, 67% là lệnh kiểu I, và 7% là lệnh kiểu J.

7 Lời kết

Qua dự án bài tập lớn lần này, nhóm em không chỉ tích lũy được kinh nghiệm học thuật khi thực hiện các nội dung mà thầy cô đưa ra, ngoài ra chúng em còn được luyện tập giao tiếp, làm việc nhóm một cách có năng suất, hiệu quả, đồng thời có thêm nhiều động lực hơn khi học môn này.
Tuy vậy, trong quá trình thực hiện dự án bài tập lớn, khó tránh khỏi sự sai sót trong quá trình hiện thực code và do trình độ lý luận còn hạn chế nên bài báo cáo không thể không có thiếu xót, nhóm chúng em rất mong có thể nhận được sự góp ý của các thầy cô, anh chị để tiếp thu đồng thời tích lũy kinh nghiệm trong các dự án sắp tới.
Để kết thúc dự án bài tập lớn này, nhóm xin một lần cuối gửi lời cảm ơn chân thành nhất đến quý thầy, các anh chị, các bạn sinh viên Đại học Quốc Gia - TP HCM nói chung và sinh viên trường Đại học Bách Khoa - TP HCM nói riêng đã giúp nhóm chúng em hoàn thành dự án bài tập lớn Kiến Trúc Máy Tính của học kỳ này.

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