Step 1: By Hand

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |
|  | 12 | 6 | 13 | 19 | 3 | 16 | 7 | 10 | 8 |  | 18 | 4 | 15 | 9 | 20 | 17 | 11 | 14 | 1 | 2 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | | | 5 |  | | | | | | | | | | |
|  | 2 | 6 | 13 | 19 | 3 | 16 | 7 | 10 | 8 |  | 18 | 4 | 15 | 9 | 20 | 17 | 11 | 14 | 1 | 12 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 1 | 13 | 19 | 3 | 16 | 7 | 10 | 8 |  | 18 | 4 | 15 | 9 | 20 | 17 | 11 | 14 | 6 | 12 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 1 | 4 | 19 | 3 | 16 | 7 | 10 | 8 |  | 18 | 13 | 15 | 9 | 20 | 17 | 11 | 14 | 6 | 12 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 | 1 | 4 | 3 | 19 | 16 | 7 | 10 | 8 |  | 18 | 13 | 15 | 9 | 20 | 17 | 11 | 14 | 6 | 12 |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |
|  |  | 1 |  |  | 5 |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  | 2 |  | 4 | 3 |  | 16 | 7 | 10 | 8 | 19 | 18 | 13 |  | 9 | 20 | 17 | 11 | 14 | 6 | 12 |  |
| PIVOT POSITION HAS BEEN SORTED SO NEW PIVIOT POINT FOR SUB-LISTS | | | | | | | | | | | | | | | | | | | | | |
|  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 |  | 4 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FIRST SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2 |  | 4 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |
|  | 1 |  |  |  | 5 |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  |  | 2 | 4 | 3 |  | 16 | 7 | 10 | 8 | 19 | 18 | 13 |  | 9 | 20 | 17 | 11 | 14 | 6 | 12 |  |
| PIVOT POSITION HAS BEEN SORTED SO FIRST SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 16 | 7 | 10 | 8 | 19 | 18 | 13 |  | 9 | 20 | 17 | 11 | 14 | 6 | 12 |  |
| FOCUS ON THE SECOND SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 16 | 7 | 10 | 8 | 19 | 18 | 13 |  | 9 | 20 | 17 | 11 | 14 | 6 | 12 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 12 | 7 | 10 | 8 | 19 | 18 | 13 |  | 9 | 20 | 17 | 11 | 14 | 6 | 16 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 12 | 7 | 10 | 8 | 6 | 18 | 13 |  | 9 | 20 | 17 | 11 | 14 | 19 | 16 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 12 | 7 | 10 | 8 | 6 | 14 | 13 |  | 9 | 20 | 17 | 11 | 18 | 19 | 16 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 12 | 7 | 10 | 8 | 6 | 14 | 13 |  | 9 | 11 | 17 | 20 | 18 | 19 | 16 |  |
| POINTERS MET UP AND THE POINTER VALUE IS IN ORDER WITH THE PIVOT VALUE SO SWAP THE PIVOT WITH THE VALUE TO THE LEFT OF THE POINTER | | | | | | | | | | | | | | | | | | | | | |
|  | 1 |  |  |  | 5 |  |  |  |  |  |  |  |  |  | 15 |  |  |  |  |  |  |
|  |  | 2 | 4 | 3 |  | 12 | 7 | 10 | 8 | 6 | 14 | 13 | 11 | 9 |  | 17 | 20 | 18 | 19 | 16 |  |
| PIVOT POSITION HAS BEEN SORTED SO SECOND SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  | 1 |  | 4 |  | 5 |  |  |  |  | 6 |  |  |  |  | 15 |  |  | 18 |  |  |  |
|  |  | 2 |  | 3 |  | 12 | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  | 17 | 20 |  | 19 | 16 |  |
| NEW PIVOT POINTS FOR EACH SUBLIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 2 |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FIRST SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 2 |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |
|  | 1 |  |  | 4 | 5 |  |  |  |  | 6 |  |  |  |  | 15 |  |  | 18 |  |  |  |
|  |  | 2 | 3 |  |  | 12 | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  | 17 | 20 |  | 19 | 16 |  |
| PIVOT POSITION HAS BEEN SORTED SO FIRST SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 6 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 12 | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  |  |  |  |  |  |  |
| FOCUS ON THE SECOND SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 6 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 12 | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  |  |  |  |  |  |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |
|  | 1 |  |  | 4 | 5 | 6 |  |  |  |  |  |  |  |  | 15 |  |  | 18 |  |  |  |
|  |  | 2 | 3 |  |  |  | 7 | 10 | 8 | 12 | 14 | 13 | 11 | 9 |  | 17 | 20 |  | 19 | 16 |  |
| PIVOT POSITION HAS BEEN SORTED SO SECOND SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 18 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 17 | 20 |  | 19 | 16 |  |
| FOCUS ON THE THIRD SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 18 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 17 | 20 |  | 19 | 16 |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 18 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 17 | 16 |  | 19 | 20 |  |
| POINTERS MET UP AND THE POINTER VALUE IS IN ORDER WITH THE PIVOT VALUE SO SWAP THE PIVOT WITH THE VALUE TO THE LEFT OF THE POINTER WHICH IS ITSELF | | | | | | | | | | | | | | | | | | | | | |
|  | 1 |  |  | 4 | 5 | 6 |  |  |  |  |  |  |  |  | 15 |  |  | 18 |  |  |  |
|  |  | 2 | 3 |  |  |  | 7 | 10 | 8 | 12 | 14 | 13 | 11 | 9 |  | 17 | 16 |  | 19 | 20 |  |
| PIVOT POSITION HAS BEEN SORTED SO THIRD SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 |  | 4 | 5 | 6 |  |  |  | 12 |  |  |  |  | 15 | 17 |  | 18 | 19 |  |  |
|  |  |  | 3 |  |  |  | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  |  | 16 |  |  | 20 |  |
| NEW PIVOT POINTS FOR EACH SUBLIST | | | | | | | | | | | | | | | | | | | | | |
|  |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FIRST SUB-LIST | | | | | | | | | | | | | | | | | | | | | |

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|  |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| POINTERS MET UP AND THE POINTER VALUE IS IN ORDER WITH THE PIVOT VALUE SO SWAP THE PIVOT WITH THE VALUE TO THE LEFT OF THE POINTER WHICH IS ITSELF | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 |  | 4 | 5 | 6 |  |  |  | 12 |  |  |  |  | 15 | 17 |  | 18 | 19 |  |  |
|  |  |  | 3 |  |  |  | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  |  | 16 |  |  | 20 |  |
| PIVOT POSITION HAS BEEN SORTED SO FIRST SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 12 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  |  |  |  |  |  |  |
| FOCUS ON THE SECOND SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 12 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 7 | 10 | 8 |  | 14 | 13 | 11 | 9 |  |  |  |  |  |  |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 12 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 7 | 10 | 8 |  | 9 | 13 | 11 | 14 |  |  |  |  |  |  |  |
| POINTER SCANNING LEFT DETECTS LARGER ITEM THAN PIVOT AND POINTER ON RIGHT DETECTS SMALLER NUMBER THAN PIVOT SO SWAP POINTER VALUES | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 12 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 7 | 10 | 8 |  | 9 | 11 | 13 | 14 |  |  |  |  |  |  |  |
| POINTERS MET UP AND THE POINTER VALUE IS IN ORDER WITH THE PIVOT VALUE SO SWAP THE PIVOT WITH THE VALUE TO THE LEFT OF THE POINTER | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 |  | 4 | 5 | 6 |  |  |  |  |  | 12 |  |  | 15 | 17 |  | 18 | 19 |  |  |
|  |  |  | 3 |  |  |  | 7 | 10 | 8 | 11 | 9 |  | 13 | 14 |  |  | 16 |  |  | 20 |  |
| PIVOT POSITION HAS BEEN SORTED SO SECOND SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 17 |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 16 |  |  |  |  |
| FOCUS ON THE THIRD SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 17 |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 16 |  |  |  |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 |  | 4 | 5 | 6 |  |  |  |  |  | 12 |  |  | 15 |  | 17 | 18 | 19 |  |  |
|  |  |  | 3 |  |  |  | 7 | 10 | 8 | 11 | 9 |  | 13 | 14 |  | 16 |  |  |  | 20 |  |
| PIVOT POSITION HAS BEEN SORTED SO THIRD SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 19 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 20 |  |
| FOCUS ON THE FOURTH SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 19 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 20 |  |
| POINTERS MET UP AND THE POINTER VALUE IS IN ORDER WITH THE PIVOT VALUE SO SWAP THE PIVOT WITH THE VALUE TO THE LEFT OF THE POINTER WHICH IS ITSELF | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 |  | 4 | 5 | 6 |  |  |  |  |  | 12 |  |  | 15 |  | 17 | 18 | 19 |  |  |
|  |  |  | 3 |  |  |  | 7 | 10 | 8 | 11 | 9 |  | 13 | 14 |  | 16 |  |  |  | 20 |  |
| PIVOT POSITION HAS BEEN SORTED SO FOURTH SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 |  |  | 8 |  |  | 12 | 13 |  | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  | 7 | 10 |  | 11 | 9 |  |  | 14 |  |  |  |  |  |  |  |
| NEW PIVOT POINTS FOR EACH SUBLIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FIRST SUB-LIST | | | | | | | | | | | | | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 |  |  | 8 |  |  | 12 | 13 |  | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  | 7 | 10 |  | 11 | 9 |  |  | 14 |  |  |  |  |  |  |  |
| ONLY ITEM IN SUB-LIST EQUALS PIVOT IS IN PLACE SO FIRST SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  | 8 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 7 | 10 |  | 11 | 9 |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE SECOND SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  | 8 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | 7 | 10 |  | 11 | 9 |  |  |  |  |  |  |  |  |  |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 |  | 8 |  |  |  | 12 | 13 |  | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  | 7 |  | 10 | 11 | 9 |  |  | 14 |  |  |  |  |  |  |  |
| PIVOT POSITION HAS BEEN SORTED SO SECOND SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 13 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | 14 |  |  |  |  |  |  |  |
| FOCUS ON THE THIRD SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 13 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | 14 |  |  |  |  |  |  |  |
| POINTERS MET UP AND THE POINTER VALUE IS IN ORDER WITH THE PIVOT VALUE SO SWAP THE PIVOT WITH THE VALUE TO THE LEFT OF THE POINTER WHICH IS ITSELF | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 |  | 8 |  |  |  | 12 | 13 |  | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  | 7 |  | 10 | 11 | 9 |  |  | 14 |  |  |  |  |  |  |  |
| PIVOT POSITION HAS BEEN SORTED SO THIRD SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 16 |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FOURTH SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 |  | 8 |  |  |  | 12 | 13 |  | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  | 7 |  | 10 | 11 | 9 |  |  | 14 |  |  |  |  |  |  |  |
| ONLY ITEM IN SUB-LIST EQUALS PIVOT IS IN PLACE SO FOURTH SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 20 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FIFTH SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 |  | 8 |  |  |  | 12 | 13 |  | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  | 7 |  | 10 | 11 | 9 |  |  | 14 |  |  |  |  |  |  |  |
| ONLY ITEM IN SUB-LIST EQUALS PIVOT IS IN PLACE SO FIFTH SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |  | 11 |  | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  | 10 |  | 9 |  |  |  |  |  |  |  |  |  |  |
| NEW PIVOT POINTS FOR EACH SUBLIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  | 7 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FIRST SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |  | 11 |  | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  | 10 |  | 9 |  |  |  |  |  |  |  |  |  |  |
| ONLY ITEM IN SUB-LIST EQUALS PIVOT IS IN PLACE SO FIRST SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 11 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | 10 |  | 9 |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE SECOND SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  | 11 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | 10 |  | 9 |  |  |  |  |  |  |  |  |  |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |  |  | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  | 10 | 9 |  |  |  |  |  |  |  |  |  |  |  |
| PIVOT POSITION HAS BEEN SORTED SO SECOND SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | 14 |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE THIRD SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |  |  | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  | 10 | 9 |  |  |  |  |  |  |  |  |  |  |  |
| ONLY ITEM IN SUB-LIST EQUALS PIVOT IS IN PLACE SO THIRD SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 10 |  | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  |  | 9 |  |  |  |  |  |  |  |  |  |  |  |
| NEW PIVOT POINTS FOR EACH SUBLIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  | 10 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 9 |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  | 10 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 9 |  |  |  |  |  |  |  |  |  |  |  |
| POINTERS MEET AND POINTER VALUE IS OUT OF ORDER WITH PIVOT SO SWAP PLACES | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  | 9 |  |  |  |  |  |  |  |  |  |  |  |  |
| PIVOT POSITION HAS BEEN SORTED SO FIRST SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| NEW PIVOT POINTS FOR EACH SUBLIST | | | | | | | | | | | | | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  | 9 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| FOCUS ON THE FIRST SUB-LIST | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| ONLY ITEM IN SUB-LIST EQUALS PIVOT IS IN PLACE SO FIRST SUB-LIST IS DONE | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| LIST HAS BEEN SORTED PROGRAM IS FINISHED | | | | | | | | | | | | | | | | | | | | | |

Step 2: Approach

Create a function called segregate() that takes in an array and two index points, named index\_start and index\_end, as parameters and works on organizing the array from smallest to largest from a pivot point. If there is more than one item in the array, then a pivot is created called index\_pivot and it’s picked from the middle of the two index points. Starting at index\_start search for the first value in the array that is larger than the index\_pivot value. After that search for the first value that is smaller than the index\_pivot value starting at index\_end. Once both values are found, swap the two values and continue searching while index\_start is less than index\_end. When index\_start is equal to index\_end, or vice versa, then the pivot needs to be relocated in the array. If the value of index\_start is greater than the value of index\_pivot, then swap the values of index\_start minus one and the value of index\_pivot and return index\_pivot. If the size of the sub-list is zero or one, then return the list because the sub-list is already sorted. Next, sort the sub-list to the left then right of the pivot until the array is sorted smallest to largest value.

Step 3.1: Structure chart

A diagram of data flow

AI-generated content may be incorrect.

Step 3.2: Pseudocode

Segregate(data, index\_start, index\_end)

IF index\_start = index\_end

RETUNR index\_start

index\_pivot <- (index\_start + index\_end) / 2

WHILE index\_start < index\_end

WHILE data[index\_start] <= data[index\_pivot]

index\_start += 1

WHILE data[index\_end] >= data[index\_pivot]

index\_end -= 1

IF index\_start < index\_end

SWAP data[index\_start], data[index\_end]

IF index\_start > index\_pivot AND data[index\_start] > data[index\_pivot]

index\_start -= 1

SWAP data[index\_start], data[index\_pivot]

RETURN index\_pivot <- index\_start, data

Step 4: Copilot

FUNCTION segregate(array, index\_start, index\_end):

IF index\_end - index\_start <= 0:

RETURN array // Sub-list is already sorted

SET index\_pivot = (index\_start + index\_end) // 2

SET pivot\_value = array[index\_pivot]

WHILE index\_start < index\_end:

// Find first value from the left greater than pivot

WHILE array[index\_start] <= pivot\_value AND index\_start < index\_end:

INCREMENT index\_start

// Find first value from the right less than pivot

WHILE array[index\_end] >= pivot\_value AND index\_start < index\_end:

DECREMENT index\_end

IF index\_start < index\_end:

SWAP array[index\_start] WITH array[index\_end]

// At this point, index\_start == index\_end

IF array[index\_start] > pivot\_value:

SWAP array[index\_start - 1] WITH array[index\_pivot]

SET index\_pivot = index\_start - 1

ELSE:

SWAP array[index\_start] WITH array[index\_pivot]

SET index\_pivot = index\_start

// Recursively sort left and right sublists

CALL segregate(array, original\_index\_start, index\_pivot - 1)

CALL segregate(array, index\_pivot + 1, original\_index\_end)

RETURN array

Step 5: Compare and Contrast

The CoPilot solution looks quite similar to mine but it incorporates a recursive section to handle the sub-lists created after the first pass of sorting. I was going to have the sort function handle this step but I see that I could potentially incorporate it into this step or another function entirely. It also handles the final pivot value swap slightly differently and I’m not sure if it’s more effective or not than what I did in my code.

Step6: Update

I plan to incorporate the recursive portion into my own code and see if the results are better than what I initially intended to do.

Step 1 By Hand: 180 minutes

Step 2 Approach: 30 minutes

Step 3 Pseudocode and Structure Chart: 120 minutes

Step 4 Copilot: 10 minutes

Step 5 Compare and Contrast: 15 minutes

Step 6 Update: 5 minutes