

**By: Nicholas & Tiffany**

1) Please check our GitHub files in the following repository link to see our bubble sort, insertion sort, and selection sort code: <https://github.com/HikariNoRyu/DataStructureGroupAssignment/tree/main>  
Yes, we decided to do those 3 basic sorting algorithms.

## 2 & 3) Insertion sort:

```
Pre sort: 9,4,3,3,1,9,7,2,8,2}9,4,3,3,1,9,7,2,8,2}
Post sort: 1, 2, 2, 3, 3, 4, 7, 8, 9, 9,

The runtime for this code is 2 milliseconds
F:\Assign\DataStructuresAssAttempt3\x64\Debug\DataStructuresAssAttempt3.exe (process 15924) exited with code 0.
Press any key to close this window . . .
```

Running time: 2 milliseconds  
input size: 10

```
Pre sort: 34,33,45,42,12,27,33,53,88,35,1,37,64,38,69,41,96,69,30,13,74,80,88,3,14,2,85,86,21,45,67,66,4,28,12,38,65,72,
98,50,73,91,62,9,62,11,72,33,86,66,23,81,64,48,32,72,95,45,21,94,62,61,16,92,19,82,13,83,7,65,4,65,20,23,46,87,75,93,51,
94,12,21,37,81,24,39,91,79,67,25,28,45,42,66,64,25,47,73,91,12)34,33,45,42,12,27,33,53,88,35,1,37,64,38,69,41,96,69,30,1,
3,74,80,88,3,14,2,85,86,21,45,67,66,4,28,12,38,65,72,98,50,73,91,62,9,62,11,72,33,86,66,23,81,64,48,32,72,95,45,21,94,62,
61,16,92,19,82,13,83,7,65,4,65,20,23,46,87,75,93,51,94,12,21,37,81,24,39,91,79,67,25,28,45,42,66,64,25,47,73,91,12)
Post sort: 1, 2, 3, 4, 4, 7, 9, 11, 12, 12, 12, 12, 13, 14, 12, 21, 37, 81, 24, 39, 91, 79, 67, 25, 28, 45, 42, 66, 64, 25, 47, 73, 91, 12)
30, 32, 33, 33, 33, 34, 35, 37, 37, 38, 39, 41, 42, 42, 45, 45, 45, 46, 47, 48, 50, 51, 53, 61, 62, 62, 62, 64,
64, 64, 65, 65, 65, 66, 66, 66, 67, 67, 69, 69, 72, 72, 72, 73, 73, 74, 75, 79, 80, 81, 81, 82, 83, 85, 86, 86, 87, 88,
88, 91, 91, 91, 92, 93, 94, 94, 95, 96, 98,

The runtime for this code is 11 milliseconds
F:\Assign\DataStructuresAssAttempt3\x64\Debug\DataStructuresAssAttempt3.exe (process 27256) exited with code 0.
Press any key to close this window . . .
```

Running time: 11 milliseconds  
Input size: 100

[illegible]

Running time: 412 milliseconds  
Input size: 1000

Input size: 100

```
The runtime for this code is 190 milliseconds
F:\Assign\DataStructuresAssAttempt3\src\Debug\DataStructuresAssAttempt3.exe (process 14216) exited with code 0.
Press any key to close this window.
```

Input size: 1000

```
The runtime for this code is 2177 milliseconds
F:\Assign\DataStructuresAssAttempt3\x64\Debug\DataStructuresAssAttempt3.exe (process 15804) exited with code
Press any key to close this window
```

Input size: 10000

Bubble sort:

```
Pre sort: 9,4,3,1,9,7,2,8,2}9,4,3,3,1,9,7,2,8,2}
Post sort: 1, 2, 2, 3, 3, 7, 4, 8, 9, 9,

The runtime for this code is 7 milliseconds
F:\Assign\DataStructuresAssAttempt3\X64\Debug\DataStructuresAssAttempt3.exe (process 25096) exited with code 0.
Press any key to close this window . . .
```

Running time: 7 milliseconds

Input size: 10

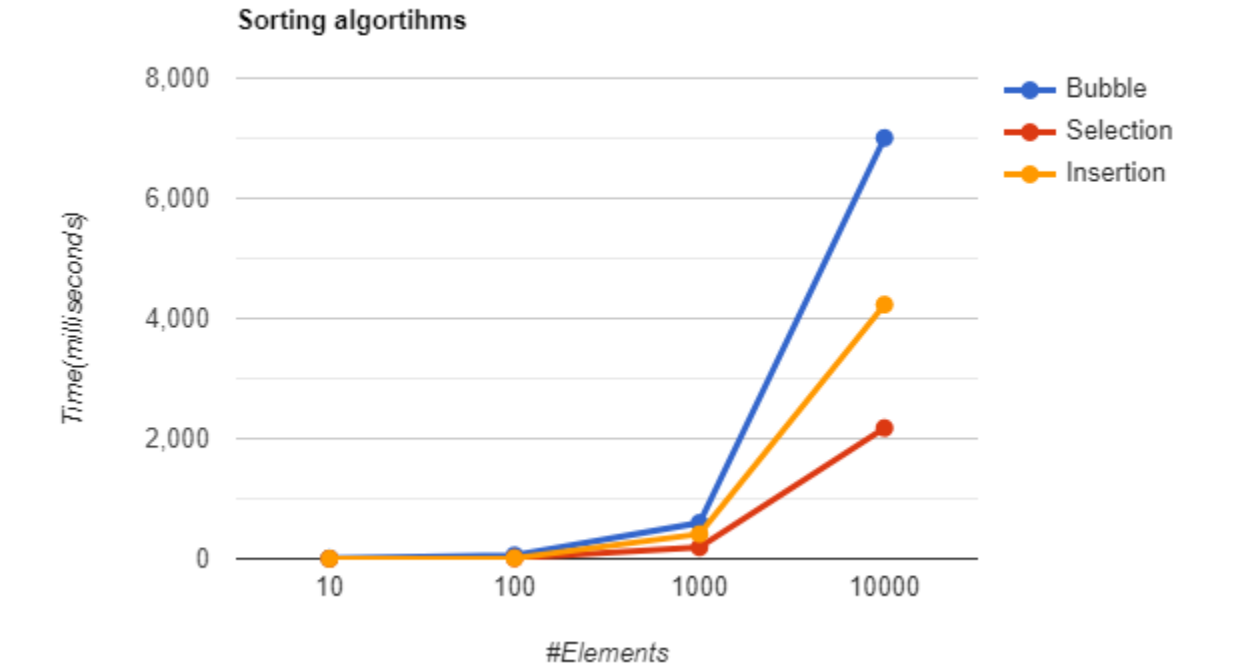
```
Pre sort: 34,33,45,42,12,27,33,53,88,35,1,37,64,38,69,41,96,69,30,13,74,80,88,3,14,2,85,86,21,45,67,66,4,28,12,38,65,72,
98,50,73,91,96,9,62,11,72,33,86,66,23,81,64,48,32,72,95,45,21,94,62,16,92,19,82,13,83,7,65,4,65,20,46,87,75,93,51,
94,12,21,37,81,24,39,91,79,67,25,28,45,42,66,64,25,47,73,91,12}34,33,45,42,12,27,33,53,88,35,1,37,64,38,69,41,96,69,30,1
3,74,80,88,3,14,2,85,86,21,45,67,66,4,28,12,38,65,72,98,50,73,91,62,9,62,11,72,33,86,66,23,81,64,48,32,72,95,45,21,94,62
,61,16,92,19,82,13,83,7,65,4,65,20,46,87,75,93,51,94,12,21,37,81,24,39,91,79,67,25,28,45,42,66,64,25,47,73,91,12}
Post sort: 1, 2, 3, 4, 4, 7, 9, 11, 12, 12, 12, 12, 13, 13, 14, 16, 19, 20, 21, 21, 21, 23, 23, 24, 25, 25, 27, 28, 28,
30, 32, 33, 33, 34, 35, 37, 37, 38, 38, 39, 41, 42, 42, 45, 45, 45, 46, 47, 48, 50, 51, 53, 61, 62, 62, 62, 64, 64,
64, 64, 65, 65, 65, 66, 66, 66, 67, 67, 69, 69, 72, 72, 72, 73, 73, 74, 75, 79, 80, 81, 81, 82, 83, 85, 86, 86, 87, 88,
88, 91, 91, 91, 92, 93, 94, 94, 95, 96, 98,

The runtime for this code is 58 milliseconds
F:\Assign\DataStructuresAssAttempt3\X64\Debug\DataStructuresAssAttempt3.exe (process 12164) exited with code 0.
Press any key to close this window . . .
```

Running time: 58 milliseconds

Input size: 100

```
Pre sort: 11,780,202,571,115,920,140,507,729,108,201,345,960,534,362,805,399,642,10,275,450,322,103,475,75,182,230,930,615,939,158,47,85,204,167,211,817,200,940,841,499,731,628,230,550,720,640,980,101,607,891,401,603,90,427,305,507,723,1
60,912,323,978,427,23,232,483,777,582,356,963,767,60,793,863,640,404,368,561,957,136,777,651,105,142,418,394,420,674,701,110,105,77,34,607,267,861,996,482,971,389,684,958,641,190,261,224,671,325,23,485,866,415,880,393,850,475,23,449,728,
803,197,102,986,358,876,795,991,248,640,780,527,426,781,331,360,327,045,42,97,615,454,009,941,440,27,780,813,2,742,991,331,231,471,501,480,243,345,86,871,720,604,381,626,29,339,477,212,728,500,222,933,811,420,931,251,900,551,697,868,564,46
6,715,570,51,577,777,532,2,688,66,846,800,907,399,615,562,930,511,880,139,781,683,148,810,811,415,911,027,171,367,400,510,587,291,240,889,410,727,882,237,81,600,1800,939,454,75,687,135,23,120,650,681,580,373,267,380,416,82,289,27,488,1
91,318,288,776,851,964,592,594,190,476,811,480,770,593,128,716,297,277,968,446,188,654,521,630,344,122,431,826,157,775,614,370,524,386,99,498,136,233,4,80,255,986,549,374,88,646,372,570,343,442,407,621,130,620,316,17,231,598,65,887,586,6
25,423,713,385,29,414,115,745,613,337,451,473,881,416,416,437,401,762,417,207,130,112,718,352,74,800,654,266,783,849,144,363,330,796,626,779,934,327,668,162,644,433,983,6,481,572,774,140,4,243,670,713,406,23,333,331,30,739
,224,995,120,456,612,525,478,34,916,770,85,461,539,334,215,923,104,326,22,937,588,188,62,488,392,1800,706,143,24,935,937,682,756,171,931,29,580,64,400,849,516,233,522,880,265,239,726,220,794,5,85,81,493,156,643,754,127,246,250,785,88
0,710,231,997,573,720,411,713,234,636,946,610,6,386,124,194,633,707,602,684,860,409,689,678,69,368,843,485,688,168,355,389,090,668,397,768,493,822,478,642,792,538,731,82,259,855,485,475,225,387,112,259,811,814,854,588,342,827,127,480,970,474
,893,588,550,37,140,398,380,327,440,380,827,864,421,685,333,81,124,476,120,109,90,122,460,383,243,837,306,951,912,484,681,118,702,379,32,668,075,109,12,458,409,373,853,517,694,574,895,628,304,915,872,357,555,533,926,880,510,865,207,2,256,1
97,200,986,393,132,921,53,582,797,727,681,788,326,609,945,971,955,853,963,17,262,572,243,366,134,677,337,995,406,780,106,400,460,747,858,882,390,281,683,683,680,327,618,233,508,272,366,931,835,213,100,141,973,254,848,119,587,796,973,6
33,92,966,625,468,213,954,484,211,581,159,627,226,958,727,920,318,316,307,948,869,129,995,920,799,684,716,288,533,998,69,274,721,933,418,877,246,195,658,124,569,6,318,977,641,100,540,118,891,376,443,272,217,817,887,406,412,369,583,383,7
93,180,781,690,726,728,182,780,767,671,651,634,687,641,531,986,688,55,122,427,802,448,810,830,726,114,715,509,630,836,848,468,709,774,322,614,152,55,330,351,294,593,301,217,428,822,146,762,208,29,979,616,686,940,412,492,861,299,580,670,4
56,109,31,510,858,698,134,80,188,285,933,171,156,407,54,297,718,447,116,48,104,343,908,612,676,631,1740,22,535,889,647,732,896,1705,295,245,40,361,27,286,926,43,636,637,136,199,182,848,7,644,181,259,234,458,3
97,421,618,626,542,844,715,228,329,367,568,838,220,834,304,174,15,832,36,258,918,392,731,256,968,11,427,568,823,781,681,919,433,546,951,229,102,36,338,761,963,706,160,435,183,890,736,394,868,433,442,16,672,642,561,466,140,726,824,700,90
9,884,564,701,241,338,100,431,106,410,810,798,637,647,265,188,630,674,870,444,482,256,932,407,28,267,10,4692,644,585,79,241,111,831,976,252,531,354,685,334,472,678,943,581,52,933,671,110,84,300,307,451,641,089,477,145,578,62,236,836,926
917,463,281,572,831,559,908,453,717,610,724,466,730,971,644,99,782,707,780,958,902,32,719,677,388,407,823,422,683,403,293,712,9,453,964,960,380,392,800,151,307,297,860,756,766,304,790,940,616,271,279,23,712,110,292,514,610,10
7,64,425,995,214,227,780,579,949,211,480,203,150,147,975,408,217,682,724,266,150,334,107,560,270,701,642,228,113,780,782,791,115,929,149,597,720,108,202,345,966,514,362,885,399,642,39,275,460,322,203,475,75,182,236,926,615,939,158,47
5,39,284,107,233,817,698,948,841,409,731,628,230,550,720,640,980,101,607,891,401,603,90,427,305,507,723,160,912,323,978,427,23,232,483,777,582,356,963,767,60,793,863,640,404,368,561,957,136,777,651,105,142,418,394,420,674,701,110,105,77,34,607,267,861,996,482,971,389,684,958,641,190,261,224,671,325,23,485,866,415,880,393,850,475,23,449,728,
803,197,102,986,358,876,795,991,248,640,780,527,426,781,331,360,327,045,42,97,615,454,009,941,440,27,780,813,2,742,991,331,231,471,501,480,243,345,86,871,720,604,381,626,29,339,477,212,728,500,222,933,811,420,931,251,900,551,697,868,564,466,715,570,51,577,777,532,2,688,66,846,800,907,399,615,562,930,511,880,139,781,683,148,810,811,415,911,027,171,367,400,510,587,291,240,889,410,727,882,237,81,600,1800,939,454,75,687,135,23,120,650,681,580,373,267,380,416,82,289,27,488,1
91,318,288,776,851,964,592,594,190,476,811,480,770,593,128,716,297,277,968,446,188,654,521,630,344,122,431,826,157,775,614,370,524,386,99,498,136,233,4,80,255,986,549,374,88,646,372,570,343,442,407,621,130,620,316,17,231,598,65,887,586,6
25,423,713,385,29,414,115,745,613,337,451,473,881,416,416,437,401,762,417,207,130,112,718,352,74,800,654,266,783,849,144,363,330,796,626,779,934,327,668,162,644,433,983,6,481,572,774,140,4,243,670,713,406,23,333,331,30,739
,224,995,120,456,612,525,478,34,916,770,85,461,539,334,215,923,104,326,22,937,588,188,62,488,392,1800,706,143,24,935,937,682,756,171,931,29,580,64,400,849,516,233,522,880,265,239,726,220,794,5,85,81,493,156,643,754,127,246,250,785,88
0,710,231,997,573,720,411,713,234,636,946,610,6,386,124,194,633,707,602,684,860,409,689,678,69,368,843,485,688,168,355,389,090,668,397,768,493,822,478,642,792,538,731,82,259,855,485,475,225,387,112,259,811,814,854,588,342,827,127,480,970,474
,893,588,550,37,140,398,380,327,440,380,827,864,421,685,333,81,124,476,120,109,90,122,460,383,243,837,306,951,912,484,681,118,702,379,32,668,075,109,12,458,409,373,853,517,694,574,895,628,304,915,872,357,555,533,926,880,510,865,207,2,256,1
97,200,986,393,132,921,53,582,797,727,681,788,326,609,945,971,955,853,963,17,262,572,243,366,134,677,337,995,406,780,106,400,460,747,858,882,390,281,683,683,680,327,618,233,508,272,366,931,835,213,100,141,973,254,848,119,587,796,973,6
33,92,966,625,468,213,954,484,211,581,159,627,226,958,727,920,318,316,307,948,869,129,995,920,799,684,716,288,533,998,69,274,721,933,418,877,246,195,658,124,569,6,318,977,641,100,540,118,891,376,443,272,217,817,887,406,412,369,583,383,7
93,180,781,690,726,728,182,780,767,671,651,634,687,641,531,986,688,55,122,427,802,448,810,830,726,114,715,509,630,836,848,468,709,774,322,614,152,55,330,351,294,593,301,217,428,822,146,762,208,29,979,616,686,940,412,492,861,299,580,670,4
56,109,31,510,858,698,134,80,188,285,933,171,156,407,54,297,718,447,116,48,104,343,908,612,676,631,1740,22,535,889,647,732,896,1705,295,245,40,361,27,286,926,43,636,637,136,199,182,848,7,644,181,259,234,458,3
97,421,618,626,542,844,715,228,329,367,568,838,220,834,304,174,15,832,36,258,918,392,731,256,968,11,427,568,823,781,681,919,433,546,951,229,102,36,338,761,963,706,160,435,183,890,736,394,868,433,442,16,672,642,561,466,140,726,824,700,90
9,884,564,701,241,338,100,431,106,410,810,798,637,647,265,188,630,674,870,444,482,256,932,407,28,267,10,4692,644,585,79,241,111,831,976,252,531,354,685,334,472,678,943,581,52,933,671,110,84,300,307,451,641,089,477,145,578,62,236,836,926
917,463,281,572,831,559,908,453,717,610,724,466,730,971,644,99,782,707,780,958,902,32,719,677,388,407,823,422,683,403,293,712,9,453,964,960,380,392,800,151,307,297,860,756,766,304,790,940,616,271,279,23,712,110,292,514,610,10
7,64,425,995,214,227,780,579,949,211,480,203,150,147,975,408,217,682,724,266,150,334,107,560,270,701,642,228,113,780,782,791,115,929,149,597,720,108,202,345,966,514,362,885,399,642,39,275,460,322,203,475,75,182,236,926,615,939,158,47
5,39,284,107,233,817,698,948,841,409,731,628,230,550,720,640,980,101,607,891,401,603,90,427,305,507,723,160,912,323,978,427,23,232,483,777,582,356,963,767,60,793,863,640,404,368,561,957,136,777,651,105,142,418,394,420,674,701,110,105,77,34,607,267,861,996,482,971,389,684,958,641,190,261,224,671,325,23,485,866,415,880,393,850,475,23,449,728,
803,197,102,986,358,876,795,991,248,640,780,527,426,781,331,360,327,045,42,97,615,454,009,941,440,27,780,813,2,742,991,331,231,471,501,480,243,345,86,871,720,604,381,626,29,339,477,212,728,500,222,933,811,420,931,251,900,551,697,868,564,466,715,570,51,577,777,532,2,688,66,846,800,907,399,615,562,930,511,880,139,781,683,148,810,811,415,911,027,171,367,400,510,587,291,240,889,410,727,882,237,81,600,1800,939,454,75,687,135,23,120,650,681,580,373,267,380,416,82,289,27,488,1
91,318,288,776,851,964,592,594,190,476,811,480,770,593,128,716,297,277,968,446,188,654,521,630,344,122,431,826,157,775,614,370,524,386,99,498,136,233,4,80,255,986,549,374,88,646,372,570,343,442,407,621,130,620,316,17,231,598,65,887,586,6
25,423,713,385,29,414,115,745,613,337,451,473,881,416,416,437,401,762,417,207,130,112,718,352,74,800,654,266,783,849,144,363,330,796,626,779,934,327,668,162,644,433,983,6,481,572,774,140,4,243,670,713,406,23,333,331,30,739
,224,995,120,456,612,525,478,34,916,770,85,461,539,334,215,923,104,326,22,937,588,188,62,488,392,1800,706,143,24,935,937,682,756,171,931,29,580,64,400,849,516,233,522,880,265,239,726,220,794,5,85,81,493,156,643,754,127,246,250,785,88
0,710,231,997,573,720,411,713,234,636,946,610,6,386,124,194,633,707,602,684,860,409,689,678,69,368,843,485,688,168,355,389,090,668,397,768,493,822,478,642,792,538,731,82,259,855,485,475,225,387,112,259,811,814,854,588,342,827,127,480,970,474
,893,588,550,37,140,398,380,327,440,380,827,864,421,685,333,81,124,476,120,109,90,122,460,383,243,837,306,951,912,484,681,118,702,379,32,668,075,109,12,458,409,373,853,517,694,574,895,628,304,915,872,357,555,533,926,880,510,865,207,2,256,1
97,200,986,393,132,921,53,582,797,727,681,788,326,609,945,971,955,853,963,17,262,572,243,366,134,677,337,995,406,780,106,400,460,747,858,882,390,281,683,683,680,327,618,233,508,272,366,931,835,213,100,141,973,254,848,119,587,796,973,6
33,92,966,625,468,213,954,484,211,581,159,627,226,958,727,920,318,316,307,948,869,129,995,920,799,684,716,288,533,998,69,274,721,933,418,877,246,195,658,124,569,6,318,977,641,100,540,118,891,376,443,272,217,817,887,406,412,369,583,383,7
93,180,781,690,726,728,182,780,767,671,651,634,687,641,531,986,688,55,122,427,802,448,810,830,726,114,715,509,630,836,848,468,709,774,322,614,152,55,330,351,294,593,301,217,428,822,146,762,208,29,979,616,686,940,412,492,861,299,580,670,4
56,109,31,510,858,698,134,80,188,285,933,171,156,407,54,297,718,447,116,48,104,343,908,612,676,631,1740,22,535,889,647,732,896,1705,295,245,40,361,27,286,926,43,636,637,136,199,182,848,7,644,181,259,234,458,3
97,421,618,626,542,844,715,228,329,367,568,838,220,834,304,174,15,832,36,258,918,392,731,256,968,11,427,568,823,781,681,919,433,546,951,229,102,36,338,761,963,706,160,435,183,890,
```





## 5) Based on the chart, which of the three algorithms is the fastest/slowest?

The fastest one out of the three basic sorting algorithms is selection sort meanwhile, the slowest algorithm among the three is bubble sort.

## 6) Identify each algorithm's complexity and discuss if the chart resembles the complexity function:

Bubble sort time complexity:  $O(n^2)$  in the average and worst cases – and  $O(n)$  in the best case.

Insertion sort time complexity:  $O(n^2)$  in the average and worst cases - and  $O(n)$  in the best case.

Selection sort time complexity:  $O(n^2)$  in the average and worst cases - and  $O(n^2)$  in the best case.

## Extra:

We also happened to think that our assignment was to do searching algorithms so here you go sir, here is our binary search and sequential search attempt:

## Sequential search:

```
87,50,47,65,83,91,43,43,42,77,73,29,1,41,51,28,96,33,77,10,73,65,4,74,41,32,22,5,86,60,13,45,58,64,22,55,36,93,69,34,9,31,66,2,82,26,94,27,69,96,12,74,39,12,5,32,47,72,38,77,36,55,24,67,48,66,24,32,37,32,24,17,45,32,61,92,80,70,11,11,60,28,94,10,33,33,23,6,14,67,90,7,48,58,97,87,52,5,100,72}87,50,47,65,83,91,43,43,42,77,73,29,1,41,51,28,96,33,77,10,73,65,4,74,41,32,22,5,86,60,13,45,58,64,22,55,36,93,69,34,9,31,66,2,82,26,94,27,69,96,12,74,39,12,5,32,47,72,38,77,36,55,24,67,48,66,24,32,37,32,24,17,45,32,61,92,80,70,11,11,60,28,94,10,33,33,23,6,14,67,90,7,48,58,97,87,52,5,100,72}
Element is present at index: 9
Time taken by function: 21milliseconds
```

Running time: 21 milliseconds

The element being searched for: 77

Result: element 77 is found at index 9 of the array.

## Binary Search:

```
52,912,484,601,118,702,379,22,660,675,199,12,350,493,373,953,517,694,574,865,638,304,915,873,357,555,553,926,806,510,865,207,5,250,107,200,908,293,132,921,53,582,797,727,681,788,326,60,9,945,971,955,853,963,17,262,572,543,366,134,67,337,995,406,780,106,469,480,460,747,858,892,390,281,603,683,608,327,618,233,508,272,366,931,835,213,100,141,973,254,848,119,587,796,973,513,392,966,625,468,213,954,484,211,501,159,627,226,905,272,920,318,316,307,948,869,129,995,920,799,684,716,288,533,998,69,274,721,933,418,877,246,195,658,124,569,6,318,877,641,160,540,118,891,376,443,272,217,817,887,406,412,369,503,383,783,180,781,450,726,738,182,794,767,671,651,914,607,641,511,986,688,55,122,427,802,248,189,920,736,114,735,509,620,836,848,468,750,774,292,614,152,55,330,351,294,503,301,317,428,822,146,762,208,29,979,856,986,940,412,492,961,299,589,670,456,109,31,56,160,858,698,134,88,188,285,933,171,156,407,54,297,718,447,116,48,194,343,900,612,676,631,157,740,22,535,889,647,732,987,995,287,273,830,169,245,49,361,27,286,926,43,636,637,175,293,673,136,189,182,848,7,664,181,259,234,458,397,421,618,626,542,844,7,15,228,329,367,568,838,220,834,304,174,15,832,336,258,918,392,713,256,968,11,427,560,823,781,681,919,433,546,951,229,102,36,338,761,963,706,160,435,183,890,736,394,868,433,442,16,672,6,42,561,466,140,726,824,700,901,884,564,781,241,338,160,431,196,410,830,978,612,647,285,168,618,674,870,844,882,256,932,407,28,503,10,492,644,585,79,941,111,831,976,252,551,354,685,334,472,678,943,581,52,913,671,118,84,306,307,451,841,909,477,145,578,622,236,836,926,971,463,281,572,831,559,908,433,717,660,724,466,730,971,644,99,782,207,507,727,780,958,902,32,719,677,388,497,823,422,603,403,293,712,9,453,964,960,389,392,800,151,367,297,860,756,766,304,790,940,616,273,261,279,23,712,110,292,514,619,107,64,425,995,214,27,790,579,949,211,400,203,238,1,50,17,975,468,217,682,724,266,150,334,107,560,270,701,642,228,11}
Element is present at index 0
The runtime for this code is 251 milliseconds
```

Running time: 251 milliseconds

The element being searched for: 33

Result: element 33 is found at index 0 of the array.