EECE 7205: Introduction of Computer Engineering

Assignment 2

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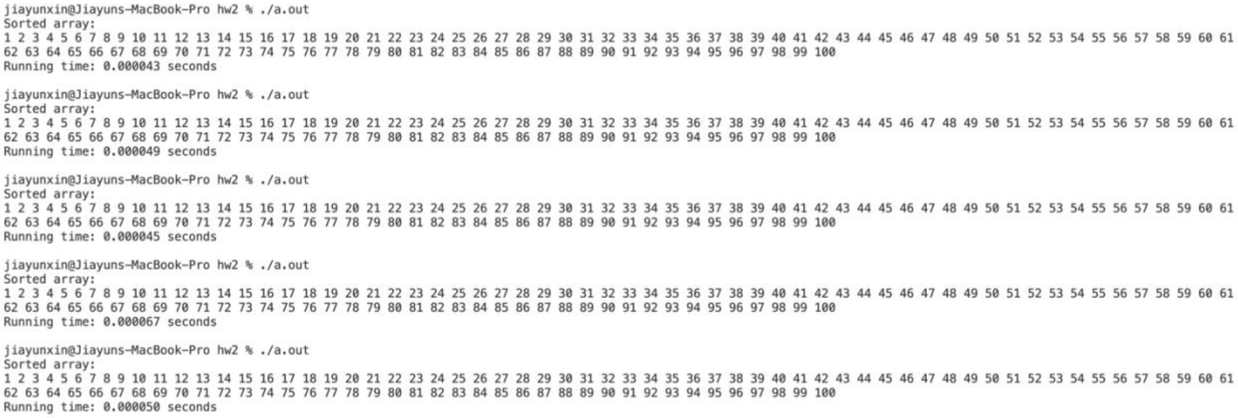
Q1

Codes:

```
#include <cstdlib>
#include <iostream>
#include <time.h>
#include <stdlib.h>
using namespace std;

int partition(int arr[], int low, int high) {
    int pivot = arr[high];
    int i = (low - 1);

    for (int j = low; j <= high - 1; j++) {
        if (arr[j] <= pivot) {
            i++;
            swap(arr[i], arr[j]);
        }
    }
    swap(arr[i + 1], arr[high]);
    return (i + 1);
}

int partition_r(int arr[], int low, int high) {
    srand(time(NULL));
    int random = low + rand() % (high - low);
    swap(arr[random], arr[high]);
    return partition(arr, low, high);
}

void quickSort(int arr[], int low, int high) {
    if (low < high) {
        int pi = partition_r(arr, low, high);
        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
    }
}
```

```
void printArray(int arr[], int size) {
    int i;
    for (i = 0; i < size; i++) printf("%d ", arr[i]);
    printf("\n");
}

int main() {
    int arr[100];
    clock_t start, finish;
    double duration;
    for (int i = 0; i < 100; ++i) {
        arr[i] = i + 1;
    }
    int n = sizeof(arr) / sizeof(arr[0]);
    start = clock();
    quickSort(arr, 0, n - 1);
    finish = clock();
    duration = (double)(finish - start) / CLOCKS_PER_SEC;

    printf("Sorted array: \n");
    printArray(arr, n);
    printf("\n");
    printf("Running time: %f seconds\n", duration);
    return 0;
}
```

Results:



```
jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Sorted array:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61
62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
Running time: 0.000043 seconds

jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Sorted array:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61
62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
Running time: 0.000049 seconds

jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Sorted array:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61
62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
Running time: 0.000045 seconds

jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Sorted array:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61
62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
Running time: 0.000067 seconds

jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Sorted array:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61
62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
Running time: 0.000050 seconds
```

The screenshot shows the sorted array results and the running time of randomized quicksort for 5 times. The average running time is 0.0000508 seconds.

Q2

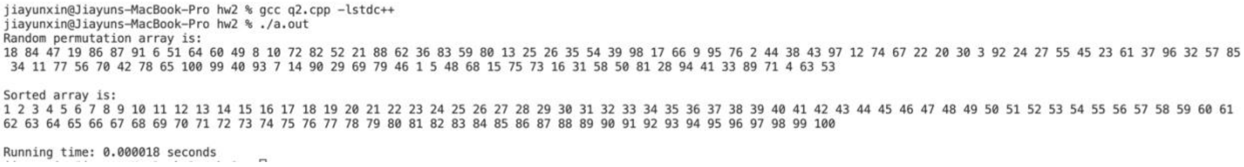
Codes:

```
#include <iostream>
#include <time.h>

using namespace std;

void heapify (int arr[], int n, int i) {
    int largest = i;
    int l = 2 * i + 1;
    int r = 2 * i + 2;

    if (l < n && arr[l] > arr[largest])
        largest = l;

    if (r < n && arr[r] > arr[largest])
        largest = r;

    if (largest != i) {
        swap(arr[i], arr[largest]);

        heapify(arr, n, largest);
    }
}

void heapSort (int arr[], int n) {
    for (int i = n / 2 - 1; i >= 0; i--) heapify(arr, n, i);

    for (int i = n - 1; i > 0; i--) {
        swap(arr[0], arr[i]);
        heapify(arr, i, 0);
    }
}

void printArray(int arr[], int n) {
    for (int i = 0; i < n; ++i) cout << arr[i] << " ";
    cout << "\n";
```

```
}

void changeValues (int *a, int *b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

void shuffleRandom ( int arr[], int n ) {
    srand ( time(NULL) );
    for (int i = n-1; i > 0; i--) {
        int j = rand() % (i+1);
        changeValues(&arr[i], &arr[j]);
    }
}

int main() {
    int arr_size = 100;
    int arr[arr_size];
    clock_t start, finish;
    double duration;
    for (int i = 0; i < arr_size; i++) {
        arr[i] = i + 1;
    }
    shuffleRandom (arr, arr_size);
    cout << "Random permutation array is: \n";
    printArray(arr, arr_size);
    cout << "\n";

    start = clock();
    heapSort(arr, arr_size);
    finish = clock();
    duration = (double)(finish - start) / CLOCKS_PER_SEC;
    cout << "Sorted array is: \n";
    printArray(arr, arr_size);
    cout << "\n";
    printf("Running time: %f seconds\n", duration);
```

```
}
```

Reports:



```
jiayunxin@Jiayuns-MacBook-Pro hw2 % gcc q2.cpp -lstdc++
jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Random permutation array is:
18 84 47 19 86 87 91 6 51 64 60 49 8 10 72 82 52 21 88 62 36 83 59 80 13 25 26 35 54 39 98 17 66 9 95 76 2 44 38 43 97 12 74 67 22 20 30 3 92 24 27 55 45 23 61 37 96 32 57 85
 34 11 77 56 70 42 78 65 100 99 40 93 7 14 90 29 69 79 46 1 5 48 68 15 75 73 16 31 58 50 81 28 94 41 33 89 71 4 63 53

Sorted array is:
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61
62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Running time: 0.000018 seconds
```

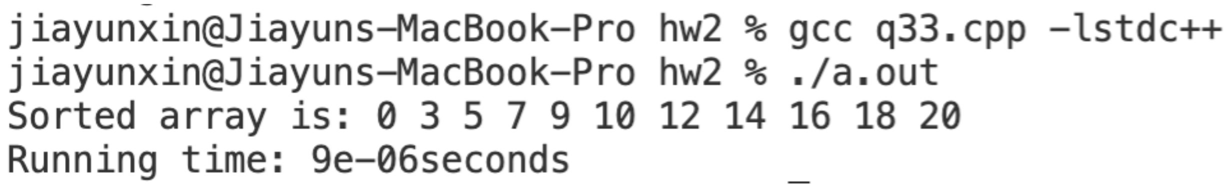
Q3

Codes:

```
#include <iostream>
using namespace std;

void countSort(int array[], int size) {
  int output[21];
  int count[21];
  int max = array[0];

  for (int i = 1; i < size; i++) {
    if (array[i] > max)
      max = array[i];
  }

  for (int i = 0; i <= max; ++i) {
    count[i] = 0;
  }

  for (int i = 0; i < size; i++) {
    count[array[i]]++;
  }

  for (int i = 1; i <= max; i++) {
    count[i] += count[i - 1];
  }

  for (int i = size - 1; i >= 0; i--) {
    output[count[array[i]] - 1] = array[i];
    count[array[i]]--;
  }

  for (int i = 0; i < size; i++) {
    array[i] = output[i];
  }
}
```

```
void printArray(int array[], int size) {
  for (int i = 0; i < size; i++)
    cout << array[i] << " ";
  cout << endl;
}

int main() {
    int array[] = {20, 18, 5, 7, 16, 10, 9, 3, 12, 14, 0};
    int n = sizeof(array) / sizeof(array[0]);
    clock_t start, finish;
    double duration;
    start = clock();
    countSort(array, n);
    finish = clock();
    cout << "Sorted array is: ";
    printArray(array, n);
    duration = (double)(finish - start) / CLOCKS_PER_SEC;
    cout << "Running time: " << duration << "seconds" "\n";
}
```

Results:



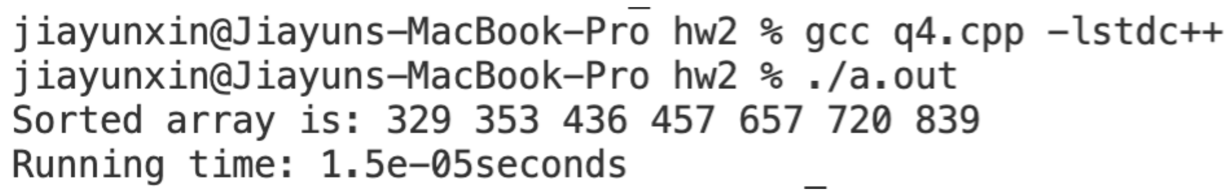
```
jiayunxin@Jiayuns-MacBook-Pro hw2 % gcc q33.cpp -lstdc++
jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Sorted array is: 0 3 5 7 9 10 12 14 16 18 20
Running time: 9e-06seconds
```

Q4
Codes:

```cpp
#include <iostream>
using namespace std;

int getMax(int arr[], int n) {
    int mx = arr[0];
    for (int i = 1; i < n; i++)
        if (arr[i] > mx)
            mx = arr[i];
    return mx;
}

void countSort(int arr[], int n, int exp) {
    int output[n];
    int i, count[10] = { 0 };

    for (i = 0; i < n; i++)
        count[(arr[i] / exp) % 10]++;

    for (i = 1; i < 10; i++)
        count[i] += count[i - 1];

    for (i = n - 1; i >= 0; i--) {
        output[count[(arr[i] / exp) % 10] - 1] = arr[i];
        count[(arr[i] / exp) % 10]--;
    }

    for (i = 0; i < n; i++)
        arr[i] = output[i];
}

void radixsort(int arr[], int n) {
    int m = getMax(arr, n);
    for (int exp = 1; m / exp > 0; exp *= 10)
        countSort(arr, n, exp);
}
```

```
void print(int arr[], int n) {
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
}

int main() {
    int arr[] = {329, 457, 657, 839, 436, 720, 353};
    int n = sizeof(arr) / sizeof(arr[0]);
    clock_t start, finish;
    double duration;
    start = clock();
    radixsort(arr, n);
    finish = clock();
    printf("Sorted array is: ");
    print(arr, n);
    printf("\n");
    duration = (double)(finish - start) / CLOCKS_PER_SEC;
    cout << "Running time: " << duration << "seconds" "\n";
    return 0;
}
```

Results:



```
jiayunxin@Jiayuns-MacBook-Pro hw2 % gcc q4.cpp -lstdc++
jiayunxin@Jiayuns-MacBook-Pro hw2 % ./a.out
Sorted array is: 329 353 436 457 657 720 839
Running time: 1.5e-05seconds
```