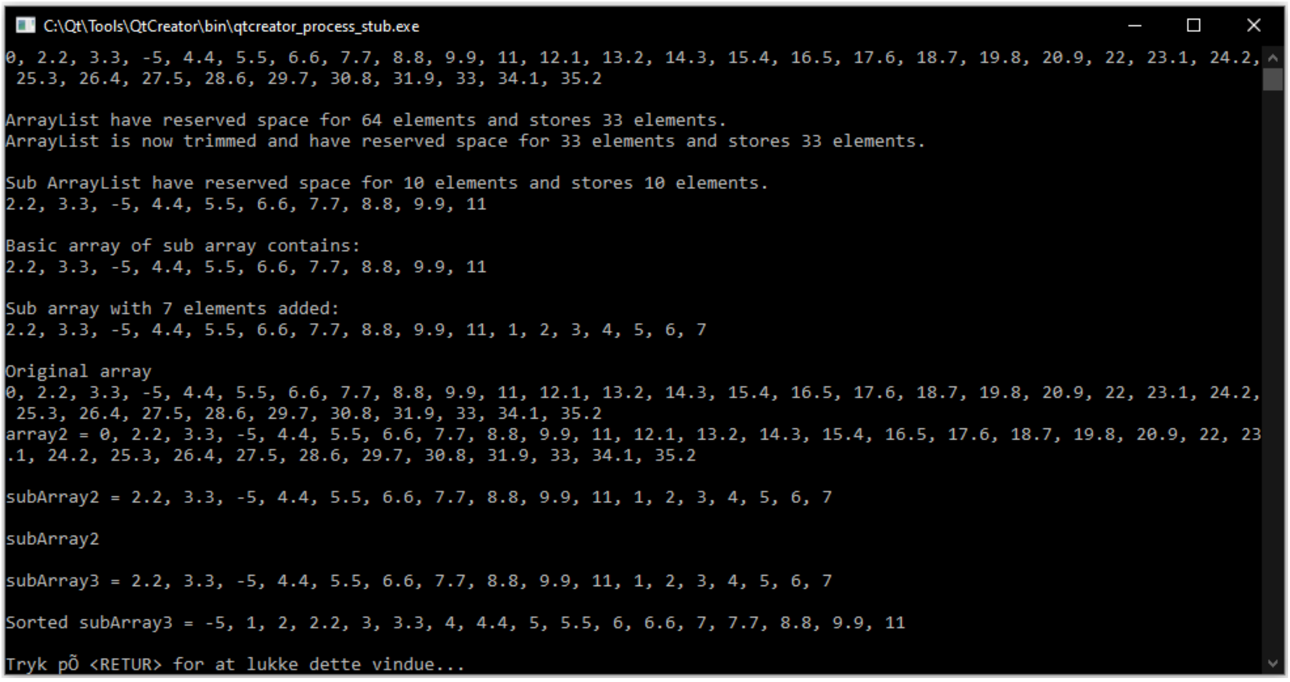
Lektion 12: Opgave 18.1 (TA)

Output:



```
0, 2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11, 12.1, 13.2, 14.3, 15.4, 16.5, 17.6, 18.7, 19.8, 20.9, 22, 23.1, 24.2,
 25.3, 26.4, 27.5, 28.6, 29.7, 30.8, 31.9, 33, 34.1, 35.2

ArrayList have reserved space for 64 elements and stores 33 elements.
ArrayList is now trimmed and have reserved space for 33 elements and stores 33 elements.

Sub ArrayList have reserved space for 10 elements and stores 10 elements.
2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11

Basic array of sub array contains:
2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11

Sub array with 7 elements added:
2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11, 1, 2, 3, 4, 5, 6, 7

Original array
0, 2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11, 12.1, 13.2, 14.3, 15.4, 16.5, 17.6, 18.7, 19.8, 20.9, 22, 23.1, 24.2,
 25.3, 26.4, 27.5, 28.6, 29.7, 30.8, 31.9, 33, 34.1, 35.2
array2 = 0, 2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11, 12.1, 13.2, 14.3, 15.4, 16.5, 17.6, 18.7, 19.8, 20.9, 22, 23
.1, 24.2, 25.3, 26.4, 27.5, 28.6, 29.7, 30.8, 31.9, 33, 34.1, 35.2

subArray2 = 2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11, 1, 2, 3, 4, 5, 6, 7

subArray2

subArray3 = 2.2, 3.3, -5, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9, 11, 1, 2, 3, 4, 5, 6, 7

Sorted subArray3 = -5, 1, 2, 2.2, 3, 3.3, 4, 4.4, 5, 5.5, 6, 6.6, 7, 7.7, 8.8, 9.9, 11

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Kildekode:

ArrayList.h

```cpp
#ifndef ARRAYLIST_H
#define ARRAYLIST_H

#include <iostream>

template <typename T>
class ArrayList {

public:
    // Default constructor, initialized as null
    ArrayList() {
        mSize = 0;
        mReserved = 0;
        mElems = nullptr;
    }

    // Copy constructor
    ArrayList(const ArrayList<T>& c) {
        mSize = c.mSize;                            // Set attributes from Arraylist c to be equal to the new
 objects attributes
        mReserved = c.mReserved;

        if (mSize > 0) {
            mElems = new T[mReserved];              // Reserve space for the new object
        }

        for (int i = 0; i < mSize; ++i) {
            mElems[i] = c.mElems[i];                // Set the elements in the new object equal to those of A
rraylist c
        }
    }

    // Move constructor
    ArrayList(ArrayList<T>&& c) {
        mElems = c.mElems;                          // Set attributes from Arraylist c to be equal to the new
 objects attributes
        mSize = c.mSize;
        mReserved = c.mReserved;

        c.mElems = nullptr;                         // Remove old Arraylist (Arraylist c)
        c.mSize = 0;
        c.mReserved = 0;
    }
    // Constructor with initialization of "initialized" elements
    ArrayList(int initialized) {
        if (initialized <= 0) {
            throw std::invalid_argument("Initialization has to be larger than zero!");
        }

        mSize = 0;
        mReserved = initialized;                    // Set the reserved member variable to the initialized si
ze
        mElems = new T[mReserved];                  // Reserve space for the new object with a given initiali
zed size
    }

    // Destructor
    virtual ~ArrayList() {
        if (mReserved > 0) {
            delete[] mElems;                        // Destructs the object by deleting the reserved space
        }
    }

    // Copy assignment operator
    ArrayList<T >& operator=(const ArrayList<T>& a) {
        if (mReserved > 0) {
            delete[] mElems;                        // Deletes contents of member variable mElems
        }
        mSize = a.mSize;                            // Sets attributes to be equal to ArrayList a's attribute
s
        mReserved = a.mReserved;

        if (mSize > 0) {
            mElems = new T[mReserved];              // Reserve new space equal to the size of ArrayList a
        }

        for (int i = 0; i < mSize; ++i) {
            mElems[i] = a.mElems[i];                // Copy the elements of ArrayList a to the new object
        }

        return *this;
    }

    // Move assignment operator
    ArrayList <T>& operator=(ArrayList <T>&& a) {
        if (mReserved > 0) {
            delete[] mElems;                        // Deletes contents of member variable mElems
        }
        mElems = a.mElems;                          // Set attributes from ArrayList a to be equal to the new
objects attributes
        mSize = a.mSize;
        mReserved = a.mReserved;

        a.mElems = nullptr;                         // Remove old Arraylist (Arraylist a)
        a.mSize = 0;
        a.mReserved = 0;

        return *this;
    }

    // Add element to dynamic array
    void add(const T& element) {
        if (mSize == mReserved)                     // If the ArrayList is full extend storage
            extendStorage();

        mElems[mSize] = element;                    // Add the new element to the end of the ArrayList
        ++mSize;                                    // Update the size of the ArrayList
    }

    /*
     * Inserts the element at placement "idx" in array and moves the remaining
     * items by one place, restoring the old element at "idx".
     * check whether it is needed to extend the storage .
     * move all elements from mSize to idx (reverse) one element to the right in the array
     * set mElems [idx] equal to the element to be inserted
     */
    void add(int idx, const T& element) {
        if (idx <= 0) {
            throw std::invalid_argument("Index has to be larger than zero!");
        }

        if (mSize == mReserved)                     // If the ArrayList is full extend storage
            extendStorage();

        for (int i = mSize + 1; i > idx; --i) {
            mElems[i] = mElems[i - 1];              // Moves all elements one element to the right
        }
        mElems[idx] = element;                      // Add the new element to the ArrayList at idx
        ++mSize;                                    // Update the size of the ArrayList
    }

    // Get a const reference to the element at idx
    const T& operator[](int idx) const {
        if (idx > mSize || idx < 0) {
            throw std::invalid_argument("Index out of range!");
        }
        return mElems[idx];                         // Retruns a const reference
    }

    // Get a reference to the element at idx
    T& operator[](int idx) {
        if (idx > mSize || idx < 0) {
            throw std::invalid_argument("Index out of range!");
        }
        return mElems[idx];                         // Retruns a reference
    }

    /*
     * Removes the element at placement "idx" by moving all the remaining elements
     * by one place to the left in the array
     */
    void remove(int idx) {
        if (idx > mSize || idx < 0) {
            throw std::invalid_argument("Index out of range!");
        }

        for (int i = idx; i < mSize; i++) {
            mElems[i] = mElems[i + 1];              // Moves remaining elements to the left overwriting idx
        }
        --mSize;                                    // Update the size of the ArrayList
    }

    // Returns the number of elements stored
    int size() const { return mSize; }

    // Returns the number of items currently reserved inmemory
    int reserved() const { return mReserved; }

    // Returns true if number of elements in array is zero
    bool isEmpty() const { return (mSize == 0) ? true : false; }

    // Trims the storage array to the exact number of elements stored.
    void trimToSize() {
        mReserved = mSize;                          // Updates the reserved member variable to be equale to t
he actual size
        T* tmp = new T[mReserved];                  // Reserves space in temporary variable

        for (int i = 0; i < mSize; i++) {
            tmp[i] = mElems[i];                     // Copies elements into tmp
        }

        delete[] mElems;                            // Delets elements in original ArrayList
        mElems = new T[mReserved];                  // Reserves space equal to the actual size of the array

        for (int i = 0; i < mSize; i++) {
            mElems[i] = tmp[i];                     // Copies elements back into the newly reserved space
        }
        delete[] tmp;                               // Deletes the temporary variable
    }

    /*
     * Sorts the array using insertion sort (or another algorithm)
     * You are not allowed to use standard algorithms from algorithm header.
     */
    void sort() {
        T key;
        int i, j;
            for (i = 1; i < mSize; i++) {           // Move elements of arr[0..i-
1], that are greater than key,
                key = mElems[i];                    // to one position ahead of their current position
                j = i - 1;

                while (j >= 0 && mElems[j] > key) {
                    mElems[j + 1] = mElems[j];
                    j = j - 1;
                }
                mElems[j + 1] = key;
            }
    }

    // Returns a new ArrayList with elements from "fromIdx" index to "toIdx"
    ArrayList<T> subArrayList(int fromIdx, int toIdx) const {
        if (fromIdx > toIdx) {
            throw std::invalid_argument("fromIdx is larger than toIdx");
        } else if (fromIdx == toIdx) {
            throw std::invalid_argument("fromIdx and toIdx is equal");
        } else if (fromIdx < 0 || toIdx < 0) {
            throw std::invalid_argument("fromIdx or toIdx is less than zero");
        } else if (fromIdx > mSize || toIdx > mSize) {
            throw std::invalid_argument("fromIdx or toIdx is larger than the size of the ArrayList");
        }

        ArrayList<T> array((toIdx - fromIdx) + 1);  // Create a new ArrayList with the reserved size of the d
ifferance between the indexes

        for (int i = fromIdx, j = 0; i <= toIdx; ++i, ++j) {
            array.mElems[j] = mElems[i];            // Copy the elements to the new ArrayList
        }
        array.mSize = array.mReserved;              // Set the new ArrayList's size attribute
```

```cpp
        return array;                               // Return the new ArrayList
    }

    // Returns a new C style array (copy created with new) with all elements
    T* toArray() {
        T* cArray = new T[mSize];                   // Reserves space for C style array

        for (int i = 0; i < mSize; i++) {
            cArray[i] = mElems[i];                  // Copies the elements into the newly reserved space
        }
        return cArray;                              // Returns the C style array
    }


private:
    /*
     * extendStorage():
     * create new array with size 2* mReserved
     * copy old data to the new array
     * delete old array
     * update pointer mElems to point to the new array
     * (Since this method is private, the method will only be used internally,
     * but the functionality is needed).
     */
    void extendStorage() {
        mReserved = (mReserved == 0) ? 1 : mReserved * 2;   // If the reserved space is 0, set it to 1, else multiply it with 2
        T* tmp = new T[mReserved];                  // Reserves space in temporary variable

        for (int i = 0; i < mSize; i++) {
            tmp[i] = mElems[i];                     // Copies elements into tmp
        }

        delete[] mElems;                            // Delets elements in original ArrayList
        mElems = new T[mReserved];                  // Reserves space equal to the new size of the array

        for (int i = 0; i < mSize; i++) {
            mElems[i] = tmp[i];                     // Copies elements back into the newly reserved space
        }

        delete[] tmp;                               // Deletes the temporary variable
    }

    // Member variables
    int mReserved; // The current capacity of " mElems " array
    int mSize; // The number of elements stored
    T* mElems; // Array for storing the elements
};

# endif // ARRAYLIST_H
```

main.cpp

```cpp
#include <iostream>
#include "ArrayList.h"

int main () {
    ArrayList<double> array;

    for (int i = 0; i < 33; ++i) {
        array.add (i * 1.1);
    }

    array.add(4, -5);
    array.remove(1);

    for (int i = 0; i < array.size(); ++i) {
        std::cout << array[i] << ", ";
    }
    std::cout << "\b\b " << std::endl << std::endl;

    std::cout << "ArrayList have reserved space for " << array.reserved()
              << " elements and stores " << array.size () << " elements." << std::endl;

    array.trimToSize();

    std::cout << "ArrayList is now trimmed and have reserved space for " << array.reserved()
              << " elements and stores " << array.size() << " elements." << std::endl << std::endl;

    ArrayList<double> subArray = array.subArrayList(1 ,10);

    std::cout << "Sub ArrayList have reserved space for " << subArray.reserved()
              << " elements and stores " << subArray.size() << " elements." << std::endl;

    for (int i = 0; i < subArray.size(); ++i) {
        std::cout << subArray[i] << ", ";
    }
    std::cout << "\b\b " << std::endl << std::endl;

    double* sArray = subArray.toArray();

    for (int i = 0; i < 7; ++i) {
        subArray.add(i+1);
    }

    // The basic array prints after adding elements to subArray
    std::cout << "Basic array of sub array contains: " << std::endl;
    for (int i = 0; i < subArray.size() - 7; ++i) {
```

```cpp
    std::cout << sArray[i] << ", ";
}
std::cout << "\b\b " << std::endl << std::endl;

// The sub array now has elements
std::cout << "Sub array with 7 elements added: " << std::endl;
for (int i = 0; i < subArray.size(); ++i) {
    std::cout << subArray[i] << ", ";
}
std::cout << "\b\b " << std::endl << std::endl;

// The original array has
std::cout << "Original array " << std::endl;
for (int i = 0; i < array.size(); ++i) {
    std::cout << array[i] << ", ";
}
std::cout << "\b\b " << std::endl;

// Copy constructor
// Copy assignment
ArrayList<double> array2 = array;
ArrayList<double> subArray2;
subArray2 = subArray;

std::cout << "array2 = ";
for (int i = 0; i < array2.size(); ++i) {
    std::cout << array2[i] << ", ";
}
std::cout << "\b\b " << std::endl << std::endl;

std::cout << "subArray2 = ";
for (int i = 0; i < subArray2.size(); ++i) {
    std::cout << subArray2[i] << ", ";
}
std::cout << "\b\b " << std::endl << std::endl;


// Move assignment operator
ArrayList<double> subArray3 = std::move(subArray2);
array2 = std::move(subArray2);

std::cout << "subArray2 = ";
for (int i = 0; i < subArray2.size(); ++i) {
    std::cout << subArray2[i] << ", ";
}
std::cout << "\b\b " << std::endl << std::endl;
```

```cpp
    std::cout << "subArray3 = ";
    for (int i = 0; i < subArray3.size(); ++i) {
        std::cout << subArray3[i] << ", ";
    }
    std::cout << "\b\b " << std::endl << std::endl;

    // Insertion sort
    subArray3.sort();
    std::cout << "Sorted subArray3 = ";
    for (int i = 0; i < subArray3.size(); ++i) {
        std::cout << subArray3[i] << ", ";
    }

    std::cout << "\b\b " << std::endl << std::endl;

    return 0;
}
```