

Exercises week 1

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November 20, 2017

Exercise 1

Attain some familiarity with the way functions are selected from namespaces

We used the following code,

Exercise 2

Learn why streams can be used to determine the truth values of conditions, but not to assign values to bool variables.

Note: The code given in the exercise is incomplete, and therefore won't compile even without the intended mistake. So first of all we state the following code as a starting point:

header.ih

```
1 | #include <iostream>
2 | #include <string>
3 |
4 | using namespace std;
5 |
6 | bool promptGet(istream &in, string &str);
7 | void process(string const &str);
```

main.cc

```
1 | #include "header.ih"
2 |
3 | int main()
4 | {
5 |     string str;
6 |     while (promptGet(cin, str))
7 |         process(str);
8 | }
```

process.cc

```
1 | #include "header.ih"
2 |
3 | void process(string const &str)
4 | {
5 |     cout << "processed: " << str << '\n';
6 | }
```

promptget.cc

```
1 | #include "header.ih"
2 |
3 | bool promptGet(istream &in, string &str)
4 | {
5 |     cout << "Enter a line or ^D\n";      // ^D signals end-of-input
6 |
7 |     return getline(in, str);
8 | }
```

1.

This code doesn't work, because `getline(in, str)` cannot be returned as a `bool` in `promptGet`. This is because the class `istream` defines `explicit operator bool() const`. This allows the compiler to only perform a conversion to a `bool` when this is explicitly required (as in a `while` statement), but not implicitly (as in the `return` statement above).

2.

By changing `promptGet`'s body in the following way, the code does compile:

promptget.cc

```
1 | #include "header.ih"
2 |
3 | bool promptGet(istream &in, string &str)
4 | {
5 |     cout << "Enter a line or ^D\n";      // ^D signals end-of-input
6 |
7 |     return static_cast<bool>(getline(in, str));
8 | }
```

3.

By changing `promptGet` (and the declaration in the internal header) in the following way, the code does compile:

promptget.cc

```
1 #include "header.ih"
2
3 istream &promptGet(istream &in, string &str)
4 {
5     cout << "Enter a line or ^D\n";      // ^D signals end-of-input
6
7     return getline(in, str);
8 }
```

Exercise 3

Learn to implement index operators

The Matrix class that is used here, is derived from the solutions of exercise 64.

We used the following code,

```
matrix/matrix.h
1  #ifndef INCLUDED_MATRIX_
2  #define INCLUDED_MATRIX_
3
4  #include <iosfwd>
5  #include <initializer_list>
6
7  class Matrix
8  {
9      size_t d_nRows = 0;
10     size_t d_nCols = 0;
11     double *d_data = 0;           // in fact R x C matrix
12
13     // exercise 5
14     // =====
15     size_t d_idxColStart = 0;
16     size_t d_idxRowStart = 0;
17     size_t d_nColEnd = d_nCols;
18     size_t d_nRowEnd = d_nRows;
19
20     std::istream &(Matrix::*d_extractMode)(
21         std::istream &in, Matrix const &matrix) const = &Matrix::extractRows;
22
23     public:
24         typedef std::initializer_list<std::initializer_list<double>> IniList;
25
26         Matrix() = default;
27         Matrix(size_t nRows, size_t nCols);           // 1
28         Matrix(Matrix const &other);                 // 2
29         Matrix(Matrix &&tmp);                         // 3
30         explicit Matrix(IniList inilist);           // 4
31
32         ~Matrix();
```

```

33
34 Matrix &operator=(Matrix const &rhs);
35 Matrix &operator=(Matrix &&tmp);
36
37 size_t nRows() const;
38 size_t nCols() const;
39 size_t size() const;           // nRows * nCols
40
41 static Matrix identity(size_t dim);
42
43 Matrix &tr();                  // transpose (must be square)
44 Matrix transpose() const;     // any dim.
45
46 void swap(Matrix &other);
47
48     // exercise 3
49     // =====
50 double *operator[](size_t index);
51 double const *operator[](size_t index) const;
52
53     // exercise 4
54     // =====
55 friend Matrix operator+(Matrix const &lhs, Matrix const &rhs);
56 friend Matrix operator+(Matrix &&lhs, Matrix const &rhs);
57 Matrix &operator+=(Matrix const &other) &;           // 1
58 Matrix operator+=(Matrix const &other) &&;           // 2
59
60     // exercise 5
61     // =====
62 friend std::ostream &operator<<(
63     std::ostream &out, Matrix const &matrix);
64 friend std::istream &operator>>(
65     std::istream &in, Matrix const &matrix);
66
67 enum Mode
68 {
69     BY_ROWS,
70     BY_COLS
71 };
72
73 Matrix &operator()(

```

```

74         size_t nRows, size_t nCols, Mode byCols = BY_ROWS); // 1
75 Matrix &operator()(
76     Mode byCols, size_t idxStart = 0, size_t remLines = 0); // 2
77 Matrix &operator()(
78     Mode byCols, size_t idxRowStart, size_t nSubRows,
79     size_t idxColStart, size_t nSubCols); // 3
80
81 private:
82     double &el(size_t row, size_t col) const;
83     void transpose(double *dest) const;
84
85         // exercise 3
86         // ===== // private backdoor
87     double *operatorIndex(size_t index) const;
88
89         // exercise 4
90         // =====
91     void add(Matrix const &rhs);
92
93         // exercise 5
94         // =====
95     std::istream &extractRows(
96         std::istream &in, Matrix const &matrix) const;
97     std::istream &extractCols(
98         std::istream &in, Matrix const &matrix) const;
99 };
100
101 inline size_t Matrix::nCols() const
102 {
103     return d_nCols;
104 }
105
106 inline size_t Matrix::nRows() const
107 {
108     return d_nRows;
109 }
110
111 inline size_t Matrix::size() const
112 {
113     return d_nRows * d_nCols;
114 }

```

```

115 |
116 | inline double &Matrix::el(size_t row, size_t col) const
117 | {
118 |     return d_data[row * d_nCols + col];
119 | }
120 |
121 |     // exercise 3
122 |     // =====
123 | inline double *Matrix::operatorIndex(size_t index) const
124 | {
125 |     return d_data + index * d_nCols;
126 | }
127 |
128 | inline double *Matrix::operator[](size_t index)
129 | {
130 |     return operatorIndex(index);
131 | }
132 |
133 | inline double const *Matrix::operator[](size_t index) const
134 | {
135 |     return operatorIndex(index);
136 | }
137 |
138 |
139 | #endif

```


Exercise 4

Learn to implement and spot opportunities for overloaded operators

The header is shown in exercise 3, the implementations of the added functions are shown below:

matrix/add.cc

```
1 | #include "matrix.ih"
2 |
3 | void Matrix::add(Matrix const &rhs)
4 | {
5 |     if (rhs.d_nCols != d_nCols or rhs.d_nRows != d_nRows)
6 |     {
7 |         cerr << "Warning: Matrices have differnt size, "
8 |             "so cannot be added!\n";
9 |         exit(1);
10 |    }
11 |
12 |    for (size_t idx = size(); idx--> 0; )
13 |        d_data[idx] += rhs.d_data[idx];
14 | }
```

matrix/operatoradd.cc

```
1 | #include "matrix.ih"
2 |
3 | Matrix operator+(Matrix const &lhs, Matrix const &rhs)
4 | {
5 |     Matrix tmp{ lhs };
6 |     tmp.add(rhs);
7 |     return tmp;
8 | }
```

matrix/operatoradd2.cc

```
1 | #include "matrix.ih"
2 |
```

```

3 | Matrix operator+(Matrix &&lhs, Matrix const &rhs)
4 | {
5 |     lhs.add(rhs);
6 |     return move(lhs);
7 | }

```

matrix/operatorcompadd1.cc

```

1 | #include "matrix.ih"
2 |
3 | Matrix &Matrix::operator+=(Matrix const &other) &
4 | {
5 |     Matrix tmp{ *this };
6 |     tmp.add(other);
7 |     swap(tmp);
8 |     return *this;
9 | }

```

matrix/operatorcompadd2.cc

```

1 | #include "matrix.ih"
2 |
3 | Matrix Matrix::operator+=(Matrix const &other) &&
4 | {
5 |     add(other);
6 |     return move(*this);
7 | }

```

Exercise 5

Learn to insert/extract objects of your own class

We used the following code,

matrix/extractcols.cc

```
1 #include "matrix.ih"
2
3 std::istream &Matrix::extractCols(
4     std::istream &in, Matrix const &matrix) const
5 {
6     for (size_t colIdx = matrix.d_idxColStart;
7         colIdx != matrix.d_nColEnd;
8         ++colIdx)
9         for (size_t rowIdx = matrix.d_idxRowStart;
10            rowIdx != matrix.d_nRowEnd;
11            ++rowIdx)
12             in >> matrix.el(rowIdx, colIdx);
13     return in;
14 }
```

matrix/extractrows.cc

```
1 #include "matrix.ih"
2
3 std::istream &Matrix::extractRows(
4     std::istream &in, Matrix const &matrix) const
5 {
6     for (size_t rowIdx = matrix.d_idxRowStart;
7         rowIdx != matrix.d_nRowEnd;
8         ++rowIdx)
9         for (size_t colIdx = matrix.d_idxColStart;
10            colIdx != matrix.d_nColEnd;
11            ++colIdx)
12             in >> matrix.el(rowIdx, colIdx);
13     return in;
14 }
```

matrix/functor1.cc

```

1  #include "matrix.ih"
2
3  Matrix &Matrix::operator()(size_t nRows, size_t nCols, Mode byCols)
4  {
5      Matrix tmp{ nRows, nCols };
6      swap(tmp);
7      if (byCols)
8          d_extractMode = &Matrix::extractCols;
9      return *this;
10 }
```

matrix/functor2.cc

```

1  #include "matrix.ih"
2
3  Matrix &Matrix::operator()(Mode byCols, size_t idxStart, size_t nSubLines)
4  {
5      if (byCols)
6      {
7          d_extractMode = &Matrix::extractCols;
8
9          if (idxStart >= d_nCols)
10         {          // if requested submatrix lies outside matrix, do nothing
11             d_idxColStart = d_nColEnd;
12             return *this;
13         }
14         d_idxColStart = idxStart;
15         // if a submatrix lies within matrix set end of submatrix
16         if (d_idxColStart + nSubLines < d_nCols)
17             d_nColEnd = d_idxColStart + nSubLines;
18     }
19     else          // extract by rows
20     {
21         if (idxStart >= d_nRows)
22         {          // if requested submatrix lies outside matrix, do nothing
23             d_idxRowStart = d_nRowEnd;
24             return *this;
25         }

```

```

26         d_idxRowStart = idxStart;
27         // if a submatrix lies within matrix set end of submatrix
28         if (d_idxRowStart + nSubLines < d_nRows)
29             d_nRowEnd = d_idxRowStart + nSubLines;
30     }
31
32     return *this;
33 }

```

matrix/functor3.cc

```

1  #include "matrix.ih"
2
3  Matrix &Matrix::operator()(Mode byCols,
4      size_t idxRowStart, size_t nSubRows, size_t idxColStart, size_t nSubCols)
5  {
6      if (idxRowStart >= d_nRows or idxColStart >= d_nCols)
7      {
8          // if submatrix lies outside matrix then do nothing
9          d_idxRowStart = d_nRowEnd;
10         d_idxColStart = d_nColEnd;
11         return *this;
12     }
13
14     d_idxRowStart = idxRowStart; // set start values submatrix
15     d_idxColStart = idxColStart;
16
17     if (byCols)
18         d_extractMode = &Matrix::extractCols;
19
20     // set end values submatrix if within matrix
21     if (d_idxRowStart + nSubRows < d_nRows)
22         d_nRowEnd = d_idxRowStart + nSubRows;
23
24     if (d_idxColStart + nSubCols < d_nCols)
25         d_nColEnd = d_idxColStart + nSubCols;
26
27     return *this;
28 }

```

matrix/operatorextract.cc

```
1 | #include "matrix.ih"
2 |
3 | istream &operator>>(istream &in, Matrix const &matrix)
4 | {
5 |     return static_cast<istream &>(
6 |         (matrix.*matrix.d_extractMode)(in, matrix));
7 | }
```

matrix/operatorinsert.cc

```
1 | #include "matrix.ih"
2 |
3 | ostream &operator<<(ostream &out, Matrix const &matrix)
4 | {
5 |     for (size_t rowIdx = 0; rowIdx != matrix.d_nRows; ++rowIdx)
6 |     {
7 |         for (size_t colIdx = 0; colIdx != matrix.d_nCols; ++colIdx)
8 |             out << matrix.el(rowIdx, colIdx) << " ";
9 |         out << '\n'; // add newline after each row
10 |    }
11 |    return out;
12 | }
```

Exercise 6

Exercise 7

Learn to implement and spot opportunities for overloaded operators

1.

The following two overloaded operators are added to compare two `Matrix` objects for (in)equality:

matrix/operatorequalto.cc

```
1 #include "matrix.ih"
2
3 bool operator==(Matrix const &lhs, Matrix const &rhs)
4 {
5     if (lhs.d_nCols != rhs.d_nCols or lhs.d_nRows != rhs.d_nRows)
6         return false;
7
8     for (size_t idx = lhs.size(); --idx; )
9     {
10         if (lhs.d_data[idx] != rhs.d_data[idx])
11             return false;
12     }
13     return true;
14 }
```

matrix/operatornotequalto.cc

```
1 #include "matrix.ih"
2
3 bool operator!=(Matrix const &lhs, Matrix const &rhs)
4 {
5     if (!(lhs == rhs))
6         return true;
7
8     return false;
9 }
```


Exercise 8

Exercise 9

Exercise 10