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Course: ECE596C  
Section: T01

Assignment ID: cpp\_basics  
Assignment Title: C++ Basics

Submission Source: [https://github.com/uvic-seng475-2020-05/cpp\\_basics-JudeOnyia.git](https://github.com/uvic-seng475-2020-05/cpp_basics-JudeOnyia.git)

Commit ID: 5ceed22f6bf97b14db0740bfecbcbcd96470460bb

#### Submitted Files

=====

drwxrwxr-x	4096	2020-05-22	14:30	./app
-rw-rw-r--	2213	2020-05-22	14:30	./app/test_random.cpp
-rw-rw-r--	6007	2020-05-22	14:30	./app/test_rational.cpp
-rw-rw-r--	343	2020-05-22	14:30	./CMakeLists.txt
-rw-rw-r--	140	2020-05-22	14:30	./IDENTIFICATION.txt
drwxrwxr-x	4096	2020-05-22	14:30	./include
drwxrwxr-x	4096	2020-05-22	14:30	./include/ra
-rw-rw-r--	2377	2020-05-22	14:30	./include/ra/random.hpp
-rw-rw-r--	6766	2020-05-22	14:30	./include/ra/rational.hpp
drwxrwxr-x	4096	2020-05-22	14:30	./lib
-rw-rw-r--	1287	2020-05-22	14:30	./lib/random.cpp
-rw-rw-r--	391622	2020-05-22	14:30	./README.pdf

#### Results

=====

Package	Operation	Target	Status
nonprog	generate	---	OK (0.0s)
random_orig	generate	---	OK (0.1s)
random_orig	configure	---	OK (0.8s)
random_orig	build	test_random	FAIL (2 0.1s 2L)
random_sane	generate	---	OK (0.2s)
random_sane	configure	---	OK (0.7s)
random_sane	build	test_random	FAIL (2 0.9s 155L)
rational_orig	generate	---	OK (0.1s)
rational_orig	configure	---	OK (0.9s)
rational_orig	build	test_rational	FAIL (2 0.1s 2L)
rational_sane	generate	---	OK (0.2s)
rational_sane	configure	---	OK (0.6s)
rational_sane	build	test_rational	FAIL (2 1.1s 716L)

Normally, an operation is indicated as having a status of either "OK" or "FAIL". A status of "?" indicates that the operation could not be performed for some reason (e.g., due to an earlier error or being a manual step). The time (in seconds) required for an operation is denoted by an expression consisting of a number followed by the letter "s" (e.g., "5.0s"). In the case of a test that consists of multiple test cases, the number of failed test cases and total number of test cases is expressed as a fraction (e.g., "10/50" means 10 test cases failed out of 50 test cases in total). The length (in lines) of the log file generated by an operation is denoted by an expression consisting of a number followed by the letter "L" (e.g., "10L"). To ascertain the reason for the failure of an operation, check the contents of the log file provided.

## Legend

=====

Package: nonprog  
Nonprogramming exercises

Package: random\_orig  
The code as originally submitted by the student.  
Build target: test\_random  
Build the test\_random program.

Package: random\_sane  
Code with modifications to perform API sanity checking.  
Build target: test\_random  
Build the test\_random program.

Package: rational\_orig  
The code as originally submitted by the student.  
Build target: test\_rational  
Build the test\_rational program.

Package: rational\_sane  
Code with modifications to perform API sanity checking.  
Build target: test\_rational  
Build the test\_rational program.

```
1  gmake: *** No rule to make target `test_random'.  Stop.  
2  ERROR: build failed to generate executable test_random
```

```
1 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake
2 -S/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
3 ndom_sane/source
4 -B/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
5 ndom_sane/derived --check-build-system CMakeFiles/Makefile.cmake 0
6 /usr/bin/gmake -f CMakeFiles/Makefile2 test_random
7 gmake[1]: Entering directory
8 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
9 dom_sane/derived'
10 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake
11 -S/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
12 ndom_sane/source
13 -B/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
14 ndom_sane/derived --check-build-system CMakeFiles/Makefile.cmake 0
15 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
16 cmake_progress_start
17 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
18 om_sane/derived/CMakeFiles 4
19 /usr/bin/gmake -f CMakeFiles/Makefile2 CMakeFiles/test_random.dir/all
20 gmake[2]: Entering directory
21 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
22 dom_sane/derived'
23 /usr/bin/gmake -f CMakeFiles/ra.dir/build.make CMakeFiles/ra.dir/depend
24 gmake[3]: Entering directory
25 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
26 dom_sane/derived'
27 cd
28 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
29 om_sane/derived &&
30 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
31 cmake_depends "Unix Makefiles"
32 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
33 om_sane/source
34 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
35 om_sane/source
36 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
37 om_sane/derived
38 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
39 om_sane/derived
40 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
41 om_sane/derived/CMakeFiles/ra.dir/DependInfo.cmake --color=
42 Scanning dependencies of target ra
43 gmake[3]: Leaving directory
44 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
45 dom_sane/derived'
46 /usr/bin/gmake -f CMakeFiles/ra.dir/build.make CMakeFiles/ra.dir/build
47 gmake[3]: Entering directory
48 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
49 dom_sane/derived'
50 [ 25%] Building CXX object CMakeFiles/ra.dir/lib/random.cpp.o
51 /home/frodo/public/ugls_lab-4.0.70/bin/c++
52 -I/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
53 ndom_sane/source/include -pedantic-errors -std=gnu++17 -o
54 CMakeFiles/ra.dir/lib/random.cpp.o -c
55 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
56 om_sane/source/lib/random.cpp
57 [ 50%] Linking CXX static library libra.a
58 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -P
59 CMakeFiles/ra.dir/cmake_clean_target.cmake
60 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
61 cmake_link_script CMakeFiles/ra.dir/link.txt --verbose=1
62 /usr/bin/ar qc libra.a CMakeFiles/ra.dir/lib/random.cpp.o
```

```
63 /usr/bin/ranlib libra.a
64 gmake[3]: Leaving directory
65 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
66 dom_sane/derived'
67 [ 50%] Built target ra
68 /usr/bin/gmake -f CMakeFiles/test_random.dir/build.make
69 CMakeFiles/test_random.dir/depend
70 gmake[3]: Entering directory
71 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
72 dom_sane/derived'
73 cd
74 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
75 om_sane/derived &&
76 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
77 cmake_depends "Unix Makefiles"
78 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
79 om_sane/source
80 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
81 om_sane/source
82 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
83 om_sane/derived
84 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
85 om_sane/derived
86 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
87 om_sane/derived/CMakeFiles/test_random.dir/DependInfo.cmake --color=
88 Scanning dependencies of target test_random
89 gmake[3]: Leaving directory
90 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
91 dom_sane/derived'
92 /usr/bin/gmake -f CMakeFiles/test_random.dir/build.make
93 CMakeFiles/test_random.dir/build
94 gmake[3]: Entering directory
95 `/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
96 dom_sane/derived'
97 [ 75%] Building CXX object CMakeFiles/test_random.dir/app/test_random.cpp.o
98 /home/frodo/public/ugls_lab-4.0.70/bin/c++
99 -I/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
100 ndom_sane/source/include -pedantic-errors -std=gnu++17 -o
101 CMakeFiles/test_random.dir/app/test_random.cpp.o -c
102 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
103 om_sane/source/app/test_random.cpp
104 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ran
105 om_sane/source/app/test_random.cpp: In function `int
106 main()':
107 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pac
108 kage-random_sane/source/app/test_random.cpp:18:8: error: passing `const lcg' {ak
109 a `const ra::random::linear_congruential_generator'} as `this' argument discards
110 qualifiers [-fpermissive]
111     18 |   cg == cg;
112         |         ^~
113 In file included
114 from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/packag
115 e-random_sane/source/app/test_random.cpp:2:
116 /tmp/assignment_precheck-judeonyia@
117 gls5.ece.uvic.ca-18086-eLq0zmKZ/package-random_sane/source/include/ra/random.hpp
118 :32:8: note: in call to `bool ra::random::linear_congruential_generator::opera
119 tor==(const ra::random::linear_congruential_generator&)'
120     32 |   bool operator
121 == (const linear_congruential_generator& obj) {
122         |         ^~~~~~
123 /tmp/assig
124 nment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-random_sane/so
```

```
125 urce/app/test_random.cpp:19:8: error: passing 'const lcg' {aka 'const ra::random
126 ::linear_congruential_generator'} as 'this' argument discards qualifiers [-fperm
127 issive]
128     19 |     cg != cg;
129         |         ^~
130 In file included from /tmp/assignme
131 nt_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-random_sane/sourc
132 e/app/test_random.cpp:2:
133 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18
134 086-eLq0zmKZ/package-random_sane/source/include/ra/random.hpp:37:8: note:   in c
135 all to 'bool ra::random::linear_congruential_generator::operator!=(const ra::ran
136 dom::linear_congruential_generator&)'
137     37 |     bool operator!=(const linear_con
138 gruential_generator& obj){
139         |         ^~~~~~
140 gmake[3]: *** [CMakeFiles/tes
141 t_random.dir/app/test_random.cpp.o] Error 1
142 gmake[3]: Leaving directory '/tmp/as
143 signment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-random_sane
144 /derived'
145 gmake[2]: *** [CMakeFiles/test_random.dir/all] Error 2
146 gmake[2]: Leavi
147 ng directory '/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmK
148 Z/package-random_sane/derived'
149 gmake[1]: *** [CMakeFiles/test_random.dir/rule] E
150 rror 2
151 gmake[1]: Leaving directory '/tmp/assignment_precheck-judeonyia@ugls5.ece
152 .uvic.ca-18086-eLq0zmKZ/package-random_sane/derived'
153 gmake: *** [test_random] Er
154 rror 2
155 ERROR: build failed to generate executable test_random
```

```
1  gmake: *** No rule to make target `test_rational'.  Stop.  
2  ERROR: build failed to generate executable test_rational
```

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```
1 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake
2 -S/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
3 tional_sane/source
4 -B/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
5 tional_sane/derived --check-build-system CMakeFiles/Makefile.cmake 0
6 /usr/bin/gmake -f CMakeFiles/Makefile2 test_rational
7 gmake[1]: Entering directory
8 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
9 tional_sane/derived
10 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake
11 -S/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
12 tional_sane/source
13 -B/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
14 tional_sane/derived --check-build-system CMakeFiles/Makefile.cmake 0
15 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
16 cmake_progress_start
17 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
18 onal_sane/derived/CMakeFiles 4
19 /usr/bin/gmake -f CMakeFiles/Makefile2 CMakeFiles/test_rational.dir/all
20 gmake[2]: Entering directory
21 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
22 tional_sane/derived
23 /usr/bin/gmake -f CMakeFiles/ra.dir/build.make CMakeFiles/ra.dir/depend
24 gmake[3]: Entering directory
25 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
26 tional_sane/derived
27 cd
28 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
29 onal_sane/derived &&
30 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
31 cmake_depends "Unix Makefiles"
32 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
33 onal_sane/source
34 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
35 onal_sane/source
36 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
37 onal_sane/derived
38 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
39 onal_sane/derived
40 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
41 onal_sane/derived/CMakeFiles/ra.dir/DependInfo.cmake --color=
42 Scanning dependencies of target ra
43 gmake[3]: Leaving directory
44 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
45 tional_sane/derived
46 /usr/bin/gmake -f CMakeFiles/ra.dir/build.make CMakeFiles/ra.dir/build
47 gmake[3]: Entering directory
48 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
49 tional_sane/derived
50 [ 25%] Building CXX object CMakeFiles/ra.dir/lib/random.cpp.o
51 /home/frodo/public/ugls_lab-4.0.70/bin/c++
52 -I/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
53 tional_sane/source/include -pedantic-errors -std=gnu++17 -o
54 CMakeFiles/ra.dir/lib/random.cpp.o -c
55 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
56 onal_sane/source/lib/random.cpp
57 [ 50%] Linking CXX static library libra.a
58 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -P
59 CMakeFiles/ra.dir/cmake_clean_target.cmake
60 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
61 cmake_link_script CMakeFiles/ra.dir/link.txt --verbose=1
62 /usr/bin/ar qc libra.a CMakeFiles/ra.dir/lib/random.cpp.o
```

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```
63 /usr/bin/ranlib libra.a
64 gmake[3]: Leaving directory
65 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
66 tional_sane/derived
67 [ 50%] Built target ra
68 /usr/bin/gmake -f CMakeFiles/test_rational.dir/build.make
69 CMakeFiles/test_rational.dir/depend
70 gmake[3]: Entering directory
71 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
72 tional_sane/derived
73 cd
74 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
75 onal_sane/derived &&
76 /home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E
77 cmake_depends "Unix Makefiles"
78 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
79 onal_sane/source
80 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
81 onal_sane/source
82 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
83 onal_sane/derived
84 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
85 onal_sane/derived
86 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
87 onal_sane/derived/CMakeFiles/test_rational.dir/DependInfo.cmake --color=
88 Scanning dependencies of target test_rational
89 gmake[3]: Leaving directory
90 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
91 tional_sane/derived
92 /usr/bin/gmake -f CMakeFiles/test_rational.dir/build
93 CMakeFiles/test_rational.dir/build
94 gmake[3]: Entering directory
95 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
96 tional_sane/derived
97 [ 75%] Building CXX object CMakeFiles/test_rational.dir/app/test_rational.cpp.o
98 /home/frodo/public/ugls_lab-4.0.70/bin/c++
99 -I/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ra
100 tional_sane/source/include -pedantic-errors -std=gnu++17 -o
101 CMakeFiles/test_rational.dir/app/test_rational.cpp.o -c
102 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
103 onal_sane/source/app/test_rational.cpp
104 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
105 onal_sane/source/app/test_rational.cpp: In instantiation of 'void do_test()
106 [with T = short
107 int]':
108 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/packa
109 ge-rational_sane/source/app/test_rational.cpp:86:21: required from here
110 /tmp/a
111 ssignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_s
112 ane/source/app/test_rational.cpp:35:3: error: passing 'const ra::math::rational<
113 short int>' as 'this' argument discards qualifiers [-fpermissive]
114     35 |         c.tr
115         |         ^
116         |         ^
117 In file included from /tmp/assignment_precheck-judeonyia@u
118 gls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.c
119 pp:2:
120 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/packag
121 e-rational_sane/source/include/ra/rational.hpp:80:12: note: in call to 'ra::ma
122 th::rational<T>::int_type ra::math::rational<T>::truncate() [with T = short int;
123 ra::math::rational<T>::int_type = short int]
124     80 |         int_type truncate() {
```

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```
125 |         ~~~~~
126 |
127 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-1
128 8086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:36:3: error: pa
129 ssing 'const ra::math::rational<short int>' as 'this' argument discards qualifie
130 rs [-fpermissive]
131     36 |         c.is_integer();
132         |         ^
133 In file included from /t
134 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
135 onal_sane/source/app/test_rational.cpp:2:
136 /tmp/assignment_precheck-judeonyia@ugls5
137 .ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp
138 :85:8: note: in call to 'bool ra::math::rational<T>::is_integer() [with T = sh
139 ort int]'
140     85 |         bool is_integer() {
141         |         ~~~~~
142 /tmp/assignment
143 _precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/sourc
144 e/app/test_rational.cpp:37:3: error: passing 'const ra::math::rational<short int
145 >' as 'this' argument discards qualifiers [-fpermissive]
146     37 |         !c;
147         |         ^
148 ~
149 In file included from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-1
150 8086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:2:
151 /tmp/assignm
152 nt_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/so
153 urce/include/ra/rational.hpp:90:8: note: in call to 'bool ra::math::rational<T
154 >::operator!() [with T = short int]'
155     90 |         bool operator!() {
156         |         ~~~~~
157 ~~~~~
158 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pac
159 kage-rational_sane/source/app/test_rational.cpp:38:5: error: passing 'const ra::
160 math::rational<short int>' as 'this' argument discards qualifiers [-fpermissive]
161     38 |         c == c;
162         |         ~~~~~
163 ~~~~~
164 In file included from /tmp/assignment_preche
165 ck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/t
166 est_rational.cpp:2:
167 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-e
168 lq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:95:8: note: in ca
169 ll to 'bool ra::math::rational<T>::operator==(const ra::math::rational<T>%) [wit
170 h T = short int]'
171     95 |         bool operator==(const rational& obj) {
172         |         ~~~~~
173 ~~~~~
174 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pa
175 ckage-rational_sane/source/app/test_rational.cpp:39:5: error: passing 'const ra:
176 :math::rational<short int>' as 'this' argument discards qualifiers [-fpermissive]
177     39 |         c != c;
178         |         ~~~~~
179 ~~~~~
180 In file included from /tmp/assignment_prech
181 eck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/
182 test_rational.cpp:2:
183 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-
184 eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:100:8: note: in
185 call to 'bool ra::math::rational<T>::operator!=(const ra::math::rational<T>%) [w
186 ith T = short int]'
```

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```
187     100 |         bool operator!=(const rational& obj) {
188         |         ~~~~~
189 ~~~~~
190 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/
191 package-rational_sane/source/app/test_rational.cpp:40:5: error: passing 'const r
192 a::math::rational<short int>' as 'this' argument discards qualifiers [-fpermissi
193 ve]
194     40 |         c < c;
195         |         ~~~~~
196 In file included from /tmp/assignment_prech
197 eck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/
198 test_rational.cpp:2:
199 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-
200 eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:105:8: note: in
201 call to 'bool ra::math::rational<T>::operator<(const ra::math::rational<T>%) [wi
202 th T = short int]'
203     105 |         bool operator<(const rational& obj) {
204         |         ~~~~~
205 ~~~~~
206 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pa
207 ckage-rational_sane/source/app/test_rational.cpp:41:5: error: passing 'const ra:
208 :math::rational<short int>' as 'this' argument discards qualifiers [-fpermissive]
209     41 |         c > c;
210         |         ~~~~~
211 ~~~~~
212 In file included from /tmp/assignment_prechec
213 k-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/te
214 st_rational.cpp:2:
215 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eL
216 q0zmKZ/package-rational_sane/source/include/ra/rational.hpp:110:8: note: in ca
217 ll to 'bool ra::math::rational<T>::operator<(const ra::math::rational<T>%) [with
218 T = short int]'
219     110 |         bool operator<(const rational& obj) {
220         |         ^
221 ~~~~~
222 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pack
223 age-rational_sane/source/app/test_rational.cpp:42:5: error: passing 'const ra:m
224 ath::rational<short int>' as 'this' argument discards qualifiers [-fpermissive]
225     42 |         c <= c;
226         |         ~~~~~
227 ~~~~~
228 In file included from /tmp/assignment_prechec
229 k-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/te
230 st_rational.cpp:2:
231 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eL
232 q0zmKZ/package-rational_sane/source/include/ra/rational.hpp:115:8: note: in ca
233 ll to 'bool ra::math::rational<T>::operator<=(const ra::math::rational<T>%) [wit
234 h T = short int]'
235     115 |         bool operator<=(const rational& obj) {
236         |         ~~~~~
237 ~~~~~
238 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pa
239 ckage-rational_sane/source/app/test_rational.cpp:43:5: error: passing 'const ra:
240 :math::rational<short int>' as 'this' argument discards qualifiers [-fpermissive]
241     43 |         c >= c;
242         |         ~~~~~
243 ~~~~~
244 In file included from /tmp/assignment_prech
245 eck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/
246 test_rational.cpp:2:
247 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-
248 eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:120:8: note: in
```



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```

349 call to 'bool ra::math::rational<T>::operator>=(const ra::math::rational<T>&) [w
350 ith T = short int]':
351     120 | bool operator>=(const rational& obj){
352         ^~~~~~
353
354 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/
355 package-rational_sane/source/app/test_rational.cpp: In instantiation of 'void do
356 _test() [with T = int]':
357 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18
358 086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:87:15: require
359 d from here
360 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/
361 package-rational_sane/source/app/test_rational.cpp:35:3: error: passing 'const r
362 a::math::rational<int>' as 'this' argument discards qualifiers [-fpermissive]
363
364     35 | c.truncate();
365         ^
366 In file included from /tmp/assignment_precheck
367 -judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/tes
368 t_rational.cpp:2:
369 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq
370 0zmKZ/package-rational_sane/source/include/ra/rational.hpp:80:12: note: in cal
371 l to 'ra::math::rational<T>::int_type ra::math::rational<T>::truncate() [with T
372 = int; ra::math::rational<T>::int_type = int]':
373     80 | int_type truncate() {
374         ^~~~~~
375
376 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-1
377 8086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:36:3: error: pa
378 ssing 'const ra::math::rational<int>' as 'this' argument discards qualifiers [-f
379 permissive]
380
381     36 | c.is_integer();
382         ^~~~~~
383 In file included from /tmp/ass
384 gnment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_san
385 e/source/app/test_rational.cpp:2:
386 /tmp/assignment_precheck-judeonyia@ugls5.ece.u
387 vic.ca-18086-eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:85:8:
388 note: in call to 'bool ra::math::rational<T>::is_integer() [with T = int]':
389
390     85 | bool is_integer() {
391         ^~~~~~
392 /tmp/assignment_precheck-ju
393 deonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_r
394 ational.cpp:37:3: error: passing 'const ra::math::rational<int>' as 'this' argum
395 ent discards qualifiers [-fpermissive]
396
397     37 | !c;
398         ^~
399 In file included
400 ed from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pack
401 age-rational_sane/source/app/test_rational.cpp:2:
402 /tmp/assignment_precheck-judeo
403 nyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/include/ra/ra
404 tional.hpp:90:8: note: in call to 'bool ra::math::rational<T>::operator!() [wi
405 th T = int]':
406
407     90 | bool operator!() {
408         ^~~~~~
409 /tmp/assignment
410 _precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/sourc
411 e/app/test_rational.cpp:38:5: error: passing 'const ra::math::rational<int>' as
412 'this' argument discards qualifiers [-fpermissive]
413
414     38 | c == c;

```

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```

311 |
312 |
313 In file included from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca
314 -18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:2:
315 /tmp/assign
316 nment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/
317 source/include/ra/rational.hpp:95:8: note: in call to 'bool ra::math::rational
318 <T>::operator==(const ra::math::rational<T>&) [with T = int]':
319     95 | bool ope
320 rator==(const rational& obj) {
321     ^~~~~~
322 /tmp/assignment_precheck-j
323 udeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_
324 rational.cpp:39:5: error: passing 'const ra::math::rational<int>' as 'this' argu
325 ment discards qualifiers [-fpermissive]
326
327     39 | c != c;
328         ^~~~~~
329 In fi
330 le included from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0
331 zmKZ/package-rational_sane/source/app/test_rational.cpp:2:
332 /tmp/assignment_prech
333 eck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/incl
334 ude/ra/rational.hpp:100:8: note: in call to 'bool ra::math::rational<T>::opera
335 tor!==(const ra::math::rational<T>&) [with T = int]':
336
337     100 | bool operator!==(co
338 nst rational& obj) {
339         ^~~~~~
340 /tmp/assignment_precheck-judeonyia@u
341 gls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.c
342 pp:40:5: error: passing 'const ra::math::rational<int>' as 'this' argument disca
343 rds qualifiers [-fpermissive]
344
345     40 | c < c;
346         ^~~~~~
347 In file included
348 from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package
349 -rational_sane/source/app/test_rational.cpp:2:
350 /tmp/assignment_precheck-judeonyi
351 a@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/include/ra/ratio
352 nal.hpp:105:8: note: in call to 'bool ra::math::rational<T>::operator<(const r
353 a::math::rational<T>&) [with T = int]':
354
355     105 | bool operator<(const rational&
356 obj) {
357         ^~~~~~
358 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.
359 ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:41:5: error
360 : passing 'const ra::math::rational<int>' as 'this' argument discards qualifiers
361 [-fpermissive]
362
363     41 | c > c;
364         ^~~~~~
365 In file included from /tmp/assi
366 gnment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane
367 /source/app/test_rational.cpp:2:
368 /tmp/assignment_precheck-judeonyia@ugls5.ece.uv
369 ic.ca-18086-eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:110:8:
370 note: in call to 'bool ra::math::rational<T>::operator>(const ra::math::ratio
371 nal<T>&) [with T = int]':
372
373     110 | bool operator>(const rational& obj) {
374         ^~~~~~
375 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0z
376 mKZ/package-rational_sane/source/app/test_rational.cpp:42:5: error: passing 'con
377 st ra::math::rational<int>' as 'this' argument discards qualifiers [-fpermissive]

```

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```

373 |
374 | 42 | c <= c;
375     ^~~~~~
376 In file included from /tmp/assignment_prech
377 eck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/
378 test_rational.cpp:2:
379 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-
380 eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:115:8: note: in
381 call to 'bool ra::math::rational<T>::operator<=(const ra::math::rational<T>&) [w
382 ith T = int]':
383
384     115 | bool operator<=(const rational& obj) {
385         ^~~~~~
386 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/packag
387 e-rational_sane/source/app/test_rational.cpp:43:5: error: passing 'const ra::mat
388 h::rational<int>' as 'this' argument discards qualifiers [-fpermissive]
389
390     43 | c >= c;
391         ^~~~~~
392 In file included from /tmp/assignment_precheck-judeon
393 yia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_ratio
394 nal.cpp:2:
395 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/p
396 ackage-rational_sane/source/include/ra/rational.hpp:120:8: note: in call to 'b
397 ool ra::math::rational<T>::operator>=(const ra::math::rational<T>&) [with T = in
398 t]':
399
400     120 | bool operator>=(const rational& obj) {
401         ^~~~~~
402 /tmp/
403 /assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational
404 _sane/source/app/test_rational.cpp: In instantiation of 'void do_test() [with T
405 = long int]':
406 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmK
407 Z/package-rational_sane/source/app/test_rational.cpp:88:16: required from here
408
409 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rat
410 ional_sane/source/app/test_rational.cpp:35:3: error: passing 'const ra::math::ra
411 tional<long int>' as 'this' argument discards qualifiers [-fpermissive]
412
413     35 | c.truncate();
414         ^
415 In file included from /tmp/assignment_precheck-judeo
416 nyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rati
417 onal.cpp:2:
418 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/
419 package-rational_sane/source/include/ra/rational.hpp:80:12: note: in call to '
420 ra::math::rational<T>::int_type ra::math::rational<T>::truncate() [with T = long
421 int; ra::math::rational<T>::int_type = long int]':
422
423     80 | int_type truncate() {
424         ^~~~~~
425 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.
426 ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:36:3: error
427 : passing 'const ra::math::rational<long int>' as 'this' argument discards quali
428 fiers [-fpermissive]
429
430     36 | c.is_integer();
431         ^~~~~~
432 In file included from
433 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rat
434 ional_sane/source/app/test_rational.cpp:2:
435 /tmp/assignment_precheck-judeonyia@ug
436 ls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/include/ra/rational.

```

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```

435 hpp:85:8: note: in call to 'bool ra::math::rational<T>::is_integer() [with T =
436 long int]':
437
438     85 | bool is_integer() {
439         ^~~~~~
440 /tmp/assignme
441 nt_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/sou
442 rce/app/test_rational.cpp:37:3: error: passing 'const ra::math::rational<long in
443 t>' as 'this' argument discards qualifiers [-fpermissive]
444
445     37 | !c;
446         ^~
447 In file included from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-
448 18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:2:
449 /tmp/assign
450 ment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/s
451 ource/include/ra/rational.hpp:90:8: note: in call to 'bool ra::math::rational<
452 T>::operator!() [with T = long int]':
453
454     90 | bool operator!() {
455         ^~~~~~
456 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pac
457 kage-rational_sane/source/app/test_rational.cpp:38:5: error: passing 'const ra::
458 math::rational<long int>' as 'this' argument discards qualifiers [-fpermissive]
459
460     38 | c == c;
461         ^~~~~~
462 In file included from /tmp/assignment_prechec
463 k-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/te
464 st_rational.cpp:2:
465 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eL
466 q0zmKZ/package-rational_sane/source/include/ra/rational.hpp:95:8: note: in cal
467 l to 'bool ra::math::rational<T>::operator==(const ra::math::rational<T>&) [with
468 T = long int]':
469
470     95 | bool operator==(const rational& obj) {
471         ^~~~~~
472 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pack
473 age-rational_sane/source/app/test_rational.cpp:39:5: error: passing 'const ra::m
474 ath::rational<long int>' as 'this' argument discards qualifiers [-fpermissive]
475
476     39 | c != c;
477         ^~~~~~
478 In file included from /tmp/assignment_precheck
479 -judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/tes
480 t_rational.cpp:2:
481 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq
482 0zmKZ/package-rational_sane/source/include/ra/rational.hpp:100:8: note: in cal
483 l to 'bool ra::math::rational<T>::operator!==(const ra::math::rational<T>&) [with
484 T = long int]':
485
486     100 | bool operator!==(const rational& obj) {
487         ^~~~~~
488 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pack
489 age-rational_sane/source/app/test_rational.cpp:40:5: error: passing 'const ra::m
490 ath::rational<long int>' as 'this' argument discards qualifiers [-fpermissive]
491
492     40 | c < c;
493         ^~~~~~
494 In file included from /tmp/assignment_precheck-j
495 udeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_
496 rational.cpp:2:
497 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0z

```

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```
497 mKZ/package-rational_sane/source/include/ra/rational.hpp:105:8: note: in call
498 to 'bool ra::math::rational<T>::operator<(const ra::math::rational<T>&) [with T
499 = long int]'
500 105 | bool operator<(const rational& obj){
501      | ^~~~~~
502 ~~~
503 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-
504 rational_sane/source/app/test_rational.cpp:41:5: error: passing 'const ra::math:
505 :rational<long int>' as 'this' argument discards qualifiers [-fpermissive]
506 41 |
507 | c > c;
508 | ~~~~~
509 In file included from /tmp/assignment_precheck-judeo
510 nyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rati
511 onal.cpp:2:
512 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/
513 package-rational_sane/source/include/ra/rational.hpp:110:8: note: in call to '
514 bool ra::math::rational<T>::operator<(const ra::math::rational<T>&) [with T = lo
515 ng int]'
516 110 | bool operator<(const rational& obj){
517      | ^~~~~~
518 ~~~
519 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
520 onal_sane/source/app/test_rational.cpp:42:5: error: passing 'const ra::math::rat
521 ional<long int>' as 'this' argument discards qualifiers [-fpermissive]
522 42 |
523 c <= c;
524 | ~~~~~
525 In file included from /tmp/assignment_precheck-judeony
526 ia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_ration
527 al.cpp:2:
528 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pa
529 ckage-rational_sane/source/include/ra/rational.hpp:115:8: note: in call to 'bo
530 ol ra::math::rational<T>::operator<=(const ra::math::rational<T>&) [with T = lon
531 g int]'
532 115 | bool operator<=(const rational& obj){
533      | ^~~~~~
534 ~~~
535 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
536 onal_sane/source/app/test_rational.cpp:43:5: error: passing 'const ra::math::rat
537 ional<long int>' as 'this' argument discards qualifiers [-fpermissive]
538 43 |
539 c >= c;
540 | ~~~~~
541 In file included from /tmp/assignment_precheck-judeony
542 ia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_ration
543 al.cpp:2:
544 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pa
545 ckage-rational_sane/source/include/ra/rational.hpp:120:8: note: in call to 'bo
546 ol ra::math::rational<T>::operator>=(const ra::math::rational<T>&) [with T = lon
547 g int]'
548 120 | bool operator>=(const rational& obj){
549      | ^~~~~~
550 ~~~
551 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rati
552 onal_sane/source/app/test_rational.cpp: in instantiation of 'void do_test() [wit
553 h T = long long int]':
554 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-1808
555 6-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:89:21: required
556 from here
557 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/pa
558 ckage-rational_sane/source/app/test_rational.cpp:35:3: error: passing 'const ra:
```

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```
559 :math::rational<long long int>' as 'this' argument discards qualifiers [-fpermis
560 sive]
561 35 | c.truncate();
562 |
563 In file included from /tmp/assignment_
564 precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source
565 /app/test_rational.cpp:2:
566 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-1
567 8086-eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:80:12: note:
568 in call to 'ra::math::rational<T>::int_type ra::math::rational<T>::truncate()
569 [with T = long long int; ra::math::rational<T>::int_type = long long int]'
570 80 |
571 | int_type truncate(){
572 | | ^~~~~~
573 /tmp/assignment_precheck-j
574 udeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_
575 rational.cpp:36:3: error: passing 'const ra::math::rational<long long int>' as
576 'this' argument discards qualifiers [-fpermissive]
577 36 | c.is_integer();
578 |
579 |
580 In file included from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.
581 ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:2:
582 /tmp/ass
583 ignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_san
584 e/source/include/ra/rational.hpp:85:8: note: in call to 'bool ra::math::ration
585 al<T>::is_integer() [with T = long long int]'
586 85 | bool is_integer(){
587      | ^~~~~~
588 ~~~
589 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-
590 eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:37:3: error: passing
591 'const ra::math::rational<long long int>' as 'this' argument discards qualifier
592 s [-fpermissive]
593 37 | !c;
594 | ~
595 In file included from /tmp/assignmen
596 t_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/sour
597 ce/app/test_rational.cpp:2:
598 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca
599 -18086-eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:90:8: note:
600 in call to 'bool ra::math::rational<T>::operator!() [with T = long long int]'
601 90 | bool operator!(){}
602 |
603 ~~~
604 /tmp/assignment_precheck-ju
605 deonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_r
606 ational.cpp:38:5: error: passing 'const ra::math::rational<long long int>' as 't
607 his' argument discards qualifiers [-fpermissive]
608 38 | c == c;
609 | ~^
610 ~~~
611 In file included from /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-1
612 8086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:2:
613 /tmp/assignm
614 nt_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/so
615 urce/include/ra/rational.hpp:95:8: note: in call to 'bool ra::math::rational<T
616 >::operator==(const ra::math::rational<T>&) [with T = long long int]'
617 95 |
618 bool operator==(const rational& obj){
619      | ^~~~~~
620 /tmp/assignment_pr
```

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```
621 echeck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/a
622 pp/test_rational.cpp:39:5: error: passing 'const ra::math::rational<long long in
623 t>' as 'this' argument discards qualifiers [-fpermissive]
624 39 | c != c;
625 |
626 ~~~
627 In file included from /tmp/assignment_precheck-judeonyia@ugls5.ece.
628 uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cpp:2:
629 /tm
630 p/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rationa
631 l_sane/source/include/ra/rational.hpp:100:8: note: in call to 'bool ra::math::
632 rational<T>::operator!=(const ra::math::rational<T>&) [with T = long long int]'
633 100 | bool operator!=(const rational& obj){
634      | ^~~~~~
635 ~~~
636 /tmp/ass
637 ignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_san
638 e/source/app/test_rational.cpp:40:5: error: passing 'const ra::math::rational<lo
639 ng long int>' as 'this' argument discards qualifiers [-fpermissive]
640 40 | c
641 < c;
642 | ~~~~~
643 In file included from /tmp/assignment_precheck-judeonyia@ug
644 ls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_rational.cp
645 p:2:
646 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package
647 -rational_sane/source/include/ra/rational.hpp:105:8: note: in call to 'bool ra
648 :math::rational<T>::operator<(const ra::math::rational<T>&) [with T = long long
649 int]'
650 105 | bool operator<(const rational& obj){
651      | ^~~~~~
652 /t
653 mp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-ration
654 al_sane/source/app/test_rational.cpp:41:5: error: passing 'const ra::math::ratio
655 nal<long long int>' as 'this' argument discards qualifiers [-fpermissive]
656 41 |
657 | c > c;
658 | ~~~~~
659 In file included from /tmp/assignment_precheck-judeon
660 yia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/test_ratio
661 nal.cpp:2:
662 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/p
663 ackage-rational_sane/source/include/ra/rational.hpp:110:8: note: in call to 'b
664 ool ra::math::rational<T>::operator>(const ra::math::rational<T>&) [with T = lon
665 g long int]'
666 110 | bool operator>(const rational& obj){
667      | ^~~~~~
668 ~~~
669 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-
670 rational_sane/source/app/test_rational.cpp:42:5: error: passing 'const ra::math:
671 :rational<long long int>' as 'this' argument discards qualifiers [-fpermissive]
672 42 |
673 c <= c;
674 | ~~~~~
675 In file included from /tmp/assignment_prechec
676 k-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/source/app/te
677 st_rational.cpp:2:
678 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eL
679 q0zmKZ/package-rational_sane/source/include/ra/rational.hpp:115:8: note: in ca
680 ll to 'bool ra::math::rational<T>::operator<=(const ra::math::rational<T>&) [wit
681 h T = long long int]'
682 115 | bool operator<=(const rational& obj){
```

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```
683 |
684 ~~~~~
685 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmK
686 Z/package-rational_sane/source/app/test_rational.cpp:43:5: error: passing 'const
687 ra::math::rational<long long int>' as 'this' argument discards qualifiers [-fpe
688 rmissive]
689 43 | c >= c;
690 | ~~~~~
691 In file included from /tmp/assignme
692 nt_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/sou
693 rce/app/test_rational.cpp:2:
694 /tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.c
695 a-18086-eLq0zmKZ/package-rational_sane/source/include/ra/rational.hpp:120:8: not
696 e: in call to 'bool ra::math::rational<T>::operator>=(const ra::math::rational
697 <T>&) [with T = long long int]'
698 120 | bool operator>=(const rational& obj){
699      | ^~~~~~
700 ~~~
701 gmake[3]: *** [CMakeFiles/test_rational.dir/app/test_rat
702 ional.cpp.o] Error 1
703 gmake[3]: Leaving directory '/tmp/assignment_precheck-judeo
704 nyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_sane/derived'
705 gmake[2]: *
706 ** [CMakeFiles/test_rational.dir/all] Error 2
707 gmake[2]: Leaving directory '/tmp/
708 assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-eLq0zmKZ/package-rational_
709 sane/derived'
710 gmake[1]: *** [CMakeFiles/test_rational.dir/rule] Error 2
711 gmake[1]:
712 : Leaving directory '/tmp/assignment_precheck-judeonyia@ugls5.ece.uvic.ca-18086-
713 eLq0zmKZ/package-rational_sane/derived'
714 gmake: *** [test_rational] Error 2
715 ERROR
716 : build failed to generate executable test_rational
```

```
1  commit b985c965a338d89c78c23abef0753310181f7f60
2  Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
3  Date:   Sat May 16 21:50:59 2020 -0700
4
5      First commit. Added IDENTIFICATION text file
6
7  commit 4ff2d9e74af1f94ec6313fc01c20c8c8e3e27d16
8  Author: Jude Onyia <judeonyia10@gmail.com>
9  Date:   Mon May 18 13:12:36 2020 -0700
10
11     B-1 part a to part e (detailed description below)
12     1) Set up the files to contain the linear_congruential_generator class
13     2) Created the type member, int_type
14     3) Created the constructor
15     4) Created the static member function, default_seed
16     5) Created data members, a_, c_, m_ and s_
17     6) Created static data member, seed_
18
19  commit 7eca19d8d2e76ce9cd63378701749c9bb635e3bf
20  Author: Jude Onyia <judeonyia10@gmail.com>
21  Date:   Mon May 18 13:51:49 2020 -0700
22
23     Moved class definition from hpp file to cpp file, fixed the
24     static function default_seed, and removed static variable seed_.
25
26  commit 6c3e60a42aad47c86ffe70982d73c3d5a64a958e
27  Author: Jude Onyia <judeonyia10@gmail.com>
28  Date:   Mon May 18 15:26:42 2020 -0700
29
30     B-1 part f to part i (detailed description below)
31     1) created the multiplier, increment and modulus functions
32     2) created the seed function to restart the sequence generation process
33     3) add a member data to indicate how many next positions should be
34         discarded in the generated sequence. This defaults to zero
35     4) created the discard function to set the discard member data
36     5) overloaded the operator() function to advance the generator to the
37         next position, and skip positions that are to be discarded
38
39  commit 9c8bd027d1dc11a56e090004d1ba352b4367890d
40  Author: Jude Onyia <judeonyia10@gmail.com>
41  Date:   Mon May 18 19:16:06 2020 -0700
42
43     B-1 part m to part o (detailed description below)
44     1) created the min and max member functions
45     2) overloaded the equality and inequality operators
46     3) provided a stream inserter (non member function)
47     4) enveloped the class and stream inserter with namespace ra::random
48
49  commit 26b588789ebd411370795830191f65b188d68c3e
50  Author: Jude Onyia <judeonyia10@gmail.com>
51  Date:   Tue May 19 01:14:59 2020 -0700
52
53     Attempt on test code for lcg class.
54
55  commit 3d58a7f5c52fe5f1cac773182784a3bba2a349e3
56  Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
57  Date:   Tue May 19 01:41:40 2020 -0700
58
59     Fixed the random.hpp file to have the proper declarations, and
60     modifies the random.cpp file to have definitions of some member functions
61     and the non-member function (operator<<).
62
```

```
63 commit 9793c850025d636b22bc0b4fc20624eab8dd0f13
64 Author: Jude Onyia <judeonyia10@gmail.com>
65 Date: Tue May 19 02:13:19 2020 -0700
66
67     Some error correction made of random.hpp and the test_random.cpp
68
69 commit ed7deaa5cea91373489078fd2cd3a38a5d18f16c
70 Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
71 Date: Tue May 19 19:47:55 2020 -0700
72
73     Corrected the definition of the seed member function and the operator()
74
75 commit b78d4a953eeabfd9cc5cf3e5866afb36e2d2378b
76 Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
77 Date: Tue May 19 20:04:24 2020 -0700
78
79     Moved the constructor and the stream inserter definitions back to the header
    file
80
81 commit 27cd751979710a2e089c05cedc0f1df4332eac70
82 Author: Jude Onyia <judeonyia10@gmail.com>
83 Date: Tue May 19 20:49:00 2020 -0700
84
85     Code Finally Builds. Moved stream inserter definition back to
86     random.cpp, removed the const prefix in stream inserter.
87
88 commit af187b18f31b16877d39b41292d52ce67087077e
89 Author: Jude Onyia <judeonyia10@gmail.com>
90 Date: Wed May 20 01:58:14 2020 -0700
91
92     Completed draft of the test of every member and non member function
93
94 commit 2d6841b73b55efdf874307fa8e8d7ec305e31d0c
95 Author: Jude Onyia <judeonyia10@gmail.com>
96 Date: Wed May 20 02:21:52 2020 -0700
97
98     Moved constructor to random.cpp
99
100 commit e76162cfa44cc606be634bb1f86470d3de21128a
101 Author: Jude Onyia <judeonyia10@gmail.com>
102 Date: Wed May 20 15:44:11 2020 -0700
103
104     Began B2 Parts a to h (detailed below)
105     1) created the template class rational
106     2) created the default constructor
107     3) created the two parameter constructor
108     4) created the numerator and denominator member functions
109
110 commit 56ef8368c9372dd7fc68ff3d3c6a54d3a4ea97f4
111 Author: Jude Onyia <judeonyia10@gmail.com>
112 Date: Wed May 20 17:04:06 2020 -0700
113
114     Wrote set up for compound assignment operators
115
116 commit 336f8371c02d5d8c31f0e09d20fbac69f6cd4d05
117 Author: Jude Onyia <judeonyia10@gmail.com>
118 Date: Wed May 20 18:18:27 2020 -0700
119
120     1) Created the truncation function
121     2) Wrote test for the default constructor
122     3) Wrote test for constructor with single argument
123     4) Wrote test for constructor with 2 arguments
```

```
124     5) Wrote test for truncation function
125
126 commit a3443247cb741d1417acf72568bdbf6b0fd88c4c
127 Author: Jude Onyia <judeonyia10@gmail.com>
128 Date:   Wed May 20 19:20:23 2020 -0700
129
130     1) Wrote is_integer function
131     2) Tested is_integer function
132
133 commit 5259695fc4569c708380890aff19c477f40c2b1a
134 Author: Jude Onyia <judeonyia10@gmail.com>
135 Date:   Wed May 20 19:40:18 2020 -0700
136
137     1) Wrote operator overload for Not(!) operator
138     2) Tested Not(!) operator overload
139
140 commit 81dea77023c36e9e44073e4a565c44f661c16674
141 Author: Jude Onyia <judeonyia10@gmail.com>
142 Date:   Wed May 20 20:11:56 2020 -0700
143
144     1) Wrote the Equality(==) and Inequality(!=) operator overloads
145     2) Tested these operator overloads
146
147 commit 1b9e521fe3e52ec3ae9281ecce871b470fa79c02
148 Author: Jude Onyia <judeonyia10@gmail.com>
149 Date:   Wed May 20 21:04:59 2020 -0700
150
151     1) Wrote the operator overloads for: <, >, <=, >=
152     2) Tested these operator overloads
153
154 commit 944cd522cd5ede4c7ac8faalb9530669cbcd38ae
155 Author: Jude Onyia <judeonyia10@gmail.com>
156 Date:   Wed May 20 23:31:28 2020 -0700
157
158     1) Wrote code for maintaining reduced form of rational number
159     2) Wrote code for ensuring that denominator is not negative
160     3) Tested both code
161
162 commit 0e547c08ff83c80e76d4ca9ca9761317ba487486
163 Author: Jude Onyia <judeonyia10@gmail.com>
164 Date:   Wed May 20 23:59:36 2020 -0700
165
166     1) Wrote condition for when the denominator is zero
167     2) Tested this condition
168
169 commit 34d8990468b542e4574f8c13a36dc4dc55b7294a
170 Author: Jude Onyia <judeonyia10@gmail.com>
171 Date:   Thu May 21 00:52:45 2020 -0700
172
173     1) Fixed the truncation function
174     2) Wrote operator overload for prefix increment and decrement
175     3) Tested operator overloads
176
177 commit e9433fdab5c078db150a3b6a98a86f3df3701b9e
178 Author: Jude Onyia <judeonyia10@gmail.com>
179 Date:   Thu May 21 01:06:11 2020 -0700
180
181     1) Wrote operator overload of postfix increment and decrement
182     2) Tested these operator overloads
183
184 commit e010f2b773d186879550d3bfe3f7f4c980737195
185 Author: Jude Onyia <judeonyia10@gmail.com>
```

```
186 Date: Thu May 21 17:27:22 2020 -0700
187
188 1) Wrote code to turn the numerator and denominator to be whole numbers
189 if they weren't.
190 2) wrote operator overloads for (+=), (-=), (*=), and (/=)
191 3) Tested these operators
192
193 commit e0548c8d558cd4ada2bd90c01f6cdee196e84d08
194 Author: Jude Onyia <judeonyia10@gmail.com>
195 Date: Thu May 21 19:21:53 2020 -0700
196
197 1) Wrote non-member operator overloads Unary plus(+) and minus(-)
198 2) Tested these overloads
199
200 commit d445a44110bbe92770b9e072335b7b5233153fbf
201 Author: Jude Onyia <judeonyia10@gmail.com>
202 Date: Thu May 21 20:23:09 2020 -0700
203
204 1) Wrote the code for operator overload of binary add, sub, mult, div
205 2) Tested these overloads
206
207 commit 9938166711a7217237a7db89686466edd839e740
208 Author: Jude Onyia <judeonyia10@gmail.com>
209 Date: Thu May 21 23:25:53 2020 -0700
210
211 1) Wrote Stream Inserter overload and Stream Extractor overload
212 2) Tested both overloads
213
214 commit 1bcd8abbd4501751eal70a67def4f3d1e4c2f202
215 Author: Jude Onyia <judeonyia10@gmail.com>
216 Date: Fri May 22 00:21:46 2020 -0700
217
218 Make sure both the random and rational classes had const correctness
219
220 commit ced72293aad6b851b297ed027b22cde116a1aa57
221 Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
222 Date: Fri May 22 01:44:33 2020 -0700
223
224 Added Fake README.pdf just to test assignment precheck
225
226 commit d00bca51cb1849ae3f839288912b9c879f2566a3
227 Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
228 Date: Fri May 22 14:04:42 2020 -0700
229
230 Added the right README.pdf
231
232 commit 5ceed22f6bf97b14db0740bfecbcbcd96470460bb
233 Author: Jude Onyia <judeonyia10@gmail.com>
234 Date: Fri May 22 14:17:39 2020 -0700
235
236 Removed the exception in stream extractor of rational.hpp
```

Name: Jude Onyia  
Student ID: V00947095  
Course: ECE 596C  
Due Date: May 22, 2020

Assignment 1: Non – Programming Exercise

8.8 a)

If the tree is balanced and we assume worst case, the asymptotic time complexity of the function is the height of the balanced tree, which is  **$O(\log n)$** .

8.8 b)

If the tree is not balanced, assuming worst case of the search for a node with the value and worst case of the imbalance of the tree, the asymptotic time complexity is  **$O(n)$** .

8.9 a)

The source code performs a sequential accumulative sum of the lower triangle of the matrix. From inspecting the source code, it is evident that the elements included in the accumulation consist of half of the matrix excluding the primary diagonal elements (i.e.  $a(0,0)$ ,  $a(1,1)$ , etc.), plus the primary diagonal elements. Since the code loops over these elements, the asymptotic time complexity is  $O(\frac{n^2-n}{2} + n)$ , this can be reduced to  **$O(n^2)$** .

8.9 b)

Since the allocation of memory for the variables created in this function are not dependent on  $n$ , assuming the maximum value of type int is greater than  $n$ , then the asymptotic space complexity of the function is  **$O(1)$** .

8.10 a)

The asymptotic time complexity of reverse\_array\_1 is  $O(\frac{n}{2})$ , this can be reduced to  **$O(n)$** . Assuming the maximum value of type int is greater than  $n$ , the asymptotic space complexity is  **$O(1)$** .

8.10 b)

The asymptotic time complexity of reverse\_array\_2 is  **$O(n)$** . The space complexity is  **$O(n)$**  because a vector of size  $n$  is created. The assumption here is also that the maximum value of type int is great than  $n$ .

8.10 c)

Based on asymptotic complexity analysis, both have the same time complexity, however, reverse\_array\_1 has a space complexity of  $O(1)$  while reverse\_array\_2 has  $O(n)$ . Therefore, reverse\_array\_1 is preferable.

8.12)

We would need to calculate the overall speedup of the program when each of the three parts are optimized.

A) If part A is optimized, the overall speedup of the program is:

$$S_o = \frac{1}{(1 - f_e) + \frac{f_e}{S_e}} = \frac{1}{(1 - 0.05) + \frac{0.05}{10}} = 1.0471$$

B) If part B is optimized, the overall speedup of the program is:

$$S_o = \frac{1}{(1 - f_e) + \frac{f_e}{S_e}} = \frac{1}{(1 - 0.5) + \frac{0.5}{1.05}} = 1.0244$$

C) If part C is optimized, the overall speedup of the program is:

$$S_o = \frac{1}{(1 - f_e) + \frac{f_e}{S_e}} = \frac{1}{(1 - 0.1) + \frac{0.1}{3}} = 1.0714$$

Based on the above calculations, the choice that would yield the most speedup is optimizing part C, therefore, part C should be optimized.

8.13 a)

If we assume the worst case of all bits having the value 1 (or even just the most significant bit having the value 1), the while loops will iterate until the most significant bit of value 1 has been checked. Hence, it will iterate for the bit-length of the integer. The number of bits of the integer is  $\log_2(n)$ , rounded up. Therefore, the asymptotic time complexity is  **$O(\log n)$** . The asymptotic space complexity is  **$O(1)$**  because if the number of bits used for  $n$  is changed, the only memory affected is that of  $n$ .

8.13 b)

The code below is an implementation of the algorithm derived from [1].

```
unsigned int hamming_2(unsigned int n){
    unsigned int total_bit_num = sizeof(int) * CHAR_BITS; // Number of bits in n
    unsigned int partition_1 = (~(unsigned int)0) / 3; // Binary 01010101
    unsigned int partition_2 = (~(unsigned int)0) / 5; // Binary 00110011
    unsigned int partition_4 = (~(unsigned int)0) / 17; // Binary 00001111

    n -= (n >> 1) & partition_1; //Count the ones of each 2 bits and
    //replace those 2 bits with result
```



```

n = (n & partition_2) + ((n >> 2) & partition_2); //Count the ones of each 4 bits
//and replace those 4 bits with result
n = (n + (n >> 4)) & partition_4; // Count the ones of each 8 bits and
//replace those 8 bits with result

if(total_bit_num > 8) n += n >> 8; //move result of each 16 bits into lowest 8 bits
if(total_bit_num > 16) n += n >> 16; //move result of each 32 bits into lowest 8 bits
if(total_bit_num > 32) n += n >> 32; //move result of each 64 bits into lowest 8 bits
return n & 0x7F; // bit AND with decimal number 127 will keep the 8 bits
}

```

The advantage of the algorithm is that it's asymptotic time complexity is **O(1)**, less than hamming\_1's complexity of  $O(\log n)$ . The disadvantage is that it requires more space in memory than hamming\_1.

8.13 c)

The reasoning behind using asymptotic complexity is to have a sense of the effect of problem size on the performance of the program as the problem size increases to relatively huge amount. The asymptotic analysis is necessary to calculate the rate of program's performance and memory requirement as the problem size increases.

## Reference

[1] Joel Yliluoma, WP2 - Nifty Revised, without multipliations, Bit-counting algorithms, 2013.  
<https://bisqwit.iki.fi/source/misc/bitcounting/>

```
1  # Specify Minimum Required Version
2  cmake_minimum_required(VERSION 3.1 FATAL_ERROR)
3
4  # Specify Project and Language
5  project(random_and_rational LANGUAGES CXX)
6
7  # Set Include Directory
8  include_directories(include)
9
10 # Add Executable Program
11 add_executable(random app/test_random.cpp lib/random.cpp)
12 add_executable(rational app/test_rational.cpp)
```

```

1  #ifndef random_hpp
2  #define random_hpp
3  #include <iostream>
4  namespace ra::random{
5      class linear_congruential_generator {
6      public:
7          typedef unsigned long long int int_type; // type member
8          static int_type default_seed(){ return (int_type)1;} // Function to return default seed of one for all objects
9
10         // Constructor that initializes the multiplier, increment and modulus. Seed is optional argument.
11         linear_congruential_generator(int_type a, int_type c, int_type m, int_type s = default_seed());
12
13         const int_type multiplier() const { return a_;} // Function to return multiplier value
14         const int_type increment() const { return c_;} // Function to return increment value
15         const int_type modulus() const { return m_;} // Function to return modulus value
16         const int_type position() const { return x_;} // Function to return the current position in the sequence
17
18         // Function to restarts the sequence generation process with a new seed value
19         void seed(int_type s);
20
21         // Operator to advance the generator to the next position in the sequence
22         // with consideration to the number of positions to be discarded
23         int_type operator() ();
24
25         // Function to discard the next n numbers in the generated sequence
26         void discard(unsigned long long n){ n_ = n; }
27
28         const int_type min() const { return c_==(int_type)0? (int_type)1 : (int_type)0; } // Function to get the smallest value
29         const int_type max() const { return m_-(int_type)1; } // Function to get the largest value in sequence
30
31         // Operator to test two linear_congruential_generator objects for equality
32         bool operator==(const linear_congruential_generator& obj){
33             return (a_==obj.multiplier() && c_==obj.increment() && m_==obj.modulus() && x_==obj.position());
34         }
35
36         // Operator to test two linear_congruential_generator objects for inequality
37         bool operator!=(const linear_congruential_generator& obj){
38             return !(a_==obj.multiplier() && c_==obj.increment() && m_==obj.modulus() && x_==obj.position());
39         }
40
41     private:
42         int_type a_; // multiplier
43         int_type c_; // increment
44         int_type m_; // modulus
45         int_type x_; // current position in the generated sequence
46         unsigned long long n_ = (unsigned long long)0; // number of positions to

```

```
    discard in the sequence
48     };
49
50     // Stream inserter
51     std::ostream& operator<<(std::ostream& outStream, const linear_congruential_
generator& objA);
52 }
53 #endif
```

```

1  #include <iostream>
2  #include "ra/random.hpp"
3
4  namespace ra::random {
5      typedef linear_congruential_generator::int_type int_type;
6
7      // Constructor that initializes the multiplier, increment and modulus. S
      eed is optional argument.
8      linear_congruential_generator::linear_congruential_generator(int_type a,
9          int_type c, int_type m, int_type s){
10          a_ = a;
11          c_ = c;
12          m_ = m;
13          if( (c_ % m_)==(int_type)0 && (s % m_)==(int_type)0 ) x_ = (int_type
14              )1;
15          else x_ = s;
16      }
17
18      // Function to restarts the sequence generation process with a new seed
19      value
20      void linear_congruential_generator::seed(int_type s){
21          if( (c_ % m_)==(int_type)0 && (s % m_)==(int_type)0 ) x_ = (int_type
22              )1;
23          else x_ = s;
24          n_ = (unsigned long long)0;
25      }
26
27      // Operator to advance the generator to the next position in the sequenc
28      e
29      // with consideration to the number of positions to be discarded
30      int_type linear_congruential_generator::operator() () {
31          ++n_;
32          do{
33              x_ = (a_ * x_ + c_) % m_;
34              --n_;
35          } while(n_);
36          return x_;
37      }
38
39      // Stream inserter
40      std::ostream& operator<<(std::ostream& outStream, const linear_congruent
41          ial_generator& objA){
42          outStream << objA.multiplier() << " " << objA.increment() << " " << o
43          bjA.modulus() << " " << objA.position();
44          return outStream;
45      }
46  }

```

```
1  #include "ra/random.hpp"
2  #include <iostream>
3  #include <random>
4
5  int main() {
6
7      typedef ra::random::linear_congruential_generator::int_type int_type;
8      using std::cout;
9      using std::endl;
10
11      // Test class against linear congruential engine in standard library
12      // Test constructor with no seed input
13      // Test the operator() and the operator<<
14      ra::random::linear_congruential_generator obj_mine(14,5,29);
15      std::linear_congruential_engine<std::uint_fast32_t,14,5,29> obj_theirs;
16      obj_mine();
17      obj_theirs();
18      cout << "lc generator object: " << obj_mine << endl;
19      cout << "lc engine current state: " << obj_theirs << endl;
20
21      // Compare their minimum and maximum
22      cout << "lc generator min value: " << obj_mine.min() << endl;
23      cout << "lc engine min value: " << obj_theirs.min() << endl;
24      cout << "lc generator max value: " << obj_mine.max() << endl;
25      cout << "lc engine max value: " << obj_theirs.max() << endl;
26
27      // Test constructor with seed input
28      // Test seed() member function
29      // Test operator== and operator!=
30      ra::random::linear_congruential_generator obj_mine_A(97,41,300,77);
31      cout << "lc generator object (seed must be 77): " << obj_mine_A << endl;
32      obj_mine_A.seed(259);
33      cout << "lc generator object (seed change to 259): " << obj_mine_A << endl;
34      obj_mine_A.seed(77);
35      ra::random::linear_congruential_generator obj_mine_B(97,41,300,77);
36      ra::random::linear_congruential_generator obj_mine_C(20,58,300,77);
37      cout << "lc generator equality check (Must be true): " << (obj_mine_A==obj_mine_B) << endl;
38      cout << "lc generator equality check (Must be false): " << (obj_mine_A==obj_mine_C) << endl;
39      ;
40      cout << "lc generator inequality check (Must be false): " << (obj_mine_A!=obj_mine_B) << endl;
41      ;
42      cout << "lc generator inequality check (Must be true): " << (obj_mine_A!=obj_mine_C) << endl;
43      ;
44
45      // Test the discard member function
46      for(int i=0; i<90; ++i){
47          obj_mine_A();
48      }
49      obj_mine_B.discard(90);
50      cout << "lc generator discard function check (Must be true): " << (obj_mine_A()==obj_mine_B())
51      << endl;
52
53      // Test condition when increment and seed are both zero
54      ra::random::linear_congruential_generator obj_mine_D(20,0,300,0);
55      cout << "lc generator seed (Must be 1): " << obj_mine_D << endl;
56
57      return 0;
58  }
```

```

1  #ifndef rational_hpp
2  #define rational_hpp
3  #include <iostream>
4  #include <algorithm>
5  #include <string>
6  #include <sstream>
7  namespace ra::math{
8  template<class T>
9  class rational {
10     public:
11         typedef T int_type;
12
13         // Function to reduce the form of the rational number
14         void reduce_form(){
15             long long the_gcd = std::__gcd((long long)n_, (long long)d_);
16             n_ = (int_type)( (long long)n_ / the_gcd ); // Also make numerator a
whole number;
17             d_ = (int_type)( (long long)d_ / the_gcd ); // Also make denominator
a whole number
18         }
19
20         // Function to Prevent denominator from having zero or negative value
21         void denominator_handle(){
22             if(d_ == (int_type)0){
23                 n_ = std::numeric_limits<int_type>::max();
24                 d_ = (int_type)1;
25             }
26             if(d_ < (int_type)0) { d_ = d_ * (int_type)(-1); n_ = n_ * (int_type
)(-1); }
27         }
28
29         // Default constructor sets rational number to 0
30         rational(){
31             n_ = (int_type)0;
32             d_ = (int_type)1;
33         }
34
35         // Constructor to specify numerator and denominator values
36         rational(int_type n, int_type d = (int_type)1){
37             n_ = n;
38             d_ = d;
39             reduce_form();
40             denominator_handle();
41         }
42
43         const int_type numerator() const { return n_; } // Function to return th
e numerator value
44         const int_type denominator() const { return d_; } // Function to return
the denominator value
45
46         // Operator for compound addition (+=)
47         rational& operator+=(const rational& obj){
48             n_ = (n_ * obj.denominator()) + (obj.numerator() * d_);
49             d_ = d_ * obj.denominator();
50             reduce_form();
51             return *this;
52         }
53
54         // Operator for compound subtraction (-=)
55         rational& operator--=(const rational& obj){
56             n_ = (n_ * obj.denominator()) - (obj.numerator() * d_);
57             d_ = d_ * obj.denominator();

```

```
58         reduce_form();
59         return *this;
60     }
61
62     // Operator for compound multiplication (*)
63     rational& operator*=(const rational& obj){
64         n_ = n_ * obj.numerator();
65         d_ = d_ * obj.denominator();
66         reduce_form();
67         return *this;
68     }
69
70     // Operator for compound division (/=)
71     rational& operator/=(const rational& obj){
72         n_ = n_ * obj.denominator();
73         d_ = d_ * obj.numerator();
74         reduce_form();
75         denominator_handle();
76         return *this;
77     }
78
79     // Function for rounding the rational number towards zero (discard fractional part)
80     int_type truncate(){
81         return (int_type)((long long)(n_ / d_));
82     }
83
84     // Function to check if rational number is an integer
85     bool is_integer(){
86         return (d_==(int_type)1 );
87     }
88
89     // Operator to check if a rational number is zero (!)
90     bool operator!(){
91         return (n_==(int_type)0);
92     }
93
94     // Operator to check equality of rational numbers (==)
95     bool operator==(const rational& obj){
96         return ( (n_/d_) == (obj.numerator()/obj.denominator()) );
97     }
98
99     // Operator to check inequality of rational numbers (!=)
100    bool operator!=(const rational& obj){
101        return ( (n_/d_) != (obj.numerator()/obj.denominator()) );
102    }
103
104    // Operator to check less than of rational numbers (<)
105    bool operator<(const rational& obj){
106        return ( (n_/d_) < (obj.numerator()/obj.denominator()) );
107    }
108
109    // Operator to check greater than of rational numbers (>)
110    bool operator>(const rational& obj){
111        return ( (n_/d_) > (obj.numerator()/obj.denominator()) );
112    }
113
114    // Operator to check less than or equals to of rational numbers (<=)
115    bool operator<=(const rational& obj){
116        return ( (n_/d_) <= (obj.numerator()/obj.denominator()) );
117    }
118
```



```
119 // Operator to check greater than or equals to of rational numbers (>=)
120 bool operator>=(const rational& obj){
121     return ( (n_/d_) >= (obj.numerator()/obj.denominator()) );
122 }
123
124 // Operator to perform prefix increment (++obj)
125 rational& operator++(){
126     n_ = n_ + d_;
127     return *this;
128 }
129
130 // Operator to perform prefix and decrement (--obj)
131 rational& operator--(){
132     n_ = n_ - d_;
133     return *this;
134 }
135
136 // Operator to perform postfix increment (obj++)
137 rational operator++(int){
138     rational<int_type> obj_copy(n_,d_);
139     n_ = n_ + d_;
140     return obj_copy;
141 }
142
143 // Operator to perform postfix decrement (obj--)
144 rational operator--(int){
145     rational<int_type> obj_copy(n_,d_);
146     n_ = n_ - d_;
147     return obj_copy;
148 }
149
150 private:
151     int_type n_; // Numerator
152     int_type d_; // Denominator
153 };
154
155 // Operator to perform Unary plus (+)
156 template<class int_type>
157 rational<int_type> operator+(const rational<int_type>& obj){
158     return rational<int_type>+(obj.numerator()),obj.denominator());
159 }
160
161 // Operator to perform Unary minus (-)
162 template<class int_type>
163 rational<int_type> operator-(const rational<int_type>& obj){
164     return rational<int_type>-(obj.numerator()),obj.denominator());
165 }
166
167 // Operator to perform Binary addition (+)
168 template<class int_type>
169 rational<int_type> operator+(const rational<int_type>& obj_A, const rational<int
170 _type>& obj_B){
171     int_type n_result = (obj_A.numerator() * obj_B.denominator()) + (obj_A.denom
172 inator() * obj_B.numerator());
173     int_type d_result = obj_A.denominator() * obj_B.denominator();
174     return rational<int_type>(n_result,d_result);
175 }
176
177 // Operator to perform Binary subtraction (-)
178 template<class int_type>
179 rational<int_type> operator-(const rational<int_type>& obj_A, const rational<int
180 _type>& obj_B){
```

```
178     int_type n_result = (obj_A.numerator() * obj_B.denominator()) - (obj_A.denom
inator() * obj_B.numerator());
179     int_type d_result = obj_A.denominator() * obj_B.denominator();
180     return rational<int_type>(n_result,d_result);
181 }
182
183 // Operator to perform Binary multiplication (*)
184 template<class int_type>
185 rational<int_type> operator*(const rational<int_type>& obj_A, const rational<int
_type>& obj_B){
186     int_type n_result = obj_A.numerator() * obj_B.numerator();
187     int_type d_result = obj_A.denominator() * obj_B.denominator();
188     return rational<int_type>(n_result,d_result);
189 }
190
191 // Operator to perform Binary division (/)
192 template<class int_type>
193 rational<int_type> operator/(const rational<int_type>& obj_A, const rational<int
_type>& obj_B){
194     int_type n_result = obj_A.numerator() * obj_B.denominator();
195     int_type d_result = obj_A.denominator() * obj_B.numerator();
196     return rational<int_type>(n_result,d_result);
197 }
198
199 // Stream Inserter
200 template<class int_type>
201 std::ostream& operator<< (std::ostream& outStream, const rational<int_type>& obj)
{
202     outStream << obj.numerator() << "/" << obj.denominator();
203     return outStream;
204 }
205
206 // Stream Extractor
207 template<class int_type>
208 std::istream& operator>>(std::istream& inStream, rational<int_type>& obj){
209     std::string the_input;
210     std::getline(inStream,the_input);
211     std::istringstream iss(the_input);
212     std::string n, d;
213     std::getline(iss,n,'/');
214     std::getline(iss,d);
215     long long n_l = std::stoll(n);
216     long long d_l = std::stoll(d);
217     if((std::to_string(n_l) + "/" + std::to_string(d_l))!=the_input){
218         inStream.setstate(std::ios_base::failbit);
219     }
220     obj = rational<int_type>((int_type)n_l, (int_type)d_l);
221     return inStream;
222 }
223
224
225
226 }
227 #endif
```

```
1  #include "ra/rational.hpp"
2  #include <iostream>
3
4  #include <string>
5  #include <sstream>
6
7  int main(){
8      using std::cout;
9      using std::endl;
10
11     ra::math::rational<double> obj_A;
12     cout << "1) Test default constructor" << endl;
13     cout << " Numerator: " << obj_A.numerator() << endl;
14     cout << " Denominator: " << obj_A.denominator() << endl << endl;
15
16     ra::math::rational<float> obj_B(-56);
17     cout << "2) Test constructor with single parameter" << endl;
18     cout << " Numerator: " << obj_B.numerator() << endl;
19     cout << " Denominator: " << obj_B.denominator() << endl << endl;
20
21     ra::math::rational<double> obj_C(31488,117);
22     cout << "3) Test constructor with double parameter and truncation function" << endl;
23     cout << " Numerator: " << obj_C.numerator() << endl;
24     cout << " Denominator: " << obj_C.denominator() << endl;
25     cout << " Truncated value: " << obj_C.truncate() << endl << endl;
26
27     ra::math::rational<double> obj_D(48,-4);
28     cout << "4) Test is_integer function" << endl;
29     cout << " Numerator: " << obj_D.numerator() << endl;
30     cout << " Denominator: " << obj_D.denominator() << endl;
31     cout << " is_integer: " << obj_D.is_integer() << endl;
32     cout << " Numerator: " << obj_C.numerator() << endl;
33     cout << " Denominator: " << obj_C.denominator() << endl;
34     cout << " is_integer: " << obj_C.is_integer() << endl << endl;
35
36     ra::math::rational<double> obj_E(0,-4);
37     cout << "5) Test the Not(!) operator" << endl;
38     cout << " Numerator: " << obj_E.numerator() << endl;
39     cout << " Not(!) operator: " << !obj_E << endl;
40     cout << " Numerator: " << obj_D.numerator() << endl;
41     cout << " Not(!) operator: " << !obj_D << endl << endl;
42
43     ra::math::rational<double> obj_F(-12);
44     cout << "6) Test Equality(==) operator" << endl;
45     cout << " Must be true: " << (obj_D==obj_F) << endl;
46     cout << " Must be false: " << (obj_F==obj_C) << endl << endl;
47
48     cout << "7) Test Inequality(!=) operator" << endl;
49     cout << " Must be true: " << (obj_C!=obj_F) << endl;
50     cout << " Must be false: " << (obj_F!=obj_D) << endl << endl;
51
52     cout << "8) Test Less than(<) operator" << endl;
53     cout << " Must be true: " << (obj_F<obj_C) << endl;
54     cout << " Must be false: " << (obj_E<obj_F) << endl;
55     cout << " Must be false: " << (obj_F<obj_D) << endl << endl;
56
57     cout << "9) Test Greater than(>) operator" << endl;
58     cout << " Must be false: " << (obj_F>obj_C) << endl;
59     cout << " Must be true: " << (obj_E>obj_F) << endl;
60     cout << " Must be false: " << (obj_F>obj_D) << endl << endl;
61
62     cout << "10) Test Less than or equals to(<=) operator" << endl;
```

```
63     cout << " Must be true: " << (obj_F<=obj_C) << endl;
64     cout << " Must be false: " << (obj_E<=obj_F) << endl;
65     cout << " Must be true: " << (obj_F<=obj_D) << endl << endl;
66
67     cout << "11) Test Greater than or equals to(>=) operator" << endl;
68     cout << " Must be false: " << (obj_F>=obj_C) << endl;
69     cout << " Must be true: " << (obj_E>=obj_F) << endl;
70     cout << " Must be true: " << (obj_F>=obj_D) << endl << endl;
71
72     cout << "12) Test Reduced form and negative denominator" << endl;
73     cout << " obj_C(31488,117): " << obj_C.numerator() << "," << obj_C.denominator()
    << endl;
74     cout << " obj_D(48,-4): " << obj_D.numerator() << "," << obj_D.denominator() <<
    endl << endl;
75
76     ra::math::rational<double> obj_G(-9,0);
77     cout << "13) Test Condition when denominator is zero" << endl;
78     cout << " obj_G(-9,0): " << obj_G.numerator() << "," << obj_G.denominator() <<
    endl << endl;
79
80     cout << "14) Test Prefix Increment(++obj) and Decrement(--obj) operators" << endl;
81     cout << " obj_D: " << obj_D.numerator() << "," << obj_D.denominator() << endl
    ;
82     cout << " increment: " << (++obj_D).numerator() << "," << obj_D.denominator()
    << endl;
83     cout << " decrement: " << (--obj_D).numerator() << "," << obj_D.denominator()
    << endl << endl;
84
85     cout << "15) Test Postfix Increment(obj++) and Decrement(obj--) operators" << endl;
86     cout << " obj_D: " << obj_D.numerator() << "," << obj_D.denominator() << endl
    ;
87     cout << " increment: " << (obj_D++).numerator() << "," << obj_D.denominator()
    << endl;
88     cout << " See change after: " << obj_D.numerator() << "," << obj_D.denominator()
    << endl;
89     cout << " decrement: " << (obj_D--).numerator() << "," << obj_D.denominator()
    << endl;
90     cout << " See change after: " << obj_D.numerator() << "," << obj_D.denominator()
    << endl << endl;
91
92     ra::math::rational<double> obj_H(-9.776,1.33);
93     cout << "16) Test case where a decimal points is used for the numerator and denominator " << endl;
94     cout << " obj_H: " << obj_H.numerator() << "," << obj_H.denominator() << endl
    << endl;
95
96     ra::math::rational<float> obj_I(8,10);
97     ra::math::rational<float> obj_J(1,5);
98     ra::math::rational<float> obj_K(2,3);
99     cout << "17) Test Operator(+=) and (-=) and (*=) and (/=)" << endl;
100    cout << " (8/10) += (1/5): " << (obj_I+=obj_J).numerator() << "/" << obj_I.denomi
    nator() << endl;
101    cout << " (prev ans) -= (2/3): " << (obj_I-=obj_K).numerator() << "/" << obj_I.deno
    minator() << endl;
102    cout << " (prev ans) *= (2/3): " << (obj_I*=obj_K).numerator() << "/" << obj_I.deno
    minator() << endl;
103    cout << " (prev ans) /= (1/5): " << (obj_I/=obj_J).numerator() << "/" << obj_I.deno
    minator() << endl << endl;
104
105    cout << "18) Test Unary minus(-) and Unary plus(+)" << endl;
106    cout << " obj_H: " << obj_H.numerator() << "," << obj_H.denominator() << endl
    ;
107    cout << " Unary Plus: " << (+obj_H).numerator() << "/" << obj_H.denominator() <
```

```
< endl;
108     cout << "    Unary Minus: " << (-obj_H).numerator() << "/" << obj_H.denominator()
    << endl;
109
110     cout << "19) Test Binary operators (+), (-), (*), and (/)" << endl;
111     cout << "    "<<obj_I<<" + "<<obj_J<< " = " << (obj_I+obj_J)<<endl;
112     cout << "    "<<obj_I<<" - "<<obj_J<< " = " << (obj_I-obj_J)<<endl;
113     cout << "    "<<obj_I<<" * "<<obj_J<< " = " << (obj_I*obj_J)<<endl;
114     cout << "    "<<obj_I<<" / "<<obj_J<< " = " << (obj_I/obj_J)<<endl<<endl;
115
116     cout << "20) Test Stream extractor" << endl;
117     std::cin >> obj_K;
118     cout << obj_K << endl;
119
120
121
122
123     return 0;
124 }
```