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 Course: ECE596C  
 Section: T01

Assignment ID: cpp\_compile\_time  
 Assignment Title: Compile-Time Computation

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

Commit ID: 9873843310751781db8f11e9558bb79da4a7f42f

#### Submitted Files

=====

```
drwxrwxr-x      145 2020-06-01 19:30 ./app
-rw-rw-r--     1658 2020-06-01 19:30 ./app/test_biquad_filter.cpp
-rw-rw-r--     2535 2020-06-01 19:30 ./app/test_cexpr_basic_string.cpp
-rw-rw-r--     1170 2020-06-01 19:30 ./app/test_cexpr_math.cpp
-rw-rw-r--      418 2020-06-01 19:30 ./app/test_mandelbrot.cpp
-rw-rw-r--      651 2020-06-01 19:30 ./CMakeLists.txt
-rw-rw-r--      146 2020-06-01 19:30 ./IDENTIFICATION.txt
drwxrwxr-x       24 2020-06-01 19:30 ./include
drwxrwxr-x      125 2020-06-01 19:30 ./include/ra
-rw-rw-r--     6019 2020-06-01 19:30 ./include/ra/biquad_filter.hpp
-rw-rw-r--     9615 2020-06-01 19:30 ./include/ra/cexpr_basic_string.hpp
-rw-rw-r--     2999 2020-06-01 19:30 ./include/ra/cexpr_math.hpp
-rw-rw-r--     2633 2020-06-01 19:30 ./include/ra/mandelbrot.hpp
-rw-rw-r--    464306 2020-06-01 19:30 ./README.pdf
```

#### Results

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Package	Operation	Target	Status
nonprog	generate	---	OK (0.0s)
string_orig	generate	---	OK (0.2s)
string_orig	configure	---	OK (2.0s)
string_orig	build	test_cexpr_basic	OK (1.0s)
string_orig	build	test_mandelbrot	OK (5.0s)
string_sane	generate	---	OK (0.6s)
string_sane	configure	---	OK (2.4s)
string_sane	build	test_cexpr_basic	FAIL (2 0.8s 414L)
string_sane	build	test_mandelbrot	OK (5.2s)
math_orig	generate	---	OK (0.3s)
math_orig	configure	---	OK (3.2s)
math_orig	build	test_cexpr_math	OK (1.9s)
math_orig	build	test_biquad_filt	OK (4.7s)
math_sane	generate	---	OK (0.5s)
math_sane	configure	---	OK (2.1s)
math_sane	build	test_cexpr_math	FAIL (2 6.5s 474L)
math_sane	build	test_biquad_filt	OK (9.7s)

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: string\_orig  
The code as originally submitted by the student.  
Build target: test\_cexpr\_basic\_string  
Build the test\_cexpr\_basic\_string program.  
Build target: test\_mandelbrot  
Build the test\_mandelbrot program.

Package: string\_sane  
Code with modifications to perform API sanity checking.  
Build target: test\_cexpr\_basic\_string  
Build the (dummy) test\_cexpr\_basic\_string program.  
Build target: test\_mandelbrot  
Build the (dummy) test\_mandelbrot program.

Package: math\_orig  
The code as originally submitted by the student.  
Build target: test\_cexpr\_math  
Build the test\_cexpr\_math program.  
Build target: test\_biquad\_filter  
Build the test\_biquad\_filter program.

Package: math\_sane  
Code with modifications to perform API sanity checking.  
Build target: test\_cexpr\_math  
Build the (dummy) test\_cexpr\_math program.  
Build target: test\_biquad\_filter  
Build the (dummy) test\_biquad\_filter program.

Jun 01, 20 19:31	Log: string_sane build test_cexpr_basic_string	Page 1/6
1	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake	
2	-S/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
3	-Judeonyia/cktmp/package-string_sane/source	
4	-B/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
5	-Judeonyia/cktmp/package-string_sane/derived --check-build-system	
6	CMakeFiles/Makefile2 cmake 0	
7	/usr/bin/gmake -f CMakeFiles/Makefile2 test_cexpr_basic_string	
8	gmake[1]: Entering directory	
9	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
10	Judeonyia/cktmp/package-string_sane/derived'	
11	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake	
12	-S/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
13	-Judeonyia/cktmp/package-string_sane/source	
14	-B/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
15	-Judeonyia/cktmp/package-string_sane/derived --check-build-system	
16	CMakeFiles/Makefile2 cmake 0	
17	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E	
18	cmake_progress_start	
19	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
20	udeonyia/cktmp/package-string_sane/derived/CMakeFiles 2	
21	/usr/bin/gmake -f CMakeFiles/Makefile2	
22	CMakeFiles/test_cexpr_basic_string.dir/all	
23	gmake[2]: Entering directory	
24	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
25	Judeonyia/cktmp/package-string_sane/derived'	
26	/usr/bin/gmake -f CMakeFiles/test_cexpr_basic_string.dir/build.make	
27	CMakeFiles/test_cexpr_basic_string.dir/depend	
28	gmake[3]: Entering directory	
29	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
30	Judeonyia/cktmp/package-string_sane/derived'	
31	cd	
32	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
33	udeonyia/cktmp/package-string_sane/derived &&	
34	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E	
35	cmake_depends "Unix Makefiles"	
36	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
37	udeonyia/cktmp/package-string_sane/source	
38	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
39	udeonyia/cktmp/package-string_sane/source	
40	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
41	udeonyia/cktmp/package-string_sane/derived	
42	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
43	udeonyia/cktmp/package-string_sane/derived	
44	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
45	udeonyia/cktmp/package-string_sane/derived/CMakeFiles/test_cexpr_basic_string.di	
46	r/DependInfo.cmake --color	
47	Scanning dependencies of target test_cexpr_basic_string	
48	gmake[3]: Leaving directory	
49	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
50	Judeonyia/cktmp/package-string_sane/derived'	
51	/usr/bin/gmake -f CMakeFiles/test_cexpr_basic_string.dir/build.make	
52	CMakeFiles/test_cexpr_basic_string.dir/build	
53	gmake[3]: Entering directory	
54	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
55	Judeonyia/cktmp/package-string_sane/derived'	
56	[ 50%] Building CXX object	
57	CMakeFiles/test_cexpr_basic_string.dir/app/test_cexpr_basic_string.cpp.o	
58	/home/frodo/public/ugls_lab-4.0.70/bin/clang++	
59	-I/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
60	-Judeonyia/cktmp/package-string_sane/source/include -pedantic-errors	
61	-std=gnu++17 -o	
62	CMakeFiles/test_cexpr_basic_string.dir/app/test_cexpr_basic_string.cpp.o -c	
63	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
64	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp	
65	clang-10: warning:	
66	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/gcc/lib64: 'linker'	
67	input unused [-Wunused-command-line-argument]	
68	clang-10: warning:	
69	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/clang/lib: 'linker'	
70	input unused [-Wunused-command-line-argument]	
71	clang-10: warning:	
72	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/boost/lib: 'linker'	
73	input unused [-Wunused-command-line-argument]	
74	clang-10: warning:	
75	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/catch/lib64: 'linker'	
76	input unused [-Wunused-command-line-argument]	
77	clang-10: warning:	
78	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/CGAL/lib64: 'linker'	
79	input unused [-Wunused-command-line-argument]	
80	clang-10: warning:	

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81	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/jasper/lib64: 'linker'	
82	input unused [-Wunused-command-line-argument]	
83	clang-10: warning:	
84	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/clang/lib64: 'linker'	
85	input unused [-Wunused-command-line-argument]	
86	clang-10: warning: argument unused during compilation:	
87	'-L/home/frodo/public/ugls_lab-4.0.70/packages/gcc/lib64'	
88	[-Wunused-command-line-argument]	
89	clang-10: warning: argument unused during compilation:	
90	'-L/home/frodo/public/ugls_lab-4.0.70/packages/clang/lib'	
91	[-Wunused-command-line-argument]	
92	clang-10: warning: argument unused during compilation:	
93	'-L/home/frodo/public/ugls_lab-4.0.70/packages/boost/lib'	
94	[-Wunused-command-line-argument]	
95	clang-10: warning: argument unused during compilation:	
96	'-L/home/frodo/public/ugls_lab-4.0.70/packages/catch/lib64'	
97	[-Wunused-command-line-argument]	
98	clang-10: warning: argument unused during compilation:	
99	'-L/home/frodo/public/ugls_lab-4.0.70/packages/CGAL/lib64'	
100	[-Wunused-command-line-argument]	
101	clang-10: warning: argument unused during compilation:	
102	'-L/home/frodo/public/ugls_lab-4.0.70/packages/jasper/lib64'	
103	[-Wunused-command-line-argument]	
104	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
105	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:14:3:	
106	warning: expression result unused [-Wunused-value]	
107	sizeof(string);	
108	~~~~~	
109	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
110	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:15:3:	
111	warning: expression result unused [-Wunused-value]	
112	sizeof(typename string::value_type);	
113	~~~~~	
114	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
115	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:16:3:	
116	warning: expression result unused [-Wunused-value]	
117	sizeof(typename string::pointer);	
118	~~~~~	
119	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
120	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:17:3:	
121	warning: expression result unused [-Wunused-value]	
122	sizeof(typename string::const_pointer);	
123	~~~~~	
124	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
125	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:18:3:	
126	warning: expression result unused [-Wunused-value]	
127	sizeof(typename string::reference);	
128	~~~~~	
129	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
130	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:19:3:	
131	warning: expression result unused [-Wunused-value]	
132	sizeof(typename string::const_reference);	
133	~~~~~	
134	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
135	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:20:3:	
136	warning: expression result unused [-Wunused-value]	
137	sizeof(typename string::iterator);	
138	~~~~~	
139	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
140	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:21:3:	
141	warning: expression result unused [-Wunused-value]	
142	sizeof(typename string::const_iterator);	
143	~~~~~	
144	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
145	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:14:3:	
146	warning: expression result unused [-Wunused-value]	
147	sizeof(string);	
148	~~~~~	
149	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
150	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:111:2:	
151	note: in instantiation of function template specialization 'test_l<char, 128>'	
152	requested here	
153	test_l<char, 128>();	
154	~~~~~	
155	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
156	udeonyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:15:3:	
157	warning: expression result unused [-Wunused-value]	
158	sizeof(typename string::value_type);	
159	~~~~~	
160	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	

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161	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:16:3:	
162	warning: expression result unused [-Wunused-value]	
163	sizeof(typename string::pointer);	
164	^	
165	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
166	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:17:3:	
167	warning: expression result unused [-Wunused-value]	
168	sizeof(typename string::const_pointer);	
169	^	
170	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
171	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:18:3:	
172	warning: expression result unused [-Wunused-value]	
173	sizeof(typename string::reference);	
174	^	
175	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
176	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:19:3:	
177	warning: expression result unused [-Wunused-value]	
178	sizeof(typename string::const_reference);	
179	^	
180	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
181	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:20:3:	
182	warning: expression result unused [-Wunused-value]	
183	sizeof(typename string::iterator);	
184	^	
185	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
186	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:21:3:	
187	warning: expression result unused [-Wunused-value]	
188	sizeof(typename string::const_iterator);	
189	^	
190	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
191	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:26:6:	
192	error: object of type 'string' (aka 'cexpr_basic_string<char, 1280UL>') cannot	
193	be assigned because its copy assignment operator is implicitly deleted	
194	s3 = s;	
195	^	
196	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
197	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:44:3	
198	4: note: explicitly defaulted function was implicitly deleted here	
199	constexpr cexpr_basic_strings operator=(const	
200	cexpr_basic_strings&) = default;	
201	^	
202	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
203	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:238:	
204	21: note: copy assignment operator of 'cexpr_basic_string<char, 128>' is	
205	implicitly deleted because field 'nullChar_' is of const-qualified type 'const	
206	ra::cexpr::cexpr_basic_string<char, 128>::value_type' (aka 'const char')	
207	const value_type nullChar_ = value_type(0);	
208	^	
209	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
210	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:27:6:	
211	error: object of type 'string' (aka 'cexpr_basic_string<char, 1280UL>') cannot	
212	be assigned because its copy assignment operator is implicitly deleted	
213	s4 = std::move(s3);	
214	^	
215	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
216	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:44:3	
217	4: note: explicitly defaulted function was implicitly deleted here	
218	constexpr cexpr_basic_strings operator=(const	
219	cexpr_basic_strings&) = default;	
220	^	
221	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
222	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:238:	
223	21: note: copy assignment operator of 'cexpr_basic_string<char, 128>' is	
224	implicitly deleted because field 'nullChar_' is of const-qualified type 'const	
225	ra::cexpr::cexpr_basic_string<char, 128>::value_type' (aka 'const char')	
226	const value_type nullChar_ = value_type(0);	
227	^	
228	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
229	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:14:3:	
230	warning: expression result unused [-Wunused-value]	
231	sizeof(string);	
232	^	
233	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
234	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:112:2:	
235	note: in instantiation of function template specialization 'test_l<unsigned	
236	char, 255>' requested here	
237	test_l<unsigned char, 255>();	
238	^	
239	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
240	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:15:3:	

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241	warning: expression result unused [-Wunused-value]	
242	sizeof(typename string::value_type);	
243	^	
244	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
245	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:16:3:	
246	warning: expression result unused [-Wunused-value]	
247	sizeof(typename string::pointer);	
248	^	
249	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
250	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:17:3:	
251	warning: expression result unused [-Wunused-value]	
252	sizeof(typename string::const_pointer);	
253	^	
254	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
255	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:18:3:	
256	warning: expression result unused [-Wunused-value]	
257	sizeof(typename string::reference);	
258	^	
259	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
260	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:19:3:	
261	warning: expression result unused [-Wunused-value]	
262	sizeof(typename string::const_reference);	
263	^	
264	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
265	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:20:3:	
266	warning: expression result unused [-Wunused-value]	
267	sizeof(typename string::iterator);	
268	^	
269	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
270	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:21:3:	
271	warning: expression result unused [-Wunused-value]	
272	sizeof(typename string::const_iterator);	
273	^	
274	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
275	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:26:6:	
276	error: object of type 'string' (aka 'cexpr_basic_string<unsigned char, 255UL>')	
277	cannot be assigned because its copy assignment operator is implicitly deleted	
278	s3 = s;	
279	^	
280	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
281	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:44:3	
282	4: note: explicitly defaulted function was implicitly deleted here	
283	constexpr cexpr_basic_strings operator=(const	
284	cexpr_basic_strings&) = default;	
285	^	
286	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
287	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:238:	
288	21: note: copy assignment operator of 'cexpr_basic_string<unsigned char, 255>'	
289	is implicitly deleted because field 'nullChar_' is of const-qualified type	
290	'const ra::cexpr::cexpr_basic_string<unsigned char, 255>::value_type' (aka	
291	'const unsigned char')	
292	const value_type nullChar_ = value_type(0);	
293	^	
294	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
295	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:27:6:	
296	error: object of type 'string' (aka 'cexpr_basic_string<unsigned char, 255UL>')	
297	cannot be assigned because its copy assignment operator is implicitly deleted	
298	s4 = std::move(s3);	
299	^	
300	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
301	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:44:3	
302	4: note: explicitly defaulted function was implicitly deleted here	
303	constexpr cexpr_basic_strings operator=(const	
304	cexpr_basic_strings&) = default;	
305	^	
306	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
307	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:238:	
308	21: note: copy assignment operator of 'cexpr_basic_string<unsigned char, 255>'	
309	is implicitly deleted because field 'nullChar_' is of const-qualified type	
310	'const ra::cexpr::cexpr_basic_string<unsigned char, 255>::value_type' (aka	
311	'const unsigned char')	
312	const value_type nullChar_ = value_type(0);	
313	^	
314	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
315	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:14:3:	
316	warning: expression result unused [-Wunused-value]	
317	sizeof(string);	
318	^	
319	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
320	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:113:2:	

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321	note: in instantiation of function template specialization 'test_l<wchar_t,	
322	64>' requested here	
323	test_l<wchar_t, 64>();	
324	^	
325	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
326	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:15:3:	
327	warning: expression result unused [-Wunused-value]	
328	sizeof(typename string::value_type);	
329	^	
330	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
331	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:16:3:	
332	warning: expression result unused [-Wunused-value]	
333	sizeof(typename string::pointer);	
334	^	
335	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
336	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:17:3:	
337	warning: expression result unused [-Wunused-value]	
338	sizeof(typename string::const_pointer);	
339	^	
340	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
341	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:18:3:	
342	warning: expression result unused [-Wunused-value]	
343	sizeof(typename string::reference);	
344	^	
345	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
346	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:19:3:	
347	warning: expression result unused [-Wunused-value]	
348	sizeof(typename string::const_reference);	
349	^	
350	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
351	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:20:3:	
352	warning: expression result unused [-Wunused-value]	
353	sizeof(typename string::iterator);	
354	^	
355	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
356	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:21:3:	
357	warning: expression result unused [-Wunused-value]	
358	sizeof(typename string::const_iterator);	
359	^	
360	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
361	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:26:6:	
362	error: object of type 'string' (aka 'cexpr_basic_string<wchar_t, 64UL>') cannot	
363	be assigned because its copy assignment operator is implicitly deleted	
364	s3 = s;	
365	^	
366	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
367	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:44:3	
368	4: note: explicitly defaulted function was implicitly deleted here	
369	constexpr cexpr_basic_string& operator=(const	
370	cexpr_basic_string&) = default;	
371	^	
372	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
373	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:238:	
374	21: note: copy assignment operator of 'cexpr_basic_string<wchar_t, 64>' is	
375	implicitly deleted because field 'nullChar_' is of const-qualified type 'const	
376	ra::cexpr::cexpr_basic_string<wchar_t, 64>::value_type' (aka 'const wchar_t')	
377	const value_type nullChar_ = value_type(0);	
378	^	
379	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
380	udeOnyia/cktmp/package-string_sane/source/app/test_cexpr_basic_string.cpp:27:6:	
381	error: object of type 'string' (aka 'cexpr_basic_string<wchar_t, 64UL>') cannot	
382	be assigned because its copy assignment operator is implicitly deleted	
383	s4 = std::move(s3);	
384	^	
385	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
386	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:44:3	
387	4: note: explicitly defaulted function was implicitly deleted here	
388	constexpr cexpr_basic_string& operator=(const	
389	cexpr_basic_string&) = default;	
390	^	
391	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
392	udeOnyia/cktmp/package-string_sane/source/include/ra/cexpr_basic_string.hpp:238:	
393	21: note: copy assignment operator of 'cexpr_basic_string<wchar_t, 64>' is	
394	implicitly deleted because field 'nullChar_' is of const-qualified type 'const	
395	ra::cexpr::cexpr_basic_string<wchar_t, 64>::value_type' (aka 'const wchar_t')	
396	const value_type nullChar_ = value_type(0);	
397	^	
398	32 warnings and 6 errors generated.	
399	gmake[3]: ***	
400	[CMakeFiles/test_cexpr_basic_string.dir/app/test_cexpr_basic_string.cpp.o]	

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401	Error 1	
402	gmake[3]: Leaving directory	
403	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
404	JudeOnyia/cktmp/package-string_sane/derived'	
405	gmake[2]: *** [CMakeFiles/test_cexpr_basic_string.dir/all] Error 2	
406	gmake[2]: Leaving directory	
407	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
408	JudeOnyia/cktmp/package-string_sane/derived'	
409	gmake[1]: *** [CMakeFiles/test_cexpr_basic_string.dir/rule] Error 2	
410	gmake[1]: Leaving directory	
411	'/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
412	JudeOnyia/cktmp/package-string_sane/derived'	
413	gmake: *** [test_cexpr_basic_string] Error 2	
414	ERROR: build failed to generate executable test_cexpr_basic_string	

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1	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake	
2	-S/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
3	-Judeonyia/cktmp/package-math_sane/source	
4	-B/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
5	-Judeonyia/cktmp/package-math_sane/derived --check-build-system	
6	CMakeFiles/Makefile2	
7	/usr/bin/gmake -f CMakeFiles/Makefile2 test_cexpr_math	
8	gmake[1]: Entering directory	
9	^/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
10	Judeonyia/cktmp/package-math_sane/derived	
11	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake	
12	-S/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
13	-Judeonyia/cktmp/package-math_sane/source	
14	-B/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
15	-Judeonyia/cktmp/package-math_sane/derived --check-build-system	
16	CMakeFiles/Makefile2	
17	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E	
18	cmake_progress_start	
19	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
20	udeonyia/cktmp/package-math_sane/derived/CMakeFiles 2	
21	/usr/bin/gmake -f CMakeFiles/Makefile2 CMakeFiles/test_cexpr_math.dir/all	
22	gmake[2]: Entering directory	
23	^/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
24	Judeonyia/cktmp/package-math_sane/derived	
25	/usr/bin/gmake -f CMakeFiles/test_cexpr_math.dir/build.make	
26	CMakeFiles/test_cexpr_math.dir/depend	
27	gmake[3]: Entering directory	
28	^/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
29	Judeonyia/cktmp/package-math_sane/derived	
30	cd	
31	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
32	udeonyia/cktmp/package-math_sane/derived &&	
33	/home/frodo/public/ugls_lab-4.0.70/packages/cmake-3.17.1/bin/cmake -E	
34	cmake_depends "Unix Makefiles"	
35	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
36	udeonyia/cktmp/package-math_sane/source	
37	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
38	udeonyia/cktmp/package-math_sane/source	
39	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
40	udeonyia/cktmp/package-math_sane/derived	
41	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
42	udeonyia/cktmp/package-math_sane/derived	
43	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
44	udeonyia/cktmp/package-math_sane/derived/CMakeFiles/test_cexpr_math.dir/DependIn	
45	fo.cmake --color	
46	Scanning dependencies of target test_cexpr_math	
47	gmake[3]: Leaving directory	
48	^/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
49	Judeonyia/cktmp/package-math_sane/derived	
50	/usr/bin/gmake -f CMakeFiles/test_cexpr_math.dir/build.make	
51	CMakeFiles/test_cexpr_math.dir/build	
52	gmake[3]: Entering directory	
53	^/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
54	Judeonyia/cktmp/package-math_sane/derived	
55	[ 50%] Building CXX object	
56	CMakeFiles/test_cexpr_math.dir/app/test_cexpr_math.cpp.o	
57	/home/frodo/public/ugls_lab-4.0.70/bin/clang++	
58	-I/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time	
59	-Judeonyia/cktmp/package-math_sane/source/include -pedantic-errors	
60	-std=gnu++17 -o CMakeFiles/test_cexpr_math.dir/app/test_cexpr_math.cpp.o -c	
61	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
62	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp	
63	clang-10: warning:	
64	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/gcc/lib64: 'linker'	
65	input unused [-Wunused-command-line-argument]	
66	clang-10: warning:	
67	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/clang/lib: 'linker'	
68	input unused [-Wunused-command-line-argument]	
69	clang-10: warning:	
70	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/boost/lib: 'linker'	
71	input unused [-Wunused-command-line-argument]	
72	clang-10: warning:	
73	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/catch/lib64: 'linker'	
74	input unused [-Wunused-command-line-argument]	
75	clang-10: warning:	
76	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/CGAL/lib64: 'linker'	
77	input unused [-Wunused-command-line-argument]	
78	clang-10: warning:	
79	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/jasper/lib64: 'linker'	
80	input unused [-Wunused-command-line-argument]	

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81	clang-10: warning:	
82	-Wl,-rpath,/home/frodo/public/ugls_lab-4.0.70/packages/clang/lib64: 'linker'	
83	input unused [-Wunused-command-line-argument]	
84	clang-10: warning: argument unused during compilation:	
85	'-L/home/frodo/public/ugls_lab-4.0.70/packages/gcc/lib64'	
86	[-Wunused-command-line-argument]	
87	clang-10: warning: argument unused during compilation:	
88	'-L/home/frodo/public/ugls_lab-4.0.70/packages/clang/lib'	
89	[-Wunused-command-line-argument]	
90	clang-10: warning: argument unused during compilation:	
91	'-L/home/frodo/public/ugls_lab-4.0.70/packages/boost/lib'	
92	[-Wunused-command-line-argument]	
93	clang-10: warning: argument unused during compilation:	
94	'-L/home/frodo/public/ugls_lab-4.0.70/packages/catch/lib64'	
95	[-Wunused-command-line-argument]	
96	clang-10: warning: argument unused during compilation:	
97	'-L/home/frodo/public/ugls_lab-4.0.70/packages/CGAL/lib64'	
98	[-Wunused-command-line-argument]	
99	clang-10: warning: argument unused during compilation:	
100	'-L/home/frodo/public/ugls_lab-4.0.70/packages/jasper/lib64'	
101	[-Wunused-command-line-argument]	
102	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
103	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:14:17: error:	
104	constexpr variable 'x6' must be initialized by a constant expression	
105	constexpr auto x6 = rcm::sin(T(5.0));	
106	~~~~~	
107	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
108	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:22:2: note: in	
109	instantiation of function template specialization 'test<float>' requested here	
110	test<float>();	
111	~~~~~	
112	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
113	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:14:3: note:	
114	constexpr evaluation hit maximum step limit; possible infinite loop?	
115	if(y == 0){	
116	^	
117	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
118	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:55:17: note:	
119	in call to 'mod(3.484586e-07, 6.283185e+00)'	
120	T reduced_x = mod<T>(x, 2*pi<T>);	
121	~~~~~	
122	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
123	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
124	in call to 'sin(3.484586e-07)'	
125	result = (3*sin(reduced_x/3)) -	
126	(4*cube(sin(reduced_x/3)));	
127	^	
128	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
129	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
130	in call to 'sin(1.045376e-06)'	
131	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
132	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
133	in call to 'sin(3.136127e-06)'	
134	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
135	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:17: note:	
136	in call to 'sin(9.408382e-06)'	
137	result = (3*sin(reduced_x/3)) -	
138	(4*cube(sin(reduced_x/3)));	
139	^	
140	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
141	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
142	(skipping ? calls in backtrace; use -fconstexpr-backtrace-limit=0 to see all)	
143	result = (3*sin(reduced_x/3)) -	
144	(4*cube(sin(reduced_x/3)));	
145	^	
146	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
147	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
148	in call to 'sin(6.172839e-02)'	
149	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
150	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
151	in call to 'sin(1.851852e-01)'	
152	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
153	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
154	in call to 'sin(5.555559e-01)'	
155	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
156	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
157	in call to 'sin(1.666667e+00)'	
158	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
159	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:14:22: note: in	
160	call to 'sin(5.000000e+00)'	

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161	constexpr auto x6 = rcm::sin(T(5.0));	
162	^	
163	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
164	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:16:17: error:	
165	constexpr variable 'x8' must be initialized by a constant expression	
166	constexpr auto x8 = rcm::tan(T(5.0));	
167	^	
168	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
169	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:38:27: note:	
170	constexpr evaluation hit maximum step limit; possible infinite loop?	
171	constexpr T mod(T x, T y){	
172	^	
173	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
174	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:55:17: note:	
175	in call to 'mod(3.484586e-07, 6.283185e+00)'	
176	T reduced_x = mod<T>(x, 2*pi<T>);	
177	^	
178	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
179	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
180	in call to 'sin(3.484586e-07)'	
181	result = (3*sin(reduced_x/3)) -	
182	^	
183	(4*cube(sin(reduced_x/3)));	
184	^	
185	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
186	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
187	in call to 'sin(1.045376e-06)'	
188	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
189	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
190	in call to 'sin(3.136127e-06)'	
191	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
192	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:17: note:	
193	in call to 'sin(9.408382e-06)'	
194	result = (3*sin(reduced_x/3)) -	
195	^	
196	(4*cube(sin(reduced_x/3)));	
197	^	
198	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
199	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
200	(skipping 8 calls in backtrace; use -fconstexpr-backtrace-limit=0 to see all)	
201	result = (3*sin(reduced_x/3)) -	
202	^	
203	(4*cube(sin(reduced_x/3)));	
204	^	
205	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
206	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
207	in call to 'sin(1.851852e-01)'	
208	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
209	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
210	in call to 'sin(1.666667e+00)'	
211	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
212	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:89:9: note:	
213	in call to 'sin(5.000000e+00)'	
214	T a = sin<T>(x);	
215	^	
216	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
217	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:16:22: note: in	
218	call to 'tan(5.000000e+00)'	
219	constexpr auto x8 = rcm::tan(T(5.0));	
220	^	
221	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
222	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:14:17: error:	
223	constexpr variable 'x6' must be initialized by a constant expression	
224	constexpr auto x6 = rcm::sin(T(5.0));	
225	^	
226	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
227	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:23:2: note: in	
228	instantiation of function template specialization 'test<double>' requested here	
229	test<double>();	
230	^	
231	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
232	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:41:3: note:	
233	constexpr evaluation hit maximum step limit; possible infinite loop?	
234	if(y == 0){	
235	^	
236	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
237	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:55:17: note:	
238	in call to 'mod(3.484586e-07, 6.283185e+00)'	
239	T reduced_x = mod<T>(x, 2*pi<T>);	
240	^	

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241	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
242	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
243	in call to 'sin(3.484586e-07)'	
244	result = (3*sin(reduced_x/3)) -	
245	^	
246	(4*cube(sin(reduced_x/3)));	
247	^	
248	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
249	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
250	in call to 'sin(1.045376e-06)'	
251	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
252	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
253	in call to 'sin(3.136127e-06)'	
254	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
255	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:17: note:	
256	in call to 'sin(9.408382e-06)'	
257	result = (3*sin(reduced_x/3)) -	
258	^	
259	(4*cube(sin(reduced_x/3)));	
260	^	
261	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
262	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
263	(skipping 7 calls in backtrace; use -fconstexpr-backtrace-limit=0 to see all)	
264	result = (3*sin(reduced_x/3)) -	
265	^	
266	(4*cube(sin(reduced_x/3)));	
267	^	
268	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
269	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
270	in call to 'sin(6.172840e-02)'	
271	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
272	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
273	in call to 'sin(5.555556e-01)'	
274	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
275	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
276	in call to 'sin(1.666667e+00)'	
277	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
278	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:14:22: note: in	
279	call to 'sin(5.000000e+00)'	
280	constexpr auto x6 = rcm::sin(T(5.0));	
281	^	
282	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
283	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:16:17: error:	
284	constexpr variable 'x8' must be initialized by a constant expression	
285	constexpr auto x8 = rcm::tan(T(5.0));	
286	^	
287	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
288	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:38:27: note:	
289	constexpr evaluation hit maximum step limit; possible infinite loop?	
290	constexpr T mod(T x, T y){	
291	^	
292	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
293	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:55:17: note:	
294	in call to 'mod(3.484586e-07, 6.283185e+00)'	
295	T reduced_x = mod<T>(x, 2*pi<T>);	
296	^	
297	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
298	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
299	in call to 'sin(3.484586e-07)'	
300	result = (3*sin(reduced_x/3)) -	
301	^	
302	(4*cube(sin(reduced_x/3)));	
303	^	
304	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
305	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
306	in call to 'sin(1.045376e-06)'	
307	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
308	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
309	in call to 'sin(3.136127e-06)'	
310	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
311	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:17: note:	
312	in call to 'sin(9.408382e-06)'	
313	result = (3*sin(reduced_x/3)) -	
314	^	
315	(4*cube(sin(reduced_x/3)));	
316	^	
317	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
318	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
319	(skipping 8 calls in backtrace; use -fconstexpr-backtrace-limit=0 to see all)	
320	result = (3*sin(reduced_x/3)) -	

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321	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
322	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
323	in call to 'sin(1.851852e-01)'	
324	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
325	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
326	in call to 'sin(5.555556e-01)'	
327	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
328	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
329	in call to 'sin(1.666667e+00)'	
330	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
331	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:89:9: note:	
332	in call to 'sin(5.000000e+00)'	
333	^	
334	T a = sin<T>(x);	
335	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
336	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:16:22: note: in	
337	call to 'tan(5.000000e+00)'	
338	constexpr auto x8 = rcm::tan(T(5.0));	
339	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
340	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:14:17: error:	
341	constexpr variable 'x6' must be initialized by a constant expression	
342	constexpr auto x6 = rcm::sin(T(5.0));	
343	^	
344	^	
345	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
346	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:24:2: note: in	
347	instantiation of function template specialization 'test<long double>' requested	
348	here	
349	test<long double>();	
350	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
351	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:41:3: note:	
352	constexpr evaluation hit maximum step limit; possible infinite loop?	
353	if(y == 0){	
354	^	
355	T reduced_x = mod<T>(x, 2*pi<T>);	
356	^	
357	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
358	in call to 'mod(3.484586e-07, 6.283185e+00)'	
359	in call to 'sin(3.484586e-07)'	
360	^	
361	result = (3*sin(reduced_x/3)) -	
362	in call to 'sin(3.484586e-07)'	
363	^	
364	(4*cube(sin(reduced_x/3)));	
365	^	
366	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
367	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
368	in call to 'sin(1.045376e-06)'	
369	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
370	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
371	in call to 'sin(3.136127e-06)'	
372	in call to 'sin(3.136127e-06)'	
373	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
374	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:17: note:	
375	in call to 'sin(9.408382e-06)'	
376	result = (3*sin(reduced_x/3)) -	
377	in call to 'sin(9.408382e-06)'	
378	^	
379	(4*cube(sin(reduced_x/3)));	
380	^	
381	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
382	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
383	(skipping 7 calls in backtrace; use -fconstexpr-backtrace-limit=0 to see all)	
384	(4*cube(sin(reduced_x/3)));	
385	^	
386	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
387	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
388	in call to 'sin(6.172840e-02)'	
389	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
390	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
391	in call to 'sin(5.555556e-01)'	
392	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
393	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
394	in call to 'sin(1.666667e+00)'	
395	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
396	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:14:22: note: in	
397	call to 'tan(5.000000e+00)'	
398	constexpr auto x6 = rcm::tan(T(5.0));	
399	^	
400	^	

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401	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
402	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:15:17: error:	
403	constexpr variable 'x8' must be initialized by a constant expression	
404	constexpr auto x8 = rcm::tan(T(5.0));	
405	^	
406	^	
407	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
408	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:38:27: note:	
409	constexpr evaluation hit maximum step limit; possible infinite loop?	
410	constexpr T mod(T X, T Y){	
411	^	
412	T reduced_x = mod<T>(x, 2*pi<T>);	
413	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
414	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:55:17: note:	
415	in call to 'mod(3.484586e-07, 6.283185e+00)'	
416	^	
417	result = (3*sin(reduced_x/3)) -	
418	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
419	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
420	in call to 'sin(3.484586e-07)'	
421	^	
422	(4*cube(sin(reduced_x/3)));	
423	^	
424	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
425	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
426	in call to 'sin(1.045376e-06)'	
427	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
428	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
429	in call to 'sin(3.136127e-06)'	
430	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
431	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:17: note:	
432	in call to 'sin(9.408382e-06)'	
433	result = (3*sin(reduced_x/3)) -	
434	in call to 'sin(9.408382e-06)'	
435	^	
436	(4*cube(sin(reduced_x/3)));	
437	^	
438	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
439	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
440	(skipping 8 calls in backtrace; use -fconstexpr-backtrace-limit=0 to see all)	
441	(4*cube(sin(reduced_x/3)));	
442	^	
443	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
444	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
445	in call to 'sin(1.851852e-01)'	
446	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
447	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:65:45: note:	
448	in call to 'sin(5.555556e-01)'	
449	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
450	udeonyia/cktmp/package-math_sane/source/include/ra/cexpr_math.hpp:89:9: note:	
451	in call to 'sin(5.000000e+00)'	
452	^	
453	T a = sin<T>(x);	
454	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-J	
455	udeonyia/cktmp/package-math_sane/source/app/test_cexpr_math.cpp:16:22: note: in	
456	call to 'tan(5.000000e+00)'	
457	constexpr auto x8 = rcm::tan(T(5.0));	
458	^	
459	^	
460	6 errors generated.	
461	gmake[3]: *** [MakeFiles/test_cexpr_math.dir/app/test_cexpr_math.cpp.o] Error 1	
462	gmake[3]: Leaving directory	
463	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
464	Judeonyia/cktmp/package-math_sane/derived'	
465	gmake[2]: *** [MakeFiles/test_cexpr_math.dir/all] Error 2	
466	gmake[2]: Leaving directory	
467	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
468	Judeonyia/cktmp/package-math_sane/derived'	
469	gmake[1]: *** [MakeFiles/test_cexpr_math.dir/rule] Error 2	
470	gmake[1]: Leaving directory	
471	/home/judeonyia/Documents/ECE596C_Assignments/ECE596C_Assgn_2/cpp_compile_time-	
472	Judeonyia/cktmp/package-math_sane/derived'	
473	gmake: *** [test_cexpr_math] Error 2	
474	ERROR: build failed to generate executable test_cexpr_math	



```
1  commit ddd44b41088d6da6abc5b4dde63be21adcc8a2bf
2  Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
3  Date:   Fri May 29 00:55:23 2020 -0700
4
5      My First Commit
6
7  commit 8b4a82ae0c0c63ccfa2fb34e288cd469e1e087bd
8  Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
9  Date:   Fri May 29 01:55:51 2020 -0700
10
11     Set up the structure of cexpr_basic_string class
12
13  commit fc4203a5fe1b1fc4d243d6f8972dd860378d44a0
14  Author: Jude Onyia <judeonyia@ugls19.ece.uvic.ca>
15  Date:   Fri May 29 02:12:34 2020 -0700
16
17     Checking Folder from assignment precheck
18
19  commit f5e4a01ac9557e6b06c7349dbc5f7e196efdff4b
20  Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
21  Date:   Fri May 29 02:16:50 2020 -0700
22
23     Removed Assign Precheck Folder
24
25  commit bfb276218a4abd78411a7355926d1c7dd748b5d
26  Author: Jude Onyia <judeonyia10@gmail.com>
27  Date:   Fri May 29 17:01:36 2020 -0700
28
29     1) Wrote the types and data members of cexpr_basic_string
30     2) Wrote the default constructor
31     3) Wrote the constructor with parameter of string pointer
32     4) Tested
33
34  commit f82e1dc817588636e0b5a8d951a623cba0fcbe66
35  Author: Jude Onyia <judeonyia10@gmail.com>
36  Date:   Sat May 30 00:53:50 2020 -0700
37
38     1) Wrote max size, size and capacity functions
39     2) Wrote data, begin and end functions
40     3) Wrote operator[] overload
41
42  commit 06a99e4cf21d3984ffe77a80ef06e08b3a5fa7ee
43  Author: Jude Onyia <judeonyia10@gmail.com>
44  Date:   Sat May 30 00:57:12 2020 -0700
45
46     Removed swp files
47
48  commit 5fe880a9fb8917e64109972b981a36c701e1a6f0
49  Author: Jude Onyia <judeonyia10@gmail.com>
50  Date:   Sat May 30 18:49:33 2020 -0700
51
52     1) Wrote push_back() and pop_back()
53     2) Wrote append(pointer), append(obj)
54     3) Wrote clear()
55
56  commit 3dfb8efadaaa7367243c3db6c29ace0a4efccf77
57  Author: Jude Onyia <judeonyia10@gmail.com>
58  Date:   Sun May 31 00:27:48 2020 -0700
59
60     1) Wrote Alias for cexpr_basic_string called cexpr_string
61     2) Wrote to_string helper function
62
```

```
63 commit ee65da40a2cec5787b274eac9e9539a84f718176
64 Author: JudeOnyia <60678029+JudeOnyia@users.noreply.github.com>
65 Date: Sun May 31 01:26:13 2020 -0700
66
67 Set up for Mandelbrot section
68
69 commit b3b55701af97708b386a6eb79a54d77292b53919
70 Author: Jude Onyia <judeonyia10@gmail.com>
71 Date: Sun May 31 21:07:54 2020 -0700
72
73 1) Wrote basic Mandelbrot hpp and cpp
74 2) Modified to_string function to accomodate clang compiler
75
76 commit 1db2c71fe13c812a0f718986d289ea88d06be7ec
77 Author: Jude Onyia <judeonyia10@gmail.com>
78 Date: Sun May 31 21:26:38 2020 -0700
79
80 1) Printed the mandelbrot to a file called mandelbrot.pnm
81 2) Displayed file on image software. Confirming it is mandelbrot
82
83 commit cf9bcf5545031c9845cbb379ec2911d3bb1b814c
84 Author: Jude Onyia <judeonyia10@gmail.com>
85 Date: Mon Jun 1 01:00:08 2020 -0700
86
87 1) Wrote template variable pi
88 2) Wrote template functions abs,sqr, cube and mod
89
90 commit e52269371567c4f87e4a75clea4650dacde9eba3
91 Author: Jude Onyia <judeonyia10@gmail.com>
92 Date: Mon Jun 1 02:33:02 2020 -0700
93
94 1) Wrote template functions for sin, cos, tan and sqrt
95
96 commit d450669cb83518f16fde276b25d96f3baf63570c
97 Author: Jude Onyia <judeonyia10@gmail.com>
98 Date: Mon Jun 1 14:44:45 2020 -0700
99
100 1) Wrote biquad_filter_coefs class
101 2) Wrote constexpr constructor to initialize parameters
102 3) Wrote constexpr constructor to copy from another obj
103
104 commit 9873843310751781db8f11e9558bb79da4a7f42f
105 Author: Jude Onyia <judeonyia10@gmail.com>
106 Date: Mon Jun 1 17:32:15 2020 -0700
107
108 1) Wrote template functions for lowpass, highpass and bandpass filters
109 2) Wrote template functions for low shelf boost and low shelf cut filters
```

Name: Jude Onyia  
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Course: ECE 596C  
Due Date: June 5, 2020

## Assignment 2: Non – Programming Exercise

8.1)

x?	lvalue
static_cast<std::vector<int>&&>(x)?	Rvalue (xvalue)
x.begin()?	Rvalue (xvalue)
++i?	lvalue
*i?	lvalue
*i += 5?	lvalue
x[0]?	lvalue
++a?	lvalue
a++?	Rvalue (prvalue)
func1(x)?	Rvalue (xvalue)
y = func1(x)?	lvalue

8.24)

Widget b(a);	Copy Constructor	Required with certainty (cannot be elided)
Widget c = a;	Copy Constructor	Required with certainty (cannot be elided)
Widget d(std::move(c));	Move Constructor	Required with certainty (cannot be elided)
Widget e = std::move(d);	Move Constructor	Required with certainty (cannot be elided)
Widget f(make_widget_1());	Move Constructor	Guaranteed to be elided
Widget g(make_widget_2(true));	Move Constructor	May be required (depending on if it can be elided)
c = a;	Copy Assignment	Required with certainty (cannot be elided)
b = std::move(c);	Move Assignment	Required with certainty (cannot be elided)
a = make_widget_1();	Move Assignment	Guaranteed to be elided
a = make_widget_2(true);	Move Assignment	May be required (depending on if it can be elided)
func_1(a);	Copy Constructor	Required with certainty (cannot be elided)
func_1(std::move(a));	Move Constructor	Required with certainty (cannot be elided)
func_1(make_widget_1());	Move Constructor	Guaranteed to be elided
func_2(std::move(b));	Move Constructor	Required with certainty (cannot be elided)

8.25)

Lines marked with ???:	Line of code where a temporary object is created:	Description and explanation:
<i>Line 67: z = x + y;</i>	<i>Line 53: counter(x)</i>	This temporary object is created within operator+. It is needed to store the result of x+=y without changing the value of x.
	<i>Line 67: x+y</i>	This temporary object is created in the main function. It is required in order to hold the return of operator+ before it can be assigned to counter z.
<i>Line 68: z = z + z;</i>	<i>Line 53: counter(x)</i>	This temporary object is created within operator+. It is needed to store the result of x+=y without changing the value of x.
	<i>Line 68: z+z</i>	This temporary object is created in the main function. It is required in order to hold the return of operator+ before it can be assigned to counter z.
<i>Line 69: y = ++z;</i>	N/A	This line does not need a temporary object because the pre-fixed operator++ returns an lvalue reference to the counter z.
<i>Line 70: z = y++;</i>	<i>Line 70: y++</i>	This temporary object is created in the main function. It is required in order to hold the return value of operator++(int) before it can be assigned to counter z.
<i>Line 71: x = z;</i>	N/A	This line does not need a temporary object because the operator= returns an lvalue reference.

8.26)

Some advantages of array-based implementation of a stack are elements stored contiguously in memory, less overhead, and it is more cache friendly. The disadvantage of array-based implementation is it cannot guarantee that each push will take constant time. This is due to the situation where the capacity of the array is full, in this case it would have to copy its entire content to a bigger section of memory before it can push that object.

An advantage of node-based implementation of a stack is that the previously discussed capacity exceeding problem is not evident here. This guarantees the push operation will be done in constant time. Another advantage is that references to objects in the stack are stable (always valid) since the objects they refer to are not forced to be copied or moved somewhere else. Disadvantages of node-based implementation include not storing elements contiguously in memory, per-element overhead, and requires more space than array-based implementation due to the overhead.

```
1  # Specify Minimum Required Version
2  cmake_minimum_required(VERSION 3.1 FATAL_ERROR)
3
4  # Specify Project and Language
5  project(cpp_compile_time LANGUAGES CXX)
6
7  # For Clang:
8  set(EXTRA_COMPILE_FLAGS "-fconstexpr-steps=100000000")
9  set_source_files_properties(app/test_mandelbrot.cpp PROPERTIES COMPILE_FLAGS ${E
XTRA_COMPILE_FLAGS})
10
11 # Set Include Directory
12 include_directories(include)
13
14 # Add Executable Program
15 add_executable(test_cexpr_basic_string app/test_cexpr_basic_string.cpp)
16 add_executable(test_mandelbrot app/test_mandelbrot.cpp)
17 add_executable(test_cexpr_math app/test_cexpr_math.cpp)
18 add_executable(test_biquad_filter app/test_biquad_filter.cpp)
```

```

1  #ifndef CEXPR
2  #define CEXPR
3  #include <cstddef>
4  #include <stdexcept>
5  #include <string>
6  namespace ra::cexpr{
7      // A basic string class template for use in constexpr contexts
8      template<class T, std::size_t M>
9      class cexpr_basic_string{
10         public:
11             // An unsigned integral type used to represent sizes
12             using size_type = std::size_t;
13
14             // The type of each character in the string (i.e., an alias for
15             // the template parameter T)
16             using value_type = T;
17
18             // The type of a mutating pointer to each character in the string
19             using pointer = T*;
20
21             // The type of a non-mutating pointer to each character in the
22             // string
23             using const_pointer = const T*;
24
25             // The type of a mutating reference to a character in the string
26             using reference = T&;
27
28             // The type of a non-mutating reference to a character in the
29             // string
30             using const_reference = const T&;
31
32             // A mutating iterator type for the elements in the string
33             using iterator = pointer;
34
35             // A non-mutating iterator type for the elements in the string
36             using const_iterator = const_pointer;
37
38             // Creates an empty string (i.e., a string containing no
39             // characters)
40             constexpr cexpr_basic_string() : charArray_{0}, charSize_(0) {}
41
42             // Explicitly default some special members
43             constexpr cexpr_basic_string(const cexpr_basic_string&) = default;
44             constexpr cexpr_basic_string& operator=(const cexpr_basic_string&) =
45             default;
46
47             ~cexpr_basic_string() = default;
48
49             // Creates a string with the contents given by the
50             // null-terminated character array pointed to by s
51             // If the string does not have sufficient capacity to hold
52             // the character data provided, an exception of type
53             // std::runtime_error is thrown
54             constexpr cexpr_basic_string(const value_type* s) : charArray_{0}, c
55             harSize_(0){
56                 while(s[charSize_] != nullChar_){
57                     if(M <= charSize_){
58                         clear();
59                         throw std::runtime_error("String does not have sufficient capacity");
60                     }
61                     else{
62                         charArray_[charSize_] = s[charSize_];

```

```
60         ++charSize_;
61     }
62 }
63
64
65 // Creates a string with the contents specified by the characters
66 // in the iterator range [first, last).
67 // If the string does not have sufficient capacity to hold
68 // the character data provided, an exception of type
69 // std::runtime_error is thrown.
70 constexpr cexpr_basic_string(const_iterator first, const_iterator la
st) : charArray_{0}, charSize_(0){
71     if(M < (last - first)){
72         throw std::runtime_error("String does not have sufficient capacity");
73     }
74     else{
75         for(const_iterator i=first; i < last; ++i){
76             charArray_[charSize_] = *i;
77             ++charSize_;
78         }
79     }
80 }
81
82 // Returns the maximum number of characters that can be held by a
83 // string of this type.
84 // The value returned is the template parameter M
85 static constexpr size_type max_size() { return M; }
86
87 // Returns the maximum number of characters that the string can
88 // hold. The value returned is always the template parameter M
89 constexpr size_type capacity() const { return M; }
90
91 // Returns the number of characters in the string (excluding the
92 // dummy null character)
93 constexpr size_type size() const { return charSize_; }
94
95 // Returns a pointer to the first character in the string
96 // The pointer that is returned is guaranteed to point to a
97 // null-terminated character array
98 // The user of this class shall not alter the dummy null
99 // character stored at data() + size().
100 value_type* data(){
101     return charArray_;
102 }
103 const value_type* data() const {
104     return charArray_;
105 }
106
107 // Returns an iterator referring to the first character in the
108 // string
109 constexpr iterator begin() {
110     return charArray_;
111 }
112 constexpr const_iterator begin() const {
113     return charArray_;
114 }
115
116 // Returns an iterator referring to the fictitious
117 // one-past-the-end character in the string
118 constexpr iterator end(){
119     return (&charArray_[charSize_]);
120 }
```

```
121     constexpr const_iterator end() const {
122         return (&charArray_[charSize_]);
123     }
124
125     // Returns a reference to the i-th character in the string if i
126     // is less than the string size; and returns a reference to the
127     // dummy null character if i equals the string size.
128     // Precondition: The index i is such that i >= 0 and i <= size().
129     constexpr reference operator[](size_type i){
130         if(i<0 || i>charSize_){
131             throw std::domain_error("invalid array access");
132         }
133         else if(i==charSize_){ return charArray_[charSize_]; }
134         else{ return charArray_[i];}
135     }
136     constexpr const_reference operator[](size_type i) const{
137         if(i<0 || i>charSize_){
138             throw std::domain_error("invalid array access");
139         }
140         else if(i==charSize_){ return nullChar_; }
141         else{ return charArray_[i];}
142     }
143
144     // Appends (i.e., adds to the end) a single character to the
145     // string. If the size of the string is equal to the capacity,
146     // the string is not modified and an exception of type
147     // std::runtime_error is thrown.
148     constexpr void push_back(const T& x){
149         if(M <= charSize_){
150             throw std::runtime_error("String does not have sufficient capacity");
151         }
152         else{
153             charArray_[charSize_] = x;
154             ++charSize_;
155         }
156     }
157
158     // Erases the last character in the string.
159     // If the string is empty, an exception of type std::runtime_error
160     // is thrown.
161     constexpr void pop_back(){
162         if(charSize_ == 0){
163             throw std::runtime_error("String does not have sufficient capacity");
164         }
165         else{
166             charArray_[charSize_ - 1] = '\0';
167             --charSize_;
168         }
169     }
170
171     // Appends (i.e., adds to the end) to the string the
172     // null-terminated string pointed to by s.
173     // Precondition: The pointer s must be non-null.
174     // If the string has insufficient capacity to hold the new value
175     // resulting from the append operation, the string is not modified
176     // and an exception of type std::runtime_error is thrown.
177     constexpr cexpr_basic_string& append(const value_type* s){
178         size_type addSize = 0;
179         if(s == nullptr) {
180             throw std::runtime_error("Null pointer");
181         }
182         else{
```



```

183         while(s[addToSize] != nullChar_){
184             if(M <= (charSize_+addToSize)){
185                 charSize_ += addToSize;
186                 for(size_type i=0; i<addToSize; ++i){
187                     pop_back();
188                 }
189                 addToSize = 0;
190                 throw std::runtime_error("String does not have sufficient capacit
y");
191                 break;
192             }
193             else{
194                 charArray_[charSize_ + addToSize] = s[addToSize];
195                 ++addToSize;
196             }
197         }
198         charSize_ += addToSize;
199     }
200     return *this;
201 }
202
203 // Appends (i.e., adds to the end) to the string another
204 // cexpr_basic_string with the same character type (but
205 // possibly a different maximum size).
206 // If the string has insufficient capacity to hold the new value
207 // resulting from the append operation, the string is not modified
208 // and an exception of type std::runtime_error is thrown.
209 template<size_type OtherM>
210 constexpr cexpr_basic_string& append(const cexpr_basic_string<value_
type, OtherM>& other){
211     size_type addToSize = 0;
212     if(M < (charSize_ + other.size())){
213         throw std::runtime_error("String does not have sufficient capacity");
214     }
215     else{
216         for(size_type i=0; i<other.size(); ++i){
217             charArray_[charSize_ + i] = other[i];
218             ++addToSize;
219         }
220         charSize_ += addToSize;
221     }
222     return *this;
223 }
224
225 // Erases all of the characters in the string, yielding an empty
226 // string.
227 constexpr void clear(){
228     for(size_type i=0; i<charSize_; ++i){
229         charArray_[i] = '\0';
230     }
231     charSize_ = 0;
232 }
233
234 private:
235     value_type charArray_[M+1];
236     size_type charSize_;
237     const value_type nullChar_ = value_type(0);
238 };
239
240 template<std::size_t M>
241 using cexpr_string = cexpr_basic_string<char, M>;

```

```
243
244     constexpr char digit_to_char(std::size_t num){
245         char mychar = '0';
246         switch(num) {
247             case std::size_t(0) : mychar = '0'; break;
248             case std::size_t(1) : mychar = '1'; break;
249             case std::size_t(2) : mychar = '2'; break;
250             case std::size_t(3) : mychar = '3'; break;
251             case std::size_t(4) : mychar = '4'; break;
252             case std::size_t(5) : mychar = '5'; break;
253             case std::size_t(6) : mychar = '6'; break;
254             case std::size_t(7) : mychar = '7'; break;
255             case std::size_t(8) : mychar = '8'; break;
256             case std::size_t(9) : mychar = '9'; break;
257             default: mychar = '0';
258         }
259         return mychar;
260     }
261
262     constexpr std::size_t to_string(std::size_t n, char* buffer, std::size_t size
, char** end){
263         std::size_t ite = 0;
264         char temp_buf = 0;
265         //char theArray[size_const] = {0};
266         //char theArray_backwards[size] = {0};
267         while(n!=0){
268             buffer[ite] = digit_to_char(n % std::size_t(10));
269             n = n / std::size_t(10);
270             ++ite;
271             if(ite > size){
272                 throw std::runtime_error("String does not have sufficient capacity");
273                 break;
274             }
275         }
276         if(ite <= size){
277             for(std::size_t i=0; i<(ite/2); ++i){
278                 temp_buf = buffer[i];
279                 buffer[i] = buffer[ite-1-i];
280                 buffer[ite-1-i] = temp_buf;
281             }
282             //buffer = theArray;
283             if(end != nullptr){
284                 *end = &buffer[ite];
285             }
286         }
287         return ite;
288     }
289     /*constexpr std::size_t to_string(std::size_t n, char* buffer, std::size_t s
ize, char** end){
290         const size_t size_const = size;
291         cexpr_string<size_const> obj;
292         std::string n_str = std::to_string(n);
293         if(n_str.size() > size_const){
294             throw std::runtime_error("String does not have sufficient capacity")
;
295         }
296         else{
297             for(size_t i=0; i<n_str.size(); ++i){
298                 obj.push_back(n_str[i]);
299             }
300             buffer = obj.data();
301             if(end != nullptr){
```

```
302         *end = obj.data() + obj.size();
303     }
304 }
305 return (obj.size());
306 }*/
307 }
308 #endif
```

```

1  #ifndef Mymandelbrot
2  #define Mymandelbrot
3  #include "ra/cexpr_basic_string.hpp"
4  #include <cstddef>
5
6  namespace ra::fractal {
7      // Function to compute mandelbrot
8      constexpr ra::cexpr::cexpr_string<1100000> mandelbrotComputation(const std::
size_t W, const std::size_t H){
9          ra::cexpr::cexpr_string<1100000> obj;
10         char W_str[10] = {0};
11         std::size_t W_str_size = 0;
12         char H_str[10] = {0};
13         std::size_t H_str_size = 0;
14
15         double c0 = 0.0;
16         double c1 = 0.0;
17         double zn_c0 = 0.0;
18         double zn_c0_next = 0.0;
19         double zn_c1 = 0.0;
20         double zn_c1_next = 0.0;
21         std::size_t n = 0;
22         bool outOfBound = false;
23
24         double a0 = -1.6;
25         double a1 = -1.1;
26         double b0 = 0.6;
27         double b1 = 1.1;
28         double mult_c0 = (b0-a0)/(W-1);
29         double mult_c1 = (b1-a1)/(H-1);
30
31         obj.push_back('P');
32         obj.push_back('l');
33         obj.push_back(' ');
34         W_str_size = ra::cexpr::to_string(W,W_str,10,nullptr);
35         for(std::size_t i=0; i<W_str_size; ++i){
36             obj.push_back(W_str[i]);
37         }
38         obj.push_back(' ');
39         H_str_size = ra::cexpr::to_string(H,H_str,10,nullptr);
40         for(std::size_t i=0; i<H_str_size; ++i){
41             obj.push_back(H_str[i]);
42         }
43         obj.push_back('\n');
44
45
46         for(std::size_t l=0; l<H; ++l){
47             c1 = a1 + ( (double)(H-1-l) * mult_c1 );
48             for(std::size_t k=0; k<W; ++k){
49                 c0 = a0 + ( (double)k * mult_c0 );
50                 while(n < 16){
51                     zn_c0_next = (zn_c0*zn_c0)-(zn_c1*zn_c1) + c0;
52                     zn_c1_next = (2.0*zn_c0*zn_c1) + c1;
53                     zn_c0 = zn_c0_next;
54                     zn_c1 = zn_c1_next;
55                     if( ((zn_c0*zn_c0)+(zn_c1*zn_c1)) > 4.0 ){
56                         outOfBound = true;
57                         break;
58                     }
59                     ++n;
60                 }
61                 if(outOfBound == false){

```

```
62         obj.push_back('1');
63     }
64     else{
65         obj.push_back('0');
66     }
67     outOfBound = false;
68     n = 0;
69     zn_c0 = 0.0;
70     zn_c1 = 0.0;
71 }
72 obj.push_back('\n');
73 }
74
75 //obj.push_back('P');
76 //obj.push_back('1');
77 //obj.push_back(' ');
78 //W_str_size = ra::cexpr::to_string(W,W_str,10,nullptr);
79 //for(std::size_t i=0; i<W_str_size; ++i){
80     //obj.push_back(W_str[i]);
81 //}
82 //obj.push_back(' ');
83 //H_str_size = ra::cexpr::to_string(H,H_str,10,nullptr);
84 //for(std::size_t i=0; i<H_str_size; ++i){
85     //obj.push_back(H_str[i]);
86 //}
87 //obj.push_back('\n');
88
89 return obj;
90
91 }
92
93 // A variable template for a string that represents an image depicting
94 // the Mandelbrot set. The image has width W and height H.
95 // This object must be of type cexpr_string<M> for some appropriate M.
96 // The string is a binary image encoded in the text-based bitmap PNM
97 // format.
98 // The values of W and H must be such that W >= 2 and H >= 2.
99 template<std::size_t W, std::size_t H>
100 constexpr auto mandelbrot = mandelbrotComputation(W,H);
101 }
102 #endif
```

```
1  #ifndef CexprMath
2  #define CexprMath
3  #include<boost/math/constants/constants.hpp>
4
5  namespace ra::cexpr_math {
6      // The math constant pi.
7      // The type T is a floating-point type.
8      template<class T>
9      constexpr T pi = boost::math::constants::pi<T>();
10
11     // Returns the absolute value of x.
12     // The type T is a floating-point type.
13     template<class T>
14     constexpr T abs(T x){
15         return (x < 0)? (-x) : x;
16     }
17
18     // Returns the square of x.
19     // The type T is a floating-point type.
20     template<class T>
21     constexpr T sqr(T x){
22         return (x * x);
23     }
24
25     // Returns the cube of x.
26     // The type T is a floating-point type.
27     template<class T>
28     constexpr T cube(T x){
29         return (x * x * x);
30     }
31
32     // Returns the remainder after division when x is divided by y.
33     // In particular, x - n y is returned where n is the result obtained by
34     // dividing x by y and then rounding (to an integer value) toward zero.
35     // If y is zero, an exception of type std::overflow_error is thrown.
36     // The type T is a floating-point type.
37     template<class T>
38     constexpr T mod(T x, T y){
39         long long n = 0;
40         T remainder = 0;
41         if(y == 0){
42             throw std::overflow_error("zero modulus");
43         }
44         n = (long long)(x / y);
45         remainder = x - ( ((T)n) * y );
46         return remainder;
47     }
48
49     // Returns the sine of x.
50     // Note that a particular algorithm must be used to implement this
51     // function.
52     // The type T is a floating-point type.
53     template<class T>
54     constexpr T sin(T x){
55         T reduced_x = mod<T>(x, 2*pi<T>);
56         T result = 0;
57         if(reduced_x < 0){
58             result = -1 * sin(abs(reduced_x));
59         }
60         else{
61             if(x <= 0.000001){
62                 result = x;
```

```
63         }
64         else{
65             result = (3*sin(reduced_x/3)) - (4*cube(sin(reduced_x/3)));
66         }
67     }
68     return result;
69 }
70
71 // Returns the cosine of x.
72 // Note that a particular algorithm must be used to implement this
73 // function.
74 // The type T is a floating-point type.
75 template<class T>
76 constexpr T cos(T x){
77     return (sin<T>( x + (pi<T>/2) ));
78 }
79
80 // Returns the tangent of x.
81 // Note that a particular algorithm must be used to implement this
82 // function.
83 // If the tangent of x is infinite, an exception of type
84 // std::overflow_error is thrown.
85 // The type T is a floating-point type.
86 template<class T>
87 constexpr T tan(T x){
88     T result = 0;
89     T a = sin<T>(x);
90     T b = cos<T>(x);
91     if(b == 0){
92         throw std::overflow_error("infinite tangent");
93     }
94     else{
95         result = a / b;
96     }
97     return result;
98 }
99
100 // Returns the square root of x.
101 // If x is negative, an exception of type std::domain_error is thrown.
102 // Note that a particular algorithm must be used to implement this
103 // function.
104 // The type T is a floating-point type.
105 template<class T>
106 constexpr T sqrt(T x){
107     T ep = std::numeric_limits<T>::epsilon();
108     T result = x;
109     T result_next = x;
110     if(x < 0){
111         throw std::domain_error("square root of negative number");
112     }
113     else{
114         do{
115             result = result_next;
116             result_next = result - ( (sqr<T>(result)-x) / (2*result) );
117         } while(abs<T>(result_next - result) > ep);
118     }
119     return result;
120 }
121 }
122 #endif
```

```

1  #ifndef BiquadFilter
2  #define BiquadFilter
3  #include "ra/cexpr_math.hpp"
4
5  namespace ra::biquad {
6      // Biquad filter coefficients class.
7      template<class Real>
8      struct biquad_filter_coefs{
9          // The real number type used to represent the filter coefficients.
10         using real = Real;
11
12         // Creates a set of filter coefficients where the coefficients
13         // a0, a1, a2, b0, b1, and b2 are initialized to a0_, a1_, a2_,
14         // b0_, b1_, and b2_, respectively.
15         constexpr biquad_filter_coefs(real a0_, real a1_, real a2_, real b0_, re
16         al b1_, real b2_) : a0(a0_), a1(a1_), a2(a2_), b0(b0_), b1(b1_), b2(b2_){}
17
18         // Creates a set of filter coefficients by copying from another set.
19         // Since Real and OtherReal need not be the same, this constructor
20         // can be used to convert between filter coefficients of different
21         // types.
22         template<class OtherReal>
23         constexpr biquad_filter_coefs(const biquad_filter_coefs<OtherReal>& coef
24         s) : a0(coefs.a0), a1(coefs.a1), a2(coefs.a2), b0(coefs.b0), b1(coefs.b1), b2(co
25         efs.b2){}
26
27         // The filter coefficients a0, a1, a2, b0, b1, and b2.
28         real a0;
29         real a1;
30         real a2;
31         real b0;
32         real b1;
33         real b2;
34     };
35
36     // Returns the coefficients for a biquad lowpass filter with normalized
37     // cutoff frequency f and Q factor q, where f in [0,1] and q > 0.
38     // The filter coefficients are always normalized such that the
39     // coefficient b0 is 1.
40     // The type Real is a floating-point type.
41     // All real arithmetic should be performed with the Real type.
42     template<class Real>
43     constexpr biquad_filter_coefs<Real> lowpass(Real f, Real q){
44         Real pi_ = ra::cexpr_math::pi<Real>;
45         Real sig_ = ra::cexpr_math::tan<Real>(f*pi_/2.0);
46         Real a0 = ra::cexpr_math::sqr<Real>(sig_);
47         Real a1 = 2.0 * a0;
48         Real a2 = a0;
49         Real b0 = a0 + (sig_ / q) + 1.0;
50         Real b1 = 2.0 * (a0 - 1.0);
51         Real b2 = a0 - (sig_ / q) + 1.0;
52
53         a0=a0/b0; a1=a1/b0; a2=a2/b0; b1=b1/b0; b2=b2/b0;
54         biquad_filter_coefs<Real> obj(a0,a1,a2,1.0,b1,b2);
55         return obj;
56     }
57
58     // Returns the coefficients for a biquad highpass filter with
59     // normalized cutoff frequency f and Q factor q, where f in [0,1]
60     // and q > 0.
61     // The filter coefficients are always normalized such that the
62     // coefficient b0 is 1.

```



```

60 // The type Real is a floating-point type.
61 // All real arithmetic should be performed with the Real type.
62 template<class Real>
63 constexpr biquad_filter_coefs<Real> highpass(Real f, Real q){
64     Real pi_ = ra::cexpr_math::pi<Real>;
65     Real sig_ = ra::cexpr_math::tan<Real>(f*pi_/2.0);
66     Real sig_sqr = ra::cexpr_math::sqr<Real>(sig_);
67     Real a0 = 1.0;
68     Real a1 = -2.0;
69     Real a2 = 1.0;
70     Real b0 = sig_sqr + (sig_/q) + 1.0;
71     Real b1 = 2.0 * (sig_sqr - 1.0);
72     Real b2 = sig_sqr - (sig_/q) + 1.0;
73
74     a0=a0/b0; a1=a1/b0; a2=a2/b0; b1=b1/b0; b2=b2/b0;
75     biquad_filter_coefs<Real> obj(a0,a1,a2,1.0,b1,b2);
76     return obj;
77 }
78
79 // Returns the coefficients for a biquad bandpass filter with
80 // normalized cutoff frequency f and Q factor q, where f in [0,1]
81 // and q > 0.
82 // The filter coefficients are always normalized such that the
83 // coefficient b0 is 1.
84 // The type Real is a floating-point type.
85 // All real arithmetic should be performed with the Real type.
86 template<class Real>
87 constexpr biquad_filter_coefs<Real> bandpass(Real f, Real q){
88     Real pi_ = ra::cexpr_math::pi<Real>;
89     Real sig_ = ra::cexpr_math::tan<Real>(f*pi_/2.0);
90     Real sig_sqr = ra::cexpr_math::sqr<Real>(sig_);
91     Real a0 = sig_ / q;
92     Real a1 = 0.0;
93     Real a2 = -a0;
94     Real b0 = sig_sqr + (sig_/q) + 1.0;
95     Real b1 = 2.0 * (sig_sqr - 1.0);
96     Real b2 = sig_sqr - (sig_/q) + 1.0;
97
98     a0=a0/b0; a1=a1/b0; a2=a2/b0; b1=b1/b0; b2=b2/b0;
99     biquad_filter_coefs<Real> obj(a0,a1,a2,1.0,b1,b2);
100    return obj;
101 }
102
103 // Returns the coefficients for a biquad low-frequency shelving
104 // boost filter with normalized cutoff frequency f and gain-control
105 // parameter a, where f in [0,1] and a >= 0.
106 // For a gain in dB of G (where G > 0), choose a = 10 ^ (G / 20).
107 // The filter coefficients are always normalized such that the
108 // coefficient b0 is 1.
109 // The type Real is a floating-point type.
110 // All real arithmetic should be performed with the Real type.
111 template<class Real>
112 constexpr biquad_filter_coefs<Real> lowshelf_boost(Real f, Real a){
113     Real pi_ = ra::cexpr_math::pi<Real>;
114     Real sig_ = ra::cexpr_math::tan<Real>(f*pi_/2.0);
115     Real sig_sqr = ra::cexpr_math::sqr<Real>(sig_);
116     Real sqrt_2a = ra::cexpr_math::sqrt<Real>(2.0 * a);
117     Real sqrt_2 = ra::cexpr_math::sqrt<Real>(2.0);
118     Real a0 = (a * sig_sqr) + (sqrt_2a * sig_) + 1.0;
119     Real a1 = 2.0 * ((a*sig_sqr) - 1.0);
120     Real a2 = (a * sig_sqr) - (sqrt_2a * sig_) + 1.0;
121     Real b0 = sig_sqr + (sqrt_2 * sig_) + 1.0;

```

```
122     Real b1 = 2.0 * (sig_sqr - 1.0);
123     Real b2 = sig_sqr - (sqrt_2 * sig_) + 1.0;
124
125     a0=a0/b0; a1=a1/b0; a2=a2/b0; b1=b1/b0; b2=b2/b0;
126     biquad_filter_coefs<Real> obj(a0,a1,a2,1.0,b1,b2);
127     return obj;
128 }
129
130 // Returns the coefficients for a biquad low-frequency shelving
131 // cut filter with normalized cutoff frequency f and gain-control
132 // parameter a, where f in [0,1] and a >= 0.
133 // For a gain in dB of G (where G < 0), choose a = 10 ^ (-G / 20).
134 // The filter coefficients are always normalized such that the
135 // coefficient b0 is 1.
136 // The type Real is a floating-point type.
137 // All real arithmetic should be performed with the Real type.
138 template<class Real>
139 constexpr biquad_filter_coefs<Real> lowshelf_cut(Real f, Real a){
140     Real pi_ = ra::cexpr_math::pi<Real>;
141     Real sig_ = ra::cexpr_math::tan<Real>(f*pi_/2.0);
142     Real sig_sqr = ra::cexpr_math::sqr<Real>(sig_);
143     Real sqrt_2a = ra::cexpr_math::sqrt<Real>(2.0 * a);
144     Real sqrt_2 = ra::cexpr_math::sqrt<Real>(2.0);
145     Real a0 = sig_sqr + (sqrt_2 * sig_) + 1.0;
146     Real a1 = 2.0 * (sig_sqr - 1.0);
147     Real a2 = sig_sqr - (sqrt_2 * sig_) + 1.0;
148     Real b0 = (a * sig_sqr) + (sqrt_2a * sig_) + 1.0;
149     Real b1 = 2.0 * ((a*sig_sqr) - 1.0);
150     Real b2 = (a * sig_sqr) - (sqrt_2a * sig_) + 1.0;
151
152     a0=a0/b0; a1=a1/b0; a2=a2/b0; b1=b1/b0; b2=b2/b0;
153     biquad_filter_coefs<Real> obj(a0,a1,a2,1.0,b1,b2);
154     return obj;
155 }
156
157 }
158 #endif
159
```

```
1  #include "ra/cexpr_basic_string.hpp"
2  #include <iostream>
3  #include <cstddef>
4
5  int main() {
6
7      using std::cout;
8      using std::endl;
9      // Test default constructor
10     ra::cexpr::cexpr_basic_string<char,10> obj_A;
11     const unsigned char s[] = {'j','u','d','e','\0'};
12     // Test constructor with single pointer
13     ra::cexpr::cexpr_basic_string<unsigned char,20> obj_B(s);
14     cout << "obj_B = " << obj_B[0] << obj_B[1] << obj_B[2] << obj_B[3] << endl;
15     cout << "max size: " << obj_B.max_size() << endl;
16     cout << "capacity: " << obj_B.capacity() << endl;
17     cout << "size: " << obj_B.size() << endl;
18     constexpr unsigned char j[] = {'o','n','y','i','a','\0'};
19     // Test constructor with pointers to first and one past last
20     constexpr ra::cexpr::cexpr_basic_string<unsigned char,6> obj_C(&j[0], &j[5])
;
21     // Test member function data()
22     const unsigned char* t = obj_C.data();
23     for(std::size_t i=0; i<obj_C.size(); ++i){
24         cout<< *t;
25         ++t;
26     }
27     cout << endl;
28     // Test prevention of pointer (from data()) to change null terminator
29     ra::cexpr::cexpr_basic_string<unsigned char,6> obj_D(obj_C);
30     unsigned char* tt = obj_D.data();
31     for(std::size_t i=0; i<=obj_D.size(); ++i){
32         cout<< *tt;
33         ++tt;
34     }
35     cout << endl;
36     tt = obj_D.end();
37     *tt = 'w';
38     --tt;
39     *tt = 'g';
40     tt = obj_D.begin();
41     for(std::size_t i=0; i<=obj_D.size(); ++i){
42         cout<< *tt;
43         ++tt;
44     }
45     cout << endl;
46     // Test push_back(), pop_back() and append()
47     cout << "obj_B.size(): "<< obj_B.size() << endl;
48     obj_B.push_back('c');
49     cout << "obj_B.size(): "<< obj_B.size() << endl;
50     cout << "obj_C.size(): "<< obj_C.size() << endl;
51     cout << "obj_B.capacity(): "<< obj_B.capacity() << endl;
52     obj_B.append(obj_C);
53     cout << "obj_B.size(): "<< obj_B.size() << endl;
54     for(std::size_t i=0; i<=obj_B.size(); ++i){
55         cout << obj_B[i];
56     }
57     cout << endl;
58     obj_B.pop_back();
59     cout << "Pop_back: ";
60     for(std::size_t i=0; i<=obj_B.size(); ++i){
61         cout << obj_B[i];
```

```
62     }
63     cout << endl;
64     obj_B.append(s);
65     cout << "Append s: ";
66     for(std::size_t i=0; i<=obj_B.size(); ++i){
67         cout << obj_B[i];
68     }
69     cout << endl;
70     // Test clear()
71     obj_B.clear();
72     cout << "obj_B.clear. Then obj_B.size(): "<< obj_B.size() << endl;
73     // Test to_string()
74     //std::size_t n = 596;
75     char* buffer = obj_A.begin();
76     //constexpr std::size_t size = 10;
77     char okay = 'a';
78     char* ptr_okay = &okay;
79     char** end = &ptr_okay;
80     cout<<"To String"<<endl;
81     cout<<"size: "<<(ra::cexpr::to_string(596,buffer,obj_A.capacity(),end))<<endl;
82     cout<<"string: "<<buffer<<endl;
83     cout<<"Before end: "<<(*(*end)-1)<<endl;
84     cout<<"end: "<<(**end)<<endl;
85     return 0;
86 }
87
```

```
1  #include<fstream>
2  #include<iostream>
3  #include"ra/mandelbrot.hpp"
4
5  int main(){
6      // Force the image (in PNM format) to be computed at compile time.
7      constexpr auto s = ra::fractal::mandelbrot<256, 256>;
8
9      std::ofstream outfile;
10     outfile.open("mandelbrot.pnm");
11
12     // Output the image (in PNM format).
13     outfile << s.begin() << std::endl;
14     outfile.close();
15     std::cout <<"Written to mandelbrot.pnm"<<std::endl;
16     return 0;
17 }
```

```
1  #include<iostream>
2  #include"ra/cexpr_math.hpp"
3
4  int main () {
5      using std::cout;
6      using std::endl;
7      constexpr long double pi_ = ra::cexpr_math::pi<long double>;
8      cout <<"Pi= "<<pi_<<endl;
9      constexpr float var_A = 23.75;
10     constexpr float var_B = -98.22;
11     cout <<"abs(23.75)= "<<ra::cexpr_math::abs<float>(var_A)<<endl;
12     cout <<"abs(-98.22)= "<<ra::cexpr_math::abs<float>(var_B)<<endl;
13     cout <<"sqr(23.75)= "<<ra::cexpr_math::sqr<float>(var_A)<<endl;
14     cout <<"cube(-98.22)= "<<ra::cexpr_math::cube<float>(var_B)<<endl;
15     cout <<"mod(-6.8*pi_,2*pi_)= "<<ra::cexpr_math::mod<long double>(-6.8*pi_,2*pi_)<
16     <endl;
17     cout <<"sin(-5000*pi_/26)= "<<ra::cexpr_math::sin<long double>(-5000*pi_/26)<<end
18     l;
19     cout <<"sin(4*pi_/3)= "<<ra::cexpr_math::sin<long double>(4*pi_/3)<<endl;
20     cout <<"cos(-5000*pi_/26)= "<<ra::cexpr_math::cos<long double>(-5000*pi_/26)<<en
21     dl;
22     cout <<"cos(4*pi_/3)= "<<ra::cexpr_math::cos<long double>(4*pi_/3)<<endl;
23     cout <<"tan(-5000*pi_/26)= "<<ra::cexpr_math::tan<long double>(-5000*pi_/26)<<end
24     l;
25     cout <<"tan(4*pi_/3)= "<<ra::cexpr_math::tan<long double>(4*pi_/3)<<endl;
26     cout <<"sqrt(1377)= "<<ra::cexpr_math::sqrt<long double>(1377)<<endl;
27
28     return 0;
29 }
```

```
1  #include<iostream>
2  #include"ra/biquad_filter.hpp"
3
4  int main () {
5      using std::cout;
6      using std::endl;
7      constexpr ra::biquad::biquad_filter_coefs<long double> obj_A(23.6,12.0,2.9,1
9.0,34.8,134.5);
8      constexpr ra::biquad::biquad_filter_coefs<float> obj_B(obj_A);
9      cout<<"obj_A(23.6,12.0,2.9,19.0,34.8,134.5): "<<obj_A.a0<<" "<<obj_A.a1<<" "<<obj_A.a2<<"
"<<obj_A.b0<<" "<<obj_A.b1<<" "<<obj_A.b2<<endl;
10     cout<<"obj_B(obj_A): "<<obj_B.a0<<" "<<obj_B.a1<<" "<<obj_B.a2<<" "<<obj_B.b0<<" "
<<obj_B.b1<<" "<<obj_B.b2<<endl;
11     constexpr ra::biquad::biquad_filter_coefs<long double> obj_lp(ra::biquad::lo
wpass(0.33,0.7071));
12     constexpr ra::biquad::biquad_filter_coefs<long double> obj_hp(ra::biquad::hi
ghpass(0.67,0.7071));
13     constexpr ra::biquad::biquad_filter_coefs<long double> obj_bp(ra::biquad::ba
ndpass(0.56,0.7071));
14     constexpr ra::biquad::biquad_filter_coefs<long double> obj_boost(ra::biquad:
:lowshelf_boost(0.33,1.77827941)); //Gain of 5
15     constexpr ra::biquad::biquad_filter_coefs<long double> obj_cut(ra::biquad::l
owshelf_cut(0.33,2.818382931)); //Gain of -9
16     cout<<"lp: "<<obj_lp.a0<<" "<<obj_lp.a1<<" "<<obj_lp.a2<<" "<<obj_lp.b0<<" "<<ob
j_lp.b1<<" "<<obj_lp.b2<<endl;
17     cout<<"hp: "<<obj_hp.a0<<" "<<obj_hp.a1<<" "<<obj_hp.a2<<" "<<obj_hp.b0<<" "<<o
bj_hp.b1<<" "<<obj_hp.b2<<endl;
18     cout<<"bp: "<<obj_bp.a0<<" "<<obj_bp.a1<<" "<<obj_bp.a2<<" "<<obj_bp.b0<<" "<<o
bj_bp.b1<<" "<<obj_bp.b2<<endl;
19     cout<<"boost: "<<obj_boost.a0<<" "<<obj_boost.a1<<" "<<obj_boost.a2<<" "<<obj_bo
ost.b0<<" "<<obj_boost.b1<<" "<<obj_boost.b2<<endl;
20     cout<<"cut: "<<obj_cut.a0<<" "<<obj_cut.a1<<" "<<obj_cut.a2<<" "<<obj_cut.b0<<"
"<<obj_cut.b1<<" "<<obj_cut.b2<<endl;
21
22
23     return 0;
24 }
```