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1 include/binio.hpp

```
/*
 * Toy Compression - Toy Compression Code
 * Written in 2018 by Gerald Lewis <lewisgdljr@gmail.com>
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 * <http://creativecommons.org/publicdomain/zero/1.0/>.
 */

#pragma once
#ifndef BINIO_HPP
#define BINIO_HPP

namespace binio {
    template <typename Iterator, typename Iterator2>
    struct bit_reader {
        Iterator      pos;
        Iterator2     end;
        std::uint8_t   buf;
        std::uint64_t  total_count;
        unsigned int   bits_left;

        bit_reader( Iterator&& begin_, Iterator2&& end_ ) :
            pos{begin_},
            end{end_},
            buf{0},
            total_count{0},
            bits_left{0} {}

        bit_reader( bit_reader const& ) = delete;
        bit_reader( bit_reader const&& ) = delete;
        bit_reader& operator=( bit_reader const& ) = delete;
        bit_reader& operator=( bit_reader const&& ) = delete;
        ~bit_reader() = default;

        void input_byte() {
            if ( pos == end ) {
                throw std::out_of_range(
                    "Attempt to read bits beyond end of range" );
            }
            bits_left = std::numeric_limits<std::uint8_t>::digits;
            buf = *pos;
            ++pos;
        }

        bool read_bit() {
            if ( bits_left == 0 ) {
                input_byte();
            }
            ++total_count;
            --bits_left;
            return ( buf >> bits_left ) & 1;
        }
    }
}
```

```

template <typename T>
T read_bits( unsigned int bits ) {
    using UT = std::make_unsigned_t<T>;
    UT temp{0};
    for ( unsigned int i = 0; i < bits; i++ ) {
        temp = ( temp << 1 ) | read_bit();
    }
    return temp;
}

};

template <typename Iterator, typename Iterator2,
        typename
        = typename std::iterator_traits<Iterator>::iterator_category>
auto make_bit_reader( Iterator&& begin, Iterator2&& end )
-> bit_reader<Iterator, Iterator2> {
    return bit_reader<Iterator, Iterator2>{std::forward<Iterator>( begin ),
                                           std::forward<Iterator2>( end )};
}

template <typename Container,
        typename = decltype( std::declval<Container>().cbegin() )>
auto make_bit_reader( Container const& c ) {
    return make_bit_reader( c.cbegin(), c.cend() );
}

template <typename stream_t>
auto make_bit_reader( stream_t& stream ) -> decltype(
    make_bit_reader( std::istream_iterator<unsigned char>( stream ),
                    std::istream_iterator<unsigned char>( ) ) ) {
    return make_bit_reader( std::istream_iterator<unsigned char>( stream ),
                           std::istream_iterator<unsigned char>( ) );
}

template <typename Iterator>
struct bit_writer {
    Iterator      pos;
    std::uint8_t  buf;
    std::uint64_t total_count;
    unsigned int  bits_left;
    bit_writer( Iterator&& begin_ ) :
        pos{std::forward<Iterator>( begin_ )},
        buf{0},
        total_count{0},
        bits_left{std::numeric_limits<std::uint8_t>::digits} {}
    ~bit_writer() {
        if ( bits_left != std::numeric_limits<std::uint8_t>::digits ) {
            flush();
        }
    }
    bit_writer( bit_writer const& ) = delete;
    bit_writer( bit_writer const&& ) = delete;
    bit_writer& operator=( bit_writer const& ) = delete;
    bit_writer& operator=( bit_writer const&& ) = delete;

    void output_byte() {

```

```

        *pos = buf;
        buf = 0;
        ++pos;
        bits_left = std::numeric_limits<std::uint8_t>::digits;
    }

    void write_bit( bool bit ) {
        --bits_left;
        ++total_count;
        buf |= ( static_cast<std::uint8_t>( bit ) << bits_left );
        if ( bits_left == 0 ) {
            output_byte();
        }
    }

    template <typename T, typename UT = std::make_unsigned_t<T>>
    void write_bits( T value, unsigned int num_bits ) {
        for ( int i = num_bits; i > 0; --i ) {
            UT mask = static_cast<UT>( 1 ) << ( i - 1 );
            write_bit( ( static_cast<UT>( value ) & mask ) != 0 );
        }
    }

    void flush() { output_byte(); }
};

template <typename Iterator,
          typename
          = typename std::iterator_traits<Iterator>::iterator_category>
auto make_bit_writer( Iterator&& begin ) -> bit_writer<Iterator> {
    return bit_writer<Iterator>{std::forward<Iterator>( begin )};
}

template <typename Container,
          typename = decltype( std::declval<Container>().begin() )>
auto make_bit_writer( Container&& c ) {
    return make_bit_writer( std::back_inserter( c ) );
}

template <typename stream_t>
auto make_bit_writer( stream_t& stream ) -> decltype(
    make_bit_writer( std::ostream_iterator<unsigned char>( stream ) ) ) {
    return make_bit_writer( std::ostream_iterator<unsigned char>( stream ) );
}
} // namespace binio

#endif // BINIO_HPP

```

2 include/codecs.hpp

```
/*
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 */

#pragma once
#ifndef CODECS_HPP_INCLUDED
#define CODECS_HPP_INCLUDED

#include "gsl/gsl"
#include <array>
#include <cmath>
#include <cstdint>
#include <exception>
#include <iostream>
#include <iterator>
#include <limits>
#include <type_traits>
#include <utility>

namespace toy_compression {

#ifndef BINIO_HPP
#include "binio.hpp"
#endif // BINIO_HPP

#ifndef INTEGER_CODES_HPP
#include "integer_codes.hpp"
#endif // INTEGER_CODES_HPP

#ifndef ZIGZAG_HPP
#include "zigzag.hpp"
#endif // ZIGZAG_HPP

#ifndef VARINT_HPP
#include "varint.hpp"
#endif // VARINT_HPP
} // namespace toy_compression
#endif // CODECS_HPP_INCLUDED
```

3 include/integer_codes.hpp

```
/*
 * Toy Compression - Toy Compression Code
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 * <http://creativecommons.org/publicdomain/zero/1.0/>.
 */

#pragma once
#ifndef INTEGER_CODES_HPP
#define INTEGER_CODES_HPP

namespace integer_codes {
    template <typename T>
    using unsigned_of = typename std::make_unsigned_t<T>;

    template <typename T>
    using signed_of = typename std::make_signed_t<T>;

    struct unary {
        template <typename T, typename Iterator,
                  typename = std::enable_if_t<std::is_unsigned_v<T>>>
        static void encode( T x, binio::bit_writer<Iterator>& storage ) {
            if ( x == 0 ) {
                throw std::invalid_argument( "unary_code can't encode 0" );
            }
            T temp{x};
            while ( temp > 1 ) {
                --temp;
                storage.write_bit( 0 );
            }
            storage.write_bit( 1 );
        }

        template <typename T, typename Iterator, typename Iterator2,
                  typename = std::enable_if_t<std::is_unsigned_v<T>>>
        static T decode( binio::bit_reader<Iterator, Iterator2>& storage ) {
            T temp{1};
            while ( !storage.read_bit() ) {
                ++temp;
            }
            return temp;
        }
    };

    struct truncated_binary {
        template <typename T, typename Iterator,
                  typename = std::enable_if_t<std::is_unsigned_v<T>>>
        static void encode( T x, T n, binio::bit_writer<Iterator>& storage ) {
            if ( n == 0 ) {
                throw std::invalid_argument(

```

```

        "for the truncated binary code, n can't be 0" );
    }

    auto k      = static_cast<T>( std::floor( std::log2( n ) ) );
    auto u      = ( static_cast<T>( 1 ) << ( k + 1 ) ) - n;
    bool lesser = x < u;
    x           = lesser ? x : x + u;
    k           = lesser ? k : k + 1;
    storage.write_bits( x, k );
}

template <typename T, typename Iterator, typename Iterator2,
          typename = std::enable_if_t<std::is_unsigned_v<T>>>
static T decode( T n, binio::bit_reader<Iterator, Iterator2>& storage ) {
    if ( n == 0 ) {
        throw std::invalid_argument(
            "for the truncated binary code, n can't be 0" );
    }
    auto k      = static_cast<T>( std::floor( std::log2( n ) ) );
    auto u      = ( static_cast<T>( 1 ) << ( k + 1 ) ) - n;
    auto x      = storage.template read_bits<T>( k );
    bool greater_eq = x >= u;
    x = greater_eq ? ( ( x << 1 ) | storage.read_bit() ) - u : x;
    return x;
}

};

struct elias_gamma {
    template <typename T, typename Iterator,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>
    static void encode( T x, binio::bit_writer<Iterator>& storage ) {
        if ( x == 0 ) {
            throw std::invalid_argument( "elias_gamma code can't encode 0" );
        }

        auto b = 1 + static_cast<T>( std::floor( std::log2( x ) ) );
        unary::template encode<T>( b, storage );
        storage.write_bits( x - ( 1 << ( b - 1 ) ), b - 1 );
    }

    template <typename T, typename Iterator, typename Iterator2,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>
    static T decode( binio::bit_reader<Iterator, Iterator2>& storage ) {
        auto b = unary::template decode<T>( storage );
        auto x = storage.template read_bits<T>( b - 1 );
        return ( 1 << ( b - 1 ) ) + x;
    }
}

};

struct elias_delta {
    template <typename T, typename Iterator,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>
    static void encode( T x, binio::bit_writer<Iterator>& storage ) {
        if ( x == 0 ) {
            throw std::invalid_argument( "elias_delta code can't encode 0" );
        }
        auto b = 1 + static_cast<T>( std::floor( std::log2( x ) ) );

```

```

        elias_gamma::template encode<T>( b, storage );
        storage.template write_bits<T>( ( x - ( 1 << ( b - 1 ) ) ), b - 1 );
    }

    template <typename T, typename Iterator, typename Iterator2,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>
    static T decode( binio::bit_reader<Iterator, Iterator2>& storage ) {
        auto b = elias_gamma::template decode<T>( storage );
        auto x = storage.template read_bits<T>( b - 1 );
        return ( 1 << ( b - 1 ) ) + x;
    }
};

struct golomb {
    template <typename T, typename Iterator,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>
    static void encode( T x, T b, binio::bit_writer<Iterator>& storage ) {
        if ( ( x == 0 ) || ( b == 0 ) ) {
            throw std::invalid_argument(
                "golomb_code can't encode 0, and can't"
                "encode with golomb parameter 0" );
        }

        auto q = ( x - 1 ) / b;
        auto r = ( x - 1 ) % b;
        unary::template encode<T>( q + 1, storage );
        truncated_binary::template encode<T>( r, b, storage );
    }

    template <typename T, typename Iterator, typename Iterator2,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>
    static T decode( T b, binio::bit_reader<Iterator, Iterator2>& storage ) {
        if ( b == 0 ) {
            throw std::invalid_argument(
                "golomb_code can't decode with golomb parameter 0" );
        }

        auto q = unary::template decode<T>( storage ) - 1;
        auto r = truncated_binary::template decode<T>( b, storage );
        return r + ( q * b ) + 1;
    }
};

struct rice {
    template <typename T, typename Iterator,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>
    static void encode( T x, T k, binio::bit_writer<Iterator>& storage ) {
        if ( x == 0 ) {
            throw std::invalid_argument( "rice_code can't encode 0" );
        }

        auto b = static_cast<T>( 1 ) << k;
        golomb::encode( x, b, storage );
    }

    template <typename T, typename Iterator, typename Iterator2,
              typename = std::enable_if_t<std::is_unsigned_v<T>>>

```



```

        static T decode( T k, binio::bit_reader<Iterator, Iterator2>& storage ) {
            auto b = static_cast<T>( 1 ) << k;
            return golomb::template decode<T>( b, storage );
        }
    };
} // namespace integer_codes

#endif // INTEGER_CODES_HPP

```

4 include/varint.hpp

```
/*
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 * with this software. If not, see
 * <http://creativecommons.org/publicdomain/zero/1.0/>.
 */

#pragma once
#ifndef VARINT_HPP
#define VARINT_HPP

namespace integer_codes {
    struct varint {
        template <typename T, typename Iterator,
                  typename = std::enable_if_t<std::is_unsigned_v<T>>>
        static void encode( T x, binio::bit_writer<Iterator>& storage ) {
            constexpr int digits = std::numeric_limits<T>::digits;
            // a varint can't get bigger than this, really
            constexpr auto bytes_to_reserve
                = static_cast<std::size_t>( digits + 6 ) / 7;
            std::array<std::uint8_t, bytes_to_reserve> temp_buffer{};
            auto pos{bytes_to_reserve - 1}; // last byte
            gsl::at( temp_buffer, pos-- ) = static_cast<std::uint8_t>( x & 127 );

            while ( x >= 7 ) {
                --x;
                gsl::at( temp_buffer, pos-- )
                    = static_cast<std::uint8_t>( 128 | ( x & 127 ) );
            }
            for ( pos++; pos < bytes_to_reserve; pos++ ) {
                storage.template write_bits<std::uint8_t>(
                    gsl::at( temp_buffer, pos ), 8 );
            }
        }

        template <typename T, typename Iterator, typename Iterator2,
                  typename = std::enable_if_t<std::is_unsigned_v<T>>>
        static T decode( binio::bit_reader<Iterator, Iterator2>& storage ) {
            T output_val = 0;
            std::uint8_t continuation_val = 0;
            do {
                auto val
                    = storage.template read_bits<std::uint8_t>( 8 );
                continuation_val = val & 0x80;
                val &= 0x7f;
                if ( continuation_val ) {
                    ++val;
                }
                output_val = ( output_val << 7 ) + val;
            } while ( continuation_val );
            return output_val;
        }
    };
}
```

```
    }  
};  
  
} // namespace integer_codes  
  
#endif // VARINT_HPP
```

5 include/zigzag.hpp

```
/*
 * Toy Compression - Toy Compression Code
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 */

#pragma once
#ifndef ZIGZAG_HPP
#define ZIGZAG_HPP

namespace integer_codes {
    namespace {
        template <typename T>
        using enable_enc
            = std::enable_if_t<std::is_integral_v<T> && std::is_signed_v<T>>;

        template <typename T>
        using enable_dec
            = std::enable_if_t<std::is_integral_v<T> && std::is_unsigned_v<T>>;
    } // namespace

    struct zigzag {
        template <typename T, typename = enable_enc<T>>
        constexpr static auto encode( T x ) -> unsigned_of<T> {
            return ( static_cast<unsigned_of<T>>( std::abs( x ) ) << 1 )
                | static_cast<unsigned_of<T>>( x <= 0 ) );
        }

        template <typename T, typename = enable_dec<T>>
        constexpr static auto decode( const T x ) -> signed_of<T> {
#define BIT_HACK
#ifdef BIT_HACK
            const signed_of<T> sign
                = -static_cast<signed_of<T>>( ( x & 1 ) && ( x != 1 ) );
            const signed_of<T> magnitude = x >> 1;
            return ( magnitude + sign ) ^ sign;
#else
            const T sign = ( x & 1 ) && ( x != 1 );
            const signed_of<T> magnitude = x >> 1;
            return sign ? -magnitude : magnitude;
#endif // BIT_HACK
#undef BIT_HACK
        }
    };

    struct offset_zigzag {
        template <typename T, typename = enable_enc<T>>
        constexpr static auto encode( T x, T offset ) -> unsigned_of<T> {
            return zigzag::encode( x - offset );
        }
    };
}
```

```

    }

    template <typename T, typename = enable_dec<T>>
    constexpr static auto decode( const T x, const signed_of<T> offset )
        -> signed_of<T> {
        return zigzag::decode( x ) + offset;
    }
};

} // namespace integer_codes

#endif // ZIGZAG_HPP

```

6 test/test.cpp

```
/*
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 */

#include "codecs.hpp"
#include "testing.hpp"
#include <stdint>
#include <iomanip>
#include <ios>
#include <iostream>
#include <sstream>
#include <vector>

using container = std::vector<std::uint8_t>;
using iterator = typename container::iterator;

using test_type = unsigned;
using signed_test_type = int;

using namespace toy_compression;

using binio::make_bit_reader;
using binio::make_bit_writer;

/* subsystem test functions... */
void test_unary_coder( test_type value ) {
    container c;
    {
        auto writer = make_bit_writer( c );
        integer_codes::unary::encode( value, writer );
    }
    auto reader = make_bit_reader( c );
    auto decoded = integer_codes::unary::decode<test_type>( reader );
    ASSERT( decoded == value );
}

void test_truncated_binary_coder( test_type value, test_type n ) {
    container c;
    {
        auto writer = make_bit_writer( c );
        integer_codes::truncated_binary::encode( value, n, writer );
    }
    auto reader = make_bit_reader( c );
    auto decoded
        = integer_codes::truncated_binary::decode<test_type>( n, reader );
    ASSERT( decoded == value );
}
```

```

void test_elias_gamma_coder( test_type value ) {
    container c;
    {
        auto writer = make_bit_writer( c );
        integer_codes::elias_gamma::encode( value, writer );
    }
    auto reader = make_bit_reader( c );
    auto decoded = integer_codes::elias_gamma::decode<test_type>( reader );
    ASSERT( decoded == value );
}

void test_elias_delta_coder( test_type value ) {
    container c;
    {
        auto writer = make_bit_writer( c );
        integer_codes::elias_delta::encode( value, writer );
    }
    auto reader = make_bit_reader( c );
    auto decoded = integer_codes::elias_delta::decode<test_type>( reader );
    ASSERT( decoded == value );
}

void test_golomb( test_type x, test_type b ) {
    container c;
    {
        auto writer = make_bit_writer( c );
        integer_codes::golomb::encode( x, b, writer );
    }
    auto reader = make_bit_reader( c );
    auto result = integer_codes::golomb::template decode<test_type>( b, reader );
    ASSERT( result == x );
}

void test_rice( test_type x, test_type b ) {
    container c;
    {
        auto writer = make_bit_writer( c );
        integer_codes::rice::encode( x, b, writer );
    }
    auto reader = make_bit_reader( c );
    auto result = integer_codes::rice::template decode<test_type>( b, reader );
    ASSERT( result == x );
}

void test_zigzag( signed_test_type value ) {
    auto encoded = integer_codes::zigzag::encode( value );
    auto decoded = integer_codes::zigzag::decode( encoded );
    ASSERT( decoded == value );
}

void test_offset_zigzag( signed_test_type value, signed_test_type offset ) {
    auto encoded = integer_codes::offset_zigzag::encode( value, offset );
    auto decoded = integer_codes::offset_zigzag::decode( encoded, offset );
    ASSERT( decoded == value );
}

```

```

void test_varint( test_type value ) {
    container c;
    {
        auto writer = make_bit_writer( c );
        integer_codes::varint::encode( value, writer );
    }
    auto reader = make_bit_reader( c );
    auto decoded = integer_codes::varint::decode<test_type>( reader );
    ASSERT( decoded == value );
}

/* suites */
toy_test::suite const reader_suite{
    "Test for bit_reader",
    {
        {"bit_reader can be created from a pair of iterators",
         [] {
             container c;
             (void)make_bit_reader( c.begin(), c.end() );
             ASSERT( true );
         }},

        {"bit_reader can be created from a container",
         [] {
             container c;
             (void)make_bit_reader( c );
             ASSERT( true );
         }},

#ifdef DISABLE_TO_AVOID_WARNING
        {"bit_reader can be created from an istream",
         [] {
             std::istringstream ss;
             (void)make_bit_reader( ss );
             ASSERT( true );
         }},
#endif // DISABLE_TO_AVOID_WARNING

        {"bit_reader throws exception when read from empty",
         [] {
             container c{};
             auto reader = make_bit_reader( c );
             THROWS( reader.read_bit(), std::out_of_range );
         }},

        {"bit_reader.read_bit() returns the first available bit",
         [] {
             container c{0x70};
             auto reader = make_bit_reader( c );
             ASSERT( reader.read_bit() == 0 );
         }},

        {"bit_reader.read_bits() returns multiple bits",
         [] {
             container c{0x70, 0x0f, 0x0};
             auto reader = make_bit_reader( c );
             (void)reader.read_bit();
         }}
    }
};

```



```

        auto temp = reader.read_bits<test_type>( 16 );
        ASSERT( temp == 0xe01e );
    }},

    });

toy_test::suite const writer_suite{
    "Test_for_bit_writer",
    {
        {"bit_writer_can_be_created_from_an_iterator",
         [] {
             container c;
             (void)make_bit_writer( std::back_inserter( c ) );
             ASSERT( true );
         }},

        {"bit_writer_can_be_created_from_a_container",
         [] {
             container c;
             (void)make_bit_writer( c );
             ASSERT( true );
         }},

#ifdef DISABLE_TO_AVOID_WARNING
        {"bit_writer_can_be_created_from_an_ostream",
         [] {
             std::ostringstream ss;
             {
                 auto writer = make_bit_writer( ss );
                 for ( int i = 0; i < 10; i++ ) {
                     writer.write_bit( true );
                 }
             }
             { (void)make_bit_writer( ss ); }

             ASSERT( true );
         }},
#endif // DISABLE_TO_AVOID_WARNING

        {"bit_writer.write_bit()_writes_a_bit_to_the_buffer",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             writer.write_bit( true );
             writer.write_bit( true );
             writer.write_bit( true );
             writer.write_bit( false );
             writer.flush();
             ASSERT( c[0] == 0xe0 );
         }},

        {"bit_writer.write_bits()_writes_a_group_of_bits_to_the_buffer",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             writer.write_bits<test_type>( 0xfaf, 12 );
             writer.flush();
         }},
    }
};

```

```

        ASSERT( ( c[0] == 0xfa ) && ( c[1] == 0xf0 ) );
    }},

    {"bit_writer flushes partial bytes to the buffer",
     [] {
         container c;
         {
             auto writer = make_bit_writer( c );
             writer.write_bit( true );
             writer.write_bit( true );
         }
         ASSERT( c[0] == 0xc0 );
     }},
    }},

toy_test::suite unary_suite{
    "test_for_unary_coder",
    {
        {"throws an exception for x=0",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             THROWS( integer_codes::unary::encode<test_type>( 0, writer ),
                     std::invalid_argument );
         }},
        {"encodes a one-value", [] { test_unary_coder( 1 ); }},
        {"encodes a small integer", [] { test_unary_coder( 2 ); }},
        {"encodes another small integer", [] { test_unary_coder( 5 ); }},
    }},

toy_test::suite truncated_binary_suite{
    "Test_for_truncated_binary_coder",
    {
        {"encode() throws an exception for n=0",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             THROWS(
                 integer_codes::truncated_binary::encode<test_type>( 1, 0, writer ),
                 std::invalid_argument );
         }},

        {"decode() throws an exception for n=0",
         [] {
             container c( 100 );
             auto reader = make_bit_reader( c );
             THROWS(
                 integer_codes::truncated_binary::decode<test_type>( 0, reader ),
                 std::invalid_argument );
         }},

        {"encodes a value of 3 using n=6",
         [] { test_truncated_binary_coder( 3, 6 ); }},

        {"encodes a value of 3 using n=4",
         [] { test_truncated_binary_coder( 3, 4 ); }},
    }},

```

```

        {"encodes_a_value_of_3_using_n=8",
         [] { test_truncated_binary_coder( 3, 8 ); }},

        {"encodes_a_value_of_7_using_n=8",
         [] { test_truncated_binary_coder( 7, 8 ); }},

    });

toy_test::suite elias_gamma_suite{
    "Test_for_elias_gamma_coder",
    {
        {"throws_an_exception_for_x=0",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             THROWS( integer_codes::elias_gamma::encode<test_type>( 0, writer ),
                     std::invalid_argument );
         }},
        {"encodes_a_value_of_2", [] { test_elias_gamma_coder( 2 ); }},
        {"encodes_a_value_of_3", [] { test_elias_gamma_coder( 3 ); }},
    });

toy_test::suite elias_delta_suite{
    "Test_for_elias_delta_coder",
    {
        {"throws_an_exception_for_x=0",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             THROWS( integer_codes::elias_delta::encode<test_type>( 0, writer ),
                     std::invalid_argument );
         }},

        {"encodes_a_value_of_1", [] { test_elias_delta_coder( 1 ); }},
        {"encodes_a_value_of_3", [] { test_elias_delta_coder( 3 ); }},
    });

toy_test::suite golomb_suite{
    "Test_for_golomb_coder",
    {
        {"encode_throws_an_exception_for_x=0",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             THROWS( integer_codes::golomb::encode<test_type>( 0, 5, writer ),
                     std::invalid_argument );
         }},

        {"encode_throws_an_exception_for_b=0",
         [] {
             container c;
             auto writer = make_bit_writer( c );
             THROWS( integer_codes::golomb::encode<test_type>( 5, 0, writer ),
                     std::invalid_argument );
         }},

        {"decode_throws_an_exception_for_b=0",

```

```

    [] {
        container c( 100 );
        auto reader = make_bit_reader( c );
        THROWS( integer_codes::golomb::decode<test_type>( 0, reader ),
            std::invalid_argument );
    },

    {"encodes_and_decodes_small_integers",
    [] {
        for ( test_type i = 1; i < 256; i++ ) {
            for ( test_type b = 1; b < 256; b++ ) {
                test_golomb( i, b );
            }
        }
    },
    }},
    });

toy_test::suite rice_suite{
    "Test_for_rice_coder",
    {
        {"throws_an_exception_for_x=0",
        [] {
            container c( 100 );
            auto writer = make_bit_writer( c );
            THROWS( integer_codes::rice::encode<test_type>( 0, 4, writer ),
                std::invalid_argument );
        },

        {"encodes_and_decodes_small_integers",
        [] {
            for ( test_type i = 1; i < 256; i++ ) {
                for ( test_type k = 0; k < 16; k++ ) {
                    test_rice( i, k );
                }
            }
        },
        }},
    });

toy_test::suite zigzag_suite{"Test_for_zigzag_coder",
    {
        {"encodes_0", [] { test_zigzag( 0 ); }},
        {"encodes_1", [] { test_zigzag( 1 ); }},
        {"encodes_-1", [] { test_zigzag( -1 ); }},

    },
    });

toy_test::suite offset_zigzag_suite{
    "Test_for_offset_zigzag_coder",
    {
        {"encodes_0_with_offset_12", [] { test_offset_zigzag( 0, 12 ); }},
        {"encodes_1_with_offset_12", [] { test_offset_zigzag( 1, 12 ); }},
        {"encodes_-1_with_offset_12", [] { test_offset_zigzag( -1, 12 ); }},

    },
    });

toy_test::suite varint_suite{"Test_for_varint_coder",
    {

```

```

        {"encodes_0", [] { test_varint( 0 ); }},
        {"encodes_1", [] { test_varint( 1 ); }},
        {"encodes_128", [] { test_varint( 128 ); }},
        {"encodes_275", [] { test_varint( 275 ); }},
        {"encodes_1,948", [] { test_varint( 1948 ); }},
        {"encodes_65538", [] { test_varint( 65538 ); }},
    });

int main() {
    toy_test::run_suites( {reader_suite, writer_suite, unary_suite,
        truncated_binary_suite, elias_gamma_suite,
        elias_delta_suite, golomb_suite, rice_suite,
        zigzag_suite, offset_zigzag_suite, varint_suite} );
}

```

7 test/testing.hpp

```
/*
 * Toy Test - Toy Unit Testing
 * Written in 2018 by Gerald Lewis <lewisgdljr@gmail.com>
 *
 * To the extent possible under law, the author(s) have dedicated all copyright
 * and related and neighboring rights to this software to the public domain
 * worldwide. This software is distributed without any warranty.
 * You should have received a copy of the CC0 Public Domain Dedication along
 * with this software. If not, see
 * <http://creativecommons.org/publicdomain/zero/1.0/>.
 */

#pragma once
#ifndef TESTING_HPP_INCLUDED
#define TESTING_HPP_INCLUDED

#include <functional>
#include <initializer_list>
#include <iostream>
#include <vector>

namespace toy_test {
    struct test_case {
        const char*      name;
        std::function<void()> run;
        void              operator()() const { run(); }
    };

    struct failure {
        const char* expr;
        int         line;
    };

    struct suite {
        const char*      name;
        std::vector<test_case> tests;

        bool run() const {
            bool ok{true};
            std::cout << "[SUITE] Running test suite: " << name << "\n"
                      << std::endl
                      << std::endl;
            for ( auto&& test : tests ) {
                try {
                    test();
                    std::cout << "[OK.] " << test.name << "\n passed."
                              << std::endl;
                } catch ( failure& caught ) {
                    ok = false;
                    std::cout << "[FAIL!] " << test.name << "\n failed."
                              << std::endl;
                    std::cout << "Failing condition: " << caught.expr
                              << "\n at line: " << caught.line << std::endl;
                }
            }
            return ok;
        }
    };
}
```

```

        if ( ok ) {
            std::cout << std::endl
                << "[OK]_All_tests_passed_for_suite:_\" << name << "\""
                << std::endl;
        } else {
            std::cout << std::endl
                << "[FAIL!]_Test_failures_detected_in_suite:_\" << name
                << "\"" << std::endl;
        }
        return ok;
    }
};

bool run_suite( suite const& suite ) { return suite.run(); }

bool run_suites( std::initializer_list<suite const> const& suites ) {
    bool ok = true;
    for ( auto const& a : suites ) {
        ok &= run_suite( std::forward<suite const>( a ) );
    }

    if ( ok ) {
        std::cout << std::endl
            << "[OK]_All_tests_passed." << std::endl
            << std::endl;
    } else {
        std::cout << std::endl
            << "[FAIL!]_Test_failures_detected." << std::endl
            << "_Check_the_output_for_details." << std::endl
            << std::endl;
    }
    return ok;
}

#define ASSERT( condition ) \
    void( ( condition ) ? 0 \
        : throw toy_test::failure( \
            {"ASSERT(\" #condition \")", __LINE__} ) )

#define THROWS( expression, exception ) \
    try { \
        ( expression ); \
        throw toy_test::failure( \
            {"THROWS(\" #expression \", \" #exception \")", __LINE__} ); \
    } catch ( exception& ) { \
    } catch ( ... ) { \
        throw toy_test::failure( \
            {"THROWS(\" #expression \", \" #exception \")", __LINE__} ); \
    }
} // namespace toy_test
#endif // TESTING_HPP_INCLUDED

```