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# GCD and LCM

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# Greatest Common Divisor and Least Common Multiple

## Introduction

The class and function templates in <boost/math/common\_factor.hpp> provide run-time and compile-time evaluation of the greatest common divisor (GCD) or least common multiple (LCM) of two integers. These facilities are useful for many numeric-oriented generic programming problems.

## Synopsis

```
namespace boost
{
namespace math
{

template < typename IntegerType >
class gcd_evaluator;
template < typename IntegerType >
class lcm_evaluator;

template < typename IntegerType >
IntegerType gcd( IntegerType const &a, IntegerType const &b );
template < typename IntegerType >
IntegerType lcm( IntegerType const &a, IntegerType const &b );

typedef see-below static_gcd_type;

template < static_gcd_type Value1, static_gcd_type Value2 >
struct static_gcd;
template < static_gcd_type Value1, static_gcd_type Value2 >
struct static_lcm;

}
}
```

## GCD Function Object

**Header:** <boost/math/common\_factor\_rt.hpp>

```
template < typename IntegerType >
class boost::math::gcd_evaluator
{
public:
    // Types
    typedef IntegerType result_type;
    typedef IntegerType first_argument_type;
    typedef IntegerType second_argument_type;

    // Function object interface
    result_type operator()( first_argument_type const &a,
        second_argument_type const &b ) const;
};
```

The `boost::math::gcd_evaluator` class template defines a function object class to return the greatest common divisor of two integers. The template is parameterized by a single type, called `IntegerType` here. This type should be a numeric type that represents integers. The result of the function object is always nonnegative, even if either of the operator arguments is negative.

This function object class template is used in the corresponding version of the GCD function template. If a numeric type wants to customize evaluations of its greatest common divisors, then the type should specialize on the `gcd_evaluator` class template.

## LCM Function Object

**Header:** `<boost/math/common_factor_rt.hpp>`

```
template < typename IntegerType >
class boost::math::lcm_evaluator
{
public:
    // Types
    typedef IntegerType    result_type;
    typedef IntegerType    first_argument_type;
    typedef IntegerType    second_argument_type;

    // Function object interface
    result_type operator ()( first_argument_type const &a,
        second_argument_type const &b ) const;
};
```

The `boost::math::lcm_evaluator` class template defines a function object class to return the least common multiple of two integers. The template is parameterized by a single type, called `IntegerType` here. This type should be a numeric type that represents integers. The result of the function object is always nonnegative, even if either of the operator arguments is negative. If the least common multiple is beyond the range of the integer type, the results are undefined.

This function object class template is used in the corresponding version of the LCM function template. If a numeric type wants to customize evaluations of its least common multiples, then the type should specialize on the `lcm_evaluator` class template.

## Run-time GCD & LCM Determination

**Header:** `<boost/math/common_factor_rt.hpp>`

```
template < typename IntegerType >
IntegerType boost::math::gcd( IntegerType const &a, IntegerType const &b );

template < typename IntegerType >
IntegerType boost::math::lcm( IntegerType const &a, IntegerType const &b );
```

The `boost::math::gcd` function template returns the greatest common (nonnegative) divisor of the two integers passed to it. The `boost::math::lcm` function template returns the least common (nonnegative) multiple of the two integers passed to it. The function templates are parameterized on the function arguments' `IntegerType`, which is also the return type. Internally, these function templates use an object of the corresponding version of the `gcd_evaluator` and `lcm_evaluator` class templates, respectively.

## Compile time GCD and LCM determination

**Header:** `<boost/math/common_factor_ct.hpp>`

```

typedef unspecified static_gcd_type;

template < static_gcd_type Value1, static_gcd_type Value2 >
struct boost::math::static_gcd : public mpl::integral_c<static_gcd_type, implementation_defined>
{
};

template < static_gcd_type Value1, static_gcd_type Value2 >
struct boost::math::static_lcm : public mpl::integral_c<static_gcd_type, implementation_defined>
{
};

```

The type `static_gcd_type` is the widest unsigned-integer-type that is supported for use in integral-constant-expressions by the compiler. Usually this the same type as `boost::uintmax_t`, but may fall back to being `unsigned long` for some older compilers.

The `boost::math::static_gcd` and `boost::math::static_lcm` class templates take two value-based template parameters of the `static_gcd_type` type and inherit from the type `boost::mpl::integral_c`. Inherited from the base class, they have a member `value` that is the greatest common factor or least common multiple, respectively, of the template arguments. A compile-time error will occur if the least common multiple is beyond the range of `static_gcd_type`.

## Example

```

#include <boost/math/common_factor.hpp>
#include <algorithm>
#include <iterator>
#include <iostream>

int main()
{
    using std::cout;
    using std::endl;

    cout << "The GCD and LCM of 6 and 15 are "
    << boost::math::gcd(6, 15) << " and "
    << boost::math::lcm(6, 15) << ", respectively."
    << endl;

    cout << "The GCD and LCM of 8 and 9 are "
    << boost::math::static_gcd<8, 9>::value
    << " and "
    << boost::math::static_lcm<8, 9>::value
    << ", respectively." << endl;

    int a[] = { 4, 5, 6 }, b[] = { 7, 8, 9 }, c[3];
    std::transform( a, a + 3, b, c, boost::math::gcd_evaluator<int>() );
    std::copy( c, c + 3, std::ostream_iterator<int>(cout, " ") );
}

```

## Header <boost/math/common\_factor.hpp>

This header simply includes the headers `<boost/math/common_factor_ct.hpp>` and `<boost/math/common_factor_rt.hpp>`.

Note this is a legacy header: it used to contain the actual implementation, but the compile-time and run-time facilities were moved to separate headers (since they were independent of each other).

## Demonstration Program

The program [common\\_factor\\_test.cpp](#) is a demonstration of the results from instantiating various examples of the run-time GCD and LCM function templates and the compile-time GCD and LCM class templates. (The run-time GCD and LCM class templates are tested indirectly through the run-time function templates.)

## Rationale

The greatest common divisor and least common multiple functions are greatly used in some numeric contexts, including some of the other Boost libraries. Centralizing these functions to one header improves code factoring and eases maintainence.

## History

- 17 Dec 2005: Converted documentation to Quickbook Format.
- 2 Jul 2002: Compile-time and run-time items separated to new headers.
- 7 Nov 2001: Initial version

## Credits

The author of the Boost compilation of GCD and LCM computations is Daryle Walker. The code was prompted by existing code hiding in the implementations of Paul Moore's rational library and Steve Cleary's pool library. The code had updates by Helmut Zeisel.