

# kmul user manual

<b>Title</b>	kmul (Constant multiplication routine generator)
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<b>v0.0.1</b>	07-06-2011 Initial release.
<b>v0.0.2</b>	20-11-2011 Minor README, Makefile updates.
<b>v0.0.3</b>	03-12-2011 Minor README updates regarding multiple releases, tutorial usage.
<b>v0.0.4</b>	17-03-2012 Split build-and-test scripts to "build" and "test".
<b>v0.0.5</b>	28-04-2013 Converted documentation to RestructuredText.
<b>v0.0.8</b>	12-06-2014 Updated contact information. Replaced COPYING.BSD by LICENSE.

## 1. Introduction

"kmul" is a generator of routines for optimized multiplication by an integer constant. In order to calculate a constant integer multiplication, it uses the public domain routines presented in the work: Preston Briggs and Tim Harvey, "Multiplication by integer constants," Technical report, Rice University, July 1994. This technical report implements Bernstein's algorithm documented in: R. Bernstein, "Multiplication by integer constants," Software - Practice and Experience, Vol. 16, No. 7, pp. 641-652, July 1986.

"kmul" can also be used for emitting a NAC (generic assembly language) or ANSI C implementation of the multiplication.

## 2. File listing

The `kmul` distribution includes the following files. Files denoted by a capital S are not available in binary releases of `kmul`:

/kmul	Top-level directory
S <code>build.sh</code>	Build script for <code>kmul</code> (source only).
S <code>LICENSE</code>	Description of the Modified BSD license.
S <code>kmul.c</code>	The source code for the application.
<code>kmul.exe</code>	Windows or Linux executable for the application.
S <code>Makefile</code>	Makefile for generating the <code>kmul</code> executable.
<code>README</code>	This file.
<code>README.html</code>	HTML version of <code>README</code> .
<code>README.pdf</code>	PDF version of <code>README</code> .
<code>test.c</code>	Sample test file.
<code>test.opt.c</code>	Expected optimized version of <code>test.c</code> .
<code>test.sh</code>	Perform some sample runs.
<code>test2.sh</code>	Another test script to perform more sample runs.

## 3. Installation

There exists a quite portable `Makefile` (`Makefile` in the current directory). Running `make` from the command prompt should compile `kmul`.

## 4. Prerequisites

- [mandatory for building] Standard UNIX-based tools
- `gcc` (tested with `gcc-3.4.4` on `cygwin/x86`)
- `make`
- `bash`

## 5. `kmul` usage

The `kmul` program can be invoked with several options (see complete option listing below). The usual tasks that can be accomplished with `kmul` are:

- generate a NAC optimized software routine for the multiplication
- generate an ANSI C optimized software routine for the multiplication.

ANSI C routines are emitted only for a width of 32-bits (see option below).  
`kmul` can be invoked as:

```
$./kmul [options]
```

The complete `kmul` options listing:

- h** Print this help.
- d** Enable debug/diagnostic output.
- mul <num>** Set the value of the multiplier. Default: 1.
- width <num>** Set the bitwidth of all operands: multiplier, multiplicand and product. Default: 32.
- signed** Construct optimized routine for signed multiplication.
- unsigned** Construct optimized routine for unsigned multiplication (default).
- nac** Emit software routine in the NAC general assembly language (default).
- ansic** Emit software routine in ANSI C (only for width=32).

Here follow some simple usage examples of `kmul`.

1. Generate the ANSI C implementation of  $n*11$  optimized routine.

```
$ ./kmul -mul 11 -width 32 -unsigned -ansic
```

2. Generate the NAC implementation of  $n*(-7)$  optimized routine.

```
$ ./kmul -mul -7 -width 32 -signed -ansic
```

3. Generate the ANSI C implementation of  $n*23$  optimized routine with debugging output.

```
$ ./kmul -mul 23 -width 32 -unsigned -ansic -d
```

## 6. Quick tutorial

`kmul` can be used for arithmetic optimizations in user programs. Assume the following user program (`test.c`):

```
// test.c
#include <stdio.h>
#include <stdlib.h>
int main(int argc, char *argv[]) {
    int a, b;
    a = atoi(argv[1]);
    b = a * 23;
    printf("b = %d\n", b);
    return b;
}
```

This file is compiled and run as follows with one additional argument:

```
$ gcc -Wall -O2 -o test.exe test.c
$ ./test.exe 155
```

and the expected result is:

```
$ b = 3565
```

The user can apply `kmul` for generating a constant multiplication routine for `a*23`:

```
$ ./kmul -mul 23 -width 32 -signed -ansic
```

and the corresponding routine is produced (local variables `t5` to `t15` can be deleted by the user; the compiler will be optimize them away eventually). Then, the user should edit a new file, let's say `test.opt.c` and include the produced routine. The resulting optimized source file should be as follows:

```
// test.opt.c
#include <stdio.h>
#include <stdlib.h>
signed int kmul_s32_p_23 (signed int x)
{
    signed int t0;
    signed int t1;
    signed int t2;
    signed int t3;
    signed int t4;
    signed int t5;
    signed int t6;
    signed int t7;
    signed int t8;
    signed int t9;
    signed int t10;
    signed int t11;
    signed int t12;
    signed int t13;
    signed int t14;
    signed int t15;
    signed int y;
    t0 = x;
    t1 = t0 << 1;
    t2 = t1 + x;
    t3 = t2 << 3;
    t4 = t3 - x;
    y = t4;
    return (y);
}

int main(int argc, char *argv[]) {
    int a, b;
    a = atoi(argv[1]);
    b = kmul_s32_p_23(a);
    printf("b = %d\n", b);
    return b;
}
```

```
}
```

This file is compiled and run as follows with one additional argument:

```
$ gcc -Wall -O2 -o test.opt.exe test.opt.c
$ ./test.opt.exe 155
```

The target platform compiler (e.g. gcc or llvm) is expected to inline the `kmul_s32_p_23` function at its call site.

## 7. Running tests

In order to build and run a series of sample tests do the following:

```
$ ./build.sh
$ ./test.sh
```

or for a more extensive set of tests:

```
$ ./test2.sh
```

## 8. Contact

You may contact me for further questions/suggestions/corrections at:

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