

## Lesson 1: Intro To Embedded Linux (Assignment 1)

### Output for Command: cat /etc/os-release

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ cat /etc/os-release
PRETTY_NAME="Debian GNU/Linux 11 (bullseye)"
NAME="Debian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
ID=debian
HOME_URL="https://www.debian.org/"
SUPPORT_URL="https://www.debian.org/support"
BUG_REPORT_URL="https://bugs.debian.org/"
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

## Output for Command: uname -a

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ uname -a
Linux raspberrypi 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr  3 17:24:16 BST 2023 aarch64 GNU/Linux
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

## Output for Command: arch

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ arch  
aarch64  
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

Show your hello.c source code and also the commands/output of building and running the code.

### ➤ Source Code

```
GNU nano 5.4 hello.c *
#include <stdio.h>

int main()
{
    puts("Hello world");
    return 0;
}
```

[ Read 7 lines ]

<b>^G</b> Help	<b>^O</b> Write Out	<b>^W</b> Where Is	<b>^K</b> Cut	<b>^T</b> Execute	<b>^C</b> Location	<b>^U</b> Undo	<b>^M</b> Set Mark
<b>^X</b> Exit	<b>^R</b> Read File	<b>^A</b> Replace	<b>^U</b> Paste	<b>^J</b> Justify	<b>^G</b> Go To Line	<b>^E</b> Redo	<b>^C</b> Copy

## ➤ Commands / Output

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ nano hello.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o hello hello.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ file hello
hello: ELF 64-bit LSB pie executable, ARM aarch64, version 1 (SYSV), dynamically linked, interpreter /lib/ld-linux-aarch64.so.1, BuildID[sha1]=78e56765bd6c0f1f9402f5edd62d73fbe0176f65, for GNU/Linux 3.7.0, not stripped
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ nano hello.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o hello hello.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ file hello
hello: ELF 64-bit LSB pie executable, ARM aarch64, version 1 (SYSV), dynamically linked, interpreter /lib/ld-linux-aarch64.so.1, BuildID[sha1]=78e56765bd6c0f1f9402f5edd62d73fbe0176f65, for GNU/Linux 3.7.0, not stripped
cxr1020@raspberrypi:~/Documents/Assignment01 $ ./hello
Hello world
cxr1020@raspberrypi:~/Documents/Assignment01 $ ldd hello
linux-vdso.so.1 (0x0000007f83590000)
libc.so.6 => /lib/aarch64-linux-gnu/libc.so.6 (0x0000007f833c8000)
/lib/ld-linux-aarch64.so.1 (0x0000007f83560000)
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ nano hello.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o hello hello.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ file hello
hello: ELF 64-bit LSB pie executable, ARM aarch64, version 1 (SYSV), dynamically linked, interpreter /lib/ld-linux-aarch64.so.1, BuildID[sha1]=78e56765bd6c0f1f9402f5edd62d73fbe0176f65, for GNU/Linux 3.7.0, not stripped
cxr1020@raspberrypi:~/Documents/Assignment01 $ ./hello
Hello world
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

Show your math.h, math.c, and math-test.c source code and also the commands/output of building and running of the code

### ➤ Source Codes

```
GNU nano 5.4 math.h
#ifndef _MATH_H_
#define _MATH_H_

int sum(int a, int b);
int prod(int a, int b);

#endif
```

[ Read 7 lines ]

<b>^G</b> Help	<b>^O</b> Write Out	<b>^W</b> Where Is	<b>^K</b> Cut	<b>^T</b> Execute	<b>^C</b> Location	<b>M-U</b> Undo	<b>M-A</b> Set Mark
<b>^X</b> Exit	<b>^R</b> Read File	<b>^L</b> Replace	<b>^U</b> Paste	<b>^J</b> Justify	<b>^_</b> Go To Line	<b>M-E</b> Redo	<b>M-C</b> Copy

```
GNU nano 5.4 math.c
#include "math.h"

// This function returns sum of two integers
int sum(int a, int b)
{
    return ( a + b );
}

// This function returns product of two integers
int prod(int a, int b)
{
    return ( a * b );
}
```

[ Read 13 lines ]

<b>^G</b> Help	<b>^O</b> Write Out	<b>^W</b> Where Is	<b>^K</b> Cut	<b>^T</b> Execute	<b>^C</b> Location	<b>M-U</b> Undo	<b>M-A</b> Set Mark
<b>^X</b> Exit	<b>^R</b> Read File	<b>^L</b> Replace	<b>^U</b> Paste	<b>^J</b> Justify	<b>^_</b> Go To Line	<b>M-E</b> Redo	<b>M-C</b> Copy

```
GNU nano 5.4                                math-test.c
#include <stdio.h>
#include "math.h"

int main()
{
    int value = 0;

    value = sum(10, 20);
    printf("value = %d\n", value);

    value = prod(10, 20);
    printf("value = %d\n", value);

    return 0;
}

[ Read 15 lines ]

^G Help      ^O Write Out  ^W Where Is   ^K Cut        ^T Execute
^X Exit      ^R Read File  ^\ Replace    ^U Paste      ^J Justify
^C Location   ^_ Go To Line ^-U Undo      ^-E Redo      ^-A Set Mark
^M-C Copy
```



## ➤ Commands/Outputs

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ nano math-test.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o math-test math-test.c
/usr/bin/ld: /tmp/cc3hjAEv.o: in function 'main':
math-test.c:(.text+0x14): undefined reference to `sum'
/usr/bin/ld: math-test.c:(.text+0x34): undefined reference to `prod'
collect2: error: ld returned 1 exit status
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o math-test math.o math-test.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ ./math-test
value = 30
value = 200
cxr1020@raspberrypi:~/Documents/Assignment01 $ ldd math-test
linux-vdso.so.1 (0x0000007fbb025000)
libc.so.6 => /lib/aarch64-linux-gnu/libc.so.6 (0x0000007fbae5d000)
/lib/ld-linux-aarch64.so.1 (0x0000007fbaff5000)
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

## Show your commands for creating libmath.so

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -shared -o libmath.so math.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ ls
hello  hello.c  libmath.so  math.c  math.h  math.o  math-test  math-test.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ file libmath.so
libmath.so: ELF 64-bit LSB shared object, ARM aarch64, version 1 (SYSV), dynamically linked, BuildID[sha1]=430827f665f5135dc598821a00d14024947013d5, not stripped
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o math-test math-test.c -lmath -L.
cxr1020@raspberrypi:~/Documents/Assignment01 $ ldd math-test
        linux-vdso.so.1 (0x0000007f868d6000)
        libmath.so => not found
        libc.so.6 => /lib/aarch64-linux-gnu/libc.so.6 (0x0000007f8670e000)
        /lib/ld-linux-aarch64.so.1 (0x0000007f868a6000)
cxr1020@raspberrypi:~/Documents/Assignment01 $ LD_LIBRARY_PATH=.
cxr1020@raspberrypi:~/Documents/Assignment01 $ ldd math-test
        linux-vdso.so.1 (0x0000007fa794a000)
        libmath.so => not found
        libc.so.6 => /lib/aarch64-linux-gnu/libc.so.6 (0x0000007fa7782000)
        /lib/ld-linux-aarch64.so.1 (0x0000007fa791a000)
cxr1020@raspberrypi:~/Documents/Assignment01 $ LD_LIBRARY_PATH=. ldd math-test
        linux-vdso.so.1 (0x0000007f8cda5000)
        libmath.so => ./libmath.so (0x0000007f8cd51000)
        libc.so.6 => /lib/aarch64-linux-gnu/libc.so.6 (0x0000007f8cbcb000)
        /lib/ld-linux-aarch64.so.1 (0x0000007f8cd75000)
cxr1020@raspberrypi:~/Documents/Assignment01 $ ls
hello  hello.c  libmath.so  math.c  math.h  math-test  math-test.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ ./math-test
./math-test: error while loading shared libraries: libmath.so: cannot open shared object file: No such file or directory
cxr1020@raspberrypi:~/Documents/Assignment01 $ LD_LIBRARY_PATH= ./math-test
-bash: LD_LIBRARY_PATH: command not found
cxr1020@raspberrypi:~/Documents/Assignment01 $ LD_LIBRARY_PATH= ./math-test
value = 30
value = 200
cxr1020@raspberrypi:~/Documents/Assignment01 $
```

Show your math-test-dynamic.c source code and also the commands/output of building and running of the code

### ➤ Source Code

```
GNU nano 5.4 math-test-dynamic.c
#include <stdio.h>
#include <dlfcn.h>

#include "math.h"

int main()
{
    void* handle = dlopen("libmath.so", RTLD_LAZY);
    if(!handle)
    {
        fprintf(stderr, "%s\n", dlerror());
    }

    int (*sum)(int a, int b);
    sum = dlsym(handle, "sum");
    if(!sum)
    {
        fprintf(stderr, "%s\n", dlerror());
    }
    else
    {
        int value = sum(10,20);
        printf("value = %d\n", value);
    }

    dlclose(handle);

    return 0;
}
```

[ Read 33 lines ]

^G Help   ^O Write Out   ^W Where Is   ^K Cut   ^T Execute   ^C Location   M-U Undo   M-A Set Mark  
^X Exit   ^R Read File   ^\ Replace   ^U Paste   ^J Justify   ^\_ Go To Line   M-E Redo   M-C Copy

### ➤ Commands/Output

```
cxr1020@raspberrypi:~/Documents/Assignment01 $ nano math-test-dynamic.c
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o math-test-dynamic math-test-dynamic.c
/usr/bin/ld: /tmp/ccLrWdUb.o: in function 'main':
math-test-dynamic.c:(.text+0x18): undefined reference to `dlopen'
/usr/bin/ld: math-test-dynamic.c:(.text+0x38): undefined reference to `dlerror'
/usr/bin/ld: math-test-dynamic.c:(.text+0x5c): undefined reference to `dlsym'
/usr/bin/ld: math-test-dynamic.c:(.text+0x7c): undefined reference to `dlerror'
/usr/bin/ld: math-test-dynamic.c:(.text+0xc0): undefined reference to `dlclose'
collect2: error: ld returned 1 exit status
cxr1020@raspberrypi:~/Documents/Assignment01 $ gcc -Wall -o math-test-dynamic math-test-dynamic.c -ldl
cxr1020@raspberrypi:~/Documents/Assignment01 $ ldd math-test-dynamic
linux-vdso.so.1 (0x0000007f97e6b000)
libdl.so.2 => /lib/aarch64-linux-gnu/libdl.so.2 (0x0000007f97e03000)
libc.so.6 => /lib/aarch64-linux-gnu/libc.so.6 (0x0000007f97c8f000)
/lib/ld-linux-aarch64.so.1 (0x0000007f97e3b000)
cxr1020@raspberrypi:~/Documents/Assignment01 $ ./math-test-dynamic
libmath.so: cannot open shared object file: No such file or directory
./math-test-dynamic: undefined symbol: sum
Segmentation fault
cxr1020@raspberrypi:~/Documents/Assignment01 $ LD_LIBRARY_PATH=. ./math-test-dynamic
value = 30
cxr1020@raspberrypi:~/Documents/Assignment01 $
```