CS1217 – Spring 2020 — Homework 1 1

Tanuj Sood — Pratyush Kumar

Collaborators: NONE

1. First Question

(a) The **#include** command is a directive (a language construct that specifies how a compiler would its input) to the pre-processor that tells the compiler to include a header file in the program.

(b) The stdio.h file used with the #include function is a directive to the pre-processor that tells the compiler to include a header file "**stdio.h**" in the program. This specific header file stands for standard input output and its use is to take inputs from the keyboard and output them on a screen or monitor. Using this with the **include** directive allows all the functionalities defined in the file within placed between the braces to be used in current file.

2. Second Question

(a)

```
(base) Tanujs-MacBook-Pro:Assignment 1 tanuj$ gcc -v myhello.c
Apple LLVM version 10.0.0 (clang-1000.10.44.4)
Target: x86_64-apple-darwin17.7.0
Thread model: posix
InstalledDir: /Library/Developer/CommandLineTools/usr/bin
 "/Library/Developer/CommandLineTools/usr/bin/clang" -cc1 -triple x86_64-apple-macosx1
0.13.0 -Wdeprecated-objc-isa-usage -Werror=deprecated-objc-isa-usage -emit-obj -mrelax
-all -disable-free -disable-llvm-verifier -discard-value-names -main-file-name myhello
.c -mrelocation-model pic -pic-level 2 -mthread-model posix -mdisable-fp-elim -fno-str
ict-return -masm-verbose -munwind-tables -target-cpu penryn -dwarf-column-info -debugg
er-tuning=lldb -target-linker-version 409.12 -v -resource-dir /Library/Developer/Comma
ndLineTools/usr/lib/clang/10.0.0 -fdebug-compilation-dir /Users/tanuj/Desktop/OS/Assig
nment 1 -ferror-limit 19 -fmessage-length 80 -stack-protector 1 -fblocks -fencode-exte
nded-block-signature -fobjc-runtime=macosx-10.13.0 -fmax-type-align=16 -fdiagnostics-s
how-option -fcolor-diagnostics -o /var/folders/__/3_65x4wd4f97vvmxdxc3zyd80000gn/T/myh
ello-e84441.o -x c myhello.c
clang -cc1 version 10.0.0 (clang-1000.10.44.4) default target x86_64-apple-darwin17.7.
0
#include "..." search starts here:
#include <...> search starts here:
 /usr/local/include
 /Library/Developer/CommandLineTools/usr/lib/clang/10.0.0/include
 /Library/Developer/CommandLineTools/usr/include
 /usr/include
 /System/Library/Frameworks (framework directory)
 /Library/Frameworks (framework directory)
End of search list.
 "/Library/Developer/CommandLineTools/usr/bin/ld" -demangle -lto_library /Library/Deve
loper/CommandLineTools/usr/lib/libLTO.dylib -no_deduplicate -dynamic -arch x86_64 -mac
osx_version_min 10.13.0 -o a.out /var/folders/__/3_65x4wd4f97vvmxdxc3zyd80000gn/T/myhe
llo-e84441.o -lSystem /Library/Developer/CommandLineTools/usr/lib/clang/10.0.0/lib/dar
win/libclang_rt.osx.a
```

3. Third Question

(a) The ./ symbol tells the compiler that the program file that we're trying to run is located in the current directory. The current working directory (**cwd**) is not a part of the **PATH** environment variable by default, we need to use ./ to specify where the executable is located. The PATH environment variables are the directories that contain executable programs that can be started without knowing and typing the whole path to the file on the command line.

(b) If **./** is not included in path, the shell will only search for the executable in PATH directory, not find the file and will give an error called : **command not found**.

4. Fourth Question

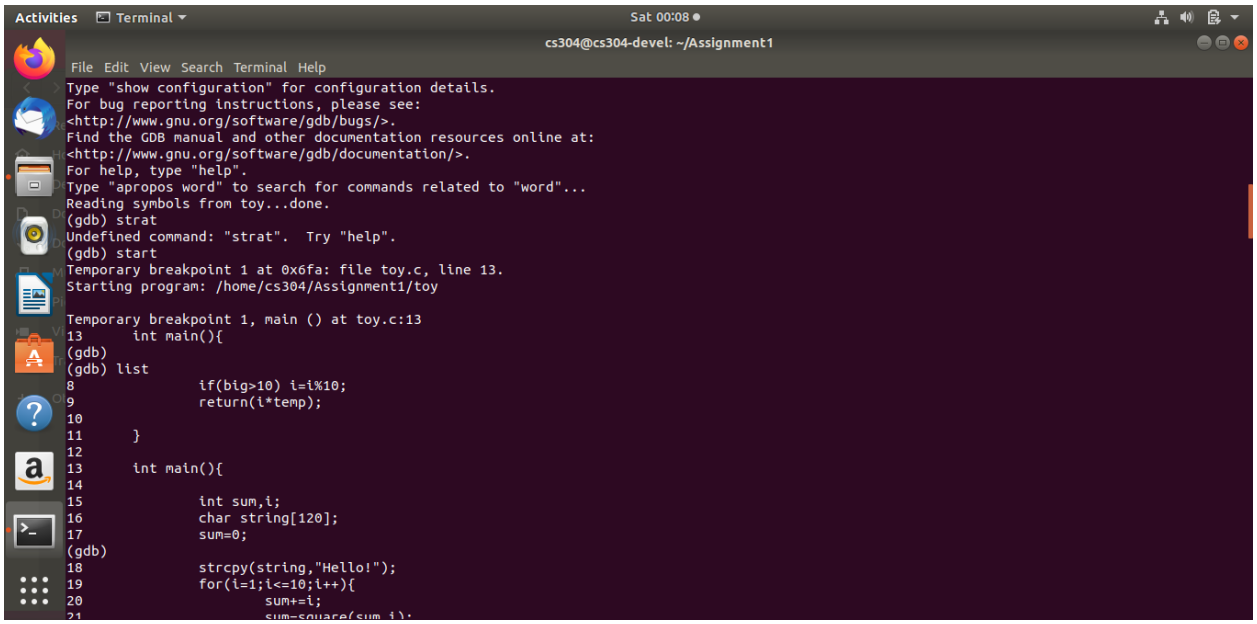
(a) The last line of Makefile: **gcc -o myhello myhello.c** is responsible for creating the myhello executable.
Changing the name is a function of **gcc**.

5. Fifth Question

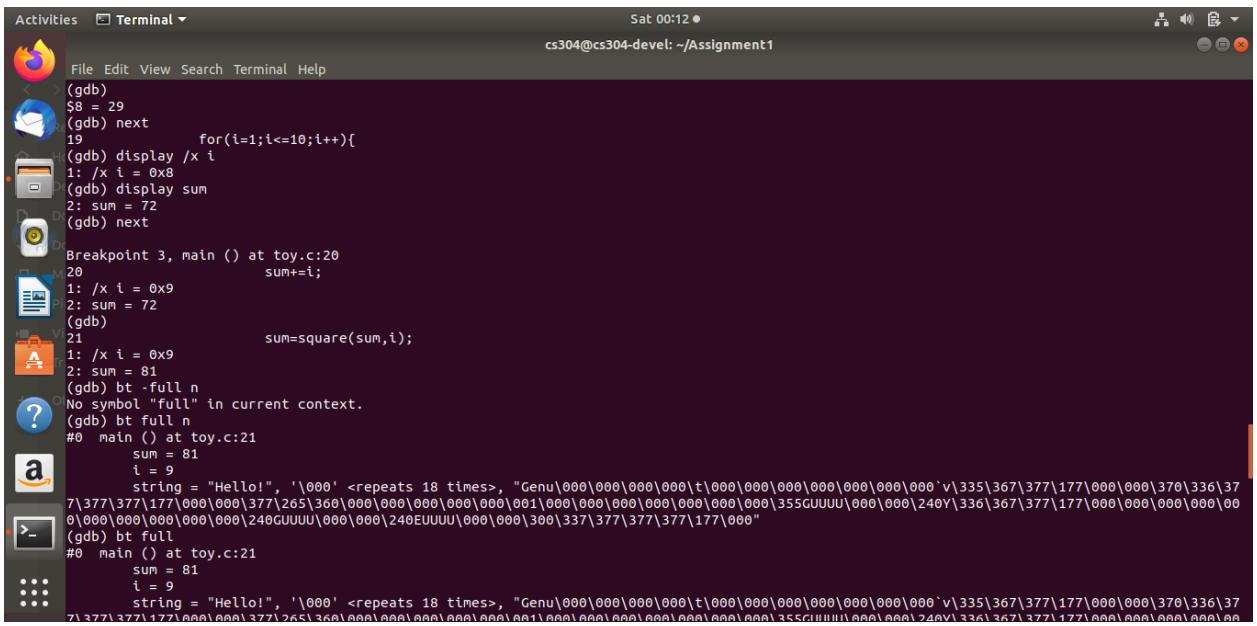
(a) The strange looking rule is used to collectively compile all the files in the directory ending in **.c** using the gcc compiler.
A change in either of the **.c** files doesn't force the re-compilation of another .c file, i.e. if main.c is changed, then only main.c and the dumb.h file is recompiled. Similar is the case when dump.c is changed; only the dumb.c file and dumb.h file is recompiled. But if **dumb.h** is changed, this forces all the **.c** files to be recompiled. Also, if no changes are made, the files are not recompiled and a message notifying that the output file is up to data is printed on the terminal.

6. Sixth Question

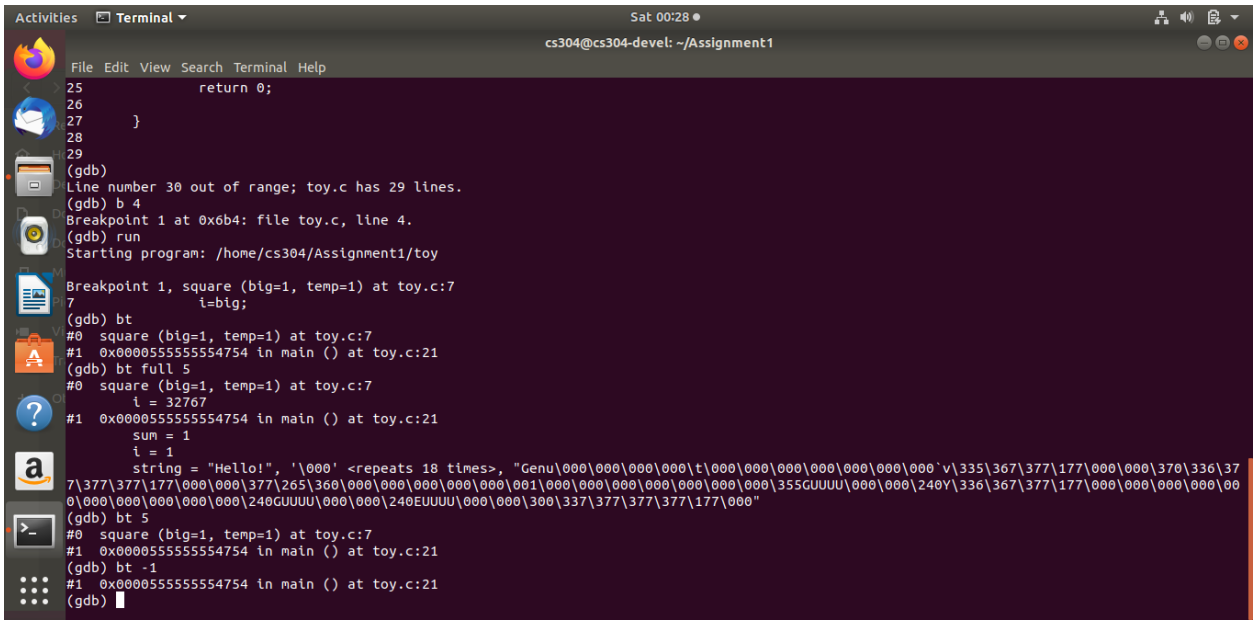
(a) The list command is used to print a fixed number of lines of from the program. If a linenumber is provided with the list command, a fixed number of lines from around that line number is printed on the shell.



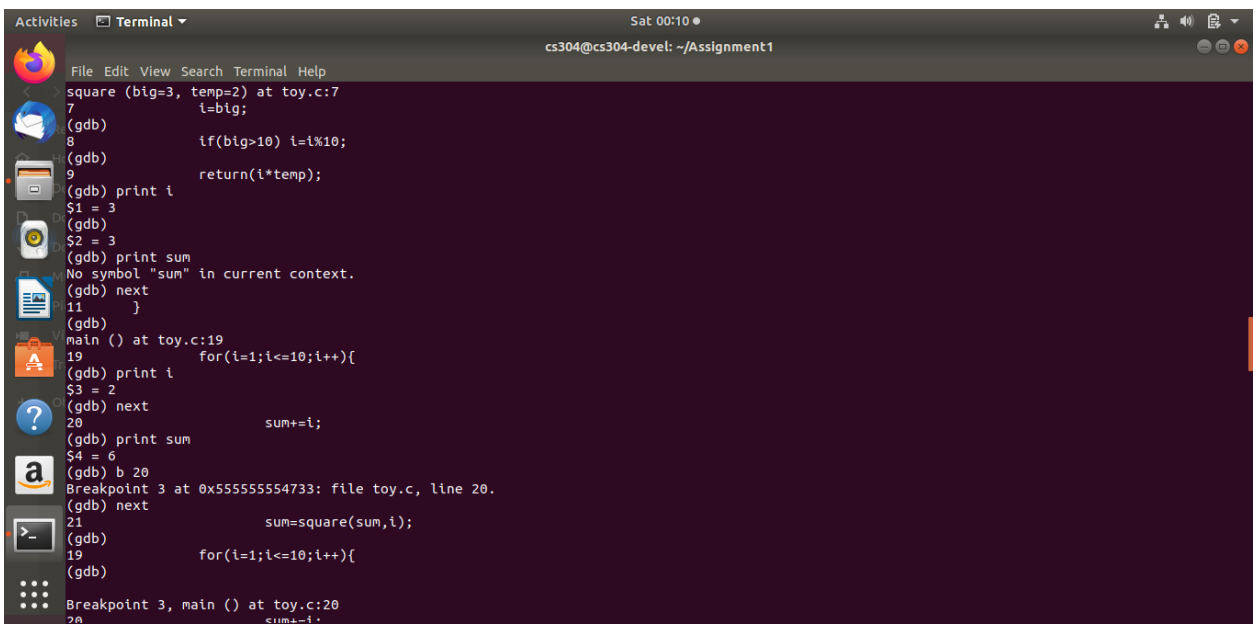
Display command allows us to display the values of certain variables, expression at breakpoints or at each step of the program.



Where or the backtrace command is useful in determinig where a particular part of code is called from. For a function, it will show where the function was called from up until the last end if the call chain.

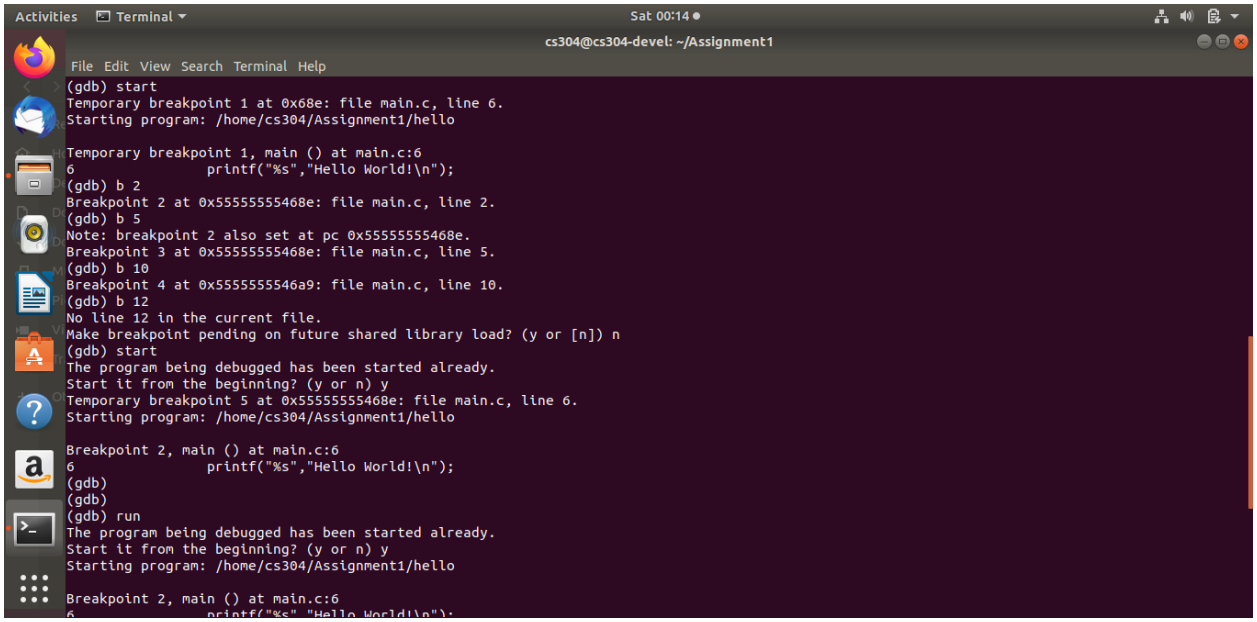


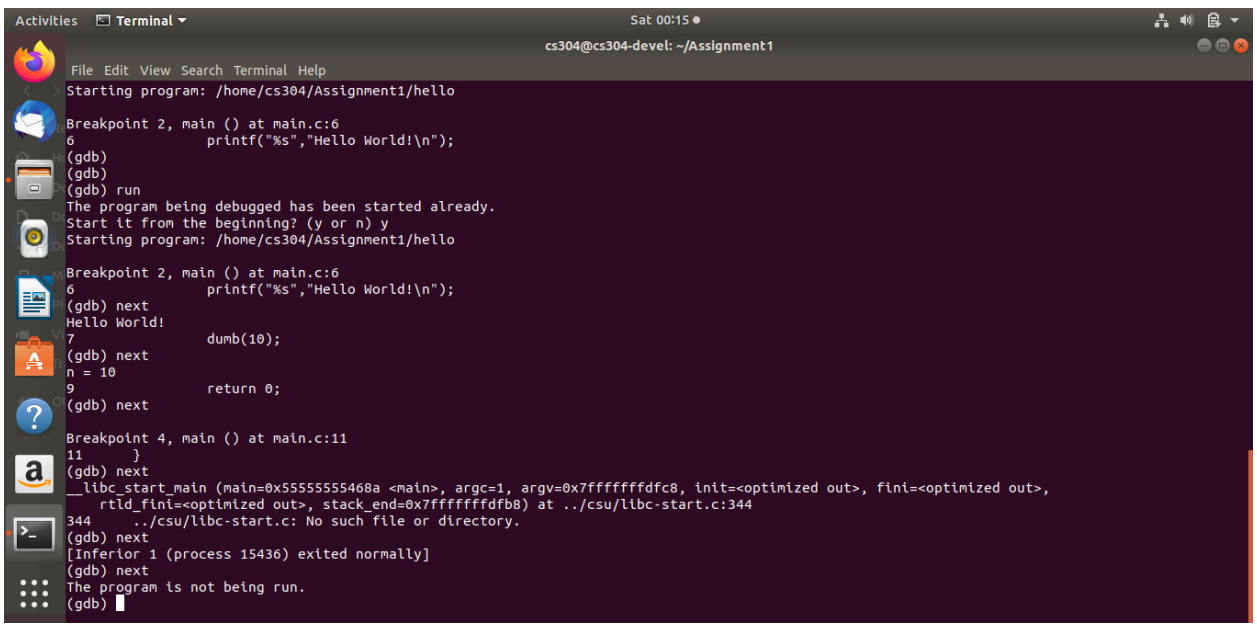
The print command is used to print the value of an expression. It can also be a variable name.



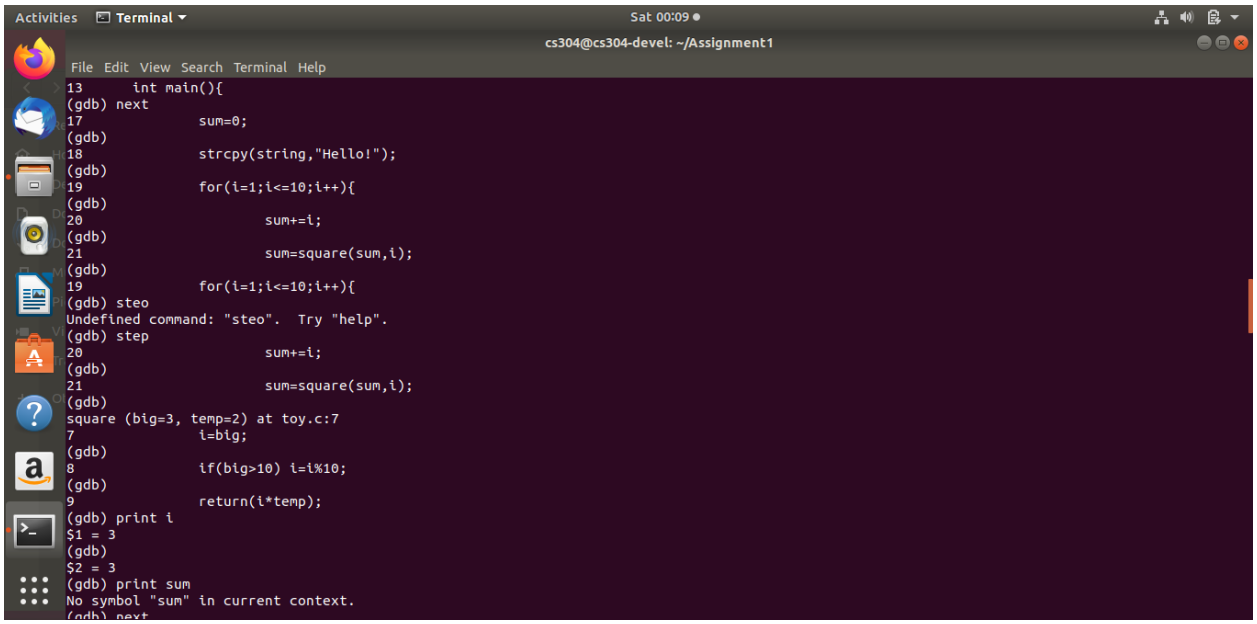
Below are the screenshots for the use of Breakpoints and stepping commands:

Breakpoints





Stepping

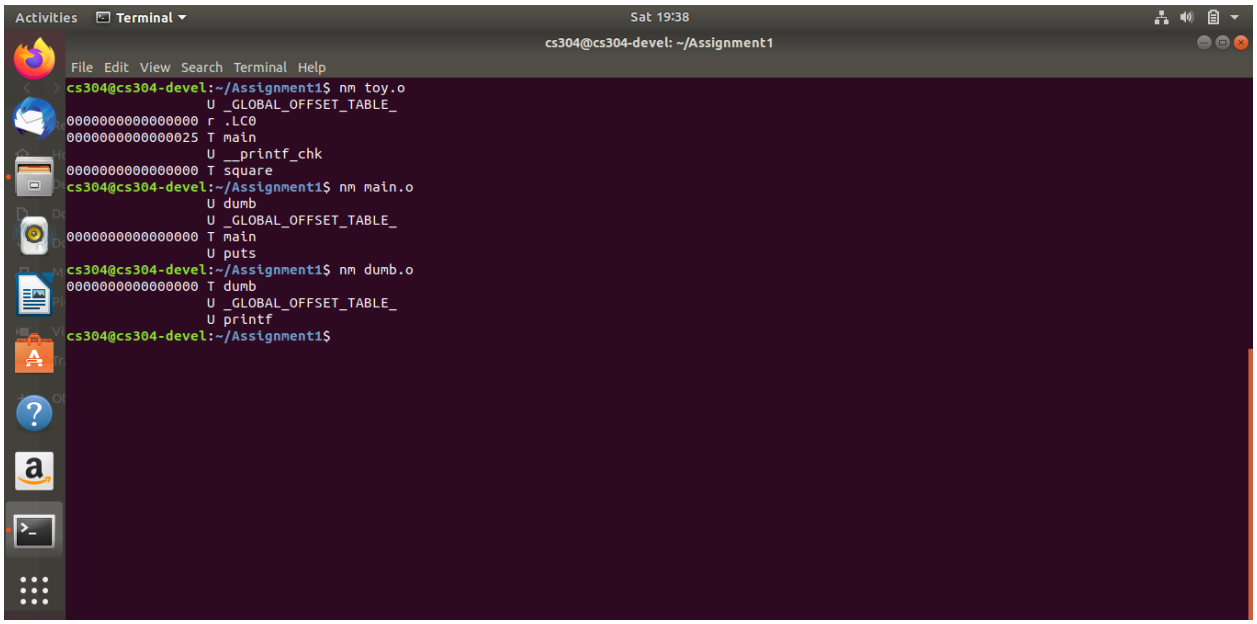


7. Seventh Question

(a) **nm** is a utility provided in UNIX based systems to examine binary files given out by programs, executable files(.exe) that are in windows, library files that generally end in .lib and other such files. The command displays the symbol table associated with these files. The output is generally in 3 columns by default:

First: the virtual address by default
Second: the symbol type
Third: the symbol name

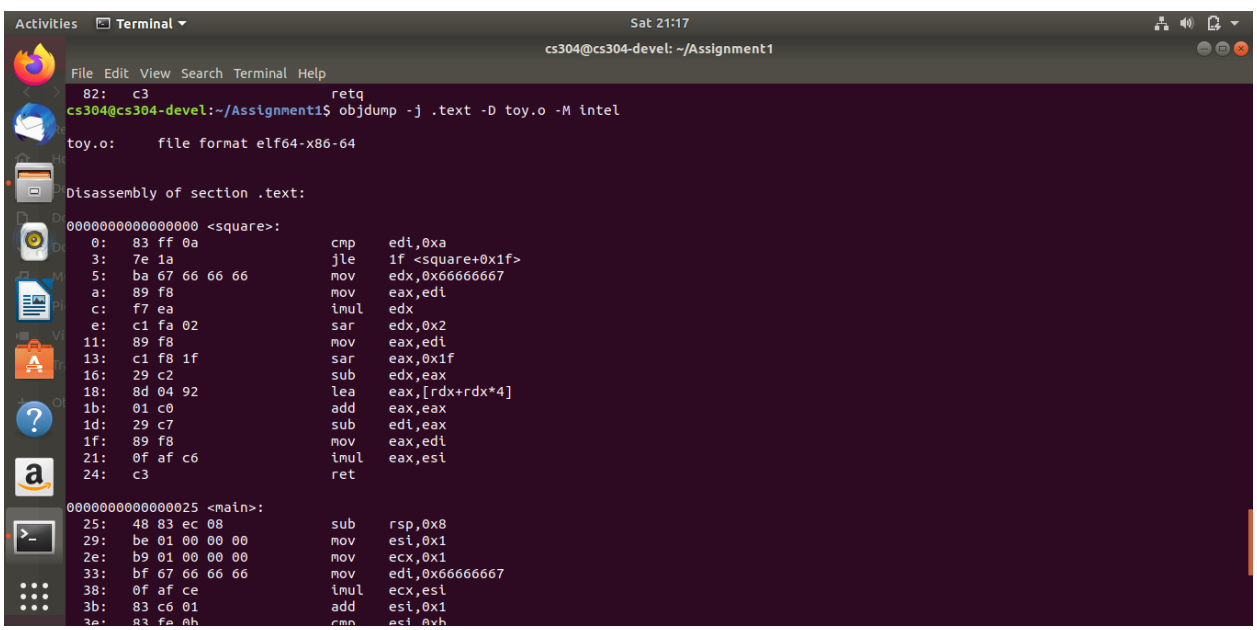
The output is a mix of lowercase and uppercase symbols types where uppercase means "External symbols" and lowercase means "Local symbols". It also tells us about different functions that are imported from external libraries. Below is a screenshot showing a use nm:



objdump is another command-line program to display various info about object files on UNIX-like OS systems. This disassembles the program and allows us to look at the assembly code of the file. The information can be used to get an overview of the control flow of the program via a series of assembly commands. The output generally has four columns:

. The virtual address of the instruction
. The actual machine code
. Last 2 columns: The actual assembly code that matches the machine code

Below is a use case of the objdump command:



```
0000000000000025 <main>:
  25:   48 83 ec 08             sub    rsp,0x8
  29:   be 01 00 00 00          mov    esi,0x1
  2e:   b9 01 00 00 00          mov    ecx,0x1
  33:   bf 67 66 66 66          mov    edi,0x66666667
  38:   0f af ce                imul   ecx,esi
  3b:   83 c6 01                add    esi,0x1
  3e:   83 fe 0b                cmp    esi,0xb
  41:   74 1e                   je     61 <main+0x3c>
  43:   01 f1                   add    ecx,esi
  45:   83 f9 0a                cmp    ecx,0xa
  48:   7e ee                   jle    38 <main+0x13>
  4a:   89 c8                   mov    eax,ecx
  4c:   f7 ef                   imul   edi
  4e:   c1 fa 02                sar    edx,0x2
  51:   89 c8                   mov    eax,ecx
  53:   c1 f8 1f                sar    eax,0x1f
  56:   29 c2                   sub    edx,eax
  58:   8d 04 92                lea    eax,[rdx+rdx*4]
  5b:   01 c0                   add    eax,eax
  5d:   29 c1                   sub    ecx,eax
  5f:   eb d7                   jmp    38 <main+0x13>
  61:   89 ca                   mov    edx,ecx
  63:   48 8d 35 00 00 00 00    lea    rsi,[rip+0x0]        # 6a <main+0x45>
  6a:   bf 01 00 00 00          mov    edi,0x1
  6f:   b8 00 00 00 00          mov    eax,0x0
  74:   e8 00 00 00 00          call   79 <main+0x54>
  79:   b8 00 00 00 00          mov    eax,0x0
  7e:   48 83 c4 08             add    rsp,0x8
  82:   c3                      ret
cs304@cs304-devel:~/Assignment1$
```

Above two are in the Intel format which is easier to read. The default is the AT&T format below:

```
0000000000000025 <main>:
  25:   48 83 ec 08             sub    $0x8,%rsp
  29:   be 01 00 00 00          mov    $0x1,%esi
  2e:   b9 01 00 00 00          mov    $0x1,%ecx
  33:   bf 67 66 66 66          mov    $0x66666667,%edi
  38:   0f af ce                imul   %esi,%ecx
  3b:   83 c6 01                add    $0x1,%esi
  3e:   83 fe 0b                cmp    $0xb,%esi
  41:   74 1e                   je     61 <main+0x3c>
  43:   01 f1                   add    %esi,%ecx
  45:   83 f9 0a                cmp    $0xa,%ecx
  48:   7e ee                   jle    38 <main+0x13>
  4a:   89 c8                   mov    %ecx,%eax
  4c:   f7 ef                   imul   %edi
  4e:   c1 fa 02                sar    $0x2,%edx
  51:   89 c8                   mov    %ecx,%eax
  53:   c1 f8 1f                sar    $0x1f,%eax
  56:   29 c2                   sub    %eax,%edx
  58:   8d 04 92                lea    (%rdx,%rdx,4),%eax
  5b:   01 c0                   add    %eax,%eax
  5d:   29 c1                   sub    %eax,%ecx
  5f:   eb d7                   jmp    38 <main+0x13>
  61:   89 ca                   mov    %ecx,%edx
  63:   48 8d 35 00 00 00 00    lea    0x0(%rip),%rsi        # 6a <main+0x45>
  6a:   bf 01 00 00 00          mov    $0x1,%edi
  6f:   b8 00 00 00 00          mov    $0x0,%eax
  74:   e8 00 00 00 00          callq  79 <main+0x54>
  79:   b8 00 00 00 00          mov    $0x0,%eax
  7e:   48 83 c4 08             add    $0x8,%rsp
  82:   c3                      retq
cs304@cs304-devel:~/Assignment1$ objdump -j .text -D toy.o
```