Part 1

Steps in Compilation of a C program.

Hello World Program in C:

```c
#include <stdio.h>
int main(){
    printf("Hello World!\n");
    return 0;
}
```

Step 1: Preprocessing:

```
ashu@Ashu-PC: ~/COE                                    —    □    ×
ashu@Ashu-PC:~/COE$ cpp hello.c > hello.i
ashu@Ashu-PC:~/COE$
```
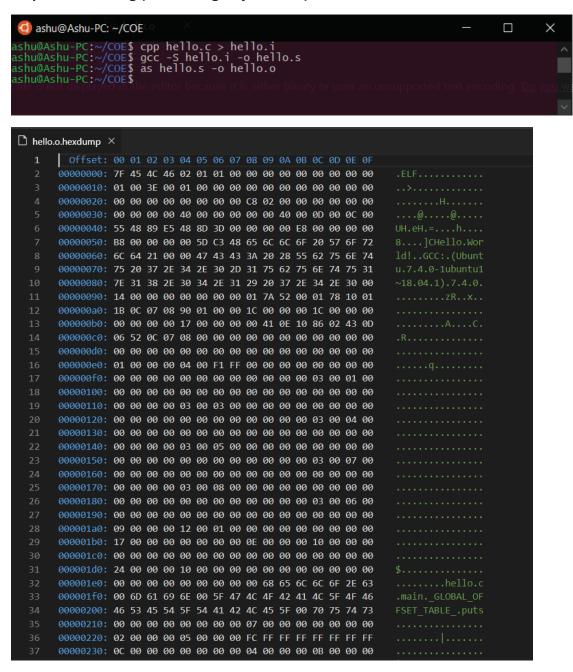
Preprocessing Output

```
C++ hello.i    ×
C++ hello.i
  1   # 1 "hello.c"
  2   # 1 "<built-in>"
  3   # 1 "<command-line>"
  4   # 31 "<command-line>"
  5   # 1 "/usr/include/stdc-predef.h" 1 3 4
  6   # 32 "<command-line>" 2
  7   # 1 "hello.c"
  8   # 1 "/usr/include/stdio.h" 1 3 4
  9   # 27 "/usr/include/stdio.h" 3 4
 10   # 1 "/usr/include/x86_64-linux-gnu/bits/libc-header-start.h" 1 3 4
 11   # 33 "/usr/include/x86_64-linux-gnu/bits/libc-header-start.h" 3 4
 12   # 1 "/usr/include/features.h" 1 3 4
 13   # 424 "/usr/include/features.h" 3 4
 14   # 1 "/usr/include/x86_64-linux-gnu/sys/cdefs.h" 1 3 4
 15   # 427 "/usr/include/x86_64-linux-gnu/sys/cdefs.h" 3 4
 16   # 1 "/usr/include/x86_64-linux-gnu/bits/wordsize.h" 1 3 4
 17   # 428 "/usr/include/x86_64-linux-gnu/sys/cdefs.h" 2 3 4
 18   # 1 "/usr/include/x86_64-linux-gnu/bits/long-double.h" 1 3 4
 19   # 429 "/usr/include/x86_64-linux-gnu/sys/cdefs.h" 2 3 4
 20   # 425 "/usr/include/features.h" 2 3 4
 21   # 448 "/usr/include/features.h" 3 4
 22   # 1 "/usr/include/x86_64-linux-gnu/gnu/stubs.h" 1 3 4
 23   # 10 "/usr/include/x86_64-linux-gnu/gnu/stubs.h" 3 4
 24   # 1 "/usr/include/x86_64-linux-gnu/gnu/stubs-64.h" 1 3 4
 25   # 11 "/usr/include/x86_64-linux-gnu/gnu/stubs.h" 2 3 4
 26   # 449 "/usr/include/features.h" 2 3 4
 27   # 34 "/usr/include/x86_64-linux-gnu/bits/libc-header-start.h" 2 3 4
 28   # 28 "/usr/include/stdio.h" 2 3 4
 29
 30
 31
 32
 33
 34   # 1 "/usr/lib/gcc/x86_64-linux-gnu/7/include/stddef.h" 1 3 4
 35   # 216 "/usr/lib/gcc/x86_64-linux-gnu/7/include/stddef.h" 3 4
 36
 37   # 216 "/usr/lib/gcc/x86_64-linux-gnu/7/include/stddef.h" 3 4
```

```
C++  hello.i    ×
C++  hello.i
772
773
774    extern int pclose (FILE *__stream);
775
776
777
778
779
780    extern char *ctermid (char *__s) __attribute__ ((__nothrow__ , __leaf__));
781    # 840 "/usr/include/stdio.h" 3 4
782    extern void flockfile (FILE *__stream) __attribute__ ((__nothrow__ , __leaf__));
783
784
785
786    extern int ftrylockfile (FILE *__stream) __attribute__ ((__nothrow__ , __leaf__)) ;
787
788
789    extern void funlockfile (FILE *__stream) __attribute__ ((__nothrow__ , __leaf__));
790    # 868 "/usr/include/stdio.h" 3 4
791
792    # 2 "hello.c" 2
793
794    # 2 "hello.c"
795    int main(){
796     printf("Hello World!\n");
797     return 0;
798    }
799
```

Step 2: Generating Assembly Code (Compiling):

```
ashu@Ashu-PC: ~/COE
ashu@Ashu-PC:~/COE$ cpp hello.c > hello.i
ashu@Ashu-PC:~/COE$ gcc -S hello.i -o hello.s
ashu@Ashu-PC:~/COE$ _
```

```
hello.s    ×
hello.s
1      .file    "hello.c"
2      .text
3      .section    .rodata
4    .LC0:
5      .string "Hello World!"
6      .text
7      .globl  main
8      .type   main, @function
9    main:
10   .LFB0:
11      .cfi_startproc
12      pushq   %rbp
13      .cfi_def_cfa_offset 16
14      .cfi_offset 6, -16
15      movq    %rsp, %rbp
16      .cfi_def_cfa_register 6
17      leaq    .LC0(%rip), %rdi
18      call    puts@PLT
19      movl    $0, %eax
20      popq    %rbp
21      .cfi_def_cfa 7, 8
22      ret
23      .cfi_endproc
24   .LFE0:
25      .size   main, .-main
26      .ident  "GCC: (Ubuntu 7.4.0-1ubuntu1~18.04.1) 7.4.0"
27      .section    .note.GNU-stack,"",@progbits
```

Step 3: Assembling (Generating Object Code):

```
ashu@Ashu-PC: ~/COE                                                    —    □    ✕
ashu@Ashu-PC:~/COE$ cpp hello.c > hello.i
ashu@Ashu-PC:~/COE$ gcc -S hello.i -o hello.s
ashu@Ashu-PC:~/COE$ as hello.s -o hello.o
ashu@Ashu-PC:~/COE$
```

```
hello.o.hexdump  ✕
  1      Offset: 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
  2    00000000: 7F 45 4C 46 02 01 01 00 00 00 00 00 00 00 00 00    .ELF............
  3    00000010: 01 00 3E 00 01 00 00 00 00 00 00 00 00 00 00 00    ..>.............
  4    00000020: 00 00 00 00 00 00 00 00 C8 02 00 00 00 00 00 00    ........H.......
  5    00000030: 00 00 00 00 40 00 00 00 00 00 40 00 0D 00 0C 00    ....@.....@.....
  6    00000040: 55 48 89 E5 48 8D 3D 00 00 00 00 E8 00 00 00 00    UH.eH.=....h....
  7    00000050: B8 00 00 00 00 5D C3 48 65 6C 6C 6F 20 57 6F 72    8....]CHello.Wor
  8    00000060: 6C 64 21 00 00 47 43 43 3A 20 28 55 62 75 6E 74    ld!..GCC:.(Ubunt
  9    00000070: 75 20 37 2E 34 2E 30 2D 31 75 62 75 6E 74 75 31    u.7.4.0-1ubuntu1
 10    00000080: 7E 31 38 2E 30 34 2E 31 29 20 37 2E 34 2E 30 00    ~18.04.1).7.4.0.
 11    00000090: 14 00 00 00 00 00 00 00 01 7A 52 00 01 78 10 01    .........zR..x..
 12    000000a0: 1B 0C 07 08 90 01 00 00 1C 00 00 00 1C 00 00 00    ................
 13    000000b0: 00 00 00 00 17 00 00 00 00 41 0E 10 86 02 43 0D    .........A....C.
 14    000000c0: 06 52 0C 07 08 00 00 00 00 00 00 00 00 00 00 00    .R..............
 15    000000d0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
 16    000000e0: 01 00 00 00 04 00 F1 FF 00 00 00 00 00 00 00 00    ......q.........
 17    000000f0: 00 00 00 00 00 00 00 00 00 00 00 00 03 00 01 00    ................
 18    00000100: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
 19    00000110: 00 00 00 00 03 00 03 00 00 00 00 00 00 00 00 00    ................
 20    00000120: 00 00 00 00 00 00 00 00 00 00 00 00 03 00 04 00    ................
 21    00000130: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
 22    00000140: 00 00 00 00 03 00 05 00 00 00 00 00 00 00 00 00    ................
 23    00000150: 00 00 00 00 00 00 00 00 00 00 00 00 03 00 07 00    ................
 24    00000160: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
 25    00000170: 00 00 00 00 03 00 08 00 00 00 00 00 00 00 00 00    ................
 26    00000180: 00 00 00 00 00 00 00 00 00 00 00 00 03 00 06 00    ................
 27    00000190: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
 28    000001a0: 09 00 00 00 12 00 01 00 00 00 00 00 00 00 00 00    ................
 29    000001b0: 17 00 00 00 00 00 00 00 0E 00 00 00 10 00 00 00    ................
 30    000001c0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00    ................
 31    000001d0: 24 00 00 00 10 00 00 00 00 00 00 00 00 00 00 00    $...............
 32    000001e0: 00 00 00 00 00 00 00 00 00 00 68 65 6C 6C 6F 2E 63    .........hello.c
 33    000001f0: 00 6D 61 69 6E 00 5F 47 4C 4F 42 41 4C 5F 4F 46    .main._GLOBAL_OF
 34    00000200: 46 53 45 54 5F 54 41 42 4C 45 5F 00 70 75 74 73    FSET_TABLE_.puts
 35    00000210: 00 00 00 00 00 00 00 00 07 00 00 00 00 00 00 00    ................
 36    00000220: 02 00 00 00 05 00 00 00 FC FF FF FF FF FF FF FF    ........|.......
 37    00000230: 0C 00 00 00 00 00 00 00 04 00 00 00 0B 00 00 00    ................
```

Step 4: Linking Generating Executable File:

```
ashu@Ashu-PC: ~/COE                                                    —    □    ✕
ashu@Ashu-PC:~/COE$  ld -static -o hello -L`gcc -print-file-name=` /usr/lib/x86_64-l
inux-gnu/crt1.o /usr/lib/x86_64-linux-gnu/crti.o hello.o /usr/lib/x86_64-linux-gnu/c
rtn.o --start-group -lc -lgcc -lgcc_eh --end-group
ashu@Ashu-PC:~/COE$ _
```

Running Executable File: