Practical 1

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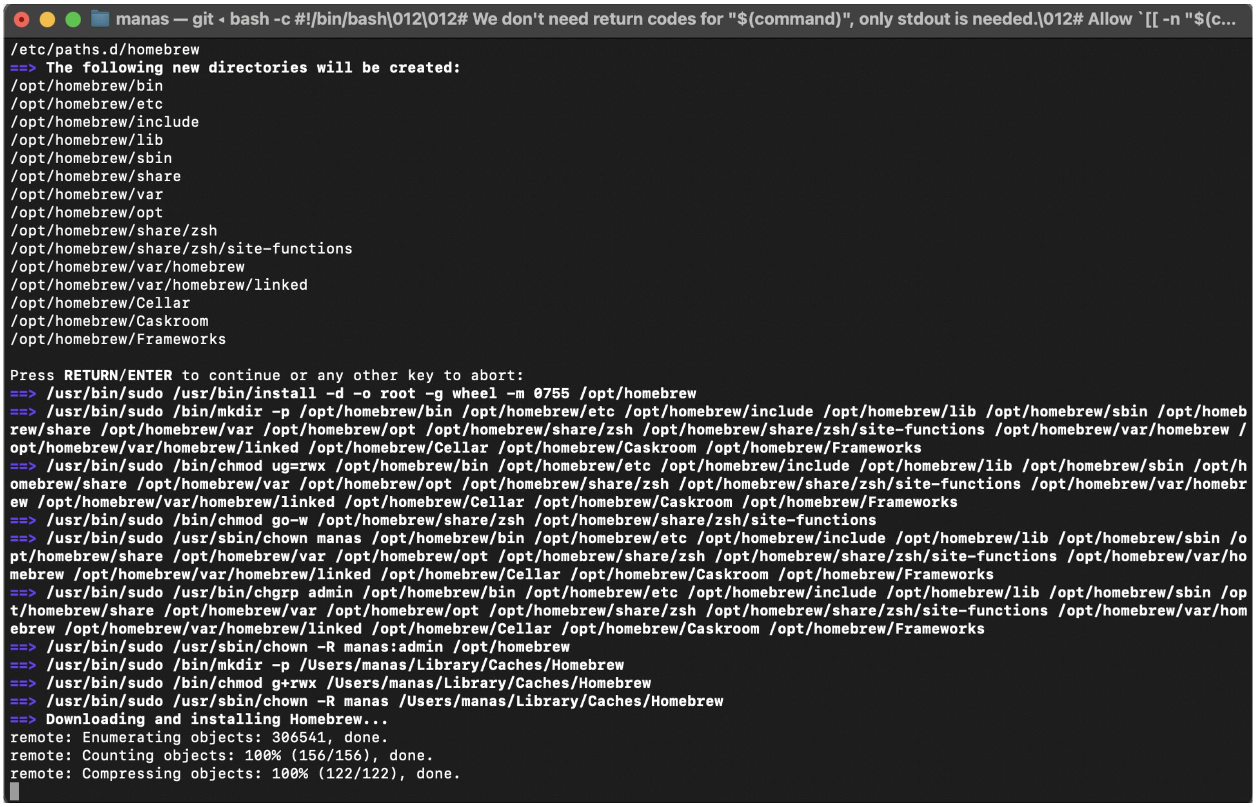
Introduction to OpenMP

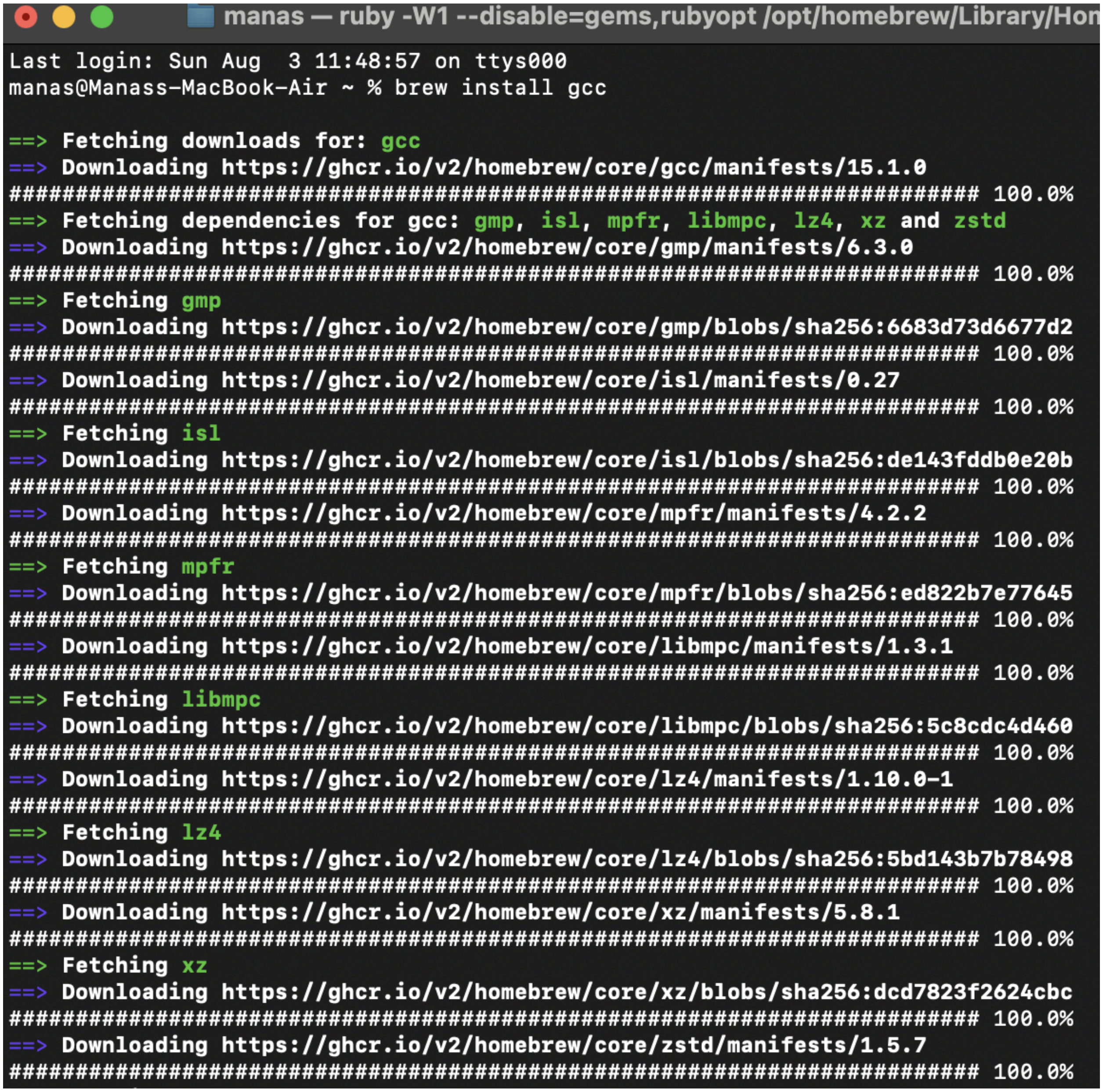
Problem Statement 1: Installation of OpenMP code in C

Installation of OpenMP:


manas — git ◂ bash -c #!/bin/bash\012\012# We don't need return codes for "$(command)", only stdout is needed.\012# Allow `[[-n "$(c...

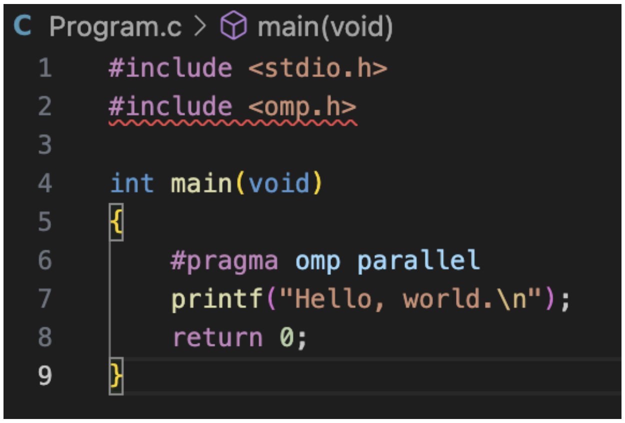
```
/etc/paths.d/homebrew
==> The following new directories will be created:
/opt/homebrew/bin
/opt/homebrew/etc
/opt/homebrew/include
/opt/homebrew/lib
/opt/homebrew/sbin
/opt/homebrew/share
/opt/homebrew/var
/opt/homebrew/opt
/opt/homebrew/share/zsh
/opt/homebrew/share/zsh/site-functions
/opt/homebrew/var/homebrew
/opt/homebrew/var/homebrew/linked
/opt/homebrew/Cellar
/opt/homebrew/Caskroom
/opt/homebrew/Frameworks

Press RETURN/ENTER to continue or any other key to abort:
==> /usr/bin/sudo /usr/bin/install -d -o root -g wheel -m 0755 /opt/homebrew
==> /usr/bin/sudo /bin/mkdir -p /opt/homebrew/bin /opt/homebrew/etc /opt/homebrew/include /opt/homebrew/lib /opt/homebrew/sbin /opt/homeb
rew/share /opt/homebrew/var /opt/homebrew/opt /opt/homebrew/share/zsh /opt/homebrew/share/zsh/site-functions /opt/homebrew/var/homebrew /
opt/homebrew/var/homebrew/linked /opt/homebrew/Cellar /opt/homebrew/Caskroom /opt/homebrew/Frameworks
==> /usr/bin/sudo /bin/chmod ug=rwx /opt/homebrew/bin /opt/homebrew/etc /opt/homebrew/include /opt/homebrew/lib /opt/homebrew/sbin /opt/h
omebrew/share /opt/homebrew/var /opt/homebrew/opt /opt/homebrew/share/zsh /opt/homebrew/share/zsh/site-functions /opt/homebrew/var/homebr
ew /opt/homebrew/var/homebrew/linked /opt/homebrew/Cellar /opt/homebrew/Caskroom /opt/homebrew/Frameworks
==> /usr/bin/sudo /bin/chmod go-w /opt/homebrew/share/zsh /opt/homebrew/share/zsh/site-functions
==> /usr/bin/sudo /usr/sbin/chown manas /opt/homebrew/bin /opt/homebrew/etc /opt/homebrew/include /opt/homebrew/lib /opt/homebrew/sbin /o
pt/homebrew/share /opt/homebrew/var /opt/homebrew/opt /opt/homebrew/share/zsh /opt/homebrew/share/zsh/site-functions /opt/homebrew/var/ho
mebrew /opt/homebrew/var/homebrew/linked /opt/homebrew/Cellar /opt/homebrew/Caskroom /opt/homebrew/Frameworks
==> /usr/bin/sudo /usr/bin/chgrp admin /opt/homebrew/bin /opt/homebrew/etc /opt/homebrew/include /opt/homebrew/lib /opt/homebrew/sbin /op
t/homebrew/share /opt/homebrew/var /opt/homebrew/opt /opt/homebrew/share/zsh /opt/homebrew/share/zsh/site-functions /opt/homebrew/var/hom
ebrew /opt/homebrew/var/homebrew/linked /opt/homebrew/Cellar /opt/homebrew/Caskroom /opt/homebrew/Frameworks
==> /usr/bin/sudo /usr/sbin/chown -R manas:admin /opt/homebrew
==> /usr/bin/sudo /bin/mkdir -p /Users/manas/Library/Caches/Homebrew
==> /usr/bin/sudo /bin/chmod g+rwx /Users/manas/Library/Caches/Homebrew
==> /usr/bin/sudo /usr/sbin/chown -R manas /Users/manas/Library/Caches/Homebrew
==> Downloading and installing Homebrew...
remote: Enumerating objects: 306541, done.
remote: Counting objects: 100% (156/156), done.
remote: Compressing objects: 100% (122/122), done.
```

Installation of GCC for running OpenMP:


manas — ruby -W1 --disable=gems,rubyopt /opt/homebrew/Library/Hon

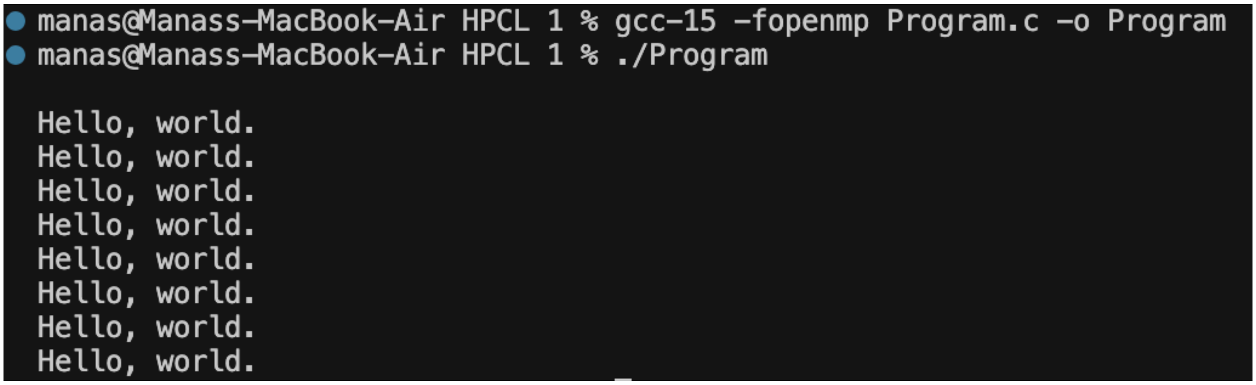
```
Last login: Sun Aug  3 11:48:57 on ttys000
manas@Manass-MacBook-Air ~ % brew install gcc

==> Fetching downloads for: gcc
==> Downloading https://ghcr.io/v2/homebrew/core/gcc/manifests/15.1.0
######################################################################### 100.0%
==> Fetching dependencies for gcc: gmp, isl, mpfr, libmpc, lz4, xz and zstd
==> Downloading https://ghcr.io/v2/homebrew/core/gmp/manifests/6.3.0
######################################################################### 100.0%
==> Fetching gmp
==> Downloading https://ghcr.io/v2/homebrew/core/gmp/blobs/sha256:6683d73d6677d2
######################################################################### 100.0%
==> Downloading https://ghcr.io/v2/homebrew/core/isl/manifests/0.27
######################################################################### 100.0%
==> Fetching isl
==> Downloading https://ghcr.io/v2/homebrew/core/isl/blobs/sha256:de143fddb0e20b
######################################################################### 100.0%
==> Downloading https://ghcr.io/v2/homebrew/core/mpfr/manifests/4.2.2
######################################################################### 100.0%
==> Fetching mpfr
==> Downloading https://ghcr.io/v2/homebrew/core/mpfr/blobs/sha256:ed822b7e77645
######################################################################### 100.0%
==> Downloading https://ghcr.io/v2/homebrew/core/libmpc/manifests/1.3.1
######################################################################### 100.0%
==> Fetching libmpc
==> Downloading https://ghcr.io/v2/homebrew/core/libmpc/blobs/sha256:5c8cdc4d460
######################################################################### 100.0%
==> Downloading https://ghcr.io/v2/homebrew/core/lz4/manifests/1.10.0-1
######################################################################### 100.0%
==> Fetching lz4
==> Downloading https://ghcr.io/v2/homebrew/core/lz4/blobs/sha256:5bd143b7b78498
######################################################################### 100.0%
==> Downloading https://ghcr.io/v2/homebrew/core/xz/manifests/5.8.1
######################################################################### 100.0%
==> Fetching xz
==> Downloading https://ghcr.io/v2/homebrew/core/xz/blobs/sha256:dcd7823f2624cbc
######################################################################### 100.0%
==> Downloading https://ghcr.io/v2/homebrew/core/zstd/manifests/1.5.7
######################################################################### 100.0%
```

OpenMP Program in C:



```c
#include <stdio.h>
#include <omp.h>

int main(void)
{
    #pragma omp parallel
    printf("Hello, world.\n");
    return 0;
}
```

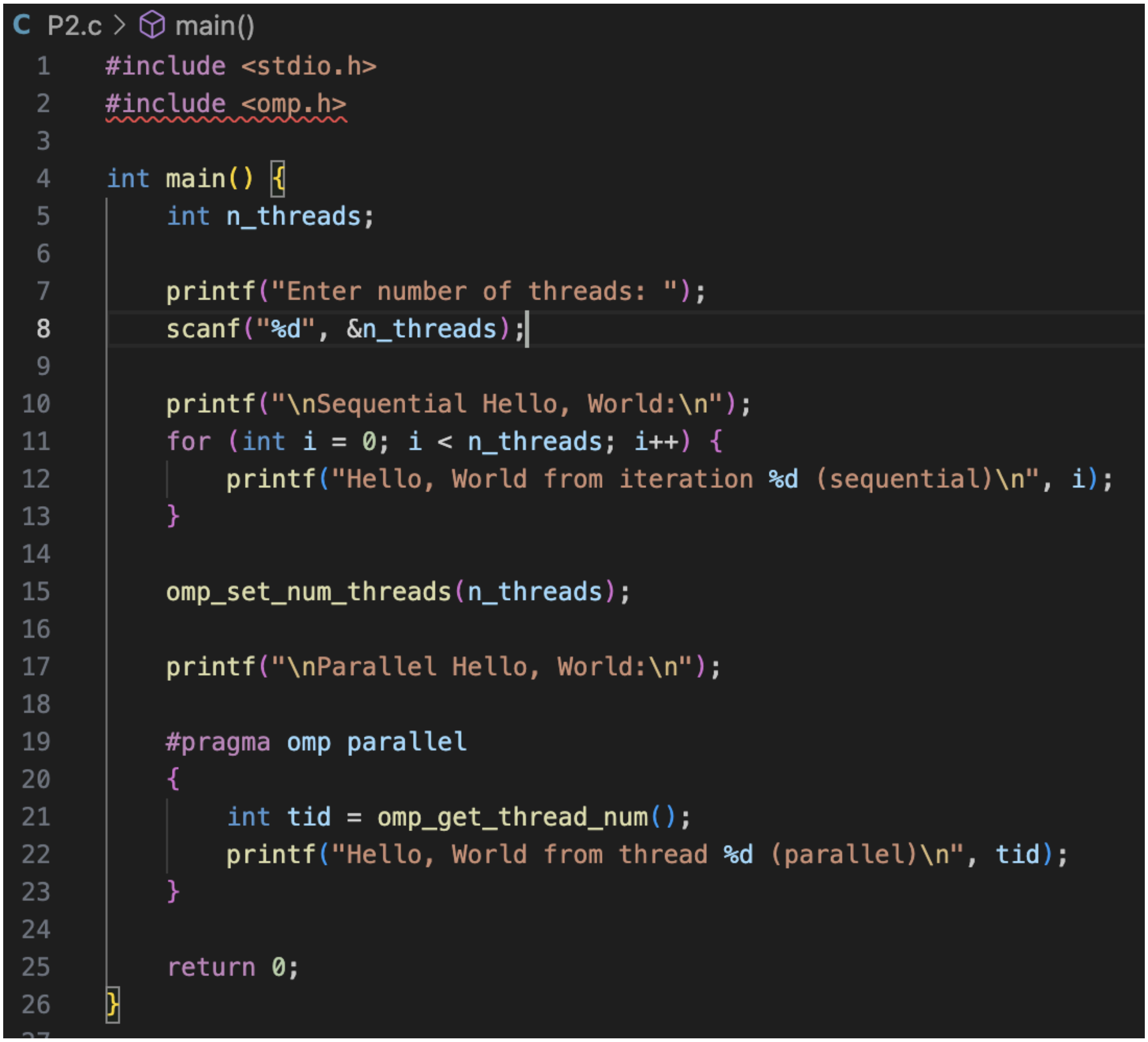
Output of the Program:



```
● manas@Manass-MacBook-Air HPCL 1 % gcc-15 -fopenmp Program.c -o Program
● manas@Manass-MacBook-Air HPCL 1 % ./Program

  Hello, world.
  Hello, world.
  Hello, world.
  Hello, world.
  Hello, world.
  Hello, world.
  Hello, world.
  Hello, world.
```

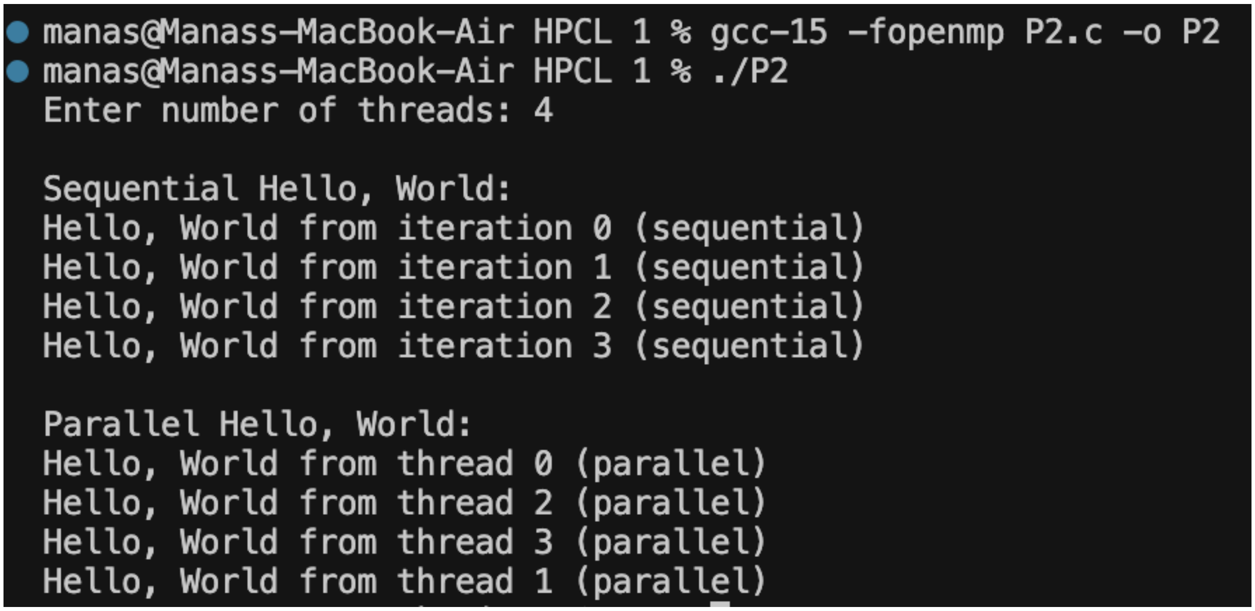
Problem Statement 2: Print Hello, World in Sequential and Parallel in OpenMP

Program:



```c
#include <stdio.h>
#include <omp.h>

int main() {
    int n_threads;

    printf("Enter number of threads: ");
    scanf("%d", &n_threads);

    printf("\nSequential Hello, World:\n");
    for (int i = 0; i < n_threads; i++) {
        printf("Hello, World from iteration %d (sequential)\n", i);
    }

    omp_set_num_threads(n_threads);

    printf("\nParallel Hello, World:\n");

    #pragma omp parallel
    {
        int tid = omp_get_thread_num();
        printf("Hello, World from thread %d (parallel)\n", tid);
    }

    return 0;
}
```

Output:



```
manas@Manass-MacBook-Air HPCL 1 % gcc-15 -fopenmp P2.c -o P2
manas@Manass-MacBook-Air HPCL 1 % ./P2
Enter number of threads: 4

Sequential Hello, World:
Hello, World from iteration 0 (sequential)
Hello, World from iteration 1 (sequential)
Hello, World from iteration 2 (sequential)
Hello, World from iteration 3 (sequential)

Parallel Hello, World:
Hello, World from thread 0 (parallel)
Hello, World from thread 2 (parallel)
Hello, World from thread 3 (parallel)
Hello, World from thread 1 (parallel)
```

Analysis:

- Takes user input for number of threads.
- Prints "Hello, World" sequentially that many times (one by one).
- Sets OpenMP to use that many threads.
- Prints "Hello, World" in parallel, where each thread prints its own line.
- scanf() → takes user input.
- omp_set_num_threads(n) → sets thread count at runtime.
- #pragma omp parallel → creates multiple threads.
- omp_get_thread_num() → gets each thread's ID.

Problem Statement 3: Calculate theoretical FLOPS of your system on which you are running the above codes.

FLOPS = Floating Point Operations Per Second
It's a measure of your system's **computational performance**, how many floating-point operations it can perform **per second**.

Theoretical FLOPS=T×f×I

penMP "Hello, World" code **does not perform floating point calculations**, so its **actual FLOPS ≈ 0**.