(B)

1. **(C++ and Pipeline processors)** Explain the following questions:
   (a) Explain how c++ works from source code to executable file.

   (b) What is the difference between compiler, Assembler and linker?

   (c) Discuss and calculate the **execution time difference** of the following assembly code running on a 2.5 GHz processor designed **with** and **without** a 5 stages pipeline (IF, ID, EX, M and W).

```
// ADD TWO INTEGER ARRAYS
LW R4, # 400
L1:
LW R1, 0 (R4) ; --Load first operand
LW R2, 400 (R4) ;-- Load second operand
ADDI R3, R1, R2 ; --Add operands
SW R3, 0 (R4) ; --Store result
SUB R4, R4, #4 ; --Calculate address of next element
BNEZ R4, L1 ; --Loop if (R4) != 0
```

   (d) What kind of hazards exist in the given code? Provide an efficient technique to solve these hazards.

2. **SPI:** Assume you want to send data between a microcontroller and small peripheral device for example a shift register. One problem is that the shift registers and microcontroller use separate clock sources. So, there is no guarantee that both sides can synchronize data transferred and it can lead to data lost.
   (a) According to the above scenario, propose an **asynchronous** solution to communicate between peripheral device and microcontroller.

   (b) Try to provide a **synchronous** solution and determine which ports do we need to have a synchronous connection.

   (c) If you want to develop system from one-way communication to two-way communication, meaning that sending data back in the opposite direction how you will do that?

3. Compare and contrast the SPI and I2C serial busses in terms of their hardware architecture and protocols.

4. Write an assembly language level pseudocode for multiplying two unsigned 8-bit numbers on a processor with 8-bit registers without a multiply instruction.