1. **[CLO 1]** Put your answers in the rectangle boxes shown on the right at the end of each part:

   (a) A microprocessor has an address bus of 16 bits and a data bus of 8-bits. What is the address space of the microprocessor? (the maximum memory in bytes that it can address).

   (b) A digital computer has 2 GB memory connected to it. The memory is word addressable. [4] (1 word=4 bytes).

   i. What should be the minimum size of its address bus?

   ii. What should be the size of the data bus?

   (c) A digital computer has a common bus system for 16 registers of 32 bits each. Bus is constructed using many multiplexers. [4]

   i. How many Multiplexers are required to implement the bus?

   ii. What should be the size of each Multiplexer?

   (d) Assume that we have a very large program with the following characteristics: [8]

   Instruction Count = 5.5 billion

   Instruction Type 1: 42%, CPI = 1

   Instruction Type 2: 37%, CPI = 2

   Instruction Type 3: 21%, CPI = 3

   Clock Rate: 2.4 GHz

   Calculate the average CPI and total execution time (in seconds) for that program. Show your working below.

   Average CPI:

   Execution Time:

2. **[CLO1]** A 32-bit register holds a hexadecimal number $\texttt{C1680000}_{sixteen}$. What will be the equivalent decimal value if the data is stored in IEEE-754 floating-point format. [10]

4. **[CLO 2]:** Assume that an array A has some integer data stored in it as shown in Figure 1 (Each data word comprises of 4 bytes). Further note that processor register x6 holds the starting memory address of the array.

Contents of Array A before the execution of the code

[0]	00000FC8
[1]	00000123
[2]	43009ABC
[3]	11223344
[4]	00000000
[5]	ABCDEF00
[6]	00000000

Figure 1

Now consider the following RISC assembly code segment:

```
lw x1, 0(x6)
lw x2, 4(x6)
add x3, x1, x2
sw x3, 12(x6)
lw x4, 8(x6)
sub x5, x4, x1
sw x5, 16(x6)
```

Note that `lw` loads one 32-bit data word from memory to a register while `sw` stores one 32-bit data word from register to memory.

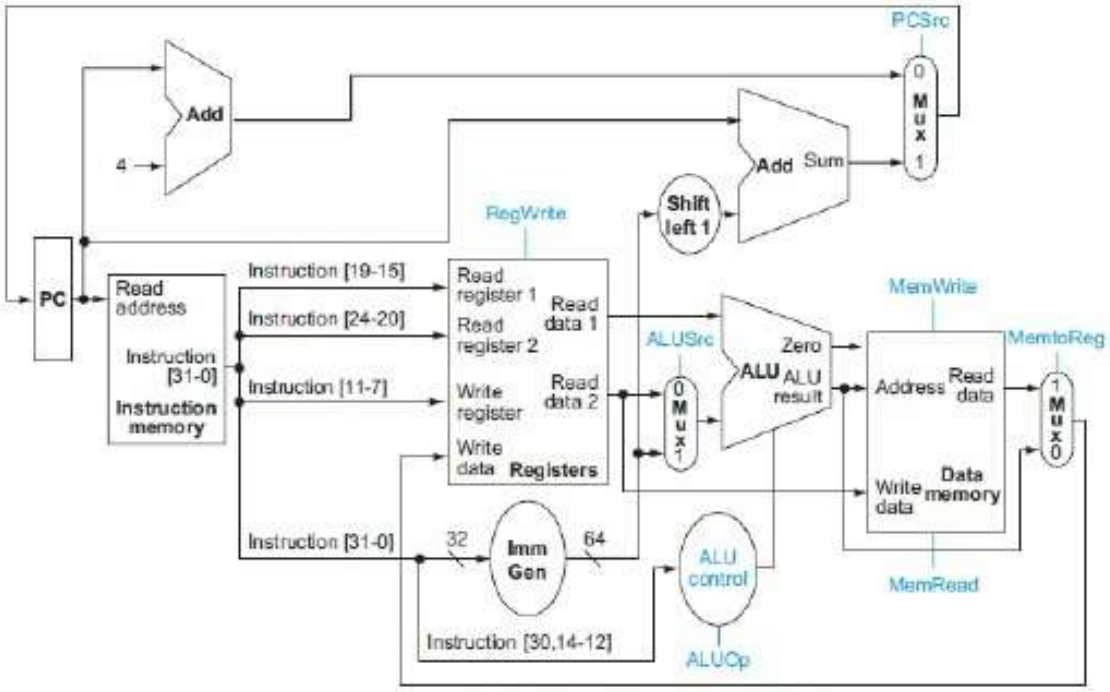
(a) Write down the Register Transfer Operations for each assembly instruction. [5]

(b) Write down the C language code for the assembly code written above. [5]

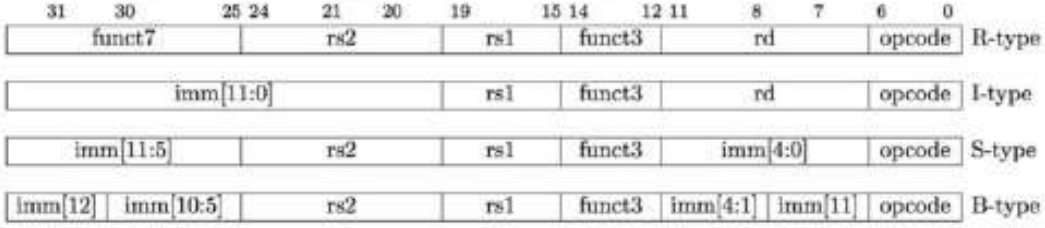
(c) Does this code modifies the array A? If yes, what will be the updated contents of the array A after the execution of the program? [5]

(d) What will be the values of the first six integer registers (x1, x2, x3, x4, x5 and x6) at the end of this program? [5]

5. **[CLO2]** Datapath (with control signals) for the single-cycle RISC processor is shown. [20]



The basic four instruction formats are as shown below for your reference.



Fill-in the control signals values (either 0 or 1) in the table for different the instructions written in the first column. Assume that both the registers x6 and x7 hold the same value.

Instruction	PCSrc	RegWrite	RegWrite	ALUSrc	MemWrite	MemRead	MemtoReg
`ld x3, 4(x2)`							
`add x5, x3, x4`							
`sd x5, 4(x2)`							
`beq x6, x7, target`							

4. [**CLO 2**]: Convert the following C language code into RISC-V assembly.

```
f = g + B[4];

h = f + A[2];
```

Assume that the variables f, g, h, i and j are assigned to registers x1, x2, x3, x4 and x5 respectively. Further assume that the address of arrays A and B are in registers x6 and x7.