1. Explain why ,in MARIE, the MAR is only 12 bits wide while the AC is 16 bits wide. Hint: Consider the difference between data and addresses

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The MAR is only 12 bits wide because it stores only the addresses of data. MARIE memory is limited to 4096 address locations, so the MAR only needs to be 12 bits wide to hold the largest address while the AC is 16 bits wide because it holds data and a 4 bit opcode to the left which specifies how the data at a specific address will be manipulated.(8 bits = 256 address locations,12 bits = 4,096 address locations, 16bits = 65,536 address locations)

2. Explain the steps of the fetch-decode-execute cycle. Your explanation should include what is happening in the various registers.

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For the model of computer execution instruction, there are three main steps (fetch, decode, execute).

- Fetch
    - This is the first step, which the CPU use the Program Counter (PC) as the pointer to the address of memory which are the storage of the next instruction, and then it retrieves the upcoming instruction from memory and loads it into the Instruction Register (IR).
- Decode
    - The instruction that was loaded into the Instruction Register (IR) in Fetch process are then analysed by the CPU. The instruction is broken down into a single component afterwards, which this include opcode (the instruction that is executed by a CPU) and operands (the address that is used for instruction execution). This information is stored in Instruction Register (IR) and will be used in the next step.
- Execute
    - The Execute stage is where data processing happens. CPU performs the operations that are generated by opcode and operand. In this step Arithmetic Logic Unit (ALU) is used to perform the operation of arithmetic and logic on the data. This was followed by the Control Unit (CU), which is used for managing the sequences of the instructions and also for the data movement between memory and registers.

3. Draw the timing diagram for MARIE's Load instruction using the format of Figure 4.16.

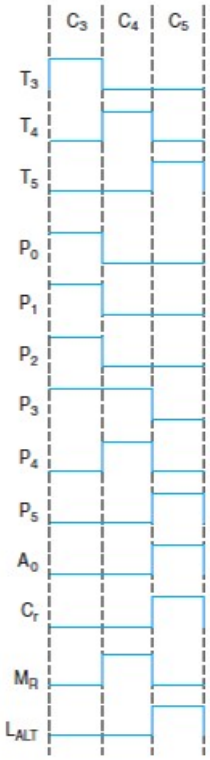

FIGURE 4.16 Timing Diagram for the Microoperations of MARIE's Add Instruction

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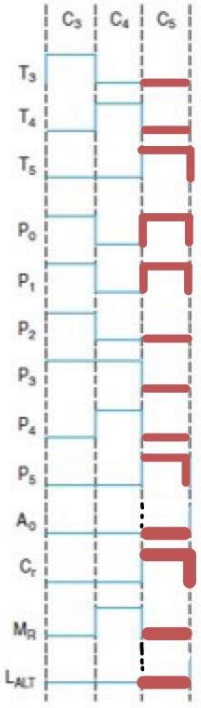

FIGURE 4.16 Timing Diagram for the Microoperations of MARIE's Add Instruction

4. The table below provides a summary of MARIE's datapath control signals. Using this information, Table 4-9, and Figure 4.20 as guides draw the control logic for MARIE's Load instruction.

Register Signals	Memory	MAR	PC	MBR	AC	IN	OUT	IR
$P_2P_1P_0$ (Read) $P_5P_4P_3$ (Write)	000	001	010	011	100	101	110	111

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