**Q1) What is a Register? Explain different types of CPU registers.**

**Answer:**

A register is a **small, fast storage unit inside the CPU** used to hold data temporarily during instruction execution.

**Types of Important Registers:**
1. **PC — Program Counter**
   Stores address of next instruction.
2. **IR — Instruction Register**
   Holds current fetched instruction.
3. **MAR — Memory Address Register**
   Holds memory address used for read/write.
4. **MDR/MBR — Memory Data Register**
   Stores data coming from or going to memory.
5. **AC — Accumulator**
   Holds intermediate arithmetic/logic results.
6. **General Purpose Registers**
   Temporary data storage (R0, R1, R2…)

Registers increase execution speed because **they are faster than memory**.

**Q2) Explain Register Transfer Language (RTL) with examples.**

**Answer:**

Register Transfer Language (RTL) is a symbolic language used to **describe data movement between registers and memory**.

**Examples:**

R1 ← R2
 Copy content of R2 into R1.

R3 ← R1 + R2
 Perform addition & store in R3.

PC ← PC + 1
 Increment program counter.

**Types of Transfers:**

1. Register → Register
   R1 ← R2
2. Memory → Register
   R1 ← M[1000]
3. Register → Memory
   M[2000] ← R4

CPU uses an internal **bus** for transfers.

**Q3) What are micro-operations? Explain types with examples.**

**Answer:**

Micro-operations are **small internal operations performed on register data**.

There are three major types:

**1) Arithmetic Micro-operations**

Perform arithmetic:

• Addition → R1 ← R1 + R2
• Increment → R1 ← R1 + 1
• Decrement → R2 ← R2 - 1

Executed in **ALU**

**2) Logic Micro-operations**

Perform bitwise operations:

• R1 ← R1 AND R2
• R1 ← R1 OR R2
• R1 ← NOT R1

Used for masking, comparison, bit manipulation

### 3) Shift Micro-operations

Shift bits left/right:

• R1 ← SHL R1
 • R1 ← SHR R1

 Used in multiplication/division & rotate operations

## Q4) Explain Arithmetic Logic Shift Unit (ALSU).

**Answer:**

ALSU is a unit inside CPU that performs:

Arithmetic operations
Logical operations
Bit shifting operations

**Diagram idea (exam me draw karna):**

Registers → ALSU → Result

It combines **ALU + Shifter**, improving processor efficiency.

## Q5) Explain Instruction Cycle in detail.

**Answer:**

Instruction Cycle is CPU execution process:

### 1) Fetch Phase

• PC stores instruction address
 • Instruction fetched into IR

### 2) Decode Phase

• CU decodes opcode & operand location

### 3) Execute Phase

• ALU/memory performs required operation

**4) Interrupt Check Phase**

• If I/O/Timer interrupt occurs, CPU handles it

**Cycle Loop:**

Fetch → Decode → Execute → Next Instruction

## Q6) Explain Instruction Format and Addressing Modes.

**Answer:**

Instruction format includes:

✔ Opcode (action)
✔ Operand/address field
✔ Mode bits

**Addressing Modes:**

1. **Immediate**
   Operand inside instruction.
   Example: MOV A,#5
2. **Direct**
   Instruction holds **memory address**.
   Example: LOAD A,1000
3. **Indirect**
   Instruction points to an address containing actual address.
4. **Register**
   Operand stored in register.
   Example: ADD A,B
5. **Register Indirect**
   Register holds memory address.
6. **Indexed**
   Effective address = base + index

## Q7) Explain register transfer bus & memory transfer mechanism.

**Answer:**

Registers connect through a **common internal bus**.

*Register Transfer:*

R1 ← R2 means
 R2 places value on bus → R1 reads data from bus.

*Memory Transfer:*

Memory Read:

MAR ← address

Read signal

MDR ← data

R1 ← MD

Memory Write:

MAR ← address

MDR ← data

Write signal

## Q8) Explain Computer Instructions – Register, Memory & I/O reference.

**Answer:**

**Memory Reference Instruction**
 Operand in memory
 Example: LOAD, STORE

**Register Reference Instruction**
 Operand in register
 Example: CLR A, CMA

**I/O Instruction**
 Data exchange with devices
 Example: IN PORT, OUT PORT

**Medium Questions**

**1. What is RTL? Give examples.**

RTL (Register Transfer Language) is a symbolic notation used to represent data transfers and operations performed between registers.

**Example:**

- `R1 ← R2`
- `PC ← PC + 1`

**2. Define micro-operations.**

Micro-operations are basic operations performed on data stored in registers, such as shift, add, move, or increment.

**3. Explain arithmetic micro-operations.**

Arithmetic micro-operations perform mathematical calculations on register data. Examples include addition, subtraction, increment, and decrement.
Example: `R1 ← R1 + R2`

**4. Differentiate register & memory transfer.**

| Register Transfer | Memory Transfer |
|---|---|
| Data transfers between registers | Data transfers between CPU registers and memory |
| Faster | Slower |
| Example: `R1 ← R2` | Example: `R1 ← M[200]` |

**5. Explain shift operations.**

Shift operations move bits in a register either to the left or right. Types include:

- Logical shift
- Arithmetic shift
- Circular/rotate shift

**6. What is an instruction cycle?**

An instruction cycle is the complete process of executing an instruction which includes:

**Fetch → Decode → Execute → Store**

**7. What is PC? What does it store?**

The **Program Counter (PC)** is a register that stores the **address of the next instruction** to be executed.

**8. Write any 4 addressing modes.**

1. Immediate Addressing
2. Direct Addressing
3. Indirect Addressing
4. Register Addressing
   (Indexed is another example)

**9. What is IR and MAR?**

- **IR (Instruction Register):** Holds the current instruction being executed.
- **MAR (Memory Address Register):** Holds the memory address where data is to be read or written.

**10. Explain interrupt concept.**

An interrupt is a mechanism in which the CPU temporarily stops its current task to handle a higher-priority event, services it, and then resumes its previous work.

**★ Short Answers**

**1. Define register.**

A register is a small, fast storage element inside the CPU used to hold data temporarily.

**2. What is program counter?**

The PC is a register that holds the address of the next instruction to be executed.

### 3. What is ALSU?

ALSU (Arithmetic Logic and Shift Unit) performs arithmetic, logical, and shift operations inside the CPU.

### 4. Give example of RTL notation.

Example: `R1 ← R2`

### 5. What is decode phase?

Decode phase is the stage where the CPU interprets the fetched instruction to understand what operation to perform.

### 6. Define instruction.

An instruction is a command given to the CPU to perform a specific operation.

### 7. Expand IR / MAR / MDR.

- IR = Instruction Register
- MAR = Memory Address Register
- MDR = Memory Data Register

### 8. Write indirect addressing.

In indirect addressing, the address of the operand is stored in another register or location.
 Example: `MOV R1, [R2]`

### 9. Write immediate addressing with example.

In immediate addressing, the operand is directly given in the instruction.
 Example: `MOV R1, 5`

### MCQ Type Questions

1. Which register holds next instruction address? → **PC**
2. RTL R1 ← R2 means? → **R1 gets value of R2**
3. Which performs arithmetic? → **ALU**
4. Shift operation moves bits? → **Left/Right**
5. Immediate mode mein operand kahan hota? → **Inside instruction**
6. ALU + Shifter = ? → **ALSU**

7. Which phase decodes opcode? → **Decode**
8. MDR stores? → **Data**