4 Processor Fundamentals – Part 2

Name: ______________ Class: __________ Date: ____________

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
machine code	机器码			
Assembly language	汇编语言			
mnemonics	助记符			
assembler	汇编器			
opcode	操作码			
operand	操作数			
addressing mode	寻址方式			
immediate addressing	立即寻址			
direct addressing	直接寻址			
indexed addressing	变址寻址			
logical shift	逻辑移位			
mask	掩码			

Recall

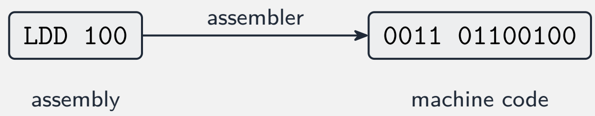
In **Part 1** you met the Von Neumann CPU (ALU, control unit, registers like the PC and accumulator), the fetch–execute cycle, and the three buses. Part 2 looks at the language the CPU runs, how it finds its data, and working on single bits —the level a real processor actually works at.

New ideas

Read these first. Each idea has a short worked example. Then do the Practice.

1 Machine code and assembly language

The CPU actually runs **machine code** 机器码—bit patterns. **Assembly language** 汇编语言 is a readable form with one instruction each, written using short **mnemonics** 助记符 like `LDD`, `ADD`, `JMP`. An **assembler** 汇编器 translates the assembly into machine code.

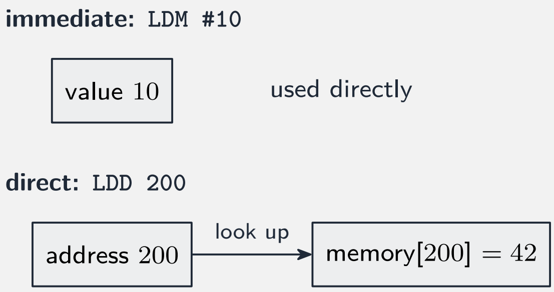


Worked example. The assembler turns the readable `ADD 100` into a pattern of bits: an **opcode** 操作码 part that means ”ADD”, and an **operand** 操作数 part that holds 100.

2 Addressing modes

The **addressing mode** 寻址方式 says how the CPU finds the operand of an instruction:

- **immediate addressing** 立即寻址—the value is *in* the instruction (`LDM #10` loads the number 10);
- **direct addressing** 直接寻址—the instruction holds an *address*; the operand is the value stored there (`LDD 200`);
- **indexed addressing** 变址寻址—the address is a base plus an index register, used to step through an array.



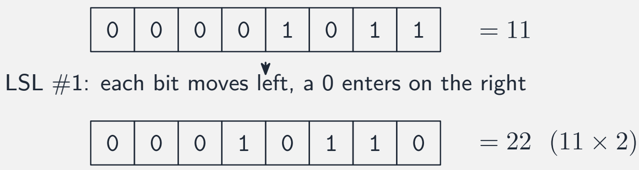
Worked example. Suppose memory location 10 holds the value 99. Then `LDM #10` loads 10 (the number written in the instruction), but `LDD 10` loads 99 (the value found at address 10) —same number, very different result.

Watch out: the `#` changes everything. `LDM #10` uses the number 10; `LDD 10` uses whatever is *stored at* address 10.

■ 3 Binary shifts and bit masks

A **logical shift** 逻辑移位 moves all the bits left or right, filling the empty places with 0:

- left by 1 → multiply by 2; right by 1 → integer divide by 2.



A **mask** 掩码 lets you change one chosen bit: **OR** with a mask **sets** a bit, **AND** with a mask **clears** a bit, **XOR** with a mask **toggles** a bit.

Worked example. To set bit 0 of `01000000` without touching the rest, OR it with the mask `00000001`: the result is `01000001`.

Practice

4.1 State what an assembler does. [1]

4.2 State which bitwise operation (AND, OR or XOR with a mask) is used to **set** a chosen bit to 1. [1]

4.3 State what each instruction loads: (a) `LDM #10`, (b) `LDD 200`. [2]

4.4 Apply `LSL #1` (left shift by one) to `00001011`. Give the result and the arithmetic operation it performs. [2]

4.5 Apply `LSR #1` (right shift by one) to `00011000`. Give the result and the operation it performs. [2]

4.6 Explain *why* a logical left shift by one is the same as multiplying by 2. [2]

4.7 Challenge. Show how to multiply 5 (`00000101`) by 4 using a logical shift. Give the shift used and the final byte. [2]