

4.2 Assembly Language

Name: _____ Class: _____ Date: _____

Total: 19 marks

Objective

Build the skills to answer exam questions on **assembly language** 汇编语言—how it relates to machine code, the two-pass assembler, the modes of addressing, and tracing a program.

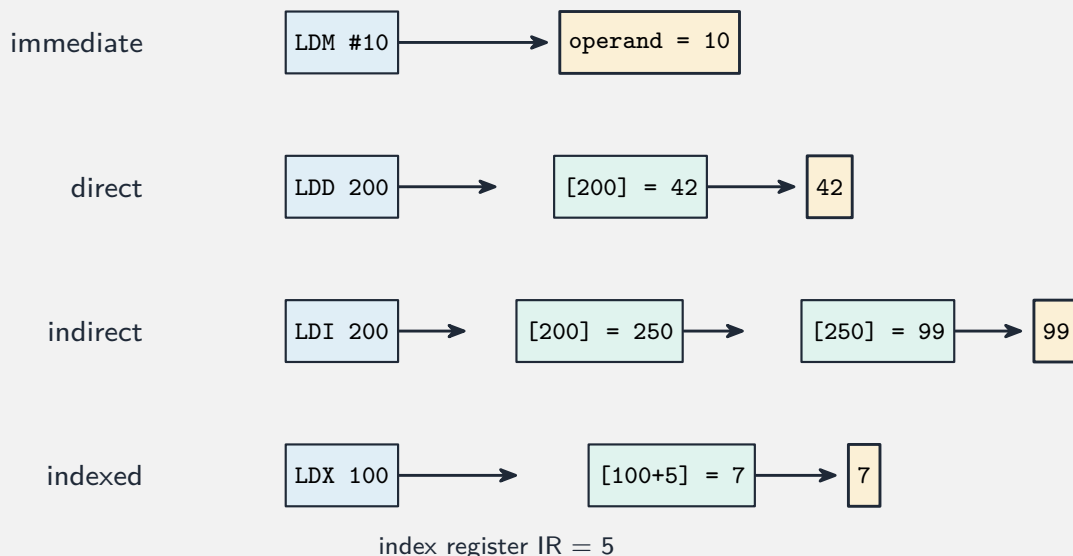
You must be able to:

- explain the relationship between **assembly language** and **machine code** 机器码
- describe the stages of a **two-pass assembler**
- use the **modes of addressing** (immediate, direct, indirect, indexed)
- **trace** a simple assembly-language program

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Assembly, machine code and the assembler



Assembly instructions use addressing modes to locate their operands

The CPU runs **machine code** (binary). **Assembly language** is a readable form—one **mnemonic** 助记符 (like LDD, ADD) per machine instruction. An **assembler** translates it. A **two-pass assembler** reads the source twice:

- **Pass 1** builds a **symbol table**—it records the address of every **label** (e.g. LOOP:).
- **Pass 2** generates the code—and when an instruction uses a label (e.g. JMP LOOP), it looks the address up.

Two passes are needed for **forward references**—a jump to a label that is defined *later* in the code.

■ Modes of addressing

The addressing mode says **how the operand is found**:

Mode	The operand is...	Example
immediate	the value in the instruction	LDM #10 → loads 10
direct	the value at the given address	LDD 200 → loads contents of 200
indirect	at the address <i>stored</i> at the given address	LDI 200
indexed	at address + index register (IX)	LDX 100, IX = 5 → reads 105

■ Common instructions

You will also meet these in traces (the exam gives the full list):

Mnemonic	What it does
STO <addr>	store the ACC into the address
ADD / INC / DEC	add to / add 1 to / subtract 1 from
CMP <addr>	compare the ACC with the contents of the address
JMP / JPE / JPN	jump always / jump if the last compare was equal / not equal
IN / OUT	input / output one character (its ASCII value)
END	stop the program

■ Tracing a program

Make a table with a column for the **ACC** and for each variable, then step through, updating after each instruction. Trace this (start: num1 = 6, num2 = 9):

Instruction	ACC	total
LDM #0	0	
STO total	0	0
LDD num1	6	0
ADD num2	15	0
STO total	15	15

So **total** ends as **15**.

2 Practice

Now apply the methods above.

2.1 State the difference between **assembly language** and **machine code**. [2]

2.2 State what each instruction loads into the ACC: (a) LDM #20 (b) LDD 20. [2]

2.3 Explain why an assembler needs **two passes**. [2]

2.4 LDX 100 is executed when the index register IX = 4. State which address is read. [1]

3 Exam-style questions

3.1 (a) Describe what happens in **pass 1** and in **pass 2** of a two-pass assembler. [4]

(b) State why two passes are needed. [1]

3.2 Explain the difference between **immediate**, **direct** and **indirect** addressing. [3]

3.3 Trace this program (start: a = 10, b = 4) and complete the table. [3]

Instruction	ACC	c
LDD	a	
ADD	b	
STO	c	
END		

3.4 Give one reason a programmer might write part of a program in assembly language rather than a high-level language. [1]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **4.2 Assembly Language** past-paper sheet in the Library, or try these in **Practice mode**:

- 9618/11 J24 —Q4 (instruction set and tracing)
- 9618/12 J25 —Q7 (modes of addressing)
- 9618/13 J25 —Q5 (trace an assembly program)
- 9618/12 N24 —Q8 (assembly language)

Solutions

2.1 Machine code is **binary** that the CPU runs directly; assembly language is a **readable** version using mnemonics, with one instruction per machine instruction.

2.2 (a) the value **20** (immediate). (b) the **contents of address 20** (direct).

2.3 A jump can refer to a label defined **later** (a forward reference); pass 1 records every label's address first, so pass 2 can fill it in.

2.4 Address **104** ($100 + IX\ 4$).

3.1 (a) **Pass 1:** scan the source and build the symbol table —record the address of each label; do not generate code yet. **Pass 2:** translate each instruction to machine code, looking up label addresses in the symbol table.

(b) To resolve **forward references** (a jump to a label defined later).

3.2 Immediate = the operand **is the value** in the instruction; direct = the operand is at the **address** given; indirect = the address given holds **another address**, which holds the data.

3.3 LDD **a** → ACC 10, c —; ADD **b** → ACC 14, c —; STO **c** → ACC 14, c 14; END → c 14.

3.4 e.g. to control hardware directly / for speed / for a small, tight routine.