

Assignment 1
Computer Organization
Deadline: 11:55pm, Monday, Oct 08, 2024

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1. 1) Define what a Turing machine is. 2) What does UTM stand for? Explain what it is. (10 points)

- a. A Turing machine is a mathematical model of computation describing an abstract machine that manipulates symbols on a strip of tape according to a table of rules.
- b. UTM stands for Universal Turing Machine.
Turing described a Turing machine that could simulate all other Turing machines.

2. Describe the seven levels of transformations of a computer system. (10 points)

Level 6. User (Executable Programs)
Level 5. High-Level Language (C++, Java, etc.)
Level 4. Assembly Language (Assembly Code)
Level 3. System Software (Operating System, Library Code)
Level 2. Machine (Instruction Set Architecture)
Level 1. Control (Microcode or Hardwired)
Level 0. Digital Logic (Circuits, Gates, etc.)

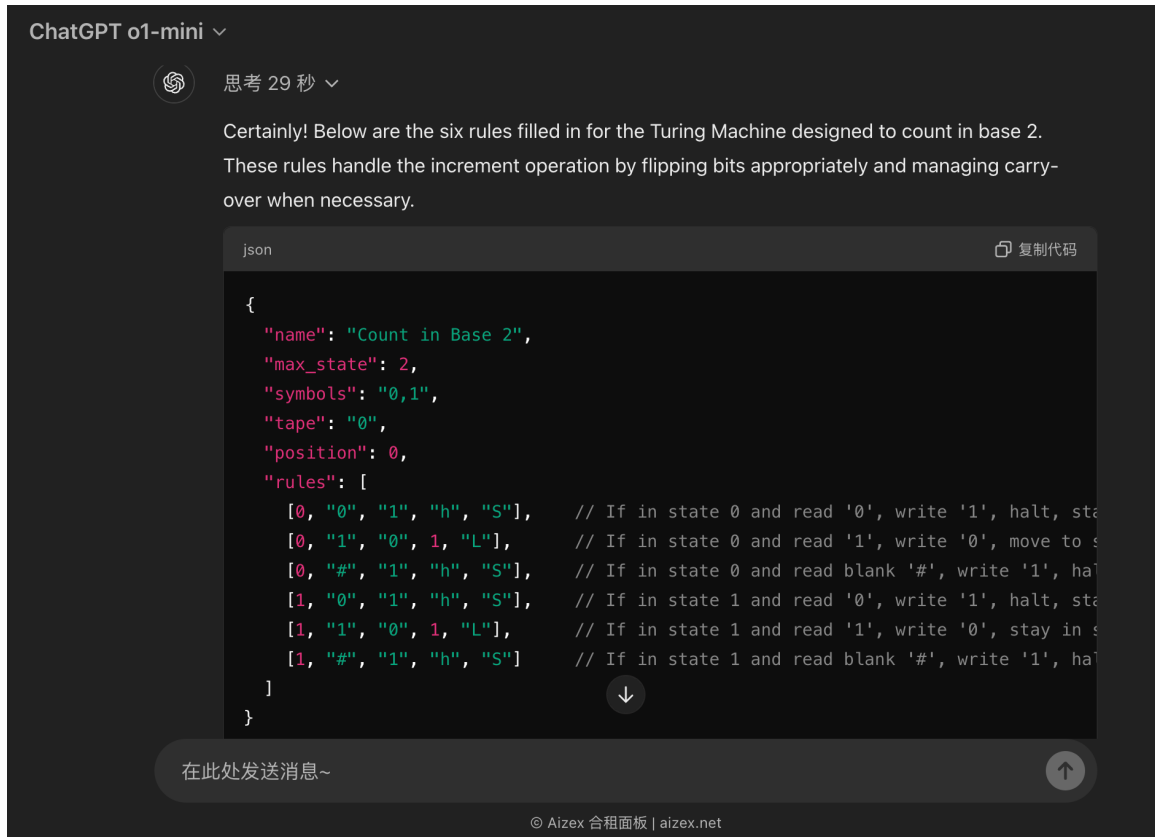
The seven levels of transformations in a computer system show how we go from recognizing a problem to creating a physical device that solves it. It all begins with understanding the issue and crafting an algorithm. Then, we turn that algorithm into a program, which is linked to an instruction set architecture. This architecture is broken down into a microarchitecture, which further translates into circuits. Finally, those circuits come together to form the actual physical devices we use.

3. Explain the fetch-decode-execute cycle of the von Neumann Architecture. (10 points)

- a. the control unit fetches the next instruction from the memory
- b. the instruction is decoded into a language that the ALU understands
- c. data operands are fetched from the memory into the registers inside CPU
- d. the ALU executes the instruction and places the result into the registers or memory

4. Given 8 bits, represent the numbers +53 and -109 into binary using the following approach: 1) Signed-magnitude; 2) One's complement; 3) Two's complement. Show your steps. (12 points)

- a. Signed-magnitude



a)

- 2) Do you think the answer provided is correct? If yes, test it on the website we used in the lab. If not, modify it accordingly. After making your adjustments, paste the runnable JSON content below. (6 points)

```

{
  "name": "Count in Base 2",
  "max_state": 2,
  "symbols": "0,1",
  "tape": "0",
  "position": 0,
  "rules": [
    [ 0, "#", "1", 1, "R" ],
    [ 0, "0", "1", 1, "R" ],
    [ 0, "1", "0", 0, "L" ],
    [ 1, "#", "#", 0, "L" ],
    [ 1, "*", "*", 1, "R" ]
  ]
}

```

- 3) Compare this Turing Machine program with Lab0 Exercise 2. Are there any differences? (4 points)

a) Yes, there is a difference in the initial tape contents.

In Lab0 Exercise 2, the Turing machine program starts with an empty tape.

In this Turing machine program, it starts with a tape containing “0”.
Because the max_state is only 2. If max_state is 3, this Turing machine program can start with an empty tape and count “0”.

7. Show that $xz = (x + y)(x + \bar{y})(\bar{x} + z)$
- 1) Using truth table; (5 points)
 - 2) Using Boolean identities; (5 points)
 - 3) Use ChatGPT or other generative AI tools to attempt the proof and attach a screenshot of your attempt. (5 points)

(1)

x	y	z	xz	$(x+y)(x+\bar{y})(\bar{x}+z)$
0	0	0	0	0
0	0	1	0	0
0	1	0	0	0
0	1	1	0	0
1	0	0	0	0
1	0	1	1	1
1	1	0	0	0
1	1	1	1	1

(2)

$$\text{RHS} = (x + y)(x + \bar{y})(\bar{x} + z) = x(\bar{x} + z) = x\bar{x} + xz = xz$$

$$\text{LHS} = xz$$

$$\text{LHS} = \text{RHS}$$

$$\text{Q.E.D.}$$

(3)

ChatGPT ▾



To prove the given Boolean algebra expression:

$$xz = (x + y)(x + \bar{y})(\bar{x} + z)$$

we will simplify the right-hand side and check if it is equivalent to xz .

Step 1: Expand the expression

We can simplify the right-hand side step by step using Boolean algebra rules (Distributive Law, De Morgan's Theorem, etc.).

First, expand the first two terms $(x + y)(x + \bar{y})$:

$$(x + y)(x + \bar{y}) = x(x + \bar{y}) + y(x + \bar{y}) = x + x\bar{y} + yx + y\bar{y}$$

Now simplify:

$$x + x\bar{y} + yx + 0 = x + yx = x$$

So we get:

$$(x + y)(x + \bar{y}) = x$$

Now substitute this into the remaining term:

$$\downarrow \bar{x} + z)$$



给“ChatGPT”发送消息



ChatGPT 也可能会犯错。请核查重要信息。

ChatGPT ▾

$$x + x\bar{y} + yx + 0 = x + yx = x$$

So we get:

$$(x + y)(x + \bar{y}) = x$$

Now substitute this into the remaining term:

$$x(\bar{x} + z)$$

Step 2: Apply distributive law

$$x(\bar{x} + z) = x\bar{x} + xz$$

Using the complement law ($x\bar{x} = 0$):

$$0 + xz = xz$$

Thus, the right-hand side simplifies to xz .

Conclusion:

Both sides are equal, so the given expression is true:

$$xz = (x + y)(x + \bar{y})(\bar{x} + z)$$

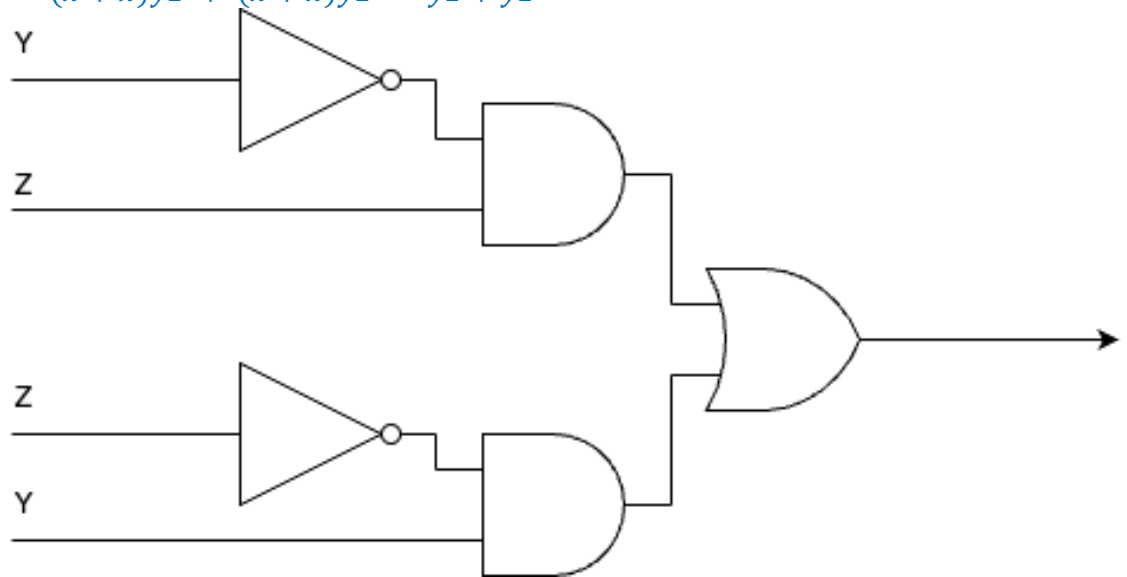
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8. The truth table for a Boolean expression is shown below. (16 points)
- Write the Boolean expression in sum-of-products form. (4 points)
 - Write the Boolean expression in product-of-sums form. (4 points)
 - Simplify the sum-of-products form using Boolean identities; (4 points)
 - Draw the logical circuit diagram for the simplified Boolean expression;(4 points)

x	y	z	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

- $F = \bar{x}\bar{y}z + \bar{x}y\bar{z} + x\bar{y}z + xy\bar{z}$
- $F = (x + y + z)(x + \bar{y} + \bar{z})(\bar{x} + y + z)(\bar{x} + \bar{y} + \bar{z})$
- $F = (\bar{x} + x)y\bar{z} + (\bar{x} + x)\bar{y}z = y\bar{z} + \bar{y}z$



- d) Simplify the above Boolean expression using K-MAP by hand. (6 points)

$$F = \bar{x}\bar{y}z + \bar{x}y\bar{z} + x\bar{y}z + xy\bar{z}$$

$x \backslash yz$	00	01	10	11
0	0	1	1	0
1	0	1	1	0

$$F = \bar{y}z + y\bar{z}$$