5.8

1. $$\text{分支额外开销} = 15\% * (90\%\text{命中} + 10\%\text{预测错误} * 4 + 10\%\text{未命中} * 3) = 0.099$$
$$\text{程序执行的CPI} = \text{没有分支的基本CPI} + \text{分支额外开销} = 1.099$$

2. 采用固定2时钟周期延迟的分支处理：$\text{CPI} = 1 + 15\% * 2 = 1.3$，所以分支目标缓冲方法执行更快

5.9

1. 没有BTB：

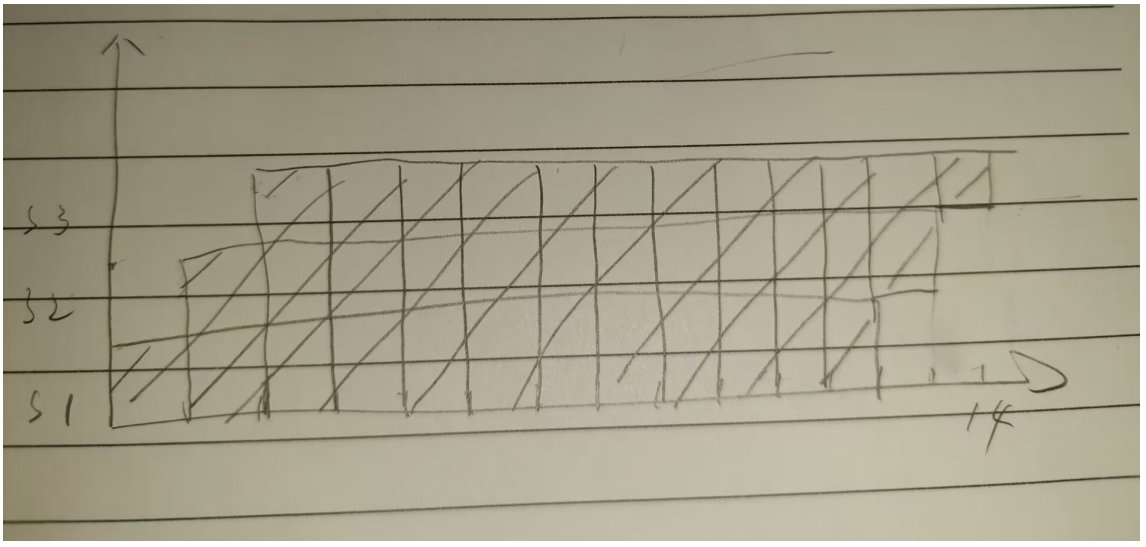
$$\text{实际CPI} = \text{理想CPI} + \text{各种停顿拍数} = 1 + 0.05L = 1.1$$
$$\Rightarrow \quad L = 2$$

2. 有BTB：

$$\text{实际CPI} = \text{理想CPI} + \text{各种停顿拍数} = 1 + 0.05 \times 0.1 \times 2 = 1.01$$

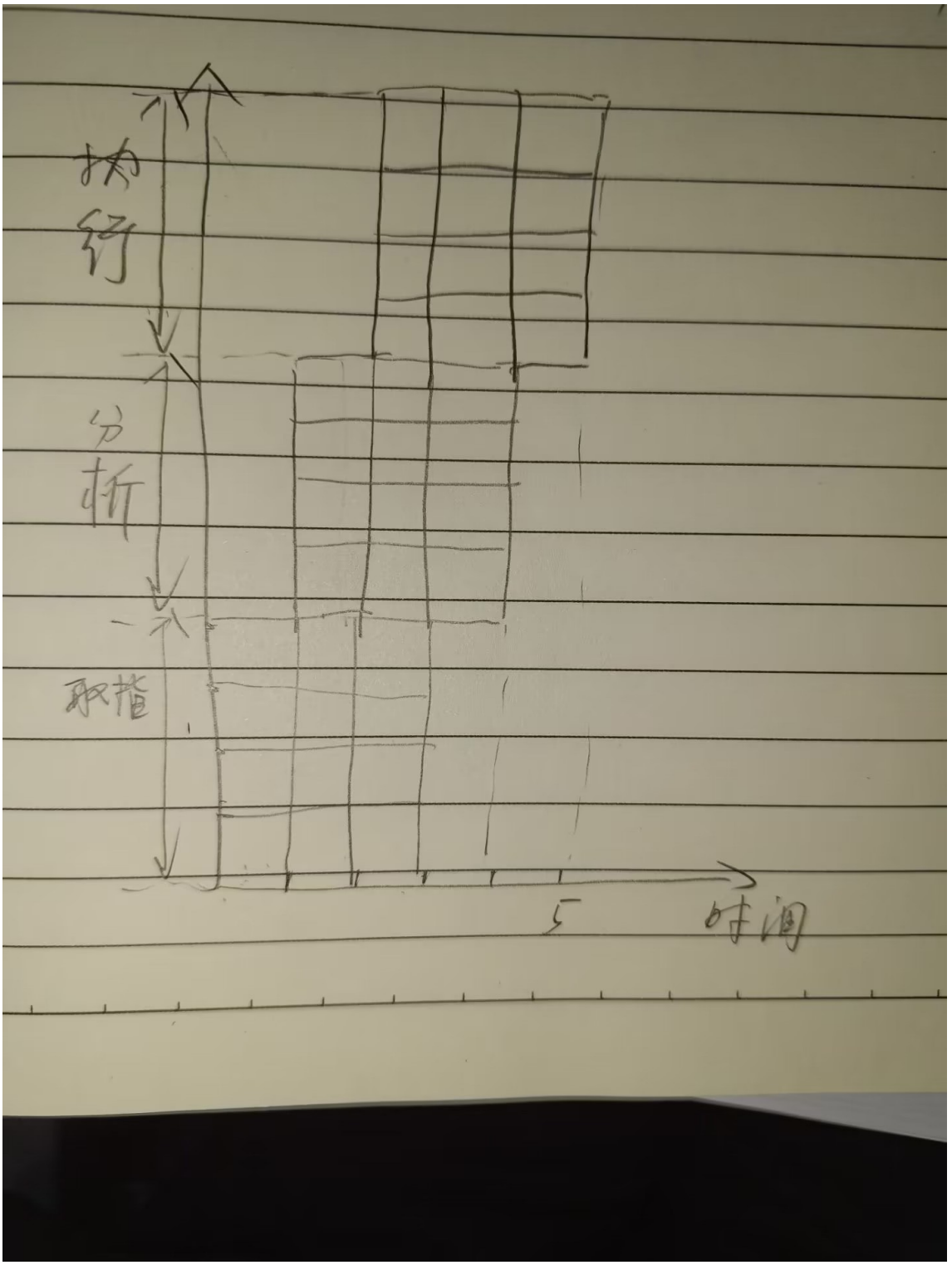
5.11

1. 标量流水



$$T_k = (k + n - 1)\Delta t = (3 + 12 - 1)\Delta t = 14\Delta t$$

2. 超标量

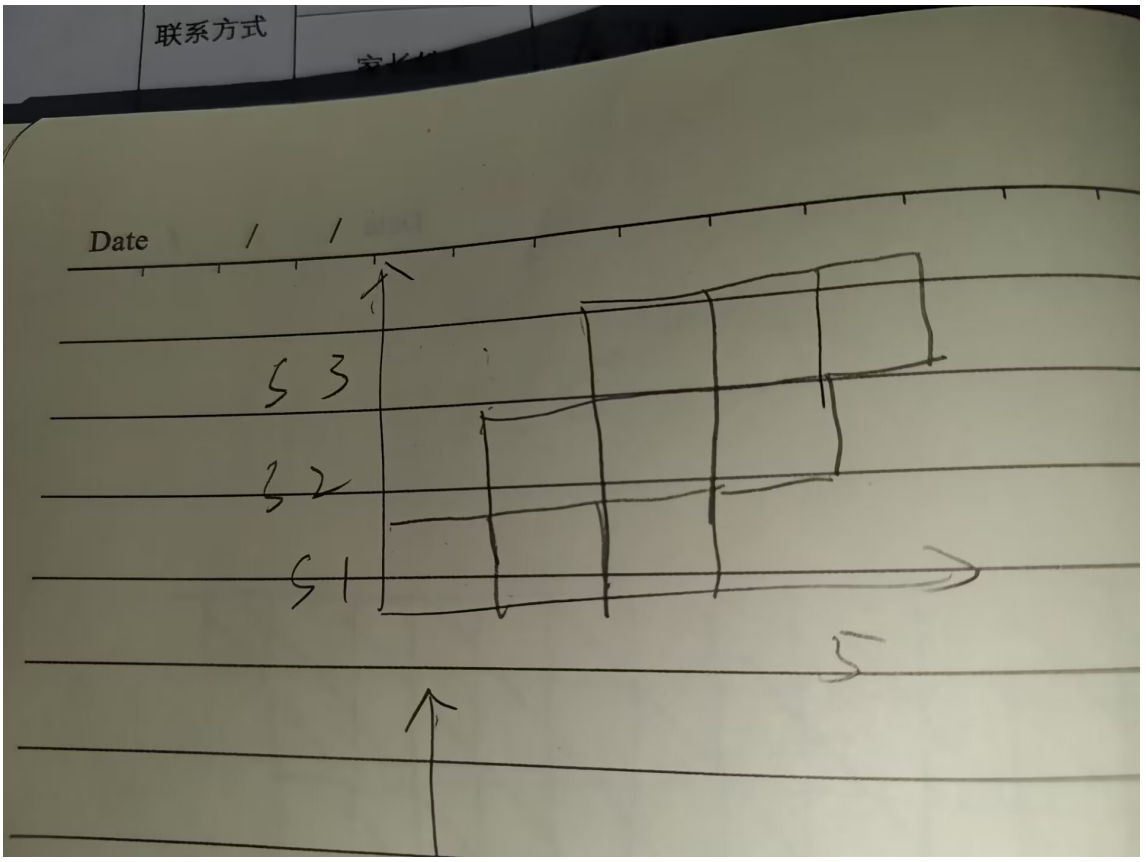


$ILP = 4$, 执行12条指令

$$T_k = (k + n - 1)\Delta t$$
$$= (3 + 3 - 1)\Delta t = 5\Delta t$$

加速比$S = 14\Delta t / 5\Delta t = 2.8$

3. 超长指令字



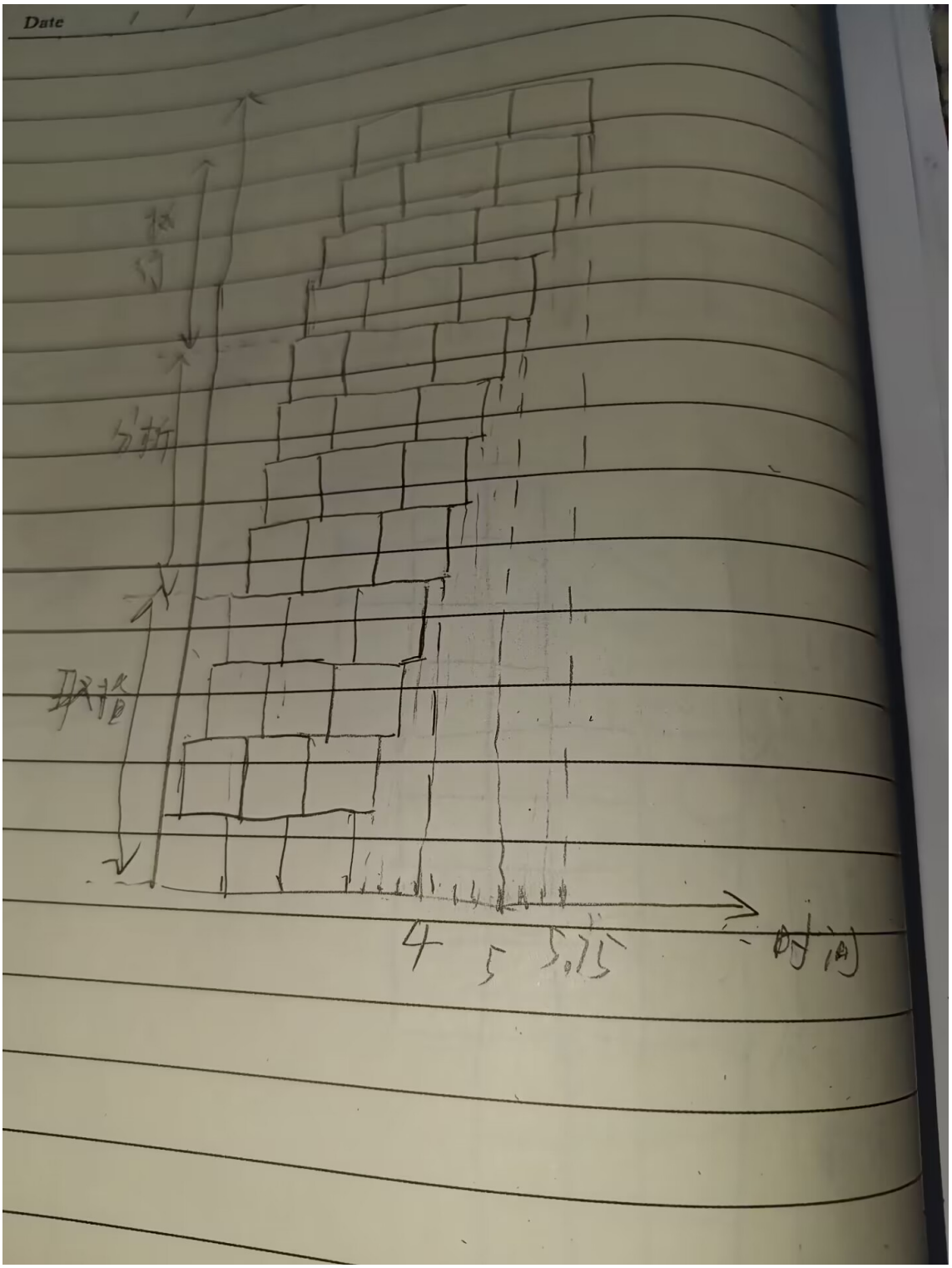
$ILP = 4, 12$个任务组装成3条长指令，每条含4条小指令，n=3

$$T_k = (k + n - 1)\Delta t$$

$$= (3 + 3 - 1)\Delta t = 5\Delta t$$

加速比$S = 14\Delta t / 5\Delta t = 2.8$

4. 超流水线



每$1/4$个时钟周期启动一条指令

执行完12条指令需要$T_4 = 5.75\Delta t$

$$T_k = (k + n - 1)\Delta t$$

$$= (3 + 3 - 1)\Delta t = 5\Delta t$$

加速比$S = 14\Delta t / 5\Delta t = 2.8$