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## PIPELINING: THE BASIC IDEA



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### 1. CHECK YOUR UNDERSTANDING (1/1 point)


Consider three different LC-3 hardware designs:

Design 1: All five phases complete in a single clock cycle.

Design 2: Each instruction takes 5 cycles—one per phase—to complete, but the design is not pipelined.

Design 3: A pipelined implementation.

Which of the following statements is **NOT** true?

- ☐ Design 1 would have a lower CPI than Design 2.
- ☒ Design 1 would have a higher CPI than Design 3. 
- ☐ Design 2 would have a higher CPI than Design 3.
- ☐ Designs 2 and 3 would be capable of having a higher clock frequency than design 1.

#### EXPLANATION

In Design 1, the CPI is 1 since all instructions take a single clock cycle, while the CPI of Design 2 is 5.

Due to the time to fill the pipeline, the CPI of Design 3 would be greater than 1. So the CPI of Design 1 would actually be lower than that of Design 3.

Design 2 has a CPI of 5 versus the CPI of just over 1 for Design 3.

Since Design 1 does all 5 phases in 1 clock cycle, Designs 2 and 3 would have higher frequency.

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## 2. CHECK YOUR UNDERSTANDING (1/1 point)

A program executes only 16 instructions before completing. What would be the CPI of the program when executed on the pipelined design discussed in the video? (Use the equation for the CPI of a pipelined design discussed in the video.)

- ☐ 1
- ☒ 1.25 
- ☐ 5
- ☐ 16

#### EXPLANATION

The CPI is calculated as

$$(N + 4)/N = (16 + 4)/16 = 1.25.$$

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