

## 1 Pre-Check

This section is designed as a conceptual check for you to determine if you conceptually understand and have any misconceptions about this topic. Please answer true/false to the following questions, and include an explanation:

- 1.1 The single cycle datapath makes use of all hardware units for each instruction.
  
  
  
  
  
  
  
  
  
  
- 1.2 It is possible to execute the stages of the single cycle datapath in parallel to speed up execution of a single instruction.
  
  
  
  
  
  
  
  
  
  
- 1.3 Combinational logic is only used in the instruction decode stage.

## 2 Single-Cycle CPU

- 2.1 For this worksheet, we will be working with the single-cycle CPU datapath on the last page.
  - (a) On the datapath, fill in each **round** box with the name of the datapath component, and each **square** box with the name of the control signal.
  - (b) Explain what happens in each datapath stage.
    - IF** Instruction Fetch
  
  
  
  
  
  
  
  
  
  
    - ID** Instruction Decode
  
  
  
  
  
  
  
  
  
  
    - EX** Execute
  
  
  
  
  
  
  
  
  
  
    - MEM** Memory
  
  
  
  
  
  
  
  
  
  
    - WB** Writeback



## 2.3 Clocking Methodology

- A **state element** is an element connected to the clock (denoted by a triangle at the bottom). The **input signal** to each state element must stabilize before each **rising edge**.
- The **critical path** is the longest delay path between state elements in the circuit. The circuit cannot be clocked faster than this, since anything faster would mean that the correct value is not guaranteed to reach the state element in the allotted time. If we place registers in the critical path, we can shorten the period by **reducing the amount of logic between registers**.

For this exercise, assume the delay for each stage in the datapath is as follows:

IF: 200 ps      ID: 100 ps      EX: 200 ps      MEM: 200 ps      WB: 100 ps

- (a) Mark the stages of the datapath that the following instructions use and calculate the total time needed to execute the instruction.

	IF	ID	EX	MEM	WB	Total Time
add						
ori						
lw						
sw						
beq						
jal						
bltu						

- (b) Which instruction(s) exercise the critical path?
- (c) What is the fastest you could clock this single cycle datapath?
- (d) Why is the single cycle datapath inefficient?
- (e) How can you improve its performance? What is the purpose of pipelining?

