

b. What is the speedup achieved by adding this improvement?



I-Mem	Add	Mux	ALU	Regs	D-Mem	Sign-Extend	Shift-Left-2
200ps	70ps	20ps	90ps	90ps	250ps	15ps	10ps

c. Which kinds of instructions require Shift - left -2?

3. The breakdown of executed instructions is as follows:

add	addi	not	beq	lw	sw
20%	20%	0%	25%	25%	10%

a. In what fraction of all cycles is the data memory used?

b. In what fraction of all cycles is the input of the sign-extend circuit needed? What is this circuit doing in cycles in which its input is not needed?

4. Assume that individual stages of the datapath have the following latencies:
Assume that instructions executed by the processor are broken down as follows:

IF	ID	EX	MEM	WB
250ps	350ps	150ps	300ps	200ps

a. What is the clock cycle time of the datapath?

alu	beq	lw	sw
45%	20%	20%	15%

b. What is the total latency of an LW instruction in the processor datapath?

5. Complete the multiplication steps as seen in a standard multiplier.

Iteration	Step	Multiplier	Multiplicand	Product
0	Initial values	0110	10010010	
1	1a: $1 \Rightarrow \text{Prod} = \text{Prod} + \text{Mcand}$			
	2: Shift left Multiplicand			
	3: Shift right Multiplier			
2				
3				
4				

6. In this exercise we examine in detail how an instruction is executed in a single-cycle datapath. Problems in this exercise refer to a clock cycle in which the processor fetches the following instruction word:

101011000110001000000000000010100 .

Assume that data memory is all zeros and that the processor's registers have the following values at the beginning of the cycle in which the above instruction word is fetched:

R0	R1	R2	R3	R4	R5	R6	R8	R12	R31
0	-1	2	-3	-4	10	6	8	2	-16

a. What are the outputs of the sign-extend and the jump “Shift left 2” unit for this instruction word?

b. What are the values of the ALU control unit's inputs for this instruction?

c. What is the new PC address after this instruction is executed?

d. For each Mux, show the values of its data output during the execution of this instruction and these register values.

e. For the ALU and the two add units, what are their data input values?

f. What are the values of all inputs for the “Registers” unit?