

INDIAN INSTITUTE OF TECHNOLOGY PATNA

CS541: Foundations of Computer Systems

Assignment 2 — Autumn 2023

Deadline: Oct. 31, 2023 —23:59 Hrs IST

Maximum Marks: 10 marks

All questions are compulsory. Without proper derivation and explanation, marks will not be given. Make necessary assumptions (as and if) required and mention the same in the solution.

Submission Guidelines: Prepare a soft copy of your solution and store it in a folder. Then compress the folder as a rar/zip file (filename should be in this format: **roll-number_assign2.rar or roll-number_assign2.zip**). For example, if your roll number is 2303RES01, store your assignment as 2303RES01_assign2.rar or 2303RES01_assign2.zip. Use admission number instead of roll number if you are not provided with your roll number. Upload the same at the below link:

<https://forms.gle/pY5gWJfTrA2spHpz6>

- Consider an instruction pipeline with 5 stages: S_1 (IF), S_2 (ID), S_3 (OF), S_4 (IE), and S_5 (MO). Stages S_1 , S_2 , S_3 , and S_5 take 1 clock cycle each for any instruction. And stage S_4 takes 1 clock cycle for ADD and SUB instructions, 3 clock cycles for MUL and BQEZ (Branch) instructions, and 4 clock cycles for DIV instruction respectively. Calculate the number of clock cycles needed to execute the following sequence of instructions, if the only branch is taken. [10 marks]

Instructions:	Meaning
I_0 : SUB R_0, R_1, R_2	$R_2 \leftarrow R_0 - R_1$
I_1 : MUL R_3, R_4, R_5	$R_5 \leftarrow R_3 \times R_4$
I_2 : DIV R_5, R_3, R_3	$R_3 \leftarrow R_5 / R_3$
I_3 : BQEZ R_3, I_9	if $R_3 \geq 0$, jump to I_9
I_4 : ADD R_2, R_6, R_5	$R_5 \leftarrow R_2 + R_6$
I_5 : ADD R_5, R_6, R_5	$R_5 \leftarrow R_5 + R_6$
I_6 : ADD R_2, R_6, R_5	$R_5 \leftarrow R_2 + R_6$
I_7 : SUB R_5, R_6, R_5	$R_5 \leftarrow R_5 - R_6$
I_8 : SUB R_2, R_6, R_5	$R_5 \leftarrow R_2 - R_6$
I_9 : SUB R_5, R_6, R_5	$R_5 \leftarrow R_5 - R_6$
I_{10} : MUL R_2, R_6, R_5	$R_5 \leftarrow R_2 \times R_6$
I_{11} : ADD R_5, R_6, R_5	$R_5 \leftarrow R_5 + R_6$

Note: Draw the table as per the format given below:

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S_3									...
S_2									...
S_1									...
	1	2	3	4	5	6	7	8	...

X