INDIAN INSTITUTE OF TECHNOLOGY PATNA
CS541: Foundations of Computer Systems
Assignment 1 — Autumn 2023

Deadline: Oct. 29, 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_assign1.rar or roll-number_assign1.zip). For example, if your roll number is 2303RES01, store your assignment as 2303RES01_assign1.rar or 2303RES01_assign1.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/mbJCC9zqNQVM4XYNA`

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1. Consider a machine with clock frequency as 210Hz and the performance parameter [Considering 100 sample instructions] as per the table given below.

Instruction Category	Occurrence	Cycles per Instruction
ALU	60	5
Load & Store	19	3
Branch	14	4
Others	7	1

Now a separate program containing 6×10^6 floating point instructions is executed on the same machine. Assume that the machine is either doing calculations in the CPU, or doing I/O operation, but it can't do both at the same time. Given that the total time taken by the program to complete I/O operations is 1 second and the CPU computation takes exact same overall time as the execution of the given sample 100 instructions, compute the performance of the machine in terms of MFLOPS. **[5 marks]**

2. 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, 2 clock cycles for MUL and BQEZ (Branch) instructions, and 3 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. **[5 marks]**

Instructions:	**Meaning**
I_0: ADD 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_5	if $R_3 \geq 0$, jump to I_5
I_4: MUL R_2, R_6, R_5	$R_5 \leftarrow R_2 \times R_6$
I_5: SUB R_5, R_6, R_5	$R_5 \leftarrow R_5 + R_6$

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

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

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