

1. Suppose you have a load-store computer with the following instruction mix:

Operation	Frequency	Number of clock cycles
ALU ops	40 %	2
Loads	20 %	4
Stores	18 %	4
Branches	22 %	6

The ALU ops (arithmetic logic unit ops) typically use operands in CPU registers and hence they take fewer clock cycles to execute. However, if you want to add a memory operand to a CPU register, then you would have to explicitly load it into a CPU register. For such ALU operations, you would say that they are paired with a load instruction since the value moved from memory would be used only for the particular ALU operation and not used anywhere else. We observe that 30% of the ALU ops are paired with a load (i.e., they occur together), and we propose to replace these ALU ops and their loads with a new instruction. Assume that this new instruction takes 4 clock cycles. However, with the new instruction added, branches will take 8 clock cycles rather than 6. Assuming that the clock rate is unchanged, would this change improve performance? Justify your answer quantitatively. Show all your work.

2. Suppose you have a load/store computer as described above with the following instruction mix:

Operation	Frequency	No. of Clock cycles
ALU ops	35%	1
Loads	25%	2
Stores	15%	2
Branches	25%	3

(a) Compute the CPI. Show all your work.

(b) We observe that 25% of the ALU ops are paired with a load, and we propose to replace these ALU ops and their loads with a new instruction. The new instruction takes 1 clock cycle. With the new instruction added, branches take 5 clock cycles. Compute the CPI for the new version. Show all your work.

(c) If the clock rate for the new version is 30% faster than the old version, which version is faster and by what percent? Justify your answer quantitatively. Show all your work.