Self-evaluation exercise on ISA

Consider two machines, P and Q:

Machine P: Its ISA has two types of instructions (here OP can be ADD or SUB):

1. OP M3, M1, M2: Performs the binary operation OP on the values stored at memory locations M1 and M2 and stores the result back into memory location M3 (M3 ← M1 OP M2).
2. OP M3, M1, Immediate: Performs a binary operation OP on the value stored at memory location M1 and value Immediate and stores the result back into memory location M3 (M3 ← M1 OP Immediate).

This machine has no registers. Note that all operations are performed directly on memory values. Both destination and source of an instruction can be the same memory value (e.g., add M5, M6, M5). Also, it is given that each instruction is encoded in 7 bytes. Further, data values are 4 bytes.

Machine Q: Its ISA has these instructions (here OP can be ADD or SUB):

1. OP R3, R1, R2: Performs a binary operation OP on the values stored at registers R1 and R2 and stores the result back into register R3 (R3 ← R1 OP R2).
2. OP R3, R1, Immediate: Performs a binary operation OP on the value stored at registers R1 and immediate value Immediate and stores the result back into register R3 (R3 ← R1 OP Immediate).
3. LD R1, M: Loads the value at memory location M into register R1.
4. ST R2, M: Stores the value in register R2 into memory location M.

Here, for performing any operation, first the values need to be loaded in the registers and then any operation can be performed. Both source and destination of an instruction can be the same register (e.g., add R1, R1, R2).

Machine Q has 32 general-purpose registers. Also, each instruction is encoded in 4 bytes. Memory data values are 4 bytes.

Now consider two programs:

Program X

A = A + 1;
B = B + 2;
C = C - 3;
D = D - 4;

Program Y

B = B + A;
C = B + A;
D = A - C;
A = D - C;

Question: Write program X for machine P

ADD A, A, 1
ADD B, B, 2
SUB C, C, 3
SUB D, D, 4

If someone wrote [A] instead of A, that is also correct.

Question: Write program Y for machine P

ADD B, B, A
ADD C, B, A
SUB D, A, C
SUB A, D, C

Question: Write program X for machine Q ensuring to (i) reuse the register values if possible and (ii) store the register values back into memory after executing all the code.

```
    LD R1, A
ADD R1, R1, 1
ST R1, A
LD R2, B
ADD R2, R2, 2
ST R2, B
LD R3, C
SUB R3, R3, 3
ST R3, C
LD R4, D
SUB R4, R4, 4
ST R4, D
```

Question: Write program Y for machine Q ensuring the above mentioned two conditions.

```
    LD R1, A
LD R2, B
ADD R3, R1, R2
ADD R4, R3, R1
SUB R5, R3, R4
SUB R6, R5, R4
ST R3, B
ST R4, C
ST R5, A
ST R6, D
```

Question: Compute the total number of bytes (instruction plus data) transferred to/from memory for each of the two programs, for each of the two machines. Then, write your answer in this table.

	Program X	Program Y
Machine P		
Machine Q		

	Program X	Program Y
Machine P	60	76
Machine Q	80	64

Question: Comment on which ISA reduces the number of bytes transferred for which program. What are the characteristic of the ISAs and the machines which make them do so?

Machine P is good for program X since X has no reuse and hence, having registers does not provide any benefit. It is better to perform operations directly on memory values.

Machine Q is good for program Y since Y has reuse and hence, instead of always accessing memory, it is better to save operands in registers and then use them.