

6. (5 points) As covered in class, the execution speed of a program on a processor can be given as:

$$Execution\ Time = N \times CPI \times 1/f$$

Where  $N$  is the number of instructions,  $CPI$  is clocks per instruction and  $f$  is the clock frequency. *Execution Time* will improve by either reducing  $N$  and  $CPI$ , or increasing  $f$  (or a combination thereof). List at least **five** improvements that can be made in order to improve the *Execution Time*.

**Solution:** Any five of the following could be accepted:

- **Reduce number of instructions**

- adopt CISC, that uses instructions that can do more
- improve the compiler so that it produces more optimized code

- **Reduce clocks per instruction**

- adopt RISC, simpler instructions can be executed faster
- add parallel execution units, do more per clock cycle

- **Increase clock frequency**

- migrate to a more modern manufacturing technology
- adopt pipelining
- redesign and improve timing critical components in the circuit (adders, alu etc)
- *Could also be accepted:* overclock the system (use higher voltage, clock frequency)