

6. We are interested in how long it takes for a specific program to run. The program has 200 million instructions and is being executed on a single-cycle processor running at a clock of 400 MHz.

- (a) (2 points) How long (in seconds) will it take for this program to run on this architecture?

**Solution:**

$$\begin{aligned}
 \text{Time to execute} &= N \cdot CPI \cdot \frac{1}{f} \\
 \text{Time to execute} &= 200.000.000 \cdot 1 \cdot \frac{1}{400.000.000 \text{ Hz}} \\
 \text{Time to execute} &= 0.5 \text{ seconds}
 \end{aligned}$$

- (b) (2 points) As an alternative, you consider a multi-cycle architecture that can run at 1.2 GHz, what is the minimum CPI that the multi cycle architecture has to achieve so that we can be faster?

**Solution:**

$$\begin{aligned}
 \text{Time to execute} &= N \cdot CPI \cdot \frac{1}{f} \\
 0.5 \text{ seconds} &= 200.000.000 \cdot CPI \cdot \frac{1}{1.200.000.000 \text{ Hz}}
 \end{aligned}$$

CPI has to be at least 3

- (c) (2 points) As yet another alternative, there is a different architecture for which the program can be compiled more efficiently into 120 million instructions. The architecture has a CPI of 2 and runs at 500 MHz. Is this option faster than the single cycle architecture from 6a?

**Solution:**

$$\begin{aligned}
 \text{Time to execute} &= N \cdot CPI \cdot \frac{1}{f} \\
 \text{Time to execute} &= 120.000.000 \cdot 2 \cdot \frac{1}{500.000.000 \text{ Hz}} \\
 \text{Time to execute} &= 0.48 \text{ seconds}
 \end{aligned}$$

It is marginally faster