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:

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

   (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:

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

   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:

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

   It is marginally faster