Question 1 (20 points): The pattern of execution of a given program depends not only on the code, the compiler, and the architecture, but also on the data input for the program. For instance a file compressor may follow different execution paths when compressing an mpeg audio file than when compressing ASCII text file. You are studying the performance of a program. You know that the instructions executed by this program can be divided into 4 classes based on the number of cycles required to execute the instruction. Class A instructions take 1 cycle, class B take 2 cycles, class C take 4 cycles and class D take 6 cycles. You run the program with profiling twice, with two different inputs `inputA` and `inputB`. The percentage of instructions of each class for each run is shown below.

Input	**Instruction Class**			
	A	B	C	D
`Input A`	60%	20%	10%	10%
`Input B`	40%	10%	30%	20%

The profiling also reveals that when running with `inputA` the program executes 20% more instructions than when running with `inputB`.

Which run of the program is faster and by how much?

$$\text{CPI}_{\text{inputA}} = 0.6 \times 1 + 0.2 \times 2 + 0.1 \times 4 + 0.1 \times 6 = 0.6 + 0.4 + 0.4 + 0.6 = 2.0 \frac{\text{clocks}}{\text{instruction}}$$

$$\text{CPI}_{\text{inputB}} = 0.4 \times 1 + 0.1 \times 2 + 0.3 \times 4 + 0.2 \times 6 = 0.4 + 0.2 + 1.2 + 1.2 = 3.0 \frac{\text{clocks}}{\text{instruction}}$$

Assume that the run with `inputB` executes x instructions. Thus the run with `inputA` executes $1.2\ x$ instructions.

$$\begin{aligned} \text{Time}_{\text{inputA}} &= 2.0 \frac{\text{clocks}}{\text{instruction}} \times 1.2\ x \text{ instructions} = 2.4\ x \text{ clocks} \\ \text{Time}_{\text{inputB}} &= 3.0 \frac{\text{clocks}}{\text{instruction}} \times x \text{ instructions} = 3.0\ x \text{ clocks} \\ \text{Speedup} &= \frac{\text{Time}_{\text{inputB}}}{\text{Time}_{\text{inputA}}} = \frac{3.0x}{2.4x} = 1.25 \end{aligned} \tag{1}$$

Thus, the run with `inputA` is 1.25 times faster than the run with `inputB`.