COMP4300 Spring 2022
Homework Assignment 1

1. Suppose that a given optimization results in an OVERALL speedup of 1.5 over the original design. If the optimization speeds up ALU operations, which collectively accounted for 40% of the execution time BEFORE the optimization, by what factor were ALU operations sped up by the optimization?

$$\text{Speedup} = \frac{1}{(1-f) + f/s} \qquad f = 0.40 \quad \text{Speedup} = 1.5 \quad s = ?$$

$$1.5 = \frac{1}{(1-0.40) + \left(\frac{0.4}{s}\right)}$$

$$1.5 = \frac{1}{0.60 + \left(\frac{0.4}{s}\right)} \Rightarrow 1.5\left(0.60 + \frac{0.4}{s}\right) = 1$$

$$0.9 + \frac{0.6}{s} = 1 \Rightarrow \frac{0.6}{s} = 0.1 \Rightarrow \boxed{s = 6}$$

2. If, in problem one, the described optimization could make ~~loads and stores~~ ALU ops take no time at all (not realistic, just for the sake of argument), what would the overall speedup to the execution time be?

* free

U per tions speedup $\approx \infty$

$$\frac{f}{s} \Rightarrow 0 \qquad \frac{1}{(1-f) + f/s} \Rightarrow \frac{1}{1-f}$$

$$\frac{1}{1-0.40} = \boxed{1.67}$$

3. Suppose a given server computer has a distributed file system on 3 disk drives. The distribution is for speed, not redundancy, so if any one of the three disk drives fails, the computer fails as a whole – it cannot serve any requests. Now suppose that that the MTTF for each of the 3 individual disk drives is 1 year. What is the MTTF of the disk drive subsystem consisting of the three drives working together. There is no other hardware in the subsystem except the three disk drives.

1 year = 365 days × 24 hours/day = 8760 hours

$$\text{Failure rate}_{\text{system}} = 3 \times \frac{1}{8760} = \frac{3}{8760}$$

$$MTTF_{system} = \frac{1}{\text{failure rate}} = \frac{1}{\left(\frac{3}{8760}\right)} = \boxed{2920 \text{ hours OR } 1/3 \text{ year}}$$

4. For a particular computer, the CPI for certain types of instructions is as follows:
   - ALU operations, 1 cycle, make up 20% of dynamic (run-time) instruction count
   - Load/store operations, 5 cycles, 40% of dynamic instruction count
   - Control flow, 3 cycles, 20% of dynamic instruction count
   - All other, 2 cycles, 20% of dynamic instruction count

   a. What is the average CPI?
   b. Suppose there is an optimization in which the CPI of load/store is reduced to 2, but cycle time is lengthened by 10%. What is the speedup due to this optimization?

a) Average CPI $= \sum_{i \in \text{inst. set}} IC_i \times CP_i$

$= ((.20 \times 1) + (.40 \times 5) + (.20 \times 3) + (.20 \times 2))$

$= \boxed{3.2}$

b) speedup $= \dfrac{\text{Execution Time}_{original}}{\text{Execution Time}_B}$

$= \dfrac{\cancel{IC} \times CT \times CPI_{orig}}{\cancel{IC} \times (CT(.10) + CT) \times CPI_B}$

$= \dfrac{CT \times CPI_{orig}}{CPI_B (CT)(.10) + CPI_B (CT)}$

$= \dfrac{\cancel{CT} \times CPI_{orig}}{\cancel{CT}(CPI_B(.10) + CPI_B)} = \dfrac{CPI_{orig}}{CPI_B(1.10)}$

$CPI_B = ((.20 \times 1) + (.40 \times 2) + (.20 \times 3) + (.20 \times 2)) = 2$

$\dfrac{CPI_{orig}}{CPI_B(1.10)} = \dfrac{3.2}{(2)(1.10)} = \boxed{1.45}$