EEE225 Solution Sheet 3

1. A clock is used to synchronise the data transfers/transformations in the CPU. The CPU is a complex finite state machine and changes of state are synchronised to clock edges. Time is the measure of computer performance but cannot be determined by clock speed alone. You first need to decide what is meant by performance. Are you are interested in throughput (bandwidth) or response time for a particular task (execution time). In the case of execution time, the performance will depend upon the instruction mix in the program. Different instructions will take different amounts of time (different number of clock cycles) to execute. Computer X with its higher clock speed will not necessarily perform better than computer Y because computer X may require more clock cycles to execute its instructions.

2. Execution $time_Y$ / Execution $time_X$ = 4
   36/ Execution $time_X$ = 4
   Execution $time_X$ = 36/4 = 9seconds

3. 20 x 0.6 x 1.2 = 14.4 seconds, saving 5.6 seconds.

4. Sequence1 executes 2 + 1 + 2 = 5 instructions, CPU clock cycles (2x1)+(1x2)+(2x3) = 10 cycles.
   Sequence2 executes 4 + 1 + 1 = 6 instructions, CPU clock cycles (4x1)+(1x2)+(1x3) = 9 cycles.
   Sequence 2 is faster even though it executes one extra instruction.

   $$\text{CPI} = \frac{\text{CPU clock cycles}}{\text{Instruction count}}$$

   Sequence1 CPI = 10/5 = 2
   Sequence2 CPI = 9/6 = 1.5

5. First find out how many clock cycles are required by computer X when running this application.

   CPU $time_X$ = CPU clock $cycles_X$ / Clock $rate_X$
   10 seconds = CPU clock $cycles_X$ / 2 x 10^9
   CPU clock $cycles_X$ = 10 x 2 x 10^9 = 20 x 10^9 cycles

   Now find the CPU time for computer Y.

   CPU $time_Y$ = 1.2 x CPU clock $cycles_X$ / Clock $rate_Y$
   6 seconds = 1.2 x 20 x 10^9 cycles / Clock $rate_Y$

   Clock $rate_Y$ = 1.2 x 20 x 10^9 cycles / 6 seconds
   = 4 x 10^9 cycles/second
   = 4 GHz

   So the target clock speed for the new computer should be 4 GHz in order to run the application in 6 seconds.

6. A CPU limited task indicates that data can be supplied to the CPU faster than it can be processed. There is a performance bottleneck caused by the CPU.

7. 32M = 32 x 2^{20} = 2^5 x 2^{20} = 2^{25}, so 25 address bits are required.

8.

A_1A_0	Z_3	Z_2	Z_1	Z_0
0 0	1	1	1	0
0 1	1	1	0	1
1 0	1	0	1	1
1 1	0	1	1	1