Brown University
School of Engineering
EN164 Design of Computing Systems
Professor Sherief Reda
HW 01. 70 points. Due Date: Tuesday, Feb 7th 2012 in class.

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1. [15 points] Consider two different implementations, P1 and P2, of the same instruction set. There are five classes of instructions (A, B, C, D, and E) in the instruction set. The clock rate and CPI of each class is given below.

	clock rate	CPI class A	CPI class B	CPI class C	CPI class D	CPI class E
P1	1.0 GHz	1	2	3	4	3
P2	1.5 GHz	2	2	2	4	4

   (a) [5 points] Assume that peak performance is defined as the fastest rate that a computer can execute any instruction sequence. What are the peak performances of P1 and P2 expressed in instructions per second?
   (b) [5 points] If the number of instructions executed in a certain program is divided equally among the classes of instructions except for class A, which occurs twice as often as each of the others. Which computer is faster? How much faster is it?
   (c) [5 points] If the number of instructions executed in a certain program is divided equally among the classes of instructions except for class E, which occurs twice as often as each of the others? Which computer is faster? How much faster is it?

2. [15 points] Consider a computer running a program with the following breakdown in execution time among the different classes of instructions (FP stands for floating point, INT stands for integer instructions, L/S stands for load and store).

	FP instr	INT instr	L/S instr	Branch inst	Total time
a.	70 s	85 s	55 s	40 s	250 s

   a. [5 points] How much is the total time reduced if the time for FP operations is reduced by 20%?
   b. [5 points] How much is the time for INT operations reduced if the total time is reduced by 20%?
   c. [5 points] Can the total time be reduced by 20% by reducing only the time for branch instructions?

3. [20 points] Although dynamic power is the primary source of power dissipation in semiconductor-based computer chips, leakage current products a static power dissipation $V \times I_{leak}$. The smaller the on-chip dimension, the more significant is the static power. Assume the figures shown in the following table for static and dynamic power dissipation for several generations of processors.

	Technology	Dynamic power (W)	Static power (W)	Voltage
i.	180 nm	50	10	1.2
ii.	70 nm	90	60	0.9

a. [5 points] For each technology, find the percentage of the total dissipated power comprised by static power.
b. [5 points] What is the value of leakage current for each technology?
c. [10 points] If the voltage of each technology is reduced by 5%, what are the new values for dynamic power, leakage power, and total power?
d. [extra reading] Why do you think voltage needs to be maintained at some lower bound for a given technology?

4. [From midterm 2011 – 20 points] For mobile computing devices it is necessary to consider both performance and power during design. A popular metric to optimize for is throughput/power, which seeks to maximize the throughput (number of instructions) per Watt.

a. [15 points] Compute the throughput and power of each of the following processors. Which processor has the highest throughput? Which processor consumes the least power? Which processor would you choose as your mobile computing processor?

- Processor A runs at 200 Mhz, executes three instructions per cycle and consumes 0.75 W during operation.
- Processor B runs at 250 Mhz, executes two instruction per cycle and consumes 0.5 W during operation.
- Processor C runs at 300 Mhz, executes one instruction per cycle and consumes 0.4 W during operation.

b. [5 points] A typical lithium ion battery in a smart phone holds an energy of about 18,000 Joules. If the power consumption of all phone components (e.g., display, transmission) but the processor is about 0.5 W. Assume you use the winning processor configuration from part (a), how long will the battery last if you running an intensive application continuously?