Part I. Regular Questions [20 points total]

1. Vocabulary: (terms you need to know to discuss the subject intelligently) – Define the following terms using 1-3 sentences (and a diagram, if needed): [3 points each]
   a. SPEC (benchmark)
   b. TFLOPs (performance measure)
   c. Kernel Benchmark
   d. Amdahl’s Law
   e. Moore’s Law

2. Concept Discussion: What are (a) the best kind of benchmarks, and why; and (b) the worst kind of benchmarks, and why? Explain your answer to get full credit. [2 pts for a), 3 pts for b)]

Part II. Problems to Solve [20 points total]

3. Calculate Performance: (a) A program $P$ has 19,978 instructions, a mean (average) CPI of 2.7, and is run on a computer $M_1$ with a clock rate of 3.4 GHz. What is the runtime?

   Then (b) if we change the instruction count in a), above to 14,997 instructions and we change the clock rate to 3.3 GHz to get a new machine $M_2$, what percent faster (or slower) will $P$ running on $M_2$ be, versus $P$ running on $M_1$? [3 pts for a), 3 pts for b)]
Part II. Problems to Solve (continued)

4. **Calculate Average CPI:** Given four types of instructions A, B, C, and D, and their CPIs and incidence figures as described in the table below (a) calculate average CPI, and (b) calculate average CPI if Type B instructions are speeded up by 38 percent. *Hint: You will need to think this one through carefully...* [3 pts for a), 3 pts for b)]

<table>
<thead>
<tr>
<th>Instruction Type</th>
<th>CPI for this Type</th>
<th>Instruction Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.2</td>
<td>333</td>
</tr>
<tr>
<td>B</td>
<td>1.9</td>
<td>252</td>
</tr>
<tr>
<td>C</td>
<td>3.7</td>
<td>936</td>
</tr>
<tr>
<td>D</td>
<td>2.6</td>
<td>220</td>
</tr>
</tbody>
</table>

5. **Amdahl’s Law:** Suppose a computer $M_3$ has an average CPI of 2.3 and a clock rate of 3.5 GHz. Please answer the following: (a) Calculate the runtime for a program $P$ with 14,362 instructions, which uses an accelerating co-processor 27 percent of the time, and (b) determine how much faster (or slower) the accelerator needs to run for $P$ to run 1.5 times as fast on $M_3$ with the faster (resp. slower) accelerator. *Hint: First set up your equation for Amdahl’s Law, and see if it can indeed be solved... a negative result means that the requested improvement is infeasible...* [3 pts for a), 5 pts for b)]

Part III. Extra Credit [10 points total]

6. **Performance:** You are a computer developer at XYZ Computer Corp. The managers want you to benchmark a new computer, and have provided you with timing results (raw measured times) to compare with timing results from other computers. Determine the following (a) which type of mean operator would you use to average the raw time data, and why; and (b) which type of mean operator you would use to average the ratios of execution times between the new computer running a program $P$ and one or more reference machines running $P$ – and why you would use this operator.

*Explain your answer in detail to get full credit.* [5 points for each part a), b)]