Problem 1

CPI

\[
CPI = 0.3 \times 2 + 0.2(0.9 \times 2 + 0.1 \times 20) + 0.4 \times 1 + 0.1 \times 4
\]

\[
CPI = 2.16
\]

Problem 2

Power

Part a

You can reduce the frequency to 50% of the original.

Part b

If \(c\), \(v\) and \(f\) are the capacitive load, voltage, and frequency respectively for the uniprocessor, then:

\[
Power_{\text{dynamic\ (singlecore)}} = \frac{1}{2}cv^2f
\]

\[
Power_{\text{dynamic\ (dualcore)}} = 2 \times \frac{1}{2}c \times \left(\frac{1}{2}v\right)^2 \times \frac{1}{2}f
\]

The dynamic power for the dual core system is 1/4 that of the uniprocessor.

\[
Power_{\text{static\ (singlecore)}} = \text{Current}_{\text{static}} \times v
\]

\[
Power_{\text{static\ (dualcore)}} = 2 \times \text{Current}_{\text{static}} \times \frac{1}{2} \times v
\]

The static power for the dual core is the same as that of the uniprocessor.
### Problem 3

**Performance**

<table>
<thead>
<tr>
<th>Processor</th>
<th>Cores</th>
<th>Frequency</th>
<th>Memory</th>
<th>Dhrystone</th>
<th>Arith. mean</th>
<th>Arith. mean (normalized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athlon 64 X2 4800</td>
<td>2</td>
<td>2400</td>
<td>1.25</td>
<td>2.72</td>
<td>12070.5</td>
<td>1.99</td>
</tr>
<tr>
<td>Pentium EE 840</td>
<td>2</td>
<td>2200</td>
<td>1.18</td>
<td>2.48</td>
<td>11060.5</td>
<td>1.83</td>
</tr>
<tr>
<td>Pentium D 820</td>
<td>2</td>
<td>3000</td>
<td>1.1</td>
<td>2.25</td>
<td>9110</td>
<td>1.55</td>
</tr>
<tr>
<td>Athlon 64 X2 3800+</td>
<td>2</td>
<td>3200</td>
<td>1.08</td>
<td>2.25</td>
<td>10035</td>
<td>1.66</td>
</tr>
<tr>
<td>Pentium 4</td>
<td>1</td>
<td>2800</td>
<td>1</td>
<td>1</td>
<td>5176</td>
<td>1.00</td>
</tr>
<tr>
<td>Athlon 64 3000+</td>
<td>1</td>
<td>1800</td>
<td>1.08</td>
<td>1.00</td>
<td>5290.5</td>
<td>1.04</td>
</tr>
<tr>
<td>Pentium 4 570</td>
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<td>2800</td>
<td>1.28</td>
<td>1.47</td>
<td>7355.5</td>
<td>1.38</td>
</tr>
<tr>
<td>Processor X</td>
<td>1</td>
<td>3000</td>
<td>2.56</td>
<td>0.66</td>
<td>6000</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Note that Processor X looks better than the Pentium 4 570 if you look at the arithmetic mean of the normalized values, but not if you look at the arithmetic mean of the original performance.

Geometric mean of normalized dual core processors: 2.345 Geometric mean of normalized single core processors: 0.991

### Problem 4

**Yield**

\[
Yield_{\text{die}} = \text{dies per wafer} \times (1 + \frac{\text{defects} \times \text{area}_{\text{die}}}{\alpha})^{-\alpha}
\]

The die yield is approximately 22.

### Problem 5

**Amdahl’s Law**

Part a

\[
speedup = \frac{1}{f_p + f_s}
\]

Part a

a. 7.02x

Part b

b. 47.72x

Part c

 c. It would need to be 99.9976% parallelizable!