Virtual Memory

5.15.1

The base CPI is 1.5. This means that the added CPI here is

$$120/10000 = 0.012*(15+175) = 2.28$$

Therefore, the total CPI is

$$1.5+2.28 = 3.78$$

If VMM overhead doubles, it becomes 350 cycles. Thus, the total new CPI is

$$1.5+(120/10000)*(15+350) = 5.88$$

If VMM overhead is half, it becomes 87 (150/2 = 87.5). Thus, the total new CPI is

$$1.5+(120/10000)*(15+87) = 2.724$$

Without VMM, the CPI is

$$1.5+(120/10000)*15 = 1.68$$

Degradation of 10% is 1.68*1.1 = 1.848

Let x be the overhead such that the degradation is at most 10%. Then we have the inequality

$$1.5+(120/10000)*(15+x) <= 1.848 \rightarrow (120/10000)*15 + 0.012x <= 0.348$$

From this

$$0.012x <= 0.168 \rightarrow x <= 14$$

So, the overhead can be at most 14 cycles.

5.15.2

The base CPI of a non-virtualized machine is 1.5. The "bonus" CPI caused by privileged instructions is

$$(120/10000)*15 = 0.18$$

The "bonus" CPI caused by I/O is

$$(30/10000)*1100 = 3.3$$

Thus, the total CPI is

$$1.5+0.18+3.3 = 4.98$$

To find the CPI of a virtualized machine, just add the overhead:

$$1.5+(120/10000)*(15+175)+(30/10000)*(1100+175) = 7.60$$

With half I/O, these CPIS become

Non-virtualized: $1.5+(120/10000)*15+(15/10000)*1100 = 3.33$

Virtualized: $1.5+(120/10000)*(15+175)+(15/10000)*(1100+175) = 5.6875$

We see that as I/O accesses increase in frequency, the increase of CPI on a virtualized machine is notably greater than the increase of CPI on a non-virtualized machine. In other words, there is considerate performance penalty.