Homework 3 key (20 points)

Note that the key only says what to plug in and what the answer is, for your homeworks and tests you should show your working for full credit including the algebra and all the steps.

The equation for Amdahl's law is:

O.S. = 1/((1 – f) + (f/s))

Calculators are okay for the homework, (the test will be closed-calculator but the numbers on the test will be such that you can deal with simple fractions so you won't need a calculator).

1 (5 points). Suppose an engineer tells you that by adding zero-overhead looping hardware they can shave 80% off of the execution time of loop overhread for the MediaBench benchmarks on a Digital Signal Processor you are designing. In order to justify the die cost of the extra hardware and the engineer's time, you would need a 5% overall improvement in performance on the MediaBench benchmarks. What fraction of your current total execution time must be being spent on loop overhead for you to justify the design change?

Plus in O.S. = 1.05 and s = (exec. time old/exec. time new) = (1.0/0.2) = 5, solve for f=0.0595

2 (5 points). Company A claims that by upgrading your database backend to their database software you can cut the time it takes to process each customer transaction in half (and therefore double your throughput of processing customer transactions). Company B claims that by letting them rewrite your front-end web server code they can give you a 25 percent increase in customer transaction processing throughput. Your engineers, using custom benchmarks that are representative of real customer transactions, tell you that each customer transaction spends 15% of the total processing time in the web server code and the other 85% of the time waiting for the query responses from the database backend. In terms of Ahmdahl's law (and assuming no changes in the interface between the web server and database backend), which company's claim has more credibility?

One way to do this problem is to use f = 0.85 for A and f = 0.15 for B and s = infinite for both and calculate the maximum overall speedups (getting O.S. = 6.67 for A and O.S. = 1.18 for B) and compare that to their claims, which shows A's claim to be doable (2 < 6.667) and B's to be impossible (1.25 > 1.18).

Another way to do the problem is to plug in f = 0.85 for A and f = 0.15 for B and then O.S. = 2 for A and O.S. = 1.25 for B (their stated claims), then solve for s in both cases and see that B's claim gives a negative number for s which is impossible.

3 (5 points). Suppose that the claim from the company that had the more credible claim in question #2 is true. How much would they have to speed up that particular component to get the overall speedup that they promised (*w.r.t.* to your benchmarks, of course)?

Since A is more credible, plug in f = 0.85 and O.S. = 2 to get s = 2.43.

#4 (5 points) How many clock cycles would the following MIPS code take to execute, assuming 1 cycle per instruction and 1 cycle per pipeline bubble. Also assume that this is the order the instructions will be encoded in, *i.e.*, the assembler will not remove the bubbles. Assume the typical MIPS pipeline as discussed in Chapter 4 of the book, meaning we do register forwarding and everything else we can to remove pipeline bubbles, except for the ones that cannot be removed.

```
addi t2, t2, 1
add  t4, t3, t2
sll  t4, 3
lw   t5, 16(t4)
addi t5, t5, 6
sw   t5, 16(t4)
la   t3, SomeArray
addi s0, s0, 1
lw   s1, 0(t3)
lw   s2, 0(s0)
add  s3, s1, s2
lw   s4, 0(t4)
addi s3, s3, 1
add  s5, s3, s4
```

Two load use dependencies, requiring one bubble each, are highlighted above. There are 14 instructions, if you commit one instruction per cycle and there are 2 bubbles that takes 14+2=16 cycles. Optionally, you can add 5 if you don't want to assume that the pipeline is primed before you start counting, giving 12+2+5=21. Either answer is correct.