University of California, Berkeley
College of Engineering
Computer Science Division — EECS

Fall 1997 D.A. Patterson
Solution #1

Assignment 1
Solution Set
CS152 Computer Architecture and Engineering

1.51 Yield = $\frac{1}{(1+\text{defects per area} * \text{die area} / 2)^2}$
So if die area is increased then to keep the yield constant, defects per area must go down.

1.52 Yield = $\frac{1}{(1+\text{defects per area} * \text{die area} / 2)^2}$
defects per area = $(\frac{2}{\text{die area}}) * (\frac{1}{\sqrt{\text{yield}}} - 1)$

1.53 In 1980
Yield = 48%
Die area = 0.16 Sq cm.
defects per area = $\frac{2}{0.16} * (\frac{1}{\sqrt{0.48}} - 1)$
= 5.54 defects per sq cm.

In 1992
Yield = 48%
Die area = 0.97
defects per area = $\frac{2}{0.97} * (\frac{1}{\sqrt{0.48}} - 1)$
= 0.91 defects per sq cm.

2.3 CPI = $\frac{\text{MHz}}{\text{MIPS}}$
System S1 executes $200 * 10^6$ instructions in 10 seconds
MIPS of S1 = $\frac{200*10^6}{10*10^6} = 20$
CPI = $\frac{200}{20}$
System S1 CPI = 10
System 2 executes $160 * 10^6$ instructions in 5 seconds
MIPS of S2 = $\frac{160*10^6}{5*10^6} = 32$
CPI = 300/32
System S2 CPI = 9.375

2.4 Instruction count = $\frac{\text{Execution time * Cycles per Second}}{\text{CPI}}$
For S1 : Instruction count = $\frac{3*200*10^6}{10} = 60 * 10^6$
For S2 : Instruction count = $\frac{4*300*10^6}{9.375} = 128 * 10^6$

2.10 For peak performance the machine will be executing the fastest set of instructions.
M1 will be executing instructions of class A only.
Peak MIPS of M1 = $\frac{\text{MHz}}{\text{CPI}} = \frac{500}{1} = 500$ MIPS
M2 will be executing class A or class B of instructions only.
Peak MIPS of M2 = $\frac{\text{MHz}}{\text{CPI}} = \frac{750}{2} = 375$ MIPS

2.18 CPI = $\sum$ (relative occurance of instruction * CPI of instruction)
Mbase CPI = $(2 * 0.40 + 3 * 0.25 + 3 * 0.25 + 5 * 0.10) = 2.8$
Mopt CPI = $(2 * 0.40 + 2 * 0.25 + 3 * 0.25 + 4 * 0.10) = 2.45$

2.20 Mopt is $\frac{(\text{Execution time})_{\text{Mbase}}}{(\text{Execution time})_{\text{Mopt}}}$ times faster than Mbase

$$= \frac{\left(\frac{\text{Instruction count * CPI}}{\text{Clock rate}}\right)_{\text{Mbase}}}{\left(\frac{\text{Instruction count * CPI}}{\text{Clock rate}}\right)_{\text{Mopt}}}$$

Since both machine share the same instruction set, this simplifies to $\frac{\left(\frac{\text{CPI}}{\text{Clock rate}}\right)_{\text{Mbase}}}{\left(\frac{\text{CPI}}{\text{Clock rate}}\right)_{\text{Mopt}}}$

$= \frac{(2.8\ /\ 500)}{(2.45\ /\ 600)}$
$= \frac{.0056}{.0041}$
$= 1.37$ times faster or 37% faster

2.42 Let x be the fraction of time spent in floating point operations. Then, after enhancement, the time taken by the machine will be
$100 * (\frac{x}{5} + (1 - x)) = \frac{100}{3}$ (A speed up of three is be required)
So $\frac{x}{5} + 1 - x = \frac{1}{3}$
or $\frac{4x}{5} = \frac{2}{3}$
$x = \frac{5}{6}$
So $\frac{5}{6}$ of the initial 100 seconds, or 83.33 seconds, must be spent executing floating point instructions.

1.a Number of floating point operations performed during single iteration of the daxpy loop = 2

1.b Number of floating point operations performed during single execution of the daxpy function = $2 * V$

1.c Time spent executing N iterations of the daxpy function: $t = \frac{N*V*2}{10*10^6\text{FLOPS}}$

1.d Maximum measurement error = $\frac{1}{60}$ sec. We want the error due to timer resolution to be less than 5%. So, if t is the total time spent:
$t \geq \frac{1}{60*0.05}$
$t \geq \frac{1}{3}$
Therefore, $\frac{N*V*2}{10*10^6\text{FLOPS}} \geq \frac{1}{3}$

When vector size = 1000:
$\frac{1}{3} \leq \frac{N*1000*2}{10*10^6}$
$N \geq 1666.67$
$N \geq 1667$

When, Vector Size = 100000:
$\frac{1}{3} \leq \frac{N*100000*2}{10*10^6}$
$N \geq 16.67$
$N \geq 17$

2.a

By looking into the assembly code of daxpy and daxpy OPT the following information was extracted:

Arch	# of ins. in loop	
	Daxpy	Daxpy OPT
pmax	31	11
snake	25	7

System	DEC 5000 / 25 MHZ				HP 9000 / 80 MHZ			
Compiler Cmd	daxpy	daxpyO	daxpy	daxpyO	daxpy	daxpyO	daxpy	daxpyO
Vector Size	1000	1000	100000	100000	1000	1000	100000	100000
Time / element	1.75	0.73	2.95	1.95	0.46	0.15	0.59	0.27
MFLOPS	1.14	2.73	0.68	1.02	4.33	13.16	3.38	7.37
MIPS	17.74	15.01	10.52	5.64	54.08	46.05	42.27	25.78
CPI	1.41	1.67	2.38	4.44	1.48	1.74	1.89	3.10

2.b MFLOPS: 2 / Time per element (in μs)
MIPS: Number of ins. in loop / Time per element (in μs)
CPI = clock rate (in MHz) / MIPS

Grading policy
Total Points : 80

P+H Excer. Question	Points	DAXPY Question	Points
1.51	2	1.a	2
1.52	5	1.b	3
1.53	5	1.c	5
2.3	2	1.d	10
2.4	3	2.a	10
2.10	3	2.b	10
2.18	5		
2.20	5		
2.42	5		
Sub-Total	35	Sub-Total	40
		extra credit	5