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2. CPT. IC

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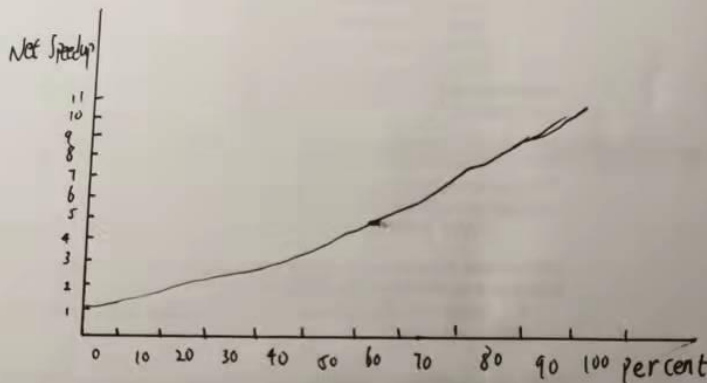
1. a. Assume T_0 is the time used for the non-vectorized code to run.
Assume 'x' equals the percentage of the code vetorized. So, $(100-x)\%$ of the code is not vectorized.

$$\text{Total time} = (100-x)\%\,T_0 + \left(\frac{x}{11}\right)\%\,T_0$$

$$\text{Net speed up} = \frac{100\%\,T_0}{(100-x)\%\,T_0 + \left(\frac{x}{11}\right)\%\,T_0} = \frac{100}{(100-x)+\frac{x}{11}}$$



b. $$1.5 = \frac{100}{100-x+\frac{x}{11}} \Rightarrow x = 36.67\%$$

c. $$\frac{\frac{x}{11}}{100-x+\frac{x}{11}} = 5\%$$

d. Maximum speed up = 11

$$\frac{11}{3} = \frac{100}{(100-x)+\frac{x}{11}} \Rightarrow x = 80\%$$

2.

(a) Execution time $= \frac{CPI \cdot IC}{\text{clock rate}}$

With the same execution time $P1 : P2 : P3 = \frac{1}{1} : \frac{1}{2} : \frac{1}{3} = 6 : 3 : 2$

(b)

$$\frac{1.5 \times 1}{(\text{clock rate})_{P1}} = \frac{1.25 \times 2}{(\text{clock rate})_{P2}} = \frac{1 \times 3}{(\text{clock rate})_{P3}}$$

clock rate $P1 : P2 : P3 = 3 : 5 : 6$

3.

0000000	00001	0000	000	0000	0110011
funct7	rs2	rs1	funct3	rd	opcode

R-type $x_i \leftarrow x_1 + x_1$

add x1, x1, x1

4. 0BADF + 1 = 0BAE0

lui x10, 0x0BAE0

addi x10, x10, 0xEED

5. 32-bit machine

(1) lw x3, 128(x5)

(2) sd x3, 256(x5)

(3) add x5, x3, x4

(4) B[g] = A[i-5A[32]+32]

lw x30, 128(x5) // A[32]

slli x31, x30, 2 // 4A[32]

~~addi x30, x3~~

add x31, x31, x30 // 5A[32]

sub x30, x10, x31 // i-5A[32]

addi x30, x30, 32 // i-5A[32]+32

slli x30, x30, 2

add x30, x30, x5 // &A[i-5A[32]+32]

lw x30, 0(x30) // A[i-5A[32]+32]

slli x31, x9, 2

add x31, x31, x6 // &B[g]

sd x30, 0(x31)

(5) (i) f = g - A[B[C[64]]]

ld x30, 256(x7)

slli x30, x30, 2

add x30, x30, x6

ld x30, 0(x30)

slli x30, x30, 2

add x30, x30, x5

ld x30, 0(x30)

sub x8, x9, x30

(ii) f = g - A[C[16] + B[32]]

ld x30, 64(x7)

ld x31, 128(x6)

add x30, x30, x31

slli x30, x30, 2

add x30, x30, x5

ld x30, 0(x30)

sub x8, x9, x30

5. (5) c.i.i) A[i] = 4B[8i-81] + 4C[32i+32]

```
slli x30, x10, 3    // 8i
addi x30, x30, -81  // 8i-81
slli x30, x30, 2
add  x30, x30, x6   // & B[8i-81]
ld   x30, 0(x30)    // B[8i-81]
slli x30, x30, 2    // 4B[8i-81]
slli x31, x10, 5    // 32i
addi x31, x31, 32   // 32i+32
slli x31, x31, 2
add  x31, x31, x7   // & C[32i+32]
ld   x31, 0(x31)    // 4C[32i+32]
slli x31, x31, 2    // 4C[32i+32]
add  x30, x30, x31
slli x31, x10, 2
add  x31, x5, x31   // A[i]
sd   x30, 0(x31)
```

b. $0x3A = (0011\ 1010)_2 = 58 = 64-4-2$

$0x5F = (0101\ 1111)_2 = 95 = 128-32-1$

0x3A left shift. 7 times ①

0x3A left shift 5 times ②

①-②-0x3A

2 shifts, 2 subtracts