Question 3

⊛ Summary of qu.

N	Instr
6	3
5	2
4	4
3	2
2	3
1	-

At level 1:

- Instr type A – 25% – 44 ns
- Instr type B – 45% – 40 ns
- Instr type C – 30% – 20ns

#Instr: 500,000

a) Number of level-1 instrs, for each level-6 instr: $3 \times 2 \times 4 \times 2 \times 3 = \boxed{144}$ instrs

b) Average instr execution time at level 1: $t_1 = \frac{25 \times 44 + 45 \times 40 + 30 \times 20}{100} = \boxed{35}$ ns

c) Number of level-1 instr, for each level-4 instr: $4 \times 2 \times 3 = 24$ instrs

→ Average instr execution time for each level-4 instr: $t_4 = 24 \times 35 = \boxed{840}$ (ns)

$(= I_4 \times t_1)$

d) Average instr execution time for each level-6 instr: $t_6 = I_6 \times t_1 = 144 \times 35 = \boxed{5040}$ ns

e) Program completion time: $T_{prog} = t_6 \times M = 500{,}000 \times 5040$

$= \boxed{252 \times 10^7}$ ns

f) Recalculation for new program:

Number of level 1 instr, for each level 6 instr: $3 \times 2 \times 4 \times 2 \times 2 = 96$ instr

Average instr execution time for each level-6 instr: $96 \times 35 = 3360$ ns

Program completion time: $T_{prog.N} = 3360 \times 500{,}000$

$= 168 \times 10^7$ ns

Ratio of new program completion time, compare to old: $\frac{T_{progN}}{T_{prog}} = \frac{168 \times 10^7}{252 \times 10^7} = \boxed{\frac{2}{3}}$

$\boxed{\text{Question 4}}$

+) Let t be the time it takes to execute a program in level 1.

+) An instruction at level n is translated into S instructions at level n - 1

→ Each level is S times as powerful as the level below it

But as optimal translation from a level to one below is hard to achieved → each additional level of translation slow the machine down.

→ Each level runs S times faster than the level above it.

+) Given the above conclusion:

Runtime at level 2 : $\frac{t}{S}$

level 3 : $\frac{\frac{t}{S}}{S} = \frac{t}{S^2}$

level 4 : $\frac{t}{S^3}$

level 5 : $\frac{t}{S^4}$

level 6 : $\frac{t}{S^5}$

. . . .

level N : $\frac{t}{S^{N-1}}$

⇒ Ratio of runtime of level 6 vs level 1

$$\frac{t}{S^5} : t = \boxed{\frac{1}{S^5}}$$

⇒ Ratio of runtime of level N vs level 1

$$\boxed{\frac{1}{S^{N-1}}}$$

Question 6

a) Number of transistors on 12 A size chip, year 0: $8000 \times 12 = 96{,}000$

Year / Doubling pe.	0	4	8	12	16	20
2 years	96000 (N_0)	$N_0 \times 2^{4/2}$ $= 384{,}000$	$N_0 \times 2^{8/2}$ $= 1{,}536{,}000$	$N_0 \times 2^{12/2}$ $= 6{,}144{,}000$	$N_0 \times 2^{16/2}$ $= 24{,}576{,}000$	$N_0 \times 2^{20/2}$ $= 98{,}304{,}000$
1.5 years (18 months)	96000 (N_0)	$N_0 \times 2^{4/1.5}$ $= 609{,}562$	$N_0 \times 2^{8/1.5}$ $= 3{,}870{,}477$	$N_0 \times 2^{12/1.5}$ $= 24{,}576{,}000$	$N_0 \times 2^{16/1.5}$ $= 156{,}047{,}873$	$N_0 \times 2^{20/1.5}$ $= 990{,}842{,}231$

(graph attached below)

b) (Since the question didn't mention the chip size, assuming chip with area A)

Length of one side of the chip: $\sqrt{A}$

Number of transistors on one side of the chip: $\sqrt{8000} = 40\sqrt{5}$

→ Length of 1 side of transistor, year 0: $\dfrac{\sqrt{A}}{40\sqrt{5}}$ (l_{old})

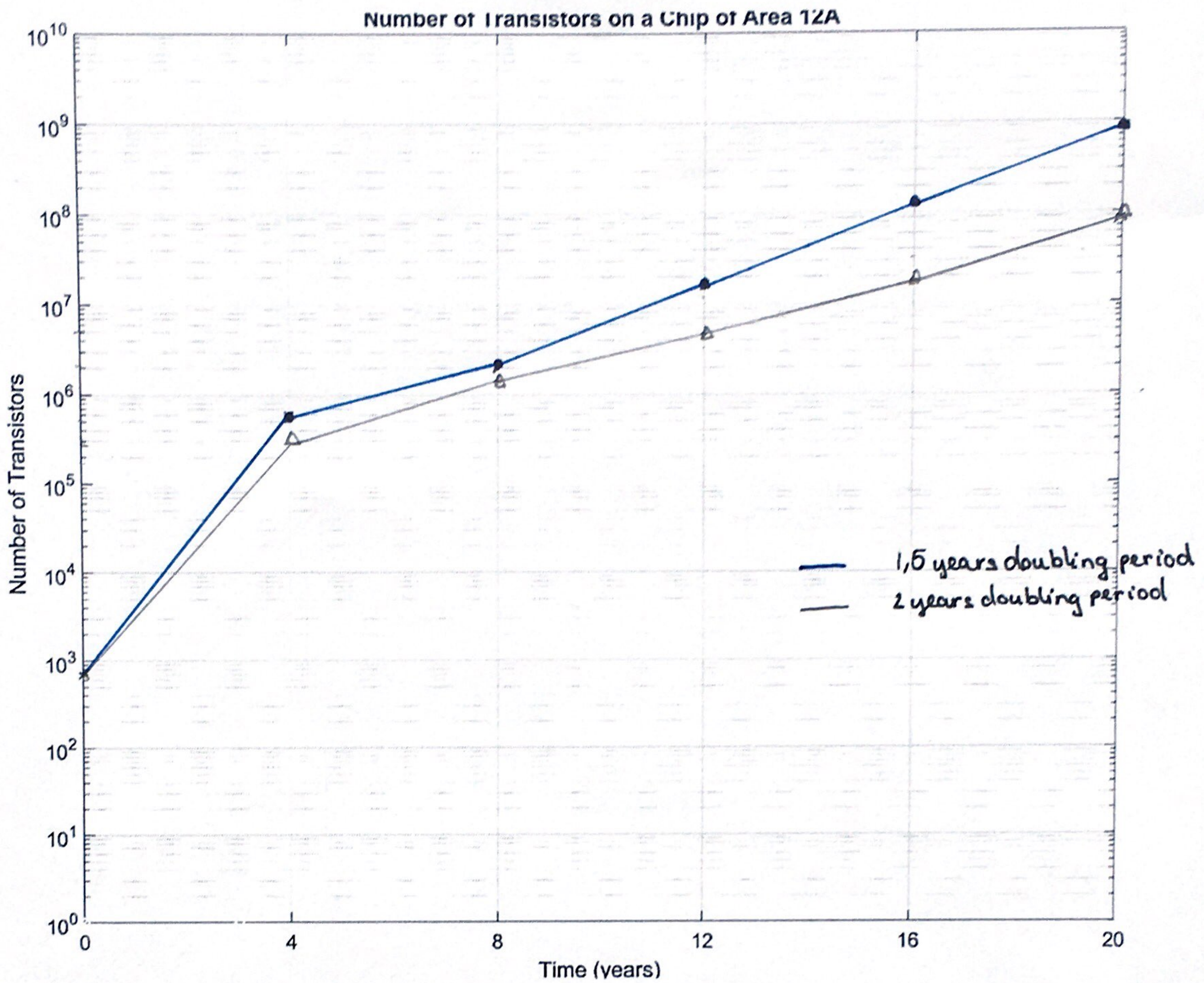
Since we have $l_{new} = \dfrac{l_{old}}{\sqrt{2^n}}$ → $\dfrac{l_{new}}{l_{old}} = \dfrac{1}{\sqrt{2^n}}$, with n is the number of doubling period

+) For 2 years doubling period.

$$\frac{l_{new}}{l_{old}} = \frac{1}{\sqrt{2^{30/2}}} = \boxed{5.524 \times 10^{-3}}$$

+) For 1.5 years (18 months) doubling period

$$\frac{l_{new}}{l_{old}} = \frac{1}{\sqrt{2^{30/1.5}}} = \boxed{\frac{1}{1024} = 9{,}766 \times 10^{-4}}$$



Number of Transistors on a Chip of Area 12A
Number of Transistors
Time (years)
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
10^{9}
10^{10}
0
4
8
12
16
20
1,5 years doubling period
2 years doubling period