1.3) The program is converted into assembly code which is then converted into machine code.

1.4) a) $1280 * 1024 * 3 = 3932160$ bytes/frame

b) $\dfrac{3932160 \cancel{\text{bytes}} \cdot 8 \frac{\text{bits}}{\cancel{\text{byte}}}}{100 \cdot 10^6 \frac{\cancel{\text{bits}}}{s}} = 0.314$ secs

1.6) a.

$$\text{Performance}_{P_1} = \frac{3 \cdot 10^9 \frac{\text{cycles}}{\text{sec}}}{1.5 \frac{\text{cycle}}{\text{instru}}} = 2 \cdot 10^9$$

$$\text{Peformance}_{P_2} = \frac{2.5 \cdot 10^9}{1} = 2.5 \cdot 10^9$$

$$\text{Performance}_{P_3} = \frac{4 \cdot 10^9}{2.2} = 1.8 \cdot 10^9$$

b.

	# of Cycles	# of instructions
P_1	$10 \cdot 3.10^9 = 30 \cdot 10^9$ cyc	$10 \cdot 2 \cdot 10^9 = 20 \cdot 10^9$ instruc
P_2	$10 \cdot 2.5 \cdot 10^9 = 25 \cdot 10^9$ cyc	$10 \cdot 2.5 \cdot 10^9 = 25 \cdot 10^9$ instruc
P_3	$10 \cdot 4 \cdot 10^9 = 40 \cdot 10^9$ cyc	$10 \cdot 1.8 \cdot 10^9 = 18 \cdot 10^9$ instruc

c. $\text{CPU time} = \dfrac{(\#\text{ instruc})(CPI)}{\text{Clock rate}}$

$$0.7 t_{cpu} = \frac{n \cdot (1.2)(CPI}{r \cdot \text{clockrate}}$$

$$r = \frac{1.2}{0.7} = 1.714$$

$$\text{Clock Rate}_{P_1} = (1.714)(3) = 5.142 \text{ GHz}$$

$$\text{Clock Rate}_{P_2} = (1.714)(2.5) = 4.285 \text{ GHz}$$

$$\text{Clock Rate}_{P_3} = (1.714)(4) = 6.856 \text{ GHz}$$

1.7) a. $\text{Global } CPI_{P_1} = (0.1)(1) + (0.2)(2) + (0.5)(3) + (0.2)(3)$

$= 2.6$

$\text{Global } CPI_{P_2} = (0.1)(2) + (0.2)(2) + (0.5)(2) + (0.2)(2)$

$= 2$

b. $P_1 \text{ Cycles} = 2.6 \cdot 10^6 \text{ cycles}$

$P_2 \text{ Cycles} = 2 \cdot 10^6 \text{ cycles}$

$\text{CPU Time}_{P_1} = \frac{2.6 \cdot 10^6 \text{ cycles}}{2.5 \cdot 10^9} = 0.00104 \text{ s} = 1.04 \cdot 10^{-3}$

$\text{CPU Time}_{P_2} = \frac{2 \cdot 10^6}{3 \cdot 10^9} = 6.67 \cdot 10^{-4}$

P_2 is faster

1.8) a. $CPI_A = \frac{1.1}{\cancel{10^9} \cdot \cancel{10^{-9}}} = 1.1$

$CPI_B = \frac{1.5}{1.2 \cdot 10^9 \cdot 10^{-9}} = 1.25$

b. $\frac{(10^9)(1.1)}{r_A} = \frac{(1.2 \cdot 10^9)(1.25)}{r_B}$

$r_B = 1.36\, r_A$

c. $(6 \cdot 10^8)(1.1) \cdot (10^{-9} s) = 0.66 \text{ s}$

$\frac{1.1}{0.66} = 1.67$ speedup for A

$\frac{1.5}{0.66} = 2.27$ speedup for B

13) 13.1) $\text{CPU Time}_{P_1} = \frac{(5 \cdot 10^9)(0.9)}{4 \cdot 10^9} = 1.125 \text{ s}$

$\text{CPU Time}_{P_2} = \frac{(1 \cdot 10^9)(0.75)}{3 \cdot 10^9} = 0.25 \text{ s}$

P_2 has a better Performance even with a lower clock rate.

13.2) $\frac{(\cancel{10^9})(0.9)}{4 \cdot \cancel{10^9}} = \frac{I_{P_2} \cdot 0.75}{3 \cdot 10^9} =$

$I_{P_2} = 0.9 \cdot 10^9$ instruc

13.3) $MIPS_{P_1} = \frac{4 \cdot 10^{9-3}}{0.9 \cdot 10^6} = 4444.44$

$MIPS_{P_2} = \frac{3 \cdot 10^9}{0.75 \cdot 10^6} = 4000$

P_1 has a higher MIPS, even though P_2 performs better.

13.4) $MFLOPS_{P_1} = \frac{0.4(5 \cdot 10^9)}{(1.125 \cdot 10^6)} = 1777.78$

$MFLOPS_{P_2} = \frac{0.4(10^9)}{0.25 \cdot 10^6} = 1600$

15.1) $CPU\ Time = \frac{(50 \cdot 10^6) + (110 \cdot 10^6) + 4(80 \cdot 10^6) + 2(16 \cdot 10^6)}{2 \cdot 10^9}$

$= 0.256\ s$

$0.128 = \frac{(50x + 110 + 320 + 32) \cdot 10^6}{2 \cdot 10^9}$

$x = -4.12$ ← Not even possible

15.2) $0.128 = \frac{(50 + 110 + 80x + 32) \cdot 10^6}{2 \cdot 10^9}$

$x = 0.8$

$\frac{4}{0.8} = 5$ times faster

15.3)

$CPU\ Time = \frac{0.6(50 \cdot 10^6) + 0.6(110 \cdot 10^6) + 0.7 \cdot 4(80 \cdot 10^6) + 0.7 \cdot 2(16 \cdot 10^6)}{2 \cdot 10^9}$

$= \boxed{0.1712s}$

$\frac{0.256}{0.1712} = 1.495$ faster