Homework #1 Solutions

1.2 A certain IBM 970 processor has a system clock frequency of 1.2 GHz. What is the clock period?

Answer: The clock period is 1.0 divided by the clock frequency. In other words, the clock period $T = (1 \div f)$ where f is the clock frequency. The clock period in this problem is $T = 1.0 \div (1.2 \times 10^9) = 0.833 \times 10^{-9}$ = 833 picoseconds.

1.3 If the cost of RAM is $95 for a 4MB module, what will it cost to install 32M words in an originally empty machine if the word size is 32 bits?

Answer: 32 bit word = 4 bytes. So, 32 MW = 32M x 4B = 128 MB. At $95 for 4 MB, this gives (128 MB/memory) x ($95 / 4MB) = $3040 per memory

1.4 How many 500 MB tapes will be required to back up a 120 GB hard drive? How long will the backup process require if one tape can be filled in 5 minutes? (No coffee breaks allowed).

Answer: One GB is a gigabyte which is 2^{30} bytes. One MB is a megabyte which is 2^{20} bytes. So, 120 GB is 120×2^{30} bytes. 500 MB is 500×2^{20} bytes. The number of tapes required is the number of bytes to be stored divided by the storage capacity of each tape. So, the number of tapes $N = (120 \times 2^{30}) \div (500 \times 2^{20}) = 0.24 \times 2^{10} = 0.24 \times 1024 =$ 245.76. So, the number of tapes is 246.

The time required to fill the tapes is t = (245.76 tapes) x (5 minutes per tape) = 1,228.8 minutes. This assumes that the last tape takes 0.76*5 = 3.8 minutes because you do not fill it completely.

1.5 a. A certain machine requires 1.5 µsec (microseconds) to process each 64-byte data record in a database. How long will it take to process a database containing 100×10^8 records?

Answer: (1.5 microseconds per record) x (100×10^8 records) = $(1.5 \times 10^{-6}) \times (100 \times 10^8)$ = 150×10^2 seconds = 15,000 seconds = 250 minutes.

b. How many 700 MB-capacity CD-ROMs will be required to store the database?

Answer: The total number of bytes in the database is $6{,}400 \times 10^8$. The number of CDs required is $6{,}400 \times 10^8$ divided by 700×2^{20}, or 871.93. Since you cannot have a partial CD you need 872 CDs.

1.8 Consider computing the electric field in a box 1.5 cm on a side. The spatial resolution in each dimension is to be 50 µm Assume that it takes 150 instructions for every point in the

3-D grid to do the calculation. How long does the computation take on a computer that can execute at a rate of 100 MLOPS (Millions of Floating Operations per Second)?

Answer: You have a big box that is 1.5 cm (1.5×10^{-2} meters) on each of its sides. The big box is made up of smaller boxes that are each 50 μm (50×10^{-6} meters) on a side. So, the number of small boxes in the big box is $[(1.5 \times 10^{-2}) \div (50 \times 10^{-6})]^3 = 27{,}000{,}000$. Each of the 27,000,000 points requires 150 instructions, so that is 4,050,000,000 instructions. If my computer can execute 100 million instructions per second then the total program will requires (4,050,000,000) ÷ (100,000,000) = 40.5 seconds.

1.14 Using only the instructions in Table 1.3, compile by hand the following C statements into VAX 11 assembly language. Assume that all variables are integers.

a. V = (W + X) * (Y + Z) ;

Answer:	ADD W, X, V;	Add W and X and store result in V
	ADD Y, Z, T;	Add Y and Z and store result in T (temporary location)
	MPY T, V, V;	Multiply T and V and store result in V

b. A = B*C*D + E ;

Answer:	MPY B, C, A;	Multiply B and C and store result in A
	MPY A, D, A;	Multiply A and D and store result in A
	ADD A, E, A;	Add A and E and store result in A

c. $Z = x*y^2$;

Answer:	MPY y, y, Z;	Multiply y and y and store result in Z
	MPY Z, x, Z;	Multiply Z and x and store result in Z

d. U = V ; W = U + Y ;

Answer:	MOV V, U;	Move V to U
	ADD U, Y, W;	Add U and Y and store result in W

Note that in all cases you cannot destroy (overwrite) the variables on the right side of each equation. In other words, you cannot use variables on the right side of the equation as temporary storage locations. You must create temporary locations such as T if you need to store an intermediate result. You can also use the location of the result as a temporary storage location.

1.15 Using only the information in Table 1.2, encode the following MC68000 assembly language instructions into machine language. Express your results in binary.

a. MOVE.W D3, D4

Answer: The only change when compared to the example in Table 1.2 is the register number of the source and destination. The 101 in the example will change to 100. The 100 in the example will change to 011. So, the new machine language becomes 0011 100 000 000 011.

b. ADDI.W #65535, D4

Answer: The only change from the example is the destination register and the data that is immediately represented in the instruction. The new destination register is 100 instead of 010. The new immediate data is $2^{16} - 1 = 65,535$. This is all 1s in a 16-bit representation. So, the new machine language instruction is:

00000110 01 000 100
1111 1111 1111 1111

1.19 a. Define the term "bus".

Answer: A "bus" is a shared communication path between multiple resources in a computer. The bus provides data and control information. The control information often includes address information as well as other forms of control signals.

b. Why are buses used in computers?

Answer: Buses are used to allow communications between multiple resources in a way that is efficient and does not require each resource to have a unique communications path to every other resource. A bus will normally save hardware in a data path implementation by allowing a communication path to be shared amongst multiple devices.

c. Describe the similarities and differences between the computer bus and the electric power grid.

Answer: The electric power grid is similar to a bus in that both are shared resources that allow movement of something (either electricity or information) from one point to another. They differ because multiple power sources can place electricity onto the grid at the same time. In other words, you might own a personal generator that could place power on the grid at the same time your power company does. You cannot have multiple sources of information attempt to place information on a computer bus simultaneously.

d. Describe the differences between the computer bus and the water system in your home.

Answer: Water generally flows in one direction in your pipes whereas information can normally flow in either direction on a bus. Hot and cold water can be mixed in your water system, but different types of information cannot be mixed on a computer bus. There is no control information flowing with your water. The water is analogous to the data on a computer bus. The computer bus transfers both data and control information.