Computer Architecture
Homework 1 - Solutions
Theme: Prerequisites
All questions carry equal weight. Show your work to receive credit.

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1. What are the decimal and hexadecimal representations of the maximum and minimum numbers which can be represented by 32-bits in 2's complement and unsigned representation?

	Max, Dec	Min, Dec	Max, Hex	Min, Hex
2's complement	2147483647	-2147483648	7FFFFFFF	80000000
Unsigned	4294967295	0	FFFFFFFF	0000

- 2's complement
  Max = $(0111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111)_2$
  $= (2147483647)_{10}$
  $= (7FFF\ FFFF)_{16}$
  Min = $(1000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000)_2$
  $= (-2147483648)_{10}$
  $= (8000\ 0000)_{16}$

- Unsigned
  Max = $(1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111\ 1111)_2$
  $= (4294967295)_{10}$
  $= (FFFF\ FFFF)_{16}$
  Min = $(0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000\ 0000)_2 = (0)_{10} = (0)_{16}$

2. Convert the following numbers from the given base to the other three bases listed in the table (for octal conversion assume numbers are unsigned, otherwise assume they are signed 2's complement):

Bit length for binary and hex representations-->	16-bits	8-bits	16-bits	16-bits
Decimal	**369**	-37	403	-15383
Binary	0000 0001 0111 0001	**1101 1011**	0000 0001 1001 0011	1100 0011 1110 1001
Octal	561	333	**623**	141751
Hex	0171	DB	**0**193	**C3E9**

- 369

  369 / 2 = 184 r 1
  184 / 2 = 92 r 0
  92 / 2 = 46 r 0
  46 / 2 = 23 r 0
  23 / 2 = 11 r 1
  11 / 2 = 5 r 1
  5 / 2 = 2 r 1
  2 / 2 = 1 r 0
  1 / 2 = 0 r 1

  $369 = (0000\ 0001\ 0111\ 0001)_2 = (0561)_8 = (0171)_{16}$

- 1101 1011

  Note that the number is negative, since it starts with a 1.
  ¬ 1101 1011 + 1= 0010 0100 + 1 = $(0010\ 0101)_2$ = - (32 + 4 + 1) = $(-37)_{10}$
  $(1101\ 1011) = (333)_8 = (DB)_{16}$

- 623

  $623 = (0000\ 0001\ 1001\ 0011)_2 = (0193)_{16} = (403)_{10}$

- C3E9

  $C3E9 = (1100\ 0011\ 1110\ 1001)_2 = (141751)_8$
  Note that the number is negative, since it starts with a 1.
  ¬ 1100 0011 1110 1001 + 1 = 0011 1100 0001 0110 + 1
  $= (0011\ 1100\ 0001\ 0111)_2 = (-15383)_{10}$

3. Provide the packed and unpacked BCD and ASCII representations of the number 927_{10} . Express your answer in hexadecimal. Hint for ACII conversion - Convert to hex and then translate each hex digit to ASCII.

   BCD: 090207 (unpacked) OR 927 (packed)

   $(927)_{10} = (39F)_{16}$
   ASCII: 0x333946

4. In Fig 1.6 what do the words MAR, MBR, IBR stand for? List and explain the main structural components of a computer and processor.

   MAR - Memory Address Register
   MBR - Memory Buffer Register
   IBR - Instruction Buffer Register

   There are four main structural components of a computer:
   1. CPU - Controls the operation of the computer and performs its data processing functions
   2. Main Memory - Stores data to be used by the computer
   3. I/O - Transfers data between the computer and its external environment
   4. System Bus - Provides communication between the different computer components

   There are four main structural components of a CPU:
   1. Control Unit - Controls the operations of the CPU and of the whole computer
   2. Arithmetic and Logic Unit (ALU) - Performs the computer's data processing functions.
   3. Registers - Provide internal storage for the CPU
   4. CPU Bus - Provides communication between the different CPU components

5. Explain Moore's Law. What are its consequences?

   Moore's Law is the prediction that the number of transistors that can be placed on a single chip will double every 1.5 years.

   Consequences:
   1. The cost of a chip has remained virtually unchanged during this period of rapid growth in density. This means that the cost of computer logic and memory circuitry has fallen at a dramatic rate.
   2. Because logic and memory elements are placed closer together on more densely packed chips, the electrical path length is shortened, increasing operating speed.
   3. The computer becomes smaller, making it more convenient to place in a variety of

environments.

4. There is a reduction in power requirements.
5. The interconnections on the integrated circuit are much more reliable than solder connections. With more circuitry on each chip, there are fewer interchip connections.

6. Discuss the differences between an embedded computer system and a general-purpose computer.

An embedded computer system is usually designed with a very specific application in mind and paired with special hardware. Examples of embedded computer systems include computerized gas pumps and computerized washing machines. A general purpose computer is designed to perform a variety of tasks suited to a variety of applications. The PCs we use daily are general purpose computers.

7. What are the advantages of using a family based approach to computer architecture?

- Similar or identical instruction set: In many cases, the exact same set of machine instructions is supported on all members of the family. Thus, a program that executes on one machine will also execute on any other. In some cases, the lower end of the family has an instruction set that is a subset of that of the top end of the family. This means that programs can move up but not down.
- Similar or identical operating system: The same basic operating system is available for all family members. In some cases, additional features are added to the higher-end members.
- Increasing speed: The rate of instruction execution increases in going from lower to higher family members.