Drexel-SDP GK-12 ACTIVITY

Activity Template

Subject Area(s): Digital Electronics

Associated Unit: None

Associated Lesson: None

Activity Title: Binary Number Game

Grade Level: 8 (7-9)

Activity Dependency: None

Time Required: 90 minutes

Group Size: 3-4 students

Expendable Cost per Group: US $0.00

Summary:

In this activity, students will learn about the practical uses, structure, mathematics and terminology of the binary number system. This activity also makes an attempt to build an appreciation for the power and speed of the electronics students use on a daily basis. As a result of this activity, the students will be able to convert a given number from the binary to the decimal number system and vice versa and perform binary addition and subtraction.

Engineering Connection:

All forms of electrical engineering are built upon the foundation of the binary number system, for example, computers, computer software programs, calculators, cell phones and any other digital electronic devices. The transmission, compression algorithms, storage and computation of binary numbers are all important concepts in electrical engineering along with its usage.

Keywords: binary number system, bit, byte, binary addition, binary subtraction

Educational Standards

Science: None
Math: 2.1 – Numbers, Number Systems and Number Relationships

Learning Objectives

After this lesson, students should be able to:

- Describe a bit and byte and understand the usage of such terminology
- Perform conversions from the binary to the decimal number system
- Perform conversion from the decimal to the binary number system
- Perform calculations involving the addition and subtraction of binary numbers

Materials List

Each group needs:

- sheet of paper
- pencil or pen
- calculator

Introduction / Motivation

Digital electronics are a part of most everyone's daily life, but not many people give a second thought as to why or how their cell phone, iPod, kitchen appliance or computer works. Generally, the intricacy and power of any device a person uses is taken for granted without a true understanding of the basic building blocks of the device. A person dialing a number on a cell phone and calling another person involves highly complex programs and algorithms to keep a network running smoothly without interference, downtime and the dreaded lost call. If people were more educated regarding the structure and intricacy of their electronics they might appreciate the existence of these devices. This lab strives to provide a means of relaying the speed of electronic device computation and the massive amount of information that is able to be stored on hardware of physically minimal size.

Vocabulary / Definitions

Word	Definition
bit	a binary digit, either a 1 or 0
byte	unit of measure of data storage, most often a group of 8 bits

Procedure

Background

Digital circuits in digital electronic devices (such as a calculators) use voltage levels to represent bits. A bit is either a 1 or 0, and two different voltage configurations can be used to distinguish between bits with values of 0 and 1. The first configuration represents 1 as a non-zero voltage and 0 as a zero voltage. The second configuration represents 1 as a high voltage value and 0 as a

low voltage value. Both configurations easily distinguish between the two different voltage levels to assign the proper binary representation. This same type of idea is applied to CD-ROMs, in which pits or non-pits exist to represent 1s and 0s. A pit is just a position on the CD that was burned when the CD was created. All of these forms of representing a bit can be used to store information or data on a hard drive, flash drive, CD-ROM or any other type of digital storage equipment. Therefore, each type of system has limited amount of space available to store the bits representing the data. It is important to note that memory for storing data is built on a structure of powers of 2 and not powers of 10. This is important because memory size is often estimated to a power of 10 since this is more familiar to most people. In reality, however, the actual size of the memory is a power of 2 as can be seen in the table below. The prefixes presented in the table below are often used to describe the number of bytes of information that can be stored on a device. For example, 12 KB (12 kilobytes) could be the size of a text document and 160 GB (160 gigabytes) could be the size of a hard drive.

Prefixes for bytes

Prefix	Symbol	Estimated Size	Actual Size
kilo	K	$1000^1=10^3$	$1024^1=2^{10}$
mega	M	$1000^2=10^6$	$1024^2=2^{20}$
giga	G	$1000^3=10^9$	$1024^3=2^{30}$
tera	T	$1000^4=10^{12}$	$1024^4=2^{40}$

Before the Activity

- Prepare the questions and answers that will be used for the game
- Research the hard drive sizes of current electronic devices such as computers and iPods to use as examples when informing students about the number of bits and bytes that devices of this size can hold

With the Students

1. Begin by asking the students if they can define the term bit or byte
2. Explain to the students what a bit and byte are and how each is applied, i.e. hard drive
3. Define a bit and byte and provide examples
4. Explain how many bits and bytes are in a kilobyte, megabyte and gigabyte
5. Provide an example of how many bits and bytes are stored on a hard drive of a large size (i.e. a 160 GB iPod)
6. Explain why a number in the decimal system would need more than one bit in binary to represent the decimal number
7. Go through at least two examples of converting a four bit or larger binary number into a decimal number
8. Go through at least two examples of converting a decimal number into a four bit or larger binary number
9. Give the students one problem for converting a number from binary to decimal and vice versa
10. Make sure that all students understand how to do the conversions
11. Break the class up into groups of three to four students
12. Go through 5-10 rounds of conversions with each round consisting of one binary to decimal and one decimal to binary conversion

13. In each round the first group to correctly answer both conversions receives a point with each group only being allowed to answer once
14. Without explaining try several rounds of addition and subtraction of binary numbers
15. Walk the students through both an addition and subtraction problem
16. Go through several more rounds of addition and subtraction of binary numbers
17. To make the game more interesting, allow the students a "final jeopardy" type round

Attachments

- Sample Questions

Safety Issues

- No safety issues

Investigating Questions

- What other base number systems could be used?
- What are the formats that keyboards use for input to a computer (i.e. ASCII)?

Assessment

Pre-Activity Assessment

Class Discussion:

- Talk with the students about examples of devices that store data digitally
- Talk with the students about different ways digital electronics represent a bit as a 1 or a 0, i.e. a CD-ROM and flash drive

Activity Embedded Assessment

Group Participation: Take a mental note of who is participating and possibly mark down when each group attempts to answer a question

Post-Activity Assessment

Handout/worksheet: Give the students a worksheet that would be collected at the end of class or the next day depending on availability of class time

Activity Extensions

- The students can explore binary multiplication and division
- The students can investigate other number systems, such as hexadecimal and octal
- The students can learn to convert binary to hexadecimal and octal number systems

Activity Scaling

- For lower grades, the activity might be scaled back to include only the structure of binary numbers and the conversion of binary to decimal and vice versa

- For upper grades, the activity should briefly introduce the conversion of the numbers and focus more on the mathematical operations of binary numbers and the conversion of binary to hexadecimal and octal

Owner: Drexel University GK-12 Program

Contributors: Travis M. Doll, ECE Department, Drexel University

Sample Questions

Binary to Decimal Conversions

0000 0000 = 0	0000 1101 = 13	1001 1001 = 153
0000 0011 = 3	0101 1111 = 95	1011 0101 = 181
0000 0101 = 5	0110 0110 = 102	1111 1111 = 255

Addition Problems

0001 1010 = 26 + 0000 1101 = 13 0010 0111 = 39	0000 0001 = 1 + 0111 1111 = 127 1000 0000 = 128	1000 1000 = 136 + 0010 0100 = 36 1010 1100 = 172
0101 0101 = 85 + 1010 1010 = 150 1111 1111 = 255	0111 1000 = 120 + 0000 1111 = 15 1000 0111 = 135	

Subtraction Problems

1110 1000 = 232 - 0000 1010 = 10 1101 1110 = 222	1001 1010 = 154 - 0011 0110 = 54 0110 0100 = 100	1011 0001 = 177 - 0010 1111 = 47 1000 0010 = 130
1000 0001 = 129 - 0010 1010 = 42 0101 0111 = 87	1000 0101 = 133 - 0001 0101 = 21 0111 0000 = 112	