#### The Memorization of Binary and Hexadecimal Patterns Daniel Johnson Boise City High School

#### Preface

To teach microprocessor development at the high school level we need appropriate teaching materials and texts.

It is my belief that the material needs to be explicit enough to allow interested math or science teachers to study the materials and teach the class. This document is an example of one section from a teaching guide written in that spirit.

Prior to using this guide teachers need to cover number bases.

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## This paper details my methodology for teaching binary hex conversion in a competitive way.

The ability to instantaneously convert between hex digits, 4 bit binary, and decimal is a fundamental skill. The required 42 patterns should be studied to the point of instant recall. Unfortunately students become bored with the learning process long before this is achieved.

High school students are competitive by nature. When the learning process is presented as a competitive game they learn the material more rapidly and throughly. This is especially true when memorization of otherwise dull material is required.

#### Overview

Each student is provided with a set of flashcards and told to commit then to memory.

After two days I give an unannounced, ungraded, quiz to let the students know they should be using the cards. For the last 15 minutes of class students pair up and drill each other using the cards. The first competition is announced.

After a week we hold our first competition. They are held weekly until the desired level of memorization is achieved.

#### Flashcards

The file were originally written with Open Office.

Open office can be downloaded from http://download.openoffice.org

For the people who would rather not install open office the files have been saved in the pdf format.

I used 110 lb stock with a HP1020 but needed to hand feed each sheet, with about 25% reprints for alignment. Please print on cards on stock your printer can handle.

Each page contains two columns of cards. The columns and rows are marked with light lines. If the lines do not match up on the front and rear either choose one or split the difference.

I packaged each set of cards in a 'snack sized' zip lock bag and distributed them to the students.

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#### Competition

Break the students up into teams of not more than 5 people including the team captain. A small group size prevents the students from getting bored waiting for their turn. The instructor acts only as a supervisor. This allows several competitions to occur simultaneously.

Each team has a work area on the blackboard. It consists of a work area and a score area. The first column of the work area consists of the given information.

HEX	BIN
А	
4	
9	
2	
В	
F	

	1
Name	Time
Bill	
Dave	
Ada	
John	
Jenny	
Team Total	

In this version of the game each team member takes their turn filling in the binary corresponding to the provided hex. The time required to complete the task is recorded in the score area. In the early stages one second is added to the score for each incorrect answer. A low penalty encourages the contestants not to 2<sup>nd</sup> guess their answers. As proficiency increases the penalty is increased to encourage correct answers. Start with a penalty of 1 second. Increase it in stages until a fast player with a single error will always have a longer time then a slower player without an error.

While one team member is writing answers a second does the timing. The others watch and point out the number of errors after the time has been determined. The team captain ensures that the things more along and is responsible for keeping order.

At the end of each round the time for the team is computed.

If you find students are attempting to memorize the answers rearrange the given numbers. I encourage the students not to react when the student at the board makes a mistake.

When you have uneven sized teams the team time can be divided by the number of team members to generate a team average.

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#### Alternate forms of the game

BIN to HEX

BIN	HEX
1010	
0100	
1001	
0010	
1011	
1111	

Name	Time
Bill	
Dave	
Ada	
John	
Jenny	

Team Total

HEX	to
DEC	

HEX	DEC
А	
D	
С	
E	
В	
F	

Name	Time
Bill	
Dave	
Ada	
John	
Jenny	

Team Total

DEC to HEX

HEX	DEC
А	10
D	13
С	12
Е	14
В	11
F	15

Name	Time
Bill	
Dave	
Ada	
John	
Jenny	

Team Total

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#### Notes

A student that can do the numbers without thinking or calculating has succeed in reaching the goal. The race aspect of the game is there to make it interesting and should have little bearing on how you grade the student.

Feel free to improvise and modify the game to suite you situation. The game as described here worked well with 2 groups of students totaling 9. Running it with 3 or more groups may require adjustments.

The hex decimal conversions are learned in the same way as the hex bin but come more easily.

There are a total of 42 patterns to remember: 16 hex to bin, 16 bin to hex, 6 hex to decimal and 6 decimal to hex. I never mention that there are 42 things to know, it sounds to daunting. Instead I say they have to learn hex to dec and hex to bin.

It may be easier to teach hex to dec first. Then hex to bin. It would reduce the number of expected patterns.

Learning the hex to bin seems to be the most difficult. The goal is to obtain instant recall but up to the point where it is achieved the following associations can be helpful. Keep in mind that these are crutches and not the final goal.

The bit value of each binary place. 0x1=0b0001, 0x2=0b0010, 0x4=0b0100, and 0x8=0b1000.

The values created by some number of zeros followed by ones: 0b0001=0x1, 0b0011=0x3, 0b0111=0x7, and 0b1111=0xF.

The patterns for 0xB=0b1011 and 0xD=0b1101 are similar but different. Bits 1 and 2 are switched.

The patterns for  $5_{10}$  and  $10_{10}$  are similar. 0x5 is 0b0101, 0xA is 0b1010. This is true because shifting one position left is the same as multiplying by two.

The pattern for 0xE=0b1110 is easy because it is one less then 0xF=0x1111.

The remaining patterns are: 0x6=0b0110, 0x9=0b1001, 0xC=0x1100. For these the students can resort to adding the values of each bit.

After the students become proficient time will be determined by how fast they can write. Continue the competitions until they approach this level. There is little value in continuing past that point. The students may not want to stop. In my class we have a competition most

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Wednesdays unless the week is short or we have testing.

One of my students is learning disabled. We handicap his score by cutting it in half. Instead of being the last student chosen he is often first. I spoke with this student in private first to ensure that this was OK with him.

We use laptop computers with the evaluation version of a program called "Egg Timer Plus" from <u>http://www.sardinesoftware.com/index.php</u>. If needed you can purchase a full license for this program for about \$5.

About the author.

Daniel Johnson is a retired software engineer. Currently he is teaching embedded systems programming at Boise City High School.

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