APCSP - Part06

Data Encodings

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Summary: Convert between binary, hexadecimal, and decimal; become familiar with the ASCII table, HTML, and CSS.

Contents

I Introduction **2**

II Binary **3**
II.1 How it Works . . . 3
II.1.1 Place values . . . 3
II.1.2 Binary -> Decimal . . . 4
II.1.3 Decimal -> Binary . . . 4
II.2 Example . . . 5
II.3 Resources . . . 5
II.4 Problem Set . . . 6

III Hexadecimal **7**
III.1 How it Works . . . 7
III.1.1 More digits please! . . . 7
III.1.2 Hexadecimal -> Decimal . . . 7
III.1.3 Binary -> Hexadecimal . . . 8
III.2 Example . . . 8
III.3 Resources . . . 8
III.4 Problem Set . . . 8

IV ASCII **10**
IV.1 How it Works . . . 10
IV.2 Example . . . 11
IV.3 Resources . . . 11
IV.4 Problem Set . . . 11

V HTML **13**
V.1 How it Works . . . 13
V.2 Example . . . 13
V.3 Resources . . . 14
V.4 Problem Set . . . 14

VI CSS **16**
VI.1 How it Works . . . 16
VI.2 Example . . . 16
VI.3 Resources . . . 16
VI.4 Problem Set . . . 17

VII Turn-in & Grading **18**

Chapter I

Introduction

This is one week worth of work. Try to complete as much as you can in class, and then do the rest during the week. You can turn this project in to Peergrade, and give and receive feedback, from home.

Chapter II

Binary

II.1 How it Works

Binary is a counting system that works in the same way as our standard counting system, which is decimal.

II.1.1 Place values

In elementary school, you learned about the one's place, ten's place, hundred's place, thousand's place, ten-thousand's place and so forth...

Place value chart

Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Ones
			6	5	2

Those numbers are equivalent to powers of ten. Remember that an exponent, such as 10^x, means that number multiplied by itself a certain number of times.

- $1 = 10^0 = 10 / 10$
- $10 = 10^1 = 10$
- $100 = 10^2 = 10 * 10$
- $1{,}000 = 10^3 = 10 * 10 * 10$
- $10{,}000 = 10^4 = 10 * 10 * 10 * 10$

and so forth.

In binary, each digits place is a power of two. So we have a one's place, a two's place, four's place, eight's place, sixteen's place, and so on.

2^7 2 x 64	2^6 2 x 32	2^5 2 x 16	2^4 2 x 8	2^3 2 x 4	2^2 2 x 2	2^1 2 x 1	2^0 1
128 One hundred twenty-eights place	**64** Sixty-fours place	**32** Thirty-twos place	**16** Sixteens place	**8** Eights place	**4** Fours place	**2** Twos place	**1** Ones place

II.1.2 Binary -> Decimal

Say you have the binary number 100100110 and want to convert it to decimal. How would you do that? Write out the place values of each digit by multiplying 2 by itself over and over again. Then, add up one of each place value for every place the binary number has a 1.

Binary to Decimal

2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
256	128	64	32	16	8	4	2	1
1	0	0	1	0	0	1	1	0

256 + 32 + 4 + 2 = 294

A great way to remember the powers of two is to play the game 2048!

II.1.3 Decimal -> Binary

Say you have a decimal number, like 42, and need to convert it to binary. How would you do that?

One way that you can convert from decimal to binary goes like this:

1. Write out the place values of the binary system, calculating the powers of two until you get to one that is larger than your decimal number.
   1, 2, 4, 8, 16, 32, 64... done!

2. Write a 1 in the last place value that was smaller than your number, and subtract that place value from your number. *We have one 32. Subtract 32 from 42 and now it's 10.*

3. Repeat this process with the result of your subtraction. *The largest power of 2 that fits inside 10 is 8. Write down '1' in the eights place and subtract 8 from 10.. now it's 2.*

4. Continue repeating until the result of your subtraction is 0. *2 fits into the two's place, and 2-2 = 0.*

5. Write out the number with zeroes in the other places that you didn't use. *1*32 + 0*16 + 1*8 + 0*4 + 1*2 + 0*1 –> 101010*

The easier way to do it goes like this:

1. Write down the decimal number.

2. Divide the number by 2.

3. Write the result underneath.

4. Write the remainder on the right hand side. This will be 0 or 1.

5. Divide the result of the division by 2 and again write down the remainder.

6. Continue dividing and writing down remainders until the result of the division is 0.

7. The most significant bit (MSB) is at the bottom of the column of remainders and the least significant bit (LSB) is at the top.

8. Read the series of 1s and 0s on the right from the bottom up. This is the binary equivalent of the decimal number.

II.2 Example

II.3 Resources

- Owlcation.com: How to Convert Decimal to Binary and Binary to Decimal
- Khan Academy

II.4 Problem Set

This is a problem set. You should get some scratch paper and a pen or pencil to do these conversions in the same way you will have to do them on the test, without a computer or calculator. Take a picture of your work or type the answers and turn them in to Peergrade.

Convert to Binary:

Decimal	**Binary**
17	
39	
53	
287	
384	
490	
962	
2746	
3285	

Convert to Decimal:

Binary	**Decimal**
11001011101	
1100001001	
10100110	
10110110010	
10010001000	
10110101	
11111111111	
110100111	
11011100	

Chapter III

Hexadecimal

III.1 How it Works

Hexadecimal is another counting system, using base 16.

In computer science hexadecimal (hex for short) is used as an **abstraction** for binary. It represents binary numbers in a better visual way, while preserving some of the patterns found in base 2 numbers.

III.1.1 More digits please!

How is it possible to use a base system larger than 10? We have ten fingers on our hands so somehow we got stuck with ten number symbols (0-9)! Hmm...

We keep counting after 9 using letters of the alphabet as number symbols.

- **Digits of base 10:** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- **Digits of base 2:** 0, 1
- **Digits of base 8:** 0, 1, 2, 3, 4, 5, 6, 7
- **Digits of base 16:** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

The letters can be uppercase or lowercase depending on your preference. They work like the king, queen, and jack in a deck of cards. A=10, B=11, C=12, D=13, E=14, and F=15.

III.1.2 Hexadecimal -> Decimal

Converting from hexadecimal to decimal is definitely easier than the other way. All you need to do:

1. Calculate the place values for hexadecimal

2. Multiply each digit by its place value

3. Add those up together for the result.

III.1.3 Binary -> Hexadecimal

Converting from binary to hex is more important and fun than converting straight from decimal to hex, so let's focus on that!

In a binary number, each block of four digits will convert to one digit of hexadecimal.

Here's your algorithm:

1. Split the binary number into blocks of 4 digits, starting from the ones place.

2. For each block, convert the 4-digit binary number to decimal by adding up the values of the eights, fours, twos, and ones places.

3. Your result should be a number between 0 and 15, which corresponds to a digit in the hexadecimal number system. Write down the correct hexadecimal digit.

4. The hexadecimal digits go in the same order as the blocks of binary that they came from.

III.2 Example

III.3 Resources

- Khan Academy
- Owlcation (Look halfway down the page)

III.4 Problem Set

Convert to Hexadecimal:

Binary	Hexadecimal
1110000000100111	
0001000001110100	
1110000011001110	
1010110000010100	
1101100111101000	
0100101010011001	
0010010001000011	
1000010110001000	
1100000101010111	
1111111111111111	

Convert to Binary:

Hexadecimal	Binary
63fc	
1a40	
e1e5	
617b	
c6d6	
26ee	
9c21	
157b	
8c1d	
f1e2	

Chapter IV

ASCII

The ASCII system (American Standard Code for Information Interchange) is the most common **text encoding** format.

In theory there are many different ways to code any given type of information into binary. For example, Morse Code is an alternative text encoding system, although it happens to be base 3 (the symbols are dash, dot, and silence). If you want to go into a rabbit hole here is an interesting discussion about what Morse is good for.

IV.1 How it Works

In ASCII, 128 different symbols, focusing on the English alphabet and symbols used in computing, are encoded using seven-digit binary numbers.

insert image of ascii table

`Check your Understanding: When you convert a seven-digit binary number to hexadecimal, how many hex digits does it have?`

While coding, you can find a copy of the ascii table at any time by typing "man ascii" into a computer terminal (even if... gasp... your Wifi's not working.) Try it!

Unicode is an expansion of ASCII that uses longer numbers to encode letters from all the world's alphabets and symbol systems. Don't worry about the different versions of it, just know that it exists and that's how we encode Chinese, Arabic, Russian, Hindi and so forth on the internet.

IV.2 Example

ASCII TABLE

Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char
0	0	[NULL]	32	20	[SPACE]	64	40	@	96	60	`
1	1	[START OF HEADING]	33	21	!	65	41	A	97	61	a
2	2	[START OF TEXT]	34	22	"	66	42	B	98	62	b
3	3	[END OF TEXT]	35	23	#	67	43	C	99	63	c
4	4	[END OF TRANSMISSION]	36	24	$	68	44	D	100	64	d
5	5	[ENQUIRY]	37	25	%	69	45	E	101	65	e
6	6	[ACKNOWLEDGE]	38	26	&	70	46	F	102	66	f
7	7	[BELL]	39	27	'	71	47	G	103	67	g
8	8	[BACKSPACE]	40	28	(	72	48	H	104	68	h
9	9	[HORIZONTAL TAB]	41	29	)	73	49	I	105	69	i
10	A	[LINE FEED]	42	2A	*	74	4A	J	106	6A	j
11	B	[VERTICAL TAB]	43	2B	+	75	4B	K	107	6B	k
12	C	[FORM FEED]	44	2C	,	76	4C	L	108	6C	l
13	D	[CARRIAGE RETURN]	45	2D	-	77	4D	M	109	6D	m
14	E	[SHIFT OUT]	46	2E	.	78	4E	N	110	6E	n
15	F	[SHIFT IN]	47	2F	/	79	4F	O	111	6F	o
16	10	[DATA LINK ESCAPE]	48	30	0	80	50	P	112	70	p
17	11	[DEVICE CONTROL 1]	49	31	1	81	51	Q	113	71	q
18	12	[DEVICE CONTROL 2]	50	32	2	82	52	R	114	72	r
19	13	[DEVICE CONTROL 3]	51	33	3	83	53	S	115	73	s
20	14	[DEVICE CONTROL 4]	52	34	4	84	54	T	116	74	t
21	15	[NEGATIVE ACKNOWLEDGE]	53	35	5	85	55	U	117	75	u
22	16	[SYNCHRONOUS IDLE]	54	36	6	86	56	V	118	76	v
23	17	[ENG OF TRANS. BLOCK]	55	37	7	87	57	W	119	77	w
24	18	[CANCEL]	56	38	8	88	58	X	120	78	x
25	19	[END OF MEDIUM]	57	39	9	89	59	Y	121	79	y
26	1A	[SUBSTITUTE]	58	3A	:	90	5A	Z	122	7A	z
27	1B	[ESCAPE]	59	3B	;	91	5B	[	123	7B	{
28	1C	[FILE SEPARATOR]	60	3C	<	92	5C	\	124	7C	|
29	1D	[GROUP SEPARATOR]	61	3D	=	93	5D	]	125	7D	}
30	1E	[RECORD SEPARATOR]	62	3E	>	94	5E	^	126	7E	~
31	1F	[UNIT SEPARATOR]	63	3F	?	95	5F	_	127	7F	[DEL]

Q: How do you spell `Kittens` in ASCII?
A: Decimal: 75 105 116 116 101 110 115
A: Hex: 4b 69 74 74 65 6e 73
Q: How do you spell `*\(^o^)/*` in ASCII?
A: Decimal: 42 92 40 94 111 94 41 47 42
A: Hex: 2a 5c 28 5e 6f 5e 29 2f 2a

IV.3 Resources

- What is the logic of the ASCII table ordering?
- man-ascii.com
- Original documentation in the Linux manual

IV.4 Problem Set

Questions about ASCII might also involve addition, subtraction, and converting between decimal and hexadecimal. Consider these questions:

1. Practice addition in hexadecimal: 14 + 3c = ? f7 - 77 = ? fe + 66 = ?

2. The ASCII values for uppercase letters of the alphabet start at 65 (base 10), and the lowercase letters start at 97 (base 10). The word "sunshine", in ASCII, is spelled 115 117 110 115 104 105 110 101. What is the ASCII code for "SUNSHINE" in all caps?

3. The ASCII values for uppercase letters of the alphabet start at 65 (base 10), and the lowercase letters start at 97 (base 10). The hexadecimal encoding of "HTML" is 48 54 4d 4c. Add to those values the hexadecimal numbers 31 1B 1F 1F. What word does the resulting sequence encode? (Work with a partner if you find this one difficult.)

Chapter V

HTML

V.1 How it Works

HTML stands for HyperText Markup Language. It is a text format that creates structure for webpages. HTML is used to label of a webpage such as the header, footer, body, and boxes of content contianing images, text, links, tables, etc.

Most websites contain a combination of HTML, CSS, and Javascript. We are already coding in Javascript. For this lesson and the next one, research a little bit about what HTML and CSS do.

V.2 Example

You can view the HTML of any website by right clicking on the page and selecting "view page source". Try it on this website: example.com!

All of the parts that use <angle brackets> are HTML statements. This is a very simple website, so it's using just the most common HTML elements.

One of the tags is <style type="text/css>̈, and inside that tag is the CSS code, which we'll talk about in the next session.

Notice these things about the html:

1. Most HTML elements have both an opening and a closing tag. For example, <head> is where the header of the web page starts, and </head> is where it ends.

2. HTML elements are stacked inside of each other, just like code, and the indentation is important. In this example, the <title></title> tag goes inside the <head> tag; and the <h1></h1> tag goes inside the <body> tag.

V.3 Resources

- W3Schools HTML reference
- Mozilla HTML reference
- One of many nice HTML tutorials available online

V.4 Problem Set

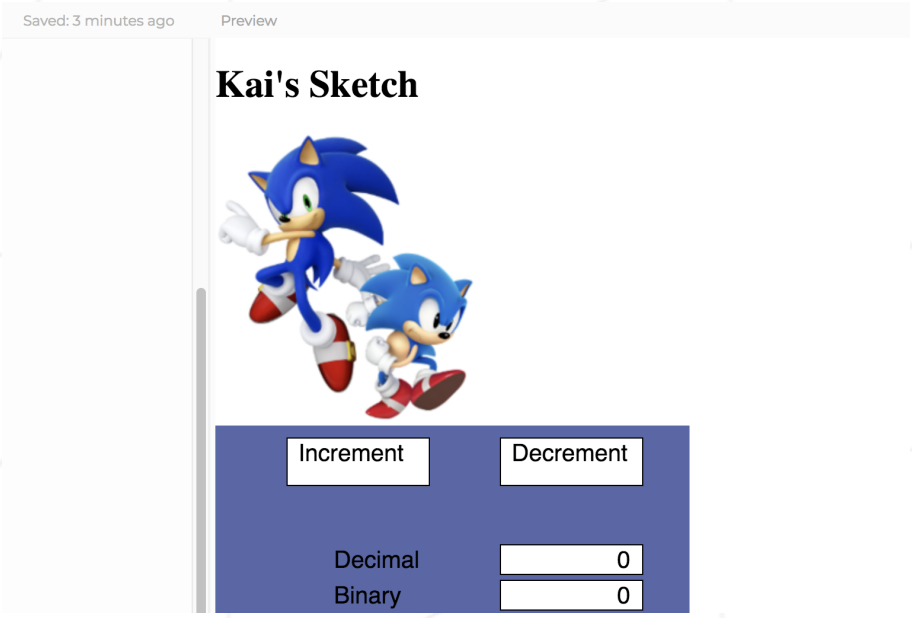
Go to your p5js editor and open one of your favorite old sketches.

From there, click the arrow to expand the file structure. See the index.html page?

I want you to make two changes to index.html inside the <body> tag and see the results. First, use the <h1> ("header one") tag and add a **Title** to your sketch.

Second, go to Google Images or Wikipedia and find a picture of one of your favorite movie / tv characters. Click around until you find one where the address of the image (right click -> open image in new tab -> look at the address bar) is not super long. Use the examples from w3schools as a guide for how to embed this image in the body of the index.html file.

Run the sketch and make sure you see both your heading and image!



You can actually run the p5js editor offline, and make many other changes to the structure of the page, if you save it on your own computer. Try making copies of all three files: index.html, style.css, and script.js in the same folder on your computer. Then double click on index.html to run the sketch!

Chapter VI

CSS

VI.1 How it Works

CSS stands for Cascading Style Sheets and it was invented several years after HTML (1980 vs 1996). While HTML provided some ways to add color and style to a web page, CSS builds on top of the HTML skeleton and provides a much more sophisticated design language that can do more complex and beautiful things.

CSS code looks like a set of Javascript objects. For each element on the page that should have different color and alignment, there is a set of curly braces with a list of attributes.

VI.2 Example

Look again at the source code of the example.com webpage. The CSS goes from line 10 to line 38.

Now, look at the source code in a diferent way and experiment with changing it! At the example.com page, right click and select "inspect".

Under the Elements menu, you'll see the HTML outline. Click the arrows next to each section to expand it. Expand the <style type="text/css"> section to view the css.

You can double-click on the CSS here and watch the page update. Try changing several things such as margins, colors, and padding to see what happens.

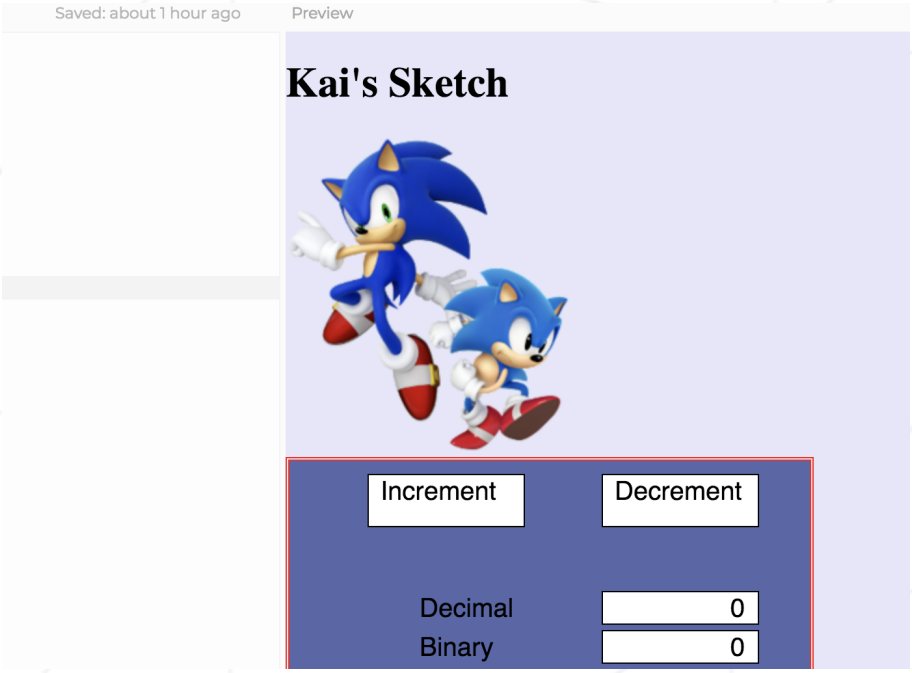
VI.3 Resources

- W3Schools CSS reference
- Mozilla CSS reference
- One of many nice CSS tutorials available online

VI.4 Problem Set

Go to your sketch in the p5js editor, where we added the title and the image. Now, edit the style.css file and add a background color to the body of the page.

Then, add three properties to the 'canvas' section so you create a border around your sketch: border-style, border-width and border-color.



Chapter VII

Turn-in & Grading

Turn this in on Peergrade and grade another student's work. You should be turning in a text file, containing:

1. Your answers for problem sets in the first three sections (binary, hexadecimal, and ASCII).

2. A link to your p5js sketch where you edited the HTML and CSS. OR, a zip file containing these files that you edited on your own computer.

