Announcements

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Turn in Project 2c

- A solution to 2c will be posted after the grace day

- Project 2d must be time stamped Friday (2:00AM) for Friday turn-in
  - Notice there are extra credit components to it

More Digital Representation

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Discrete information is represented in binary (PandA), and "continuous" information is made discrete

Return To RGB

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Images are constructed from picture elements (pixels); color uses RGB light

The RGB color intensities are specified by 3 numbers in the range [0, 255], ie 1 byte each

Black = [0, 0, 0]	0000 0000 0000 0000 0000 0000
Gray = [128,128,128]	1000 0000 1000 0000 1000 0000
White = [255,255,255]	1111 1111 1111 1111 1111 1111

White-gray-black all have same values for RGB

Colors

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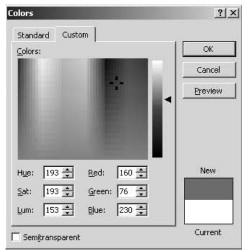
Colors use different combinations of RGB

- Husky Purple

Red=160

Green=76

Blue=230



Positional Notation

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The RGB intensities are binary numbers

Binary numbers, like decimal numbers, use *place notation*

1101 = 1x1000 + 1x100 + 0x10 + 1x1

= $1\text{x}10^3 + 1\text{x}10^2 + 0\text{x}10^1 + 1\text{x}10^0$

except that the base is 2 not 10

Base or radix

1101 = 1x8 + 1x4 + 0x2 + 1x1

= $1\text{x}2^3 + 1\text{x}2^2 + 0\text{x}2^1 + 1\text{x}2^0$

1101 in binary is 13 in decimal

Binary Numbers

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Given a binary number, add up the powers of 2 corresponding to 1s

1010 0000

$0\text{x}2^0$	= 0x1	= 0
$0\text{x}2^1$	= 0x2	= 0
$0\text{x}2^2$	= 0x4	= 0
$0\text{x}2^3$	= 0x8	= 0
$0\text{x}2^4$	= 0x16	= 0
$1\text{x}2^5$	= 1x32	= 32
$0\text{x}2^6$	= 0x64	= 0
$1\text{x}2^7$	= 1x128	= <u>128</u>
		= 160

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Binary Numbers

Given a binary number, add up the powers of 2 corresponding to 1s

0100 1100

$0x2^0$	= 0
$0x2^1$	= 0
$1x2^2$	= 4
$1x2^3$	= 8
$0x2^4$	= 0
$0x2^5$	= 0
$1x2^6$	= 64
$0x2^7$	= 0
	= 76

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Binary Numbers

Given a binary number, add up the powers of 2 corresponding to 1s

1110 0110

$0x2^0$	= 0
$1x2^1$	= 2
$1x2^2$	= 4
$0x2^3$	= 0
$0x2^4$	= 0
$1x2^5$	= 32
$1x2^6$	= 64
$1x2^7$	= 128
	= 230

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Husky Purple

Recall that Husky purple is (160,76,230) which in binary is

1010 0000 0100 1100 1110 0110
160 76 230

Suppose you decide it's not "red" enough

- Increase the red by 16 = 1 0000

```
  1010 0000
+    1 0000
  1011 0000
```

Adding in binary is pretty much like adding in decimal

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A Redder Purple

Increase by 16 more

```
  00110 000  <—— Carries
  1011 0000
+    1 0000
  1100 0000
```

The rule: When the "place sum" equals the radix or more, subtract radix & carry

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Find Binary From Decimal

The conversion algorithm

Start: x is the number to convert
1. Let d the largest numbers so $2^d \le x$
2. Is $d \ge 0$, i.e. more digits to process? No, end
3. Is $x \ge 2^d$, i.e. is x at least as large as 2^d?
   3t. Yes, the binary place is 1; $x=x-2^d$
   3f. No, the binary place is 0
4. d = d - 1, go to Step 2

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Find Binary From Decimal

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3t. Y, binary place=1;$x=x-2^d$
3f. N, binary place=0
4. d = d - 1, go to Step 2

Place	x	2^d	$x \ge 2^d$	bit
7=d	230	128	yes	1
6	102	64	yes	1
5	38	32	yes	1
4	6	16	no	0
3	6	8	no	0
2	6	4	yes	1
1	2	2	yes	1
0	0	1	no	0

1110 0110

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Another Example

Convert x = 141 to binary …

1. Let d the largest numbers so $2^d \le x$
2. Is $d \ge 0$, i.e. more digits to process? No, end
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   - 3t. Y, binary place=1;x=x-2^d
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Place	x	2^d	$x \ge 2^d$	bit
	141			

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7=d	141			

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6	13			

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Place	x	2^d	$x \ge 2^d$	bit
7=d	141	128	yes	1
6	13	64	no	0
5	13	32	no	0
4	13	16	no	0
3	13	8	yes	1
2	5			

Another Example

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Convert x = 141 to binary …

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[redacted]

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[redacted]

1000 1101

Digitizing

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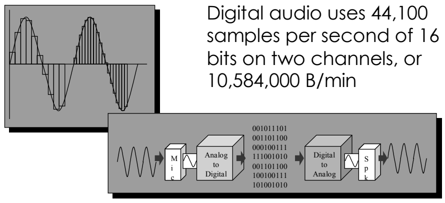
"Continuous" information like light and sound must be made "discrete"



Digital audio uses 44,100 samples per second of 16 bits on two channels, or 10,584,000 B/min

Information Processing

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Manipulating pixels is an example of "computing on a representation"

- Photoshop & other graphics SW manipulate pictures by computing on representation
- Audio is edited similarly to remove coughs and other odd sounds, speed up, etc.
- Searching the dictionary is another example

Information processing depends on computing on representations

Bits Are It

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Bits represent information, but their interpretation gives bits meaning

0000 0000 1111 0001 0000 1000 0010 0000

- Could be a number, color, instruction, ASCII, sound samples, IP address, …

Bias-free Universal Medium Principle: Bits can represent all discrete information; bits have no inherent meaning

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Summary

Bits can represent any information

* Discrete information is directly encoded using binary
* Continuous information is made discrete
* “Computing on representations” is the key to “information processing”
* Bias-free Universal Medium Principle