More Digital Representation

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

Return To RGB

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

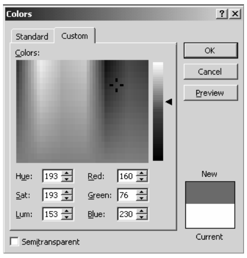
■	**Black = (0, 0, 0)**	0000 0000 0000 0000 0000 0000
▨	**Gray = (128,128,128)**	1000 0000 1000 0000 1000 0000
□	**White = (255,255,255)**	1111 1111 1111 1111 1111 1111

White-gray-black all have same values for RGB

Colors

Colors use different combinations of RGB

- **Husky Purple**
  Red=160
  Green=76
  Blue=230



Hue: 193 Red: 160
Sat: 193 Green: 76
Lum: 153 Blue: 230
□ Semitransparent

Positional Notation

The RGB intensities are binary numbers

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

1101 = 1x1000 + 1x100 + 0x10 + 1x1
= $1x10^3$ + $1x10^2$ + $0x10^1$ + $1x10^0$

except that the base is 2 not 10

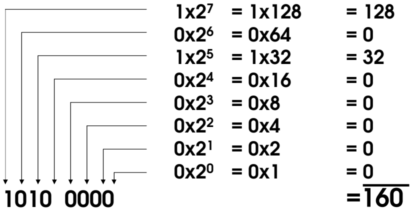
1101 = 1x8 + 1x4 + 0x2 + 1x1
= $1x2^3$ + $1x2^2$ + $0x2^1$ + $1x2^0$

Base or radix

1101 in binary is 13 in decimal

Binary Numbers

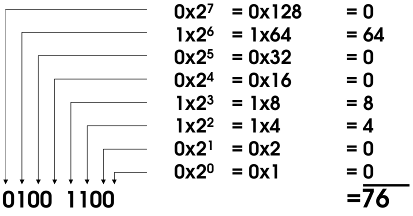
Given a binary number, add up the powers of 2 corresponding to 1s



$1x2^7$ = 1x128 = 128
$0x2^6$ = 0x64 = 0
$1x2^5$ = 1x32 = 32
$0x2^4$ = 0x16 = 0
$0x2^3$ = 0x8 = 0
$0x2^2$ = 0x4 = 0
$0x2^1$ = 0x2 = 0
$0x2^0$ = 0x1 = 0
1010 0000 =160

Binary Numbers

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



$0x2^7$ = 0x128 = 0
$1x2^6$ = 1x64 = 64
$0x2^5$ = 0x32 = 0
$0x2^4$ = 0x16 = 0
$1x2^3$ = 1x8 = 8
$1x2^2$ = 1x4 = 4
$0x2^1$ = 0x2 = 0
$0x2^0$ = 0x1 = 0
0100 1100 =76

Binary Numbers

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

$1x2^7$	**= 1x128**	**= 128**
$1x2^6$	**= 1x64**	**= 64**
$1x2^5$	**= 1x32**	**= 32**
$0x2^4$	**= 0x16**	**= 0**
$0x2^3$	**= 0x8**	**= 0**
$1x2^2$	**= 1x4**	**= 4**
$1x2^1$	**= 1x2**	**= 2**
$0x2^0$	**= 0x1**	**= 0**

1110 0110 **=230**

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

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

Find Binary From Decimal

Fill in the Table:

Num Being Converted	230	230	102	38	6	6	6	2	0
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38	6			2	0	
Binary Num	0	1	1	1	0	0	1	1	0

Find Binary From Decimal

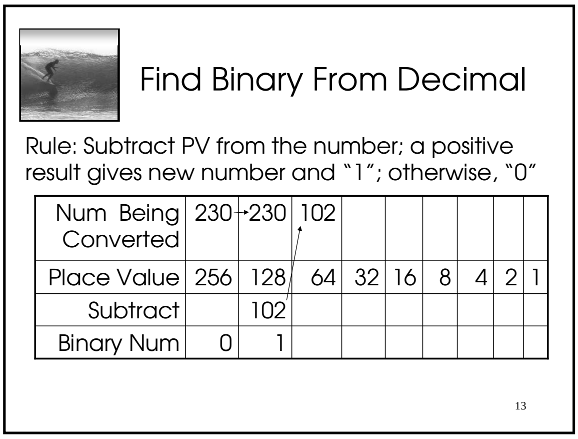
Place number to be converted into the table; fill place value row with decimal powers of 2

Num Being Converted	230								
Place Value	256	128	64	32	16	8	4	2	1
Subtract									
Binary Num									

Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and "1"; otherwise, "0"

Num Being Converted	230→	230							
Place Value	256	128	64	32	16	8	4	2	1
Subtract									
Binary Num	0								



Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and “1”; otherwise, “0”

Num Being Converted	230	→230	102						
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102							
Binary Num	0	1							

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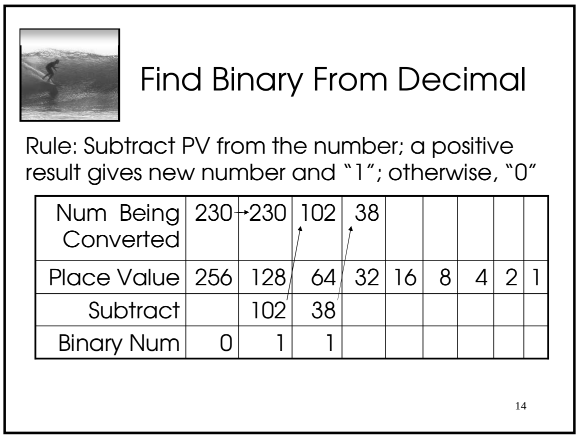

Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and “1”; otherwise, “0”

Num Being Converted	230	→230	102	38					
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38						
Binary Num	0	1	1						

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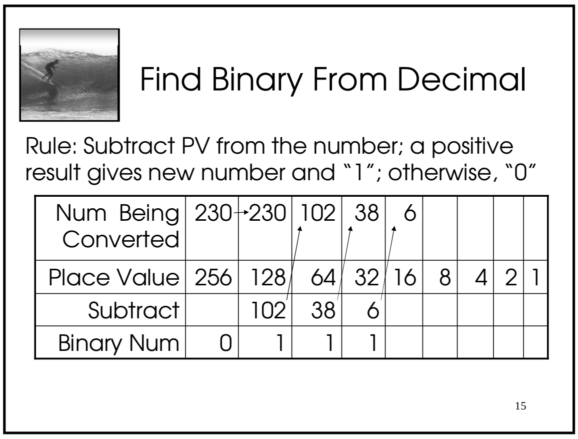

Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and “1”; otherwise, “0”

Num Being Converted	230	→230	102	38	6				
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38	6					
Binary Num	0	1	1	1					

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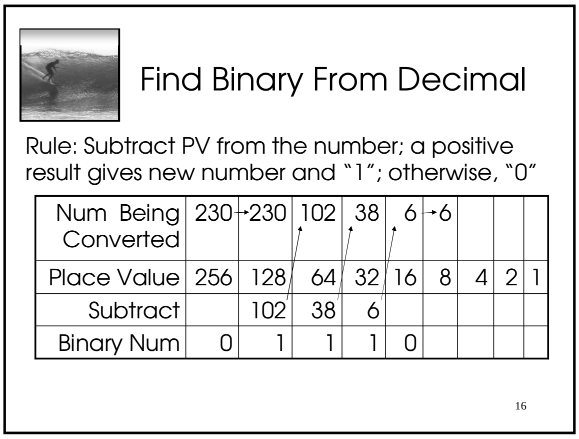
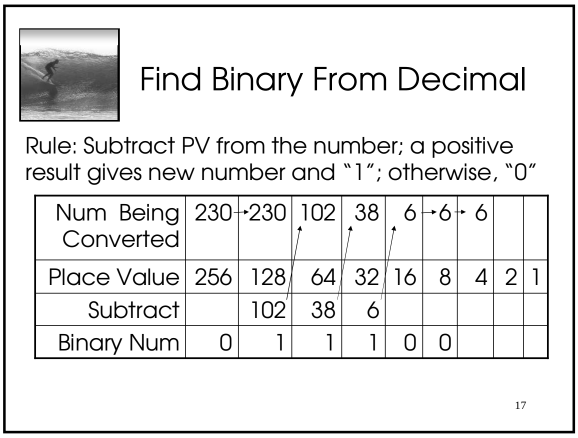


Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and “1”; otherwise, “0”

Num Being Converted	230	→230	102	38	6	→6			
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38	6					
Binary Num	0	1	1	1	0				

16



Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and “1”; otherwise, “0”

Num Being Converted	230	→230	102	38	6	→6	→6		
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38	6					
Binary Num	0	1	1	1	0	0			

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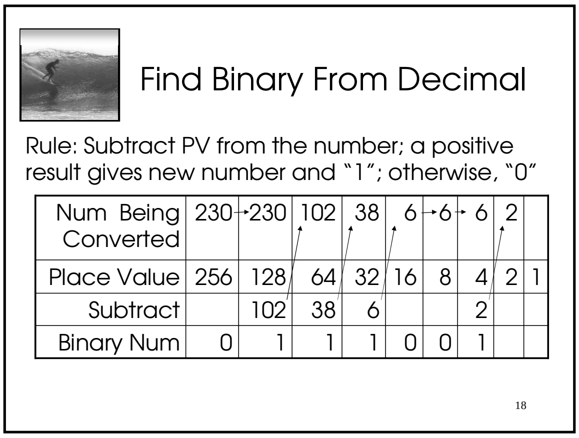

Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and “1”; otherwise, “0”

Num Being Converted	230	→230	102	38	6	→6	→6	2	
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38	6			2		
Binary Num	0	1	1	1	0	0	1		

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Find Binary From Decimal

Rule: Subtract PV from the number; a positive result gives new number and "1"; otherwise, "0"

Num Being Converted	230	230	102	38	6	6	6	2	0
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38	6			2	0	
Binary Num	0	1	1	1	0	0	1	1	

Find Binary From Decimal

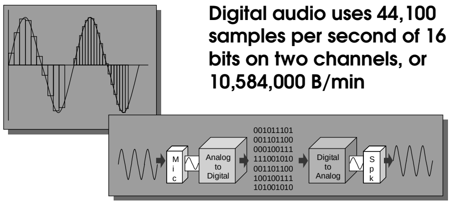
Rule: Subtract PV from the number; a positive result gives new number and "1"; otherwise, "0"

Num Being Converted	230	230	102	38	6	6	6	2	0
Place Value	256	128	64	32	16	8	4	2	1
Subtract		102	38	6			2	0	
Binary Num	0	1	1	1	0	0	1	1	0

Read off the result: 0 1110 0110

Digitizing

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



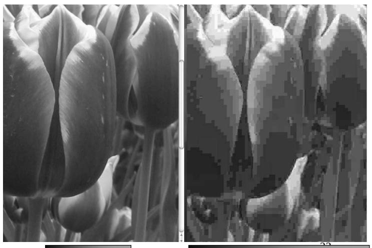
Digital audio uses 44,100 samples per second of 16 bits on two channels, or 10,584,000 B/min

Compression

Compression: use fewer bits

- Lossless – Recover the data
- Lossy– Lose the original data

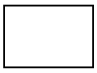
JPEG



Original **Over compressed**

Run-Length Compression

Give number of 1s, number of 0s, etc.



→	1111111111… →	(270 1s)
	1111111111…	(270 1s)
	1100000000…	(2 1s)(266 0s)(2 1s)
	1100000000…	(2 1s)(266 0s)(2 1s)
	…	…

Forget row encoding … alternate

[Size: 270x200](542)(266)(4)(266)(4)(266)(4)(266) …

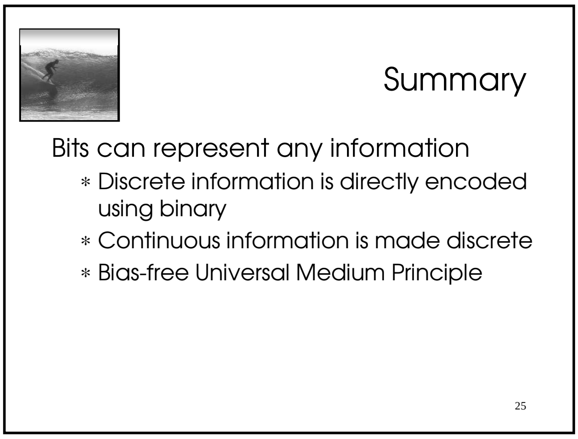
Bits Are It

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**



Summary

Bits can represent any information

- Discrete information is directly encoded using binary
- Continuous information is made discrete
- Bias-free Universal Medium Principle