Binary & Hex Warm Up, Lesson & Worksheet:

Name: _____ **Per:** _____

0. Decimal: Let's start with what we know, base 10.

A) In our standard decimal numbering scheme, how many symbols do we use to represent numbers? What are they? Write them out here:

_____

B) What number comes after 9? _____
After 99? _____
After 999? _____
After 9999? _____

C) For decimal numbers (let's just look at positive whole values), what value does the:

0) First (least significant) decimal place represent? _____

1) Second (next) decimal place represent? _____

2) Third (and the next) decimal place represent? _____

3) Fourth (and so on) decimal place represent? _____

D) What is the relationship/formula of this number sequence? (Notice I started numbering at 0)

_____

E) How many different numbers can you represent with 4 decimal places, 0 to 9999? _____

1. Binary: Extending this to Base 2

A) If we only had two symbols to represent all numbers, let's pick the numbers: **0 & 1**

B) What binary number comes after 1? _____
After 11? _____
After 111? _____
After 1111? _____

C) So what decimal value do you think each of the binary digits, **called "bits" (b),** represent?

0) First (least significant) bit represent? _____

1) Second (next) bit place represent? _____

2) Third (and the next) bit place represent? _____

3) Fourth (and so on) bit place represent? _____

D) What is the relationship/formula of this number sequence? (Notice I started numbering at 0)

_____

E) How many different numbers can you represent with 4 binary bits, 0 to 1111? _____

+ Bonus: What other number systems do you know of, perhaps from different civilizations?

(Stop Here, and don't turn the page over yet…)

Binary & Hex Warm Up, Lesson & Worksheet:

10. Counting in Binary

Based on what we have learned Count to 16 (decimal) in Binary:

0	_____
1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7	_____
8	_____
9	_____
10 (A)	_____
11 (B)	_____
12 (C)	_____
13 (D)	_____
14 (E)	_____
15 (F)	_____
16	_____

Notice the Pattern?

Which of these two numbers is easier to read?

Decimal: **212**

Binary: **11010100**

(frequently shown as 0b11010100, "0b" for binary)

11. Hexadecimal: base 16

Binary numbers can be very cumbersome to write out, so four bits of binary can be represented as a single Hexadecimal digit, representing the values 0 to 15 (decimal).

For the 16 symbols to represent 0 – 15, when we go beyond 9, we simply add the first few letters of the alphabet: **0 1 2 3 4 5 6 7 8 9 A B C D E F**

So now which is easier to read?

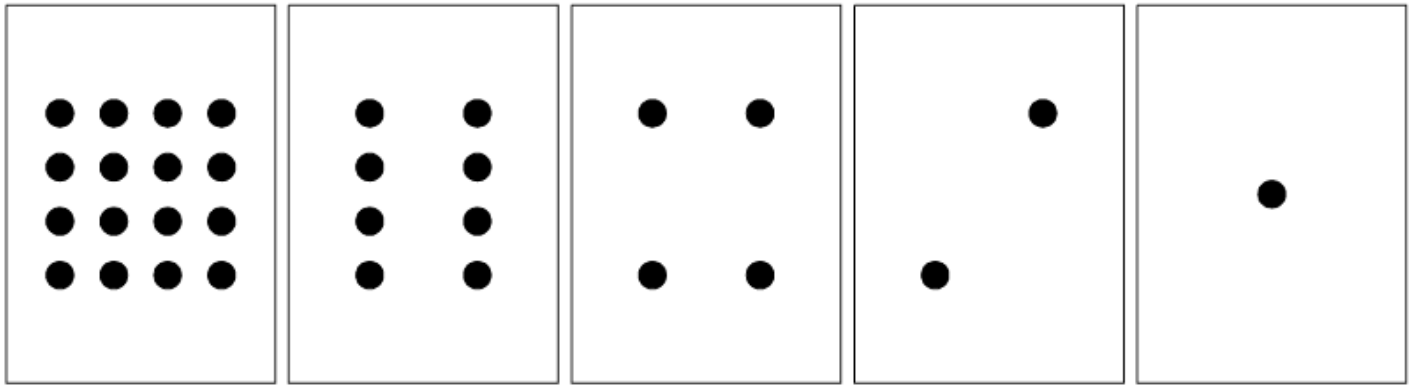
Hexadecimal : **D4**

(frequently shown as 0xD4, "0x" for hexadecimal)

Binary: **11010100**

(frequently shown as 0b11010100, "0b" for binary)

Binary Cards… For our class exercise [from "CS Unplugged" – www.csunplugged.org]



100. Convert Binary to Decimal:

A. 11 _____
B. 100 _____
C. 10101 _____
D. 00111 _____
E. 11001 _____
F. 11111 _____
G. 100000 _____

101. Decimal to Binary:

H. 7 _____
I. 9 _____
J. 16 _____
K. 22 _____
L. 27 _____
M. 30 _____
K. 33 _____

110. Can you expand what you have learned here for larger numbers? 2 to the power of:

0 1 2 3 4 5 6 7 8 **9 10 11 12 13 14 15**

1, 2, 4, 8, 16, ___, ___, _____, _____, _____, _____, _____, _____, _____, _____, _____

(NOTE: these would be ordered in reverse, right to left, when representing Binary digits!)

Binary & Hex Warm Up, Lesson & Worksheet:

111. A Byte (B) is the base unit of Memory; one Byte can encode one typical character (look up ASCII & Extended tables).
1 Byte (B) = 8 Bits (b) = 2 Hex Digits (x)
So how many values can a Byte have? 2^8 = _____
For example, Binary: 0b **01000001** = Hex: 0x **41** = Decimal **65** is an "**A**" in ASCII (char). Notice that the Hex & Decimal values are easier for to read and often preferred.

1000. So how many Bytes does a Java Integer use? `Integer.MAX_VALUE` is 2147483647 (2^{31} - 1) and `Integer.MIN_VALUE` is -2147483648 (-2^{31}). Including 0, this represents 4294967296 values, which is 2^{32} or 32 bits = **4 bytes**. Makes sense?
Here's the other primitives in Java: **double** – 8 bytes
char – 1 byte
boolean – 1 byte
+ How many bytes do you think an Object or ArrayList would take? (hint: Point@9e8c34)

[Bonus: somewhat archaic notations used in older devices and mentioned occasionally
Nibble (or nybble) is half a Byte, only 4 bits – basically one Hex digit
Octal: Some older systems have used base 8, Octal, that uses numbers 0 – 7 only, so 3 binary bits represents each number. But let's get back to Bytes…]

1001. Today's Memory Devices: are typically measured in **Gigabytes (GB)**. But this measurement can have two different values depending if it is referring to base 10 or Base 2 values...
Base 10: 1 GB = 1,000,000,000 bytes (10^9 bytes or 1000^3 bytes) or 256,000,000,000 bits. This is typically used for storage media, especially disk drives.
Base 2: 1 GB 1,073,741,824 bytes (2^{30} bytes or 1024^3 bytes) or 274,877,906,944 bits. This is typically used for the measurement of computer memory, usually RAM.

Here is a chart of other typical Memory measurements, in both Bases:

Name	Decimal (base10)	Binary (base 2)
Kilobyte (KB)	10^3 = 1000 bytes	2^{10} = 1024 bytes
Megabyte (MB)	10^6 = 1000^2 = 1,000,000 bytes	2^{20} = 1024^2 = 1,048,576 bytes
Gigabyte (GB)	10^9 = 1000^3 = 1,000,000,000 bytes	2^{30} = 1024^3 = 1,073,741,824 bytes
Terabyte (TB)	10^{12} = 1000^4 = 1,000,000,000,000 bytes	2^{40} = 1024^4 = 1,099,511,627,776 bytes
Petabyte (PB)	10^{15} = 1000^5 bytes	2^{50} = 1024^5 bytes

1010. How much can these store? (approximations depend on compression & format)
1 Kilobyte (KB): about half a page of text unformatted, a short email
1 Megabyte (MB): about 1 minute of CD quality MP3 Music
1 Gigabyte (GB): about 17 hours of Music or 40 minutes of good compressed HD video
1 Terabyte (TB): about 17,000 hours of Music (708 days) or 600 hours of video (25 days), depending on the compression used and quality of image.

Binary & Hex Warm Up, Lesson & Worksheet:

1011. Final Assignment:
I. Take the day of the month you were born: ____, convert it to base 2: _____
II. Based on the least significant bit of that binary number (which is that?) do one of these two activities:
- Least Significant Bit = 0:
Write out instructions on how to convert a **Binary Number to Decimal**, feel free to use the binary cards provided on page 3. Imagine you are explaining this to a 6th grader.
- Least Significant Bit = 1:
Write out instructions on how to convert a **Decimal Number to Binary**, feel free to use the binary cards provided on page 3. Imagine you are explaining this to a 6th grader.
+ OR Write the Pseudo code (text description of the algorithm) of how you would design one of these conversions in a program.

Extra:
1) Once you have a Decimal Number converted to a Binary number, how would you then convert it to its Hexadecimal value? Explain the process (it's not very hard).