Bits, Bytes, and Nibbles

Name of unit	Abbreviation	Contents	Bytes	Close to
1 bit	1 b (lower case)	1 symbol either 1 or 0		
1 Nibble		4 bits	½ byte	
1 Byte	1 B (upper case)	8 bits or 2 Nibbles or 2^3 bits	1 byte	
1 Kilobyte	1 KB	2^{10} bytes	1,024 bytes	1 thousand bytes
1 Megabyte	1 MB	$(2^{10})^2$ bytes	1,048,576 bytes	1 million bytes
1 Gigabyte	1 GB	$(2^{10})^3$ bytes	1,073,741,824 bytes	1 trillion bytes
1 Terabyte	1 TB	$(2^{10})^4$ bytes	1,099,511,627,776 bytes	1 quadrillion bytes
1 Petabyte	1 PB	$(2^{10})^5$ bytes	1,125,899,906,842,624 bytes	1 quintillion bytes
1 Exabyte	1 EB	$(2^{10})^6$ bytes	1,152,921,504,606,846,976	1 sextillion bytes
1 Zetabyte	1 ZB	$(2^{10})^7$ bytes	1,180,591,620,717,411,303,424 bytes	1 septillion bytes
More than is useful to know				

Most useful quantities

I get confused when my computer tells me that this application will take up 1,080 Megabytes (MB) or this movie will use 600 Kilobytes (Kb) per second. What does that mean? Should I worry that my computer will max out or that my streaming account limit will cut off the movie at an exciting part?

Let's figure this out.

Maybe you've heard of machine language or maybe you've heard of base two. Either way here's the low down. Computers are composed of electrical circuits. Each branching of a circuit can either be left or right, on or off. We notate those on or off decisions with binary representations ... either 0 or 1.

A bit of information is either a yes or a no ... on or off ... 0 or 1. You really can't compute or demonstrate much with just one bit of information. So let's look at the next biggest grouping of information.

A Nibble is made of 4 bits. Let's figure out how many pieces of information you could show with a Nibble. I arranged the digits 0 and 1 in all of the possible ways that I could order them and got 16 arrangements.

0000	0100	1000	1100
0001	0101	1001	1101
0010	0110	1010	1110
0011	0111	1011	1111

So, I guess we could represent 16 different pieces of information with a Nibble.

Each digit in the above demonstration of combinations of 4 bits can be only a 1 or a 0. So, there are only 2 possible ways to write each bit of information.

1. Why do you suppose 2 choices for the first digit, 2 choices for the second digit, 2 choices for the third digit, and 2 choices for the 4th digit turned out to be 16 possible ways of writing the 4 digits? Please explain.

2. Just to check your methods, see if you can list all of the ways that 5 bits could be arranged. Does your short-cut method work for 5 digits? Be careful, I may not have include enough cells ... or I may have used too many cells.

00000	01000			
00001	01001			
00010	01010			
00011	01011			
00100	01100			
00101	01101			
00110	01110			
00111	01111			

3. Describe an easier way to have figured this out?

4. Without counting any list of numbers, figure out how many different ways you could write a byte of information.

So when someone wants to send a page of print electronically, they have to use a series of 0s and 1s that represent each of the letters or symbols that they are trying to convey. Each of those letters or symbols probably contains a byte of information. This could get huge.

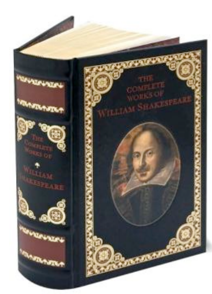
ASCII text (American Standard Code for Information Interchange) is binary machine language. The letters, digits, common symbols, and some keystrokes all have binary symbols that are used to print, calculate, or render text. For instance, a capital "A" in ASCII is 100 0001. So it takes 7 bits to store a capital "A" in binary. 7 bits is pretty close to a byte. So, it is convenient to think that each character in English requires a byte for storage.

5. Make a guess about how many bits of memory just one average-length word might require.

Maybe we had better consider a larger grouping of information clusters than just a bit or byte. The next biggest capacity is a kilobyte (KB). A kilobyte of information contains 1,024 (2^{10} bytes of information). One long paragraph of a typewritten page might contain 1 KB of binary (base 2) information.

6. Take a guess at how large a grouping a digital book might require.

I found that the <u>Complete Works of Shakespeare</u> would require 10MB of storage. That tomb has about 1,300 pages of print.



7. Choose an average-sized book that you might read, calculate what fraction of the <u>Complete Works of Shakespeare</u> your book size is, and check your guessed answer to question 6.

Photographs are even denser in file-storage-needs than printed information and require much more memory use. It's interesting that printed text requires so much less memory than images. One page of print in an average paperback book might require 2 KB of storage. A low-resolution photograph might require 100 KB of storage and a high-resolution photograph 2 megabytes (MB = $(2^{10})^2$) of storage.

Uh oh ... a megabyte (MB).

8. Using your calculator, find and rewrite $(2^{10})^2$ in standard notation.

9. What power of 10 is the number that you just wrote for problem #7 close to?

Many people use those powers of 10 numbers to approximate how many bytes of information are contained in a quantity of bytes ... like a gigabyte or terabyte.

My website will only allow me to upload 24 MB of data when I upload instructions for a webpage.

10. What sort of contents and how many images might I be able to upload to my site ... printed words, high-resolution pictures?

Movies and music are an entirely different animal. One minute of high-fidelity sound might use 10 MB of space. So, one minute of sound might require the space of two sets of the <u>Complete Works of Shakespeare</u>. Doesn't seem fair.

11. About how long are the songs that you listen to on the radio? How many MB of memory might one of those songs require? Show your work.

If I filled a pick up truck with books and digitized them, they might require 1 gigabyte of memory (GB). A gigabyte is $(2^{10})^3$ bytes of memory.

12. Rewrite $(2^{10})^3$ in standard form.

13. My camera's memory card holds 1 GB of information and photos are denser than printed information. If one high-resolution picture uses 2 MB, how many high-resolution photographs can I expect to store on my camera's memory card?

I have a 6-year old computer with only 2 GB of memory. More up-to-date computers have 4 to 16 GB of memory. My memory capacity hasn't yet been a problem for me and I program and constantly upload for the Yummymath website. Probably my image and photo work are the most memory-consuming part of my work.

But wait, it gets worse ... movies. When you play a DVD on your computer, you might be playing 17 GB of information. But, luckily that information is stored on the DVD and not in your computer. I'd guess a filmmaker would need an awful lot of memory storage space.

Which makes me wonder about Youtube. I watch quite a few clips on Youtube and sometimes include a clip on our website.

14. Am I quickly using up my computer's memory? Take a guess and explain your reasoning.

Actually, when we posted the movie called the "Three Ships to Locate" about the ingots of silver that were brought up from the ocean floor, we didn't upload that much information on our computer, our web server, or send it to your computer. That movie is housed at Youtube and we all just go there to watch it. Whew.

But how big would a Youtube video be to download to my computer? Youtube movies are usually recorded at 300 Kb/second. (Notice that the "b" is not capitalized in Kb/second. This is **kilobits** per second.) So you might figure out how many seconds the movie that you want on your computer requires and just multiply that number times 300 Kb/second. Then if you divide by 8 (cause there are 8 bits in a byte) you should get the number of KB of memory that are required for your download. Let's try that.

15. The "Three Ships to Locate" video was 2 minutes and 51 seconds long. About how much memory does Youtube have to use to store that movie for us to see? Show your work and try to use the most concise units to express your answer ... KB, MB, GB, or TB.

Just so you appreciate what you are using, high-definition video is recorded at about 2,000 Kb/second.

16. Calculate how much memory is required for a 10 minute, high-definition movie.

17. Try to find out how much storage is available on a DVD.

18. I have an iPhone with 6.3 GB of memory. My MacBook has only 2 GB of memory. Should I get a new computer?

Sources: http://searchstorage.techtarget.com/definition/How-many-bytes-for#anchor1
http://en.wikipedia.org/wiki/Byte