### Decimal Numbers: Base 10

**Digits:** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9  

**Example:**  
\[
3271 = (3\times10^3) + (2\times10^2) + (7\times10^1) + (1\times10^0)
\]

### Hexadecimal Numbers: Base 16

- **Hexadecimal:** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F  
- **Conversion:** Normal digits + 6 more from the alphabet  
- In C, written as 0x... (e.g., 0xFAB5)  

- **One hex digit is a “nibble”. Two is a “byte”**  

**Example:**  
\[
1010 1100 0011 (binary) = 0x_____
\]

### Numbers: positional notation

- **Number Base B \(\Rightarrow\) B symbols per digit:**  
  - Base 10 (Decimal): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9  
  - Base 2 (Binary): 0, 1  

- **Number representation:**  
  - \(d_1d_2...d_n\) is a 32 digit number  
  - value = \(d_1 \times B^{31} + d_2 \times B^{30} + ... + d_1 \times B^1 + d_n \times B^0\)  
  - **Binary:** 0, 1 (In binary digits called “bits”)  
  - **Often written** = 26  
  - Here 5 digit binary # turns into a 2 digit decimal #  
  - **Can we find a base that converts to binary easily?**

### Decimal vs. Hexadecimal vs. Binary

**Examples:**  
- \(00\ 0\ 0000\)  
- \(01\ 0\ 0010\)  
- \(03\ 0\ 0011\)  
- \(04\ 0\ 0100\)  
- \(05\ 0\ 0101\)  
- \(06\ 0\ 0110\)  
- \(07\ 0\ 0111\)  
- \(08\ 0\ 1000\)  
- \(09\ 0\ 1001\)  
- \(10\ 0\ 1010\)  
- \(11\ 0\ 1011\)  
- \(12\ C\ 1100\)  
- \(13\ D\ 1101\)  
- \(14\ E\ 1110\)  
- \(15\ F\ 1111\)

**How do we convert between hex and Decimal?**

**MEMORIZE!**

### Kilo, Mega, Giga, Tera, Peta, Exa, Zetta, Yotta

- **physics.nist.gov/cuu/Units/binary.html**  
- **Common use prefixes** (all SI, except K = k in SI)  

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Factor</th>
<th>SI Name</th>
<th>SI Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilo</td>
<td>K</td>
<td>(2^3)</td>
<td>1 Tera</td>
<td>(10^12)</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>(2^6)</td>
<td>1 Giga</td>
<td>(10^9)</td>
</tr>
<tr>
<td>Giga</td>
<td>G</td>
<td>(2^9)</td>
<td>1 Tera</td>
<td>(10^12)</td>
</tr>
<tr>
<td>Tera</td>
<td>T</td>
<td>(2^{12})</td>
<td>1 Peta</td>
<td>(10^15)</td>
</tr>
<tr>
<td>Peta</td>
<td>P</td>
<td>(2^{15})</td>
<td>1 Exa</td>
<td>(10^{18})</td>
</tr>
<tr>
<td>Exa</td>
<td>E</td>
<td>(2^{18})</td>
<td>1 Zetta</td>
<td>(10^{21})</td>
</tr>
<tr>
<td>Zetta</td>
<td>Z</td>
<td>(2^{21})</td>
<td>1 Yotta</td>
<td>(10^{24})</td>
</tr>
</tbody>
</table>

- **Confusing! Common usage of “kilobyte” means 1024 bytes, but the “correct” SI value is 1000 bytes**

- **Hard Disk manufacturers & Telecommunications** are the only computing groups that use SI factors, so what is advertised as a 30 GB drive will actually only hold about 28 x 230 bytes, and a 1 Mbit/s connection transfers 10^6 bps.

### kibi, mebi, gibi, tebi, pebi, exbi, zebi, yobi

- **en.wikipedia.org/wiki/Binary_prefix**

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</thead>
<tbody>
<tr>
<td>kibi</td>
<td>ki</td>
<td>(2^3)</td>
<td>1 mebi</td>
<td>(10^9)</td>
</tr>
<tr>
<td>mebi</td>
<td>Mi</td>
<td>(2^6)</td>
<td>1 gibi</td>
<td>(10^12)</td>
</tr>
<tr>
<td>gibi</td>
<td>Gi</td>
<td>(2^9)</td>
<td>1 tebi</td>
<td>(10^{15})</td>
</tr>
<tr>
<td>tebi</td>
<td>Ti</td>
<td>(2^{12})</td>
<td>1 pebi</td>
<td>(10^{18})</td>
</tr>
<tr>
<td>pebi</td>
<td>Pi</td>
<td>(2^{15})</td>
<td>1 exbi</td>
<td>(10^{21})</td>
</tr>
<tr>
<td>exbi</td>
<td>Ei</td>
<td>(2^{18})</td>
<td>1 zebi</td>
<td>(10^{24})</td>
</tr>
<tr>
<td>zebi</td>
<td>Zi</td>
<td>(2^{21})</td>
<td>1 yobi</td>
<td>(10^{27})</td>
</tr>
</tbody>
</table>

### New IEC Standard Prefixes [only to exbi officially]

- **As of this writing, this proposal has yet to gain widespread use...**

### International Electrotechnical Commission (IEC) in 1999 introduced these to specify binary quantities.

- **Names come from shortened versions of the original SI prefixes (same pronunciation) and bi is short for “binary”, but pronounced “bee” :-(**

- **Now SI prefixes only have their base-10 meaning and never have a base-2 meaning.**
MEMORIZE!

- What is $2^{34}$? How many bits addresses?
- What is $2^{32}$? How many addresses?

The way to remember #s

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