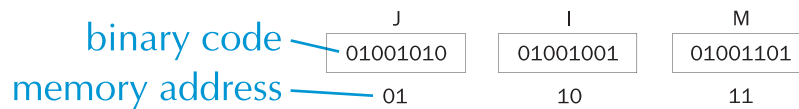


Storing Data in Memory

Computer memory is measured in bytes. For example, a computer might have 1GB of RAM. In computers and electronics *MB* stands for *megabytes* where mega represents 2^{20} or 1,048,576 bytes and *GB* stands for *gigabytes*, which is 2^{30} or 1,073,741,820 bytes.

Data stored in memory is referred to by an address. An *address* is a unique binary representation of a location in memory. Therefore, data can be stored, accessed, and retrieved from memory by its address. For data to be addressable in memory, it must usually be at least one byte in length. For example, to store JIM in memory each character is converted to Unicode and stored in two bytes of memory with each memory location designated by its address:



Because JIM is a character string, it will probably be stored in adjacent memory addresses.

Bits grouped in units of 16 to 64 (2 to 8 bytes) are called *words*. Data stored in a word is also located by an address. The size of a word depends on the computer system.

The binary representation of an integer number is usually stored in four bytes of memory. Because an integer is stored in four bytes, the range of integers that can be stored is $-2,147,483,648$ to $2,147,483,647$. An *overflow error* occurs when the number of bits that are needed to represent the integer is greater than the size of four bytes.

Real numbers, also called *floating point numbers*, are numbers that contain decimal points. The binary representation of a real number is usually in a 32-bit or 64-bit word. A 32-bit word is divided into a 1-bit sign, an 8-bit exponent, and a 23-bit significand. For example, the decimal number 821.625 in binary is 1100110101.101 and will be stored in memory as $1.100110101101 \times 2^9$. The *sign bit* is either 0 (positive) or 1 (negative). In this case, the sign bit is 0. Next, the *exponent*, in this case 9, is stored in binary form. A process called *biasing* means that the exponent is stored as $9 + 127$, or 10001000, in binary. Finally, the *significand* (significant digits) is stored with trailing zeros:



The overflow problem discussed for integers can also occur in real numbers if there are not enough bits to store the exponent. A *roundoff error* occurs when there are not enough bits to store the significand.