Binary Number System

* Binary is a base 2 system, meaning that instead of working in powers of 10 (10, 100, 1000, etc) it works in powers of 2 (2, 4, 8, 16, etc)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power of 2 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| Decimal Value | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Binary | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |

* To represent a number in binary, like 200:  
  Therefore, the binary value is “11001000”, because 200-128-64-8 = 0
* However, to convert a negative decimal number, like -21, we need to use the 2’s complement system, which also turns the 8th bit (27) into a sign bit and so isn’t used for decimal calculations. A step-by-step process for this method using -12 is given below:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power of 2 | -- | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| Decimal Value | -- | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Binary | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |

Step 1: Convert the positive version of the number to binary:

Step 2: Flip all of the signs:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power of 2 | -- | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| Decimal Value | -- | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Binary | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |

Step 3: Add 1 to the binary result:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power of 2 | -- | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| Decimal Value | -- | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Binary | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |

Therefore, the binary for -12 is: 11110100

* An important thing to note is that for SIGNED 8-bit (or 16-bit, 32-bit, etc) notation is that you can’t add two numbers together that produces a result higher than the limit. For example, you can’t add 120 and 18 together and try and represent 138 in SIGNED 8-bit binary because for normal binary this would work, but in a signed representation, the 8th bit (128) is used for the signed notation and not for decimal calculations.