Binary and Decimal

1. What is the binary integer 101, represented in decimal? \[ 4 + 1 = 5 \]

2. What is the binary integer 1010, represented in decimal? \[ 8 + 2 = 10 \]
   (How is this related to the previous answer?) Twice as much as 101

3. What is the binary integer 10100, represented in decimal? \[ 20 \]
   (What is the pattern?) Again twice as much since all ones became twice as valuable

4. What is the binary integer 101001, represented in decimal? \[ 41 \]
   (Could you write a program to use this approach?) Yes, and it is useful in LFSR!

5. What is the decimal integer 116, represented in binary?

   Right to left: see “Converting from decimal to base b” on booksite §5.1. 116 is even, so ends in a 0, preceded by representation of 116/2 = 58. 58 even so it ends in a 0, etc. \[ \Rightarrow 1110100 \]
   Left to right: biggest power of 2 that fits (\leq 116) is 64, leaving 116-64 = 52. Biggest power of 2 in this remainder is 32. Keep going with remainders, 116=64+32+16+4 = binary \[ 1110100 \].

Binary and Hex

6. What are the hexadecimal numbers C, D, and E, expressed in binary? These are twelve, thirteen, fourteen, which are \[ 1100, 1101, 1110 \].

7. Express the hexadecimal number C0DE as a sum of 4 terms corresponding to the 4 digits. What is the value of this expression when converted to binary? Note that \[ 16 = 2^4, 16^3 = 2^{12} \] and \[ \times 2 \] shifts us left by one position. C0DE is \[ 12 \times 16^3 + 0 \times 16^2 + 13 \times 16^1 + 14 \times 16^0 = 1100 \ 0000 \ 1101 \ 1110 \] (C 0 D E)

8. What is the binary number 100100110, represented in hexadecimal? (Avoid using decimal.) Reverse the previous process. 1 0010 0110 and converting each 4 bits to a hex digit, \[ 126 \]
**Bitwise Operators (In Q9 thru Q13, all numbers are in binary)**

9. What is the binary value of 1010 | 110? \(1110\)

10. What is the binary value of 1010 & 110? \(10\)

11. What is the binary value of 1010 << 10? \(101000\)

12. What is the binary value of 1010 >> 10? \(10\)

13. What is the binary value of 1010 ∧ 110? \(1100\)

14. What is the value, expressed in hexadecimal, of C05126 △ CBE245 △ C05126? (What is the trick?) Since the order of inputs to xor doesn’t matter, this equals CBE245 ∧ C05126 ∧ C05126. Since anything xor’ed with itself is 0, this is CBE245 ∧ 0 = **CBE245**

**16-bit Two’s-Complement Representations**

15. What is the complement of 0101 0000 1100 1111? \(1010 1111 0011 0000\)

16. Give the 16-bit two’s-complement binary representation of the decimal integer 116 (Use question 5) \(0000 0000 0111 0100\)

17. Give the 16-bit two’s-complement binary representation of the decimal integer -116 First complement the bits of +116, then add one, giving \(1111 1111 1000 1100\)

18. What is the 16-bit two’s-complement hexadecimal representation of the decimal integer -116? Like Q8 (converting each 4 bits to a hex digit) **FF8C**

19. What is the decimal representation of the 16-bit two’s-complement hexadecimal number FFFE? Since the first bit is 1, this number is negative. Call this negative number \(X\). Then the binary representation of the positive number \(-X\) is obtained by flipping bits (0000 0000 0000 0001) and adding one (0000 0000 0000 0010). So \(-X\) is 2, i.e. \(X\) is \(-2\).

**Challenges (Read Booksite § 6.1)**

20. What should the binary numbers 0.1 and 0.01 represent? In decimal these are \(10^{-1}\) and \(10^{-2}\). In binary these are likewise \(2^{-1} = 1/2\) and \(2^{-2} = 1/4\)