1.4 Binary, hexadecimal, and octal
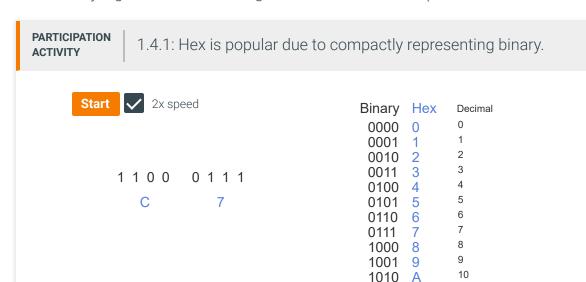
Hexadecimal

While decimal means a base 10 number, **hexadecimal** (or **hex**) means a base 16 number. Each digit is an increasing power of 16: 16^0, 16^1, 16^2, etc.

16 symbols are needed for a digit. The symbols are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.

Hexadecimal is popular due to being a compact representation of a binary number. Four binary digits can be represented as one hex digit, since both have 16 possibilities. Thus 0000 is 0, 0001 is 1, 0010 is 2, ..., 1110 is E, and 1111 is F.

More binary digits use more hex digits. Ex: 00101111 is 2F (0010 is 2, and 1111 is F).

PARTICIPATION ACTIVITY	1.4.1: Hex is popular due to compactly representing binary.	✓

Start ✓ 2x speed

1 1 0 0   0 1 1 1
   C   7

Binary	Hex	Decimal
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7
1000	8	8
1001	9	9
1010	A	10
1011	B	11
1100	C	12
1101	D	13
1110	E	14
1111	F	15

Captions ∧

1. Four bits have 16 possible combinations.
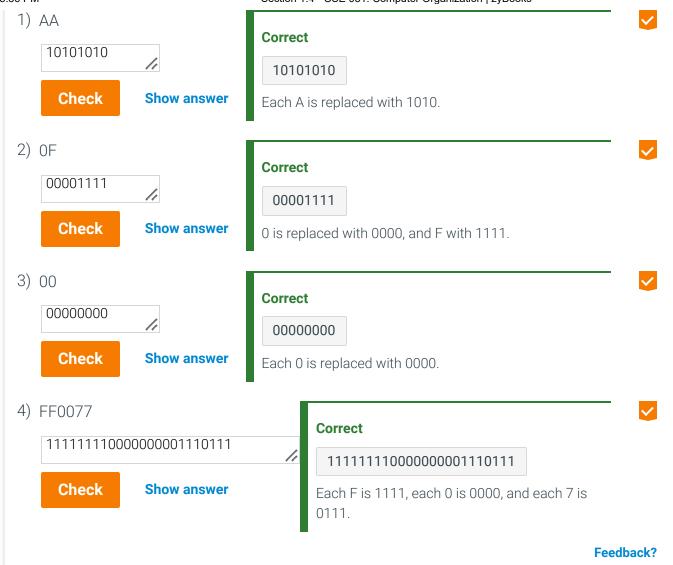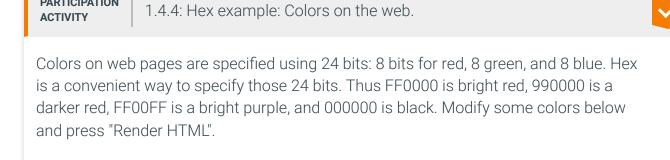2. One hex digit has 16 possible values. The first 10 use the usual numeric symbols. The next 6 use letters.
3. Given a binary number, every four bits can be represented with one hex digit. (In decimal, each hex digit represents 0 to 15).

Feedback?

PARTICIPATION
ACTIVITY
1.4.2: Converting binary to hex.

1) 0011

   ○ B

   ◉ 3

Correct

0011 is 3 in hex. The first ten binary values look like their decimal equivalents (0...9) in hex.

2) 1010

   ◉ A

   ○ 10

Correct

1010 is 10 in base 10, requiring two digits. But hex can represent 16 values in one digit, using A-F for the remaining 6 digits.

3) 1111

   ◉ F

   ○ Not possible

Correct

1111 is the max value for four bits, and F is the corresponding max value for one hex digit.

4) 11110000

   ○ FF

   ◉ F0

Correct

The rightmost four bits 0000 are 0 in hex. The leftmost four bits 1111 are F in hex.

5) 10100101

   ◉ A5

   ○ 5A

Correct

The rightmost four bits 0101 are 5 in hex. The leftmost four bits 1010 are A in hex. The hex number is more readable than all those 0's and 1's.

6) 10011

   ○ 91

   ◉ 13

Correct

The rightmost four bits 0011 are 3 in hex. The next four bits are 0001, which is 1 in hex. The 0's are implied, just like say 57 is the same as 057, 0057, 00057, etc., in base 10. Converting always starts from the right.

7) 0001111100001111

   ◉ 1F0F

   ○ F0F1

Correct

The rightmost four bits are 1111 or F. The next four are 0000 or 0. The next are 1111 or F. The leftmost four are 0001 or 1.

Feedback?

PARTICIPATION
ACTIVITY
1.4.3: Converting hex to binary.

1) AA

10101010

Check   **Show answer**

Correct

10101010

Each A is replaced with 1010.

2) 0F

00001111

Check   **Show answer**

Correct

00001111

0 is replaced with 0000, and F with 1111.

3) 00

00000000

Check   **Show answer**

Correct

00000000

Each 0 is replaced with 0000.

4) FF0077

1111111100000000001110111

Check   **Show answer**

Correct

1111111100000000001110111

Each F is 1111, each 0 is 0000, and each 7 is 0111.

Feedback?

PARTICIPATION ACTIVITY	1.4.4: Hex example: Colors on the web.

Colors on web pages are specified using 24 bits: 8 bits for red, 8 green, and 8 blue. Hex is a convenient way to specify those 24 bits. Thus FF0000 is bright red, 990000 is a darker red, FF00FF is a bright purple, and 000000 is black. Modify some colors below and press "Render HTML".

Reset

Type HTML below   **Rendered HTML**

```
<!DOCTYPE html>
<html>
<body>

<p style="background-color:#FF0000">
Line1 </p>
<p style="background-color:#990000">
Line2 </p>
<p style="background-color:#FF00FF">
Line3 </p>
<p style="background-color:#00FF00">
Line4 </p>
<p style="background-color:#777777">
Line5 </p>
<p style="background-color:#000000">
Line6 </p>
</body>
```

Line1

Line2

Line3

Line4

Line5

Line6

Render HTML

Feedback?

Hex to decimal

A hex number is converted to decimal simply by multiplying each digit's decimal value by that digit's weight and summing. Ex: A7F = $10 \times 16^2 + 7 \times 16^1 + 15 \times 16^0$ = 2560 + 112 + 15 = 2687.

| PARTICIPATION ACTIVITY | 1.4.5: Hex to decimal. | ✔ |

◄ ══ ►

1) A

- ○ 1
- ◉ 10

Correct

A in hex represents 10 in decimal, B 11, C 12, D 13, E 14, and F 15.

2) A7

- ○ 17
- ○ 107
- ◉ 167

Correct

A is 10 and 7 is 7.
$10 \times 16 + 7 \times 1 = 167$.

3) FFF

- ○ 45
- ◉ 4095
- ○ 151515

Correct

F is 15.
$15 \times 16^2 + 15 \times 16^1 + 15 \times 16^0 = 4095$.

Feedback?

Decimal to hex

Decimal is converted to hex by finding the highest hex digit where a 1 doesn't exceed the decimal value, incrementing as much as possible without exceeding the decimal value, and repeating for lower digits.

PARTICIPATION ACTIVITY	1.4.6: Decimal to hex.	✔

1) 20 decimal

   14

   Check   **Show answer**

   Correct

   14

   1×16^2 is 256: Too much.
   1×16^1 is 16: OK. 2×16^1 is 32: Too much. 4 remains.
   4×16^0 yields 16 + 4 = 20.

2) 40 decimal

   28

   Check   **Show answer**

   Correct

   28

   1×16^2 is 256: Too much.
   1×16^1 is 16: OK. 2×16^1 is 32: Largest without exceeding. 8 remains.
   8×16^0 yields 32 + 8 = 40.

3) 258 decimal

   102

   Check   **Show answer**

   Correct

   102

   1×16^2 is 256; OK. Any larger exceeds. 2 remains.
   1×16^1 is 16, exceeds 2.
   2×16^0 yields 256 + 2 = 258.
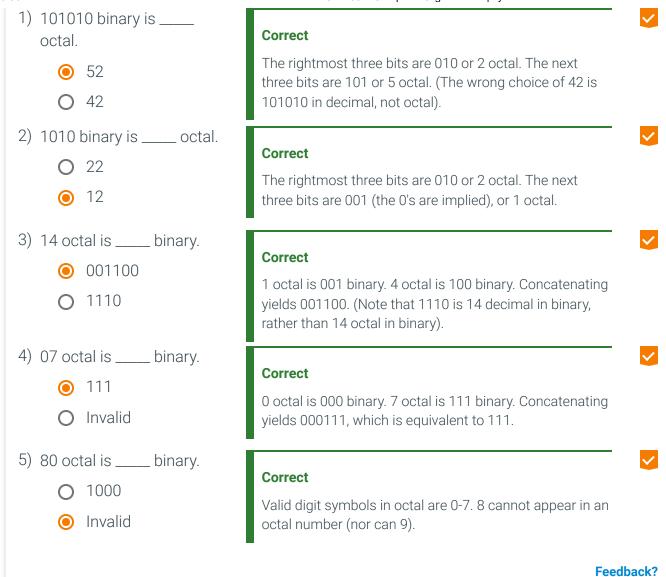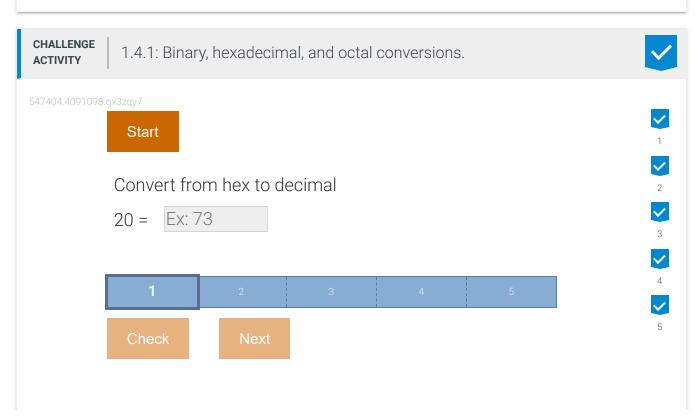
Feedback?

Octal

Octal means a base 8 number. Octal is sometimes used as a compact binary representation because three bits can be represented as one octal digit, though hex is more common. The eight symbols for an octal digit are 0, 1, 2, 3, 4, 5, 6, 7.

PARTICIPATION ACTIVITY	1.4.7: Binary to octal, octal to binary.	✔

1) 101010 binary is _____ octal.

○ 52 (selected)

○ 42

Correct

The rightmost three bits are 010 or 2 octal. The next three bits are 101 or 5 octal. (The wrong choice of 42 is 101010 in decimal, not octal).

2) 1010 binary is _____ octal.

○ 22

○ 12 (selected)

Correct

The rightmost three bits are 010 or 2 octal. The next three bits are 001 (the 0's are implied), or 1 octal.

3) 14 octal is _____ binary.

○ 001100 (selected)

○ 1110

Correct

1 octal is 001 binary. 4 octal is 100 binary. Concatenating yields 001100. (Note that 1110 is 14 decimal in binary, rather than 14 octal in binary).

4) 07 octal is _____ binary.

○ 111 (selected)

○ Invalid

Correct

0 octal is 000 binary. 7 octal is 111 binary. Concatenating yields 000111, which is equivalent to 111.

5) 80 octal is _____ binary.

○ 1000

○ Invalid (selected)

Correct

Valid digit symbols in octal are 0-7. 8 cannot appear in an octal number (nor can 9).

Feedback?

CHALLENGE ACTIVITY | 1.4.1: Binary, hexadecimal, and octal conversions.

547404.4091098.qx3zqy7

Start

Convert from hex to decimal

20 = [Ex: 73]

| **1** | 2 | 3 | 4 | 5 |

Check   **Next**

1
2
3
4
5

Feedback?

How was this section?

👍 | 👎 **Provide section feedback**