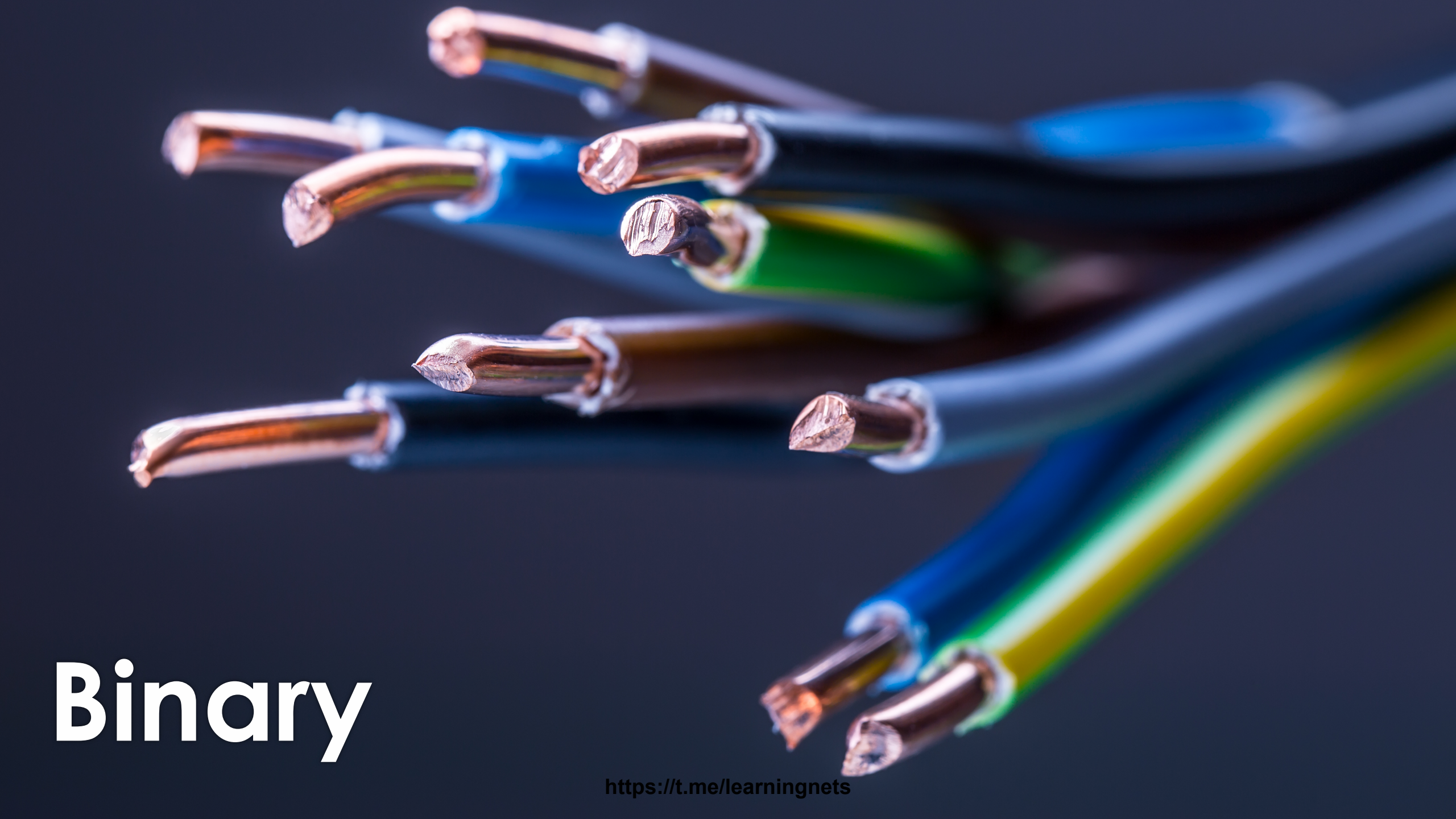
Binary

- Why do we care?
  - Subnetting
  - Access lists
  - Used in many other places

Joke

- There are only 10 types of people in the world.
- Those that understand binary and those that don’t.

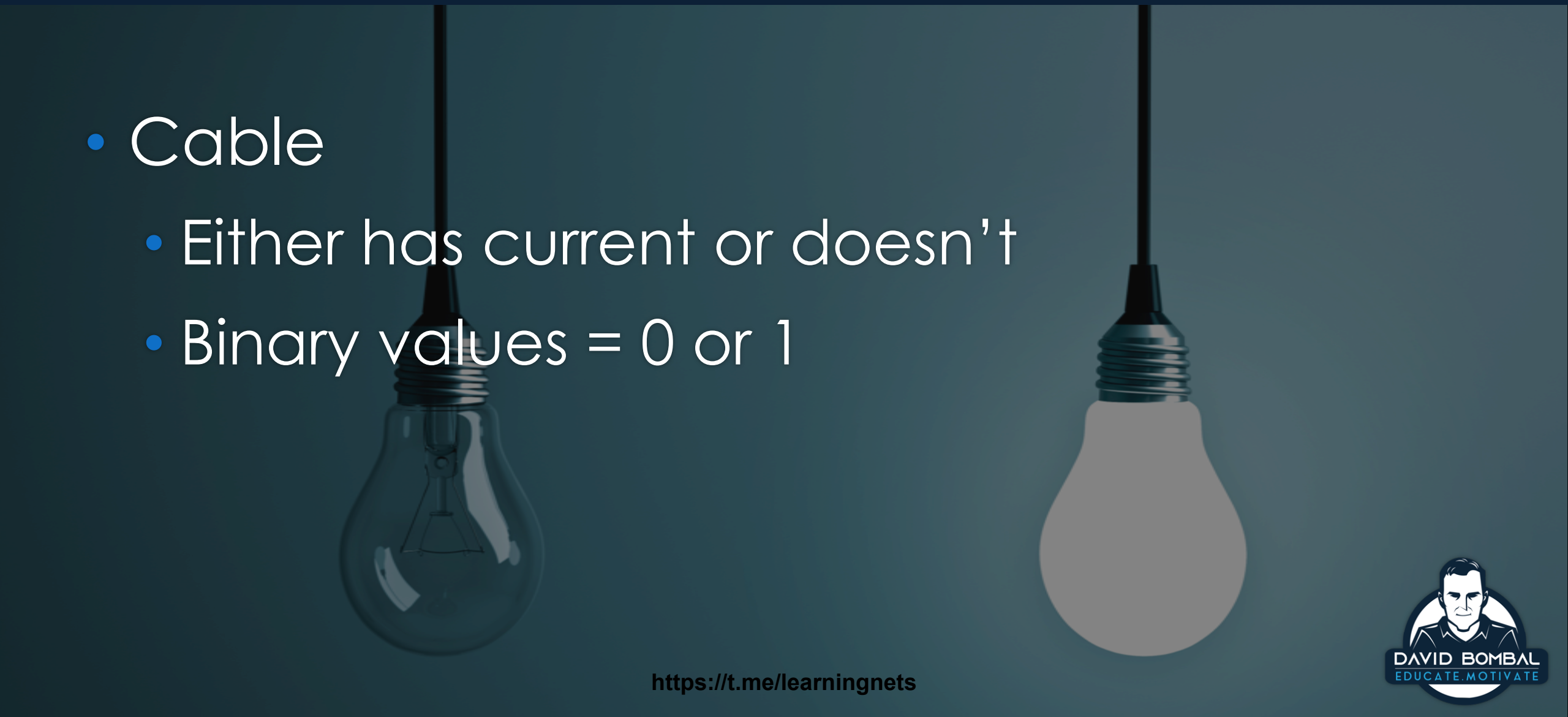


Binary

Binary

- All computers function by using a system of switches that can either be on or off
  - Off = 0
  - On = 1
- Binary values = 0 or 1

Binary



- Cable
  - Either has current or doesn't
  - Binary values = 0 or 1

Binary

0

Binary

1

0 0

1 0

0 1

1 1

Binary

- 2 states
- 2 cables

- 2 x 2 = 4
- Or $2^2 = 4$

Binary

- And so on: 4 cables gives 16 binary values:
- 0000
- 0001
- 0010
- 0011
- 0100
- 0101
- 0110
- 0111
- 1000
- 1001
- 1010
- 1011
- 1100
- 1101
- 1110
- 1111

- 2 states and 4 cables: $2^4 = 16$

Binary

- 2 states
- 4 cables

- 2 x 4 = 16
- Or $2^4 = 16$

Binary

- 2 to the power of 0 (2^0) = 1
- 2 to the power of 1 (2^1)
  - which is 2 multiplied together 1 time (2x1) = 2
- 2 to the power of 2 (2^2)
  - which is 2 multiplied together 2 times (2x2) = 4
- 2 to the power of 3 (2^3)
  - which is 2 multiplied together 3 times (2x2x2) = 8
- 2 to the power of 4 (2^4)
  - which is 2 multiplied together 4 times (2x2x2x2) = 16

Binary

- 2 to the power of 5 (2^5)
  - which is 2 multiplied together 5 times (2x2x2x2x2) = 32
- 2 to the power of 6 (2^6)
  - which is 2 multiplied together 6 times (2x2x2x2x2x2) = 64
- 2 to the power of 7 (2^7)
  - which is 2 multiplied together 7 times (2x2x2x2x2x2x2) = 128
- 2 to the power of 8 (2^8)
  - which is 2 multiplied together 8 times (2x2x2x2x2x2x2x2) = 256

A table to remember

Base Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	1	1	1	1	1	1	1	1
Decimal	128	64	32	16	8	4	2	1

Example 1

- If all binary bits are a one, the binary equivalent of 255 is:

Base	Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary		1	1	1	1	1	1	1	1
Decimal		128	64	32	16	8	4	2	1

- 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 = 255
- Or written this way:
  - 11111111 in binary = 255 in decimal

Example 2

- What is the binary equivalent of 1 in decimal?

Base Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	0	0	0	0	0	0	0	1
Decimal	~~128~~	~~64~~	~~32~~	~~16~~	~~8~~	~~4~~	~~2~~	1

- 1 in binary = 1 in decimal
- Or written this way:
  - 00000001 in binary = 1 in decimal

Example 3 Question:

- What is the binary equivalent of 192 in decimal?

Base Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	0	0	0	0	0	0	0	0
Decimal	128	64	32	16	8	4	2	1

Example 3: Answer

- What is the binary equivalent of 192 in decimal:

Base Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	1	1	0	0	0	0	0	0
Decimal	128	64	32	16	8	4	2	1

- 128 + 64 = 192 in decimal
- Or written this way:
  - 11000000 in binary = 192 in decimal

Example 4: Question

- What is the binary equivalent of 253 in decimal?

Base / Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	0	0	0	0	0	0	0	0
Decimal	128	64	32	16	8	4	2	1

Example 4: Answer

- What is the binary equivalent of 253 in decimal:

Base	Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary		1	1	1	1	1	1	0	1
Decimal		128	64	32	16	8	4	2	1

- 128 + 64 + 32 + 16 + 8 + 4 + 1= 253 in decimal
- Or written this way:
  - 11111101 in binary = 253 in decimal

IP Address Example

- An IPv4 address is an address used to uniquely identify a device on an IP network
- 4 octets in length
- Value in each octet is 8 bits (8 cables) in the range 0 to 255

10. 129. 16. 123 (decimal)

00001010.10000001.00010000.01111011 (binary)

IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)

00001010.10000001.00010000.01111011 (binary)

IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)

00001010.10000001.00010000.01111011 (binary)

Base Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	0	0	0	0	1	0	1	0
Decimal	128	64	32	16	8	4	2	1

- 8 + 2 = 10
  - 00001010 in binary = 10 in decimal

IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)

00001010.10000001.00010000.01111011 (binary)

Base Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	1	0	0	0	0	0	0	1
Decimal	128	64	32	16	8	4	2	1

- 128 + 1 = 129
  - 10000001 in binary = 129 in decimal

IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)

00001010.10000001.00010000.01111011 (binary)

Base	Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary		0	0	0	1	0	0	0	0
Decimal		128	64	32	16	8	4	2	1

- 16 = 16
  - 00001000 in binary = 16 in decimal

IP Address Example

- IP address represented in both binary and decimal:

10. 129. 16. 123 (decimal)

00001010.10000001.00010000. 01111011 (binary)

Base Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Binary	0	1	1	1	1	0	1	1
Decimal	128	64	32	16	8	4	2	1

- 64 + 32 + 16 + 8 + 2 + 1 = 123
  - 01111011 in binary = 123 in decimal

Calculators

- Binary, Decimal and Hexadecimal Converter:
  - https://davidbombal.com/binary-decimal-hexadecimal-converter/
- Visual Binary to Binary:
  - https://davidbombal.com/decimal-to-binary/
- Subnet Calculator:
  - https://davidbombal.com/subnetting-concepts-calculator/

Test yourself

- Unlimited tests:
  - https://davidbombal.com/free-quiz/
  - https://davidbombal.com/binary-to-decimal-quiz/
  - https://davidbombal.com/decimal-to-binary-quiz/