CPSC 100

Computational Thinking

Data Representation

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Agenda

- Course Admin
- Learning Goals
- Review of Binary/Ternary
- Hexadecimal
- RGB Colours

Course Admin

Learning Goals

Learning Goals

After this **today's lecture**, you should be able to:

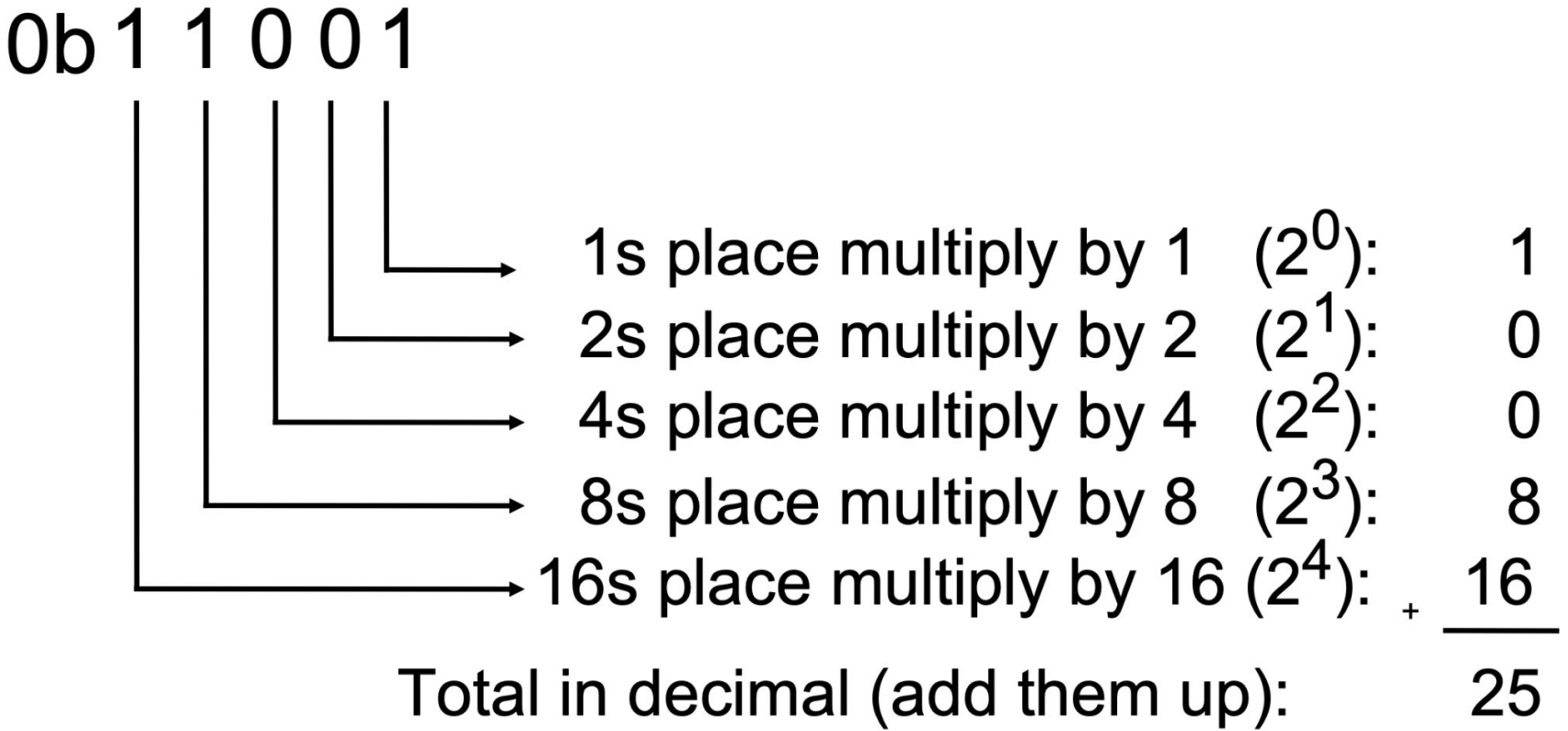
- Recognize **hexadecimal numbers** and their role in data representation.
- Count in different **standard number bases** (i.e. 2, 10, 16).
- **Translate** numbers between binary, hexadecimal, and decimal without a calculator

After watching the **take home-video**, you should be able to:

- Recognize the difference between binary and ternary numbers
- Translate numbers between binary, hexadecimal, decimal and **ternary**

Convert Binary to Decimal

Recall



Algorithm to Convert Decimal to Binary

- Start with a decimal number *n* (0 to 255)
  - Since 255 is the maximum, we need 8 bits.
- Check the highest power of 2 that fits into *n*:
  - If n < 128, set the 1st (leftmost) bit to 0; otherwise, set it to 1 and subtract 128 from *n* (*n=n-128*)
  - If n < 64, set the 2nd bit to 0; otherwise, set it to 1 and subtract 64 from *n*. (*n=n-64*)
  - If n < 32, set the 3rd bit to 0; otherwise, set it to 1 and subtract 32 from *n*. (*n=n-32*)
  - Continue this process for 16, 8, 4, 2, and finally 1.
- By the end, *n* will be either 0 or 1, which is the last (8th) bit.

Algorithm to Convert 217 to Binary

- n = 217
- Check the highest power of 2 that fits into *n*:
  - ❌ **217** < 128 (2^7), 1st Bit = **1**
    - *n = 217 - 128* ⇒ 89
  - ❌ **89** < 64 (2^6), 2nd bit = **1**
    - *n = 89 - 64* ⇒ 25
  - ✅ **25** < 32 (2^5), 3rd bit = **0**
    - *No subtraction required*
  - ❌ **25** < 16 (2^4), 4nd bit = **1**
    - *n = 25 - 16* ⇒ 9
  - ❌ **9** < 8 (2^3), 5th Bit = **1**
    - *n = 9 - 8* ⇒ 1
  - ✅ **1** < 4 (2^2), 6th bit = **0**
    - *No subtraction required*
  - ✅ **1** < 2 (2^1), 7th bit = **0**
    - *No subtraction required*
  - **Final bit = n = 1 (2^0)→ 8th bit = 1**
- **Final Answer: 11011001**

Recap

Q: What is the binary number for 9?

iClicker

A. 10001

B. 01010

C. 01011

D. 01000

E. 01001

Hexadecimal Numbers

Hexadecimal Numbers

- Computers don’t understand Decimal (base 10)
- Humans have trouble with Binary (base 2)
  - 11111111100110001110001010 10
  - Writing so many 0’s and 1’s is tedious and error prone
- **Hex digits**, short for **hex**adecimal (base 16)
  - Compromise between humans and computers
  - **Easy to convert between Hex and Binary**

Hexadecimal Numbers

- The digits of the hexadecimal numbering system are
  - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- Because there are 16 digits, they can be represented perfectly by the 16 symbols of 4-bit sequences:
  - The bit sequence **0000** is **hex 0** Bit sequence **0001** is **hex 1**
  - Bit sequence 1111, is hex F
  - Sometimes we use the representation **0x[number]** to show that a number is in **hex**.

Hexadecimal Numbers to Binary

- Because each hex digit corresponds to a 4-binary sequence, it's easy to translate between hex and binary
  - Hex → binary: replace each hexadecimal digit by the four corresponding binary digits in the conversion table

Hex:	F	A	B	4
Binary:	1111	1010	1011	0100

Binary to Hexadecimal

- Binary → hex:
  - Put extra 0's at the left of the binary number as necessary so that the total number of digits is a multiple of 4
  - then reverse the hex → binary conversion process

Binary:	0010	1011	1010	1101
Hex:	2	B	A	D

Activity - Fill in the Gaps
(Take Home)

Decimal	Binary	Hex
00	0000	0
01	0001	1
02	0010	
03		
04	0100	
05		
06		6
07		

Decimal	Binary	Hex
08		
09	1001	
10		A
11	1011	
12		
13	1101	
14		
15		F

(leading 0's, shown in gray, are useful for some conversions)

MetaCog Activity - Fill in the Gaps
(Take Home)

Decimal	Binary	Hex
00	0000	0
01	0001	1
02	0010	2
03	0011	3
04	0100	4
05	0101	5
06	0110	6
07	0111	7

Decimal	Binary	Hex
08	1000	8
09	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

(leading 0's, shown in gray, are useful for some conversions)

Q: Translate 0xAFF1 to binary

iClicker

A. 1111 1101 1101 0001

B. 1010 1101 1101 0001

C. 0001 1111 1111 1010

D. 1111 1010 1111 0001

E. 1010 1111 1111 0001

Learning Goals

After this **today's lecture**, you should be able to:

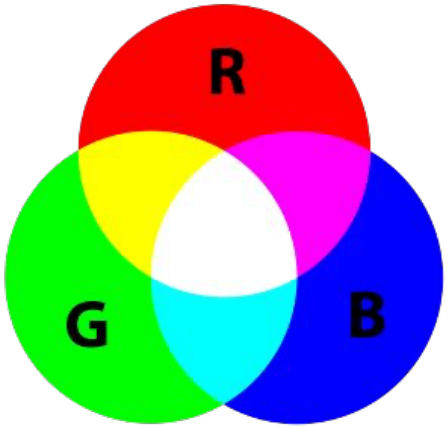
- Understand how colours are represented in the RGB model
- Describe how RGB colours are stored and represented in computing.
  - Recognize that each colour (R, G, B) has 256 intensity levels (0-255).
- Convert between different RGB representations: Decimal, Binary, & Hex

After watching the **take-home video**, you should be able to:

- Analyze how RGB colours mix to produce new colours.
- Explain and apply colour theory concepts to digital designs

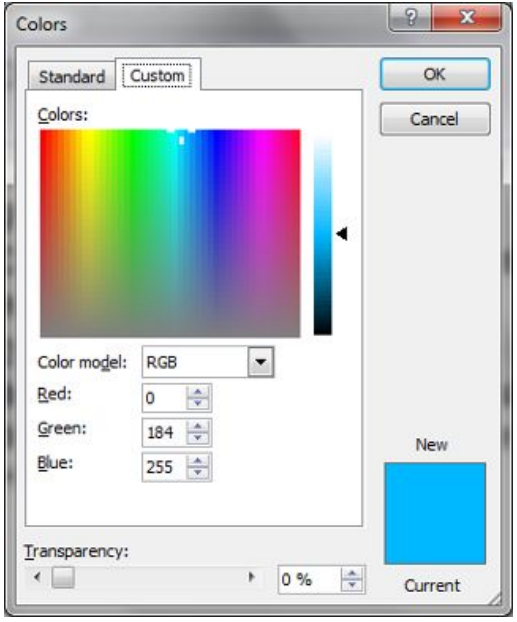
RGB Colours

RGB Colours



- Monitors, phone screens, and TVs make different colours by mixing Red, Green, and Blue lights

- Computer applications use 256 intensities (8 bits) for each of red, green, and blue.



RGB Colours

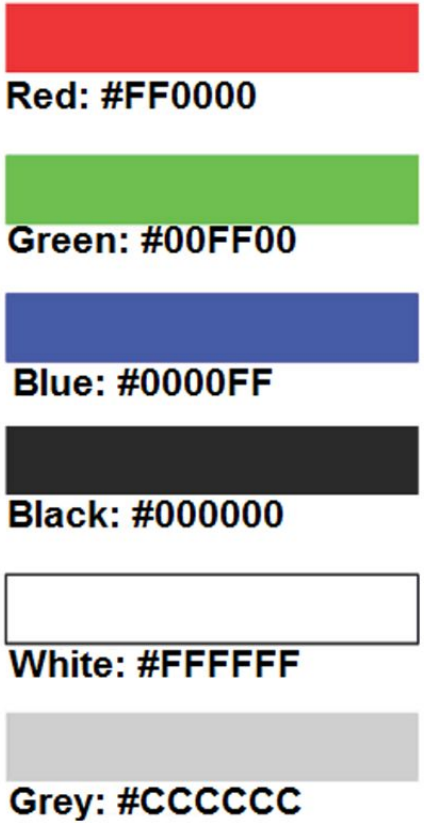
Black is the absence of light:

- 0000 0000 0000 0000 0000 0000 **(Binary)**
- 0 0 0 0 0 0 **(Hex)**
  - RGB bit assignment for black

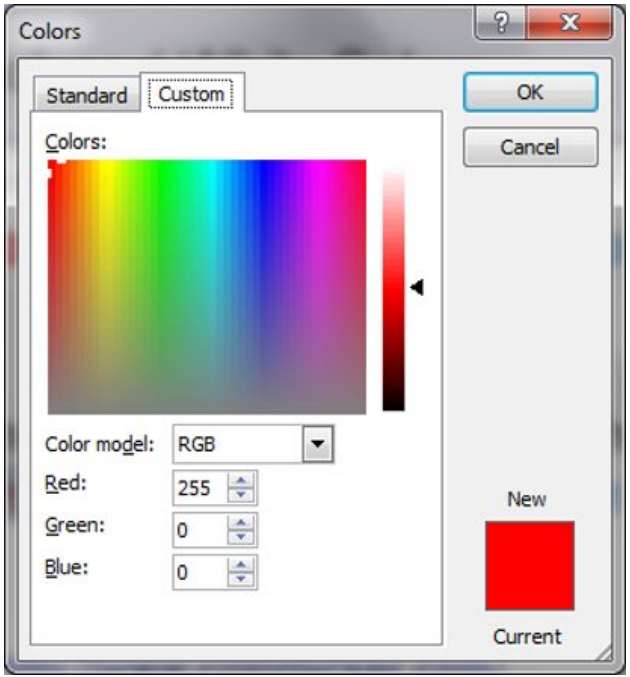
White is the full intensity of each color:

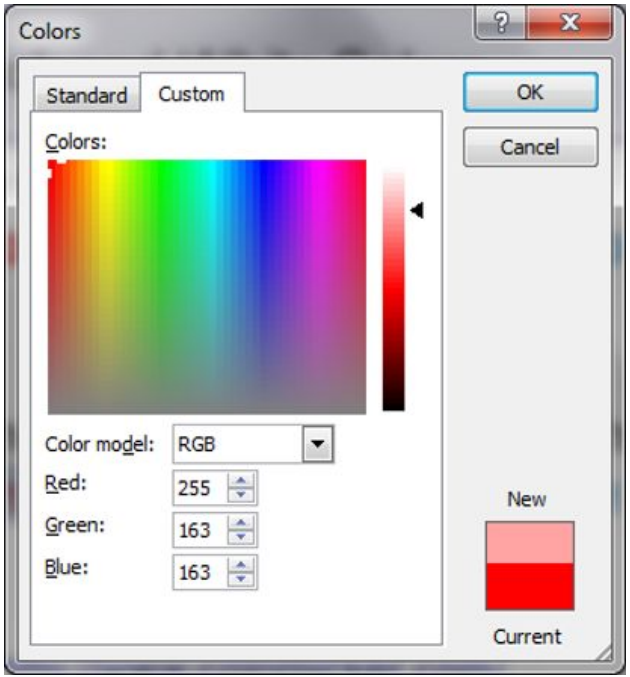
- 1111 1111 1111 1111 1111 1111 **(Binary)**
- F F F F F F **(Hex)**
  - RGB bit assignment for white

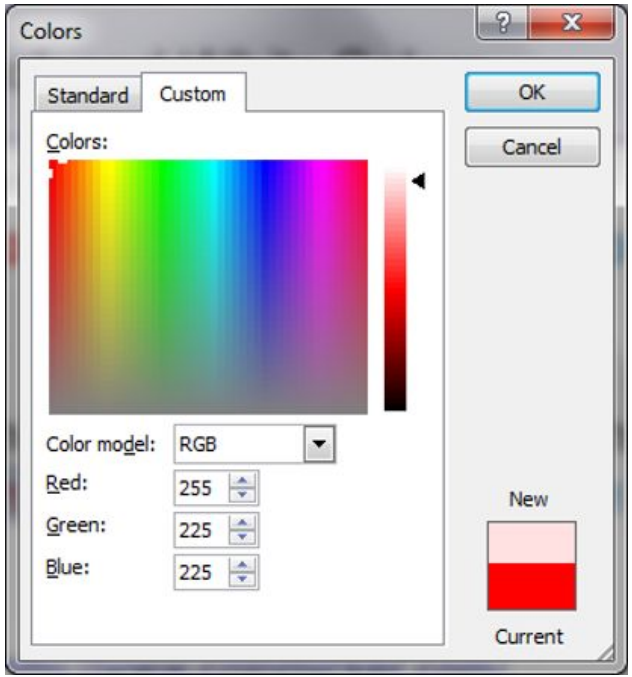
- https://www.w3schools.com/colors/colors_picker



RGB Colours in Decimal







RGB Colours

Colour		Decimal		Hex
Red	→	(255, 0, 0)	→	#FF0000
Green	→	(0, 255, 0)	→	#00FF00
Blue	→	(0, 0, 255)	→	#0000FF
White	→	(255, 255, 255)	→	#FFFFFF
Black	→	(0, 0, 0)	→	#000000

RGB Colours

- **Colour** **Decimal** **Hex**
- Red → (255, 0, 0) → #FF0000
- Green → (0, 255, 0) → #00FF00
- Blue → (0, 0, 255) → #0000FF
- White → (255, 255, 255) → #FFFFFF
- Black → (0, 0, 0) → #000000

Recall: Hexadecimal is a base-16 system where:

- *Digits 0-9 represent values 0-9.*
- *Letters A-F represent values 10-15.*

- *Example: FF (Hex) = $(F \times 16^1) + (F \times 16^0)$*

  $(15 \times 16) + (15 \times 1) \Rightarrow 255$

Decimal	Hex
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

Q: Which colour best describes the one represented by the hexadecimal colour code: #32CD32?

iClicker

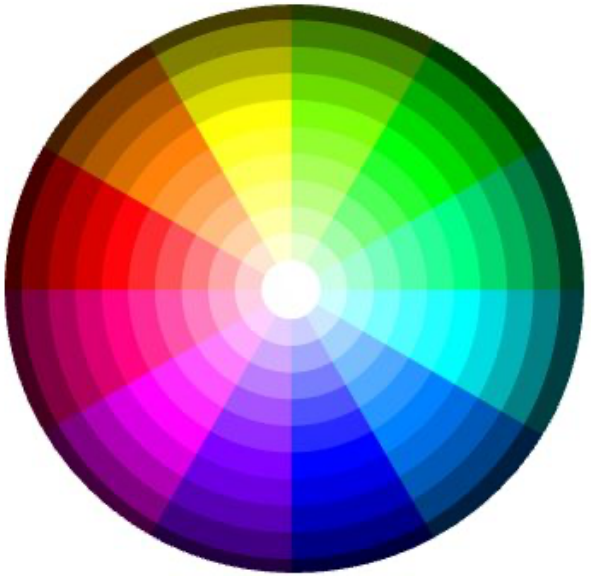
A. Shade of red

B. Shade of blue

C. Shade of green

D. Shade of purple

E. Shade of yellow



Q: Which colour best describes the one represented by the hexadecimal colour code: #800B80?

iClicker

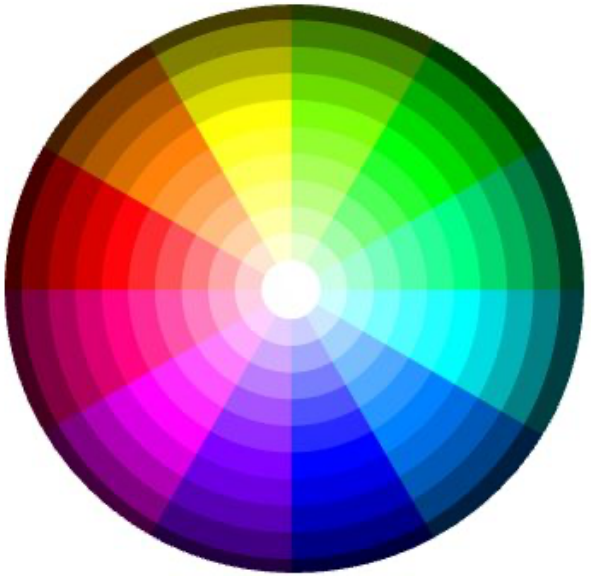
A. Shade of red

B. Shade of blue

C. Shade of green

D. Shade of purple

E. Shade of yellow



Mini-Activity

Color Mixing: Match the Colour to its Hex Rep.

Hex. Rep.	shade of …
#FFA933	Yellow
#FF99FF	Pink or Magenta
#EAE51D	Blue
#A1A2A3	Orange
#1234F8	Grey

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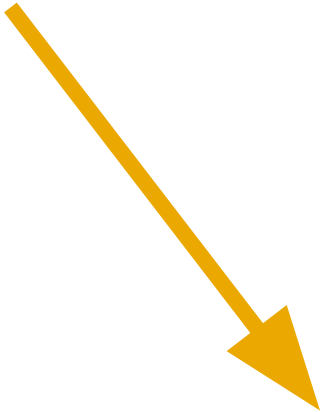

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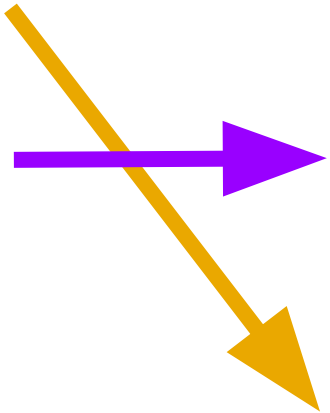

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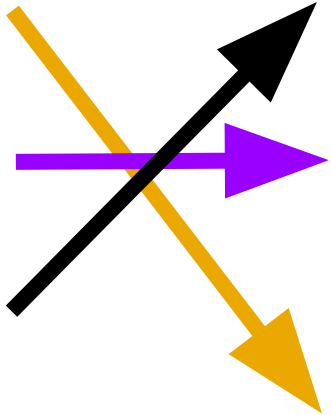

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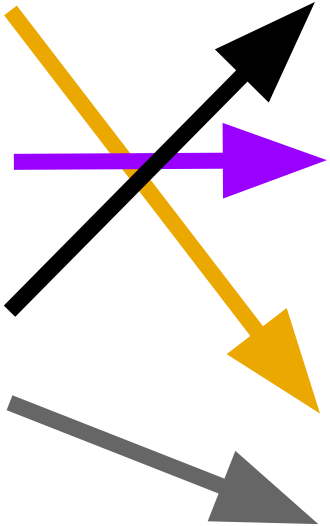

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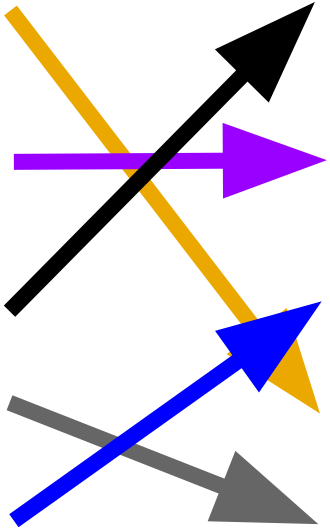

Take-Home Practice

Convert these numbers to binary

- 16
- 27
- 30
- 58
- 98
- 78
- 100
- 9
- 34

Convert 1100 1010 1111 1110 to hexadecimal

Convert 0xA19C to decimal

Convert 48 to hexadecimal

Take Home Video

Colour Theory

https://youtu.be/_2LLXnUdUlc?si=ZC0gCVCkhlmnc3KT

Another Useful Video

https://youtu.be/CBYhwcn4WSI?si=flTtLe_y5ZyqDQTA&t=57

Wrap up