Computer Engineering
Suan Sunandha Rajabhat University

Introduction to Digital Systems

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CPE1401 – Digital System Design

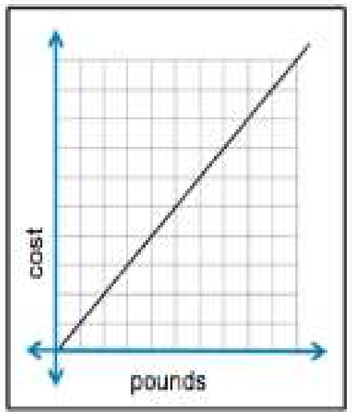
https://elchm.ssru.ac.th/pongrapee_ka/

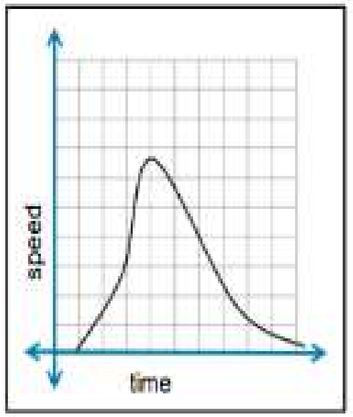
Continuous and discrete data

Continuous data

The data can take on any value within a finite or infinite interval.

Examples
Cost/Weight, Speed/Time

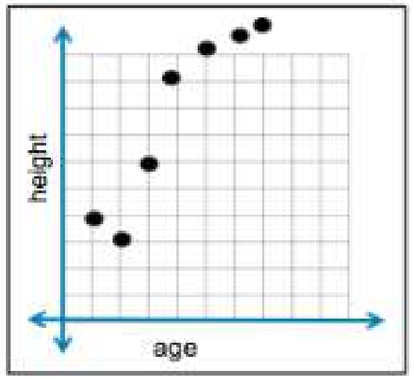


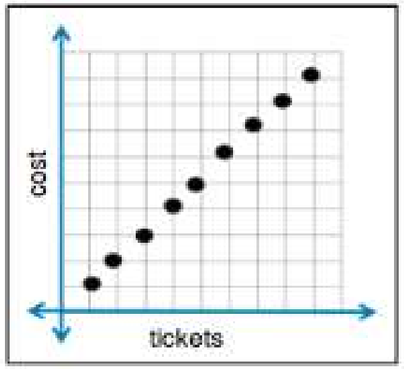


Discrete data

The data can be counted in a finite amount of time.

Examples
Height/Age, Cost/Ticket





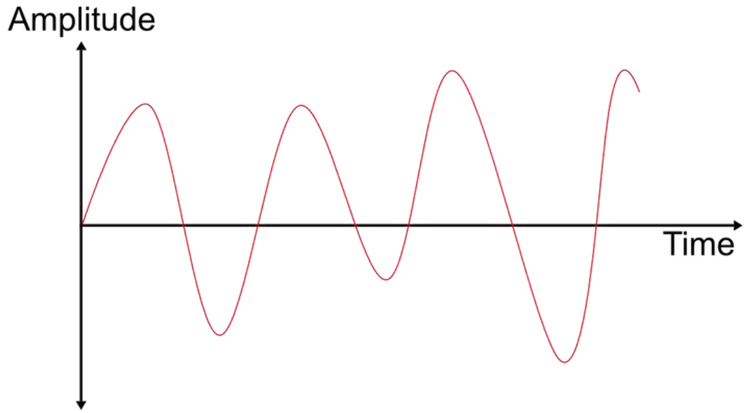
Attempt a quiz

Quiz **1**, Page **1**, Questions **1–4**

Continuous-time and discrete-time signals

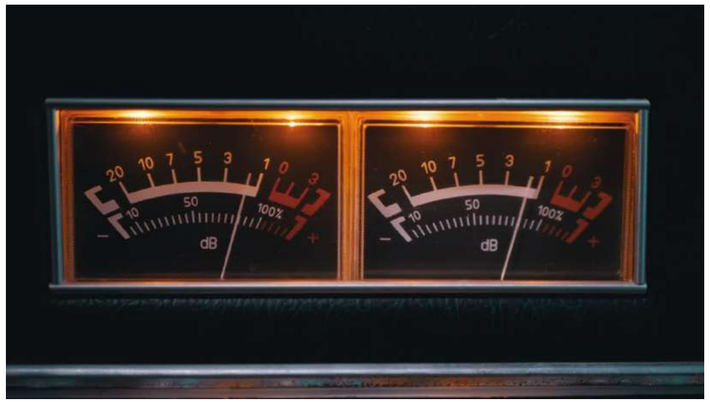
Continuous-time signal

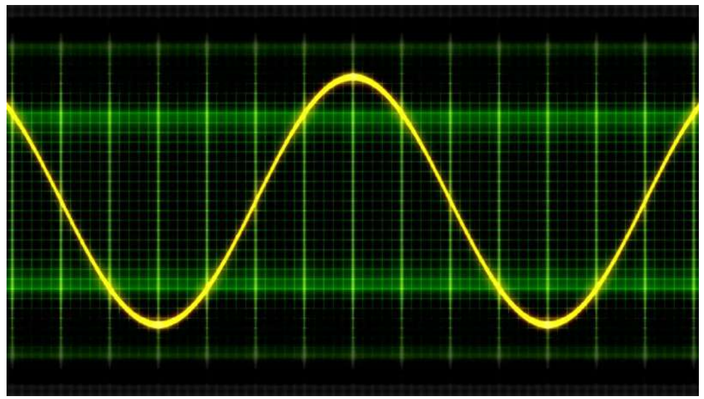
Amplitudes vary smoothly and continuously over time.



Examples

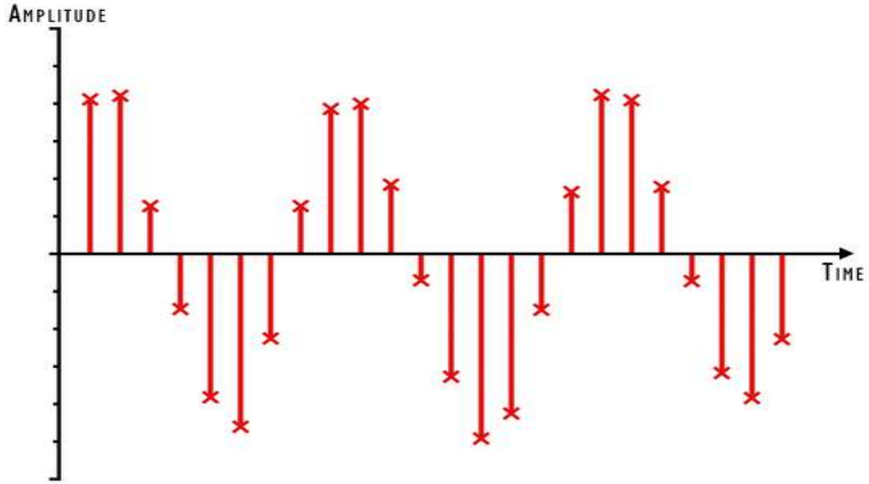
- Sound - Volume and frequency change continuously.
- AC current - Voltage changes alternately.
- Temperature - Temperature changes over time.





Discrete-time signal

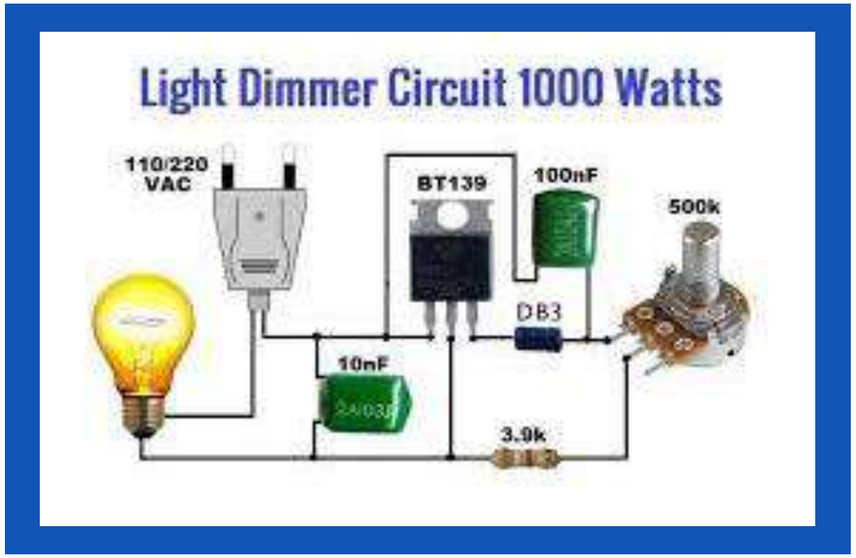
Amplitudes are defined only at specific points of time. These points are typically equally spaced, with a fixed time interval between consecutive points.

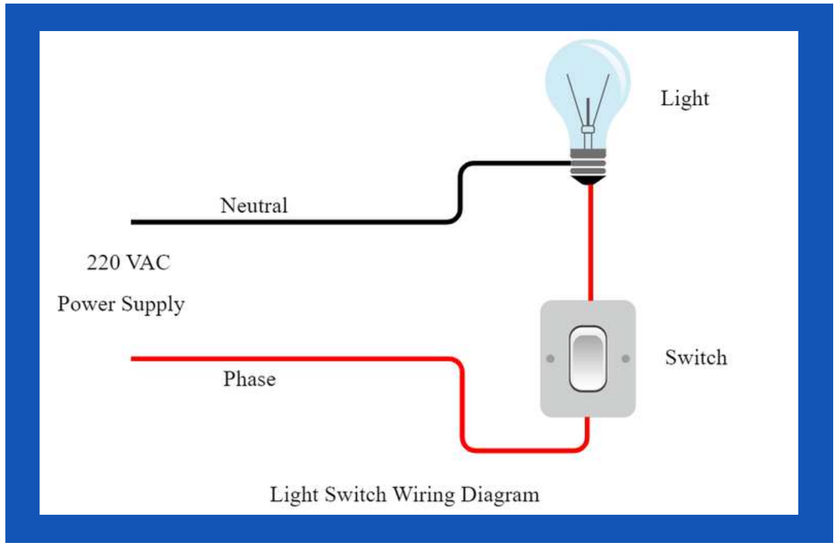


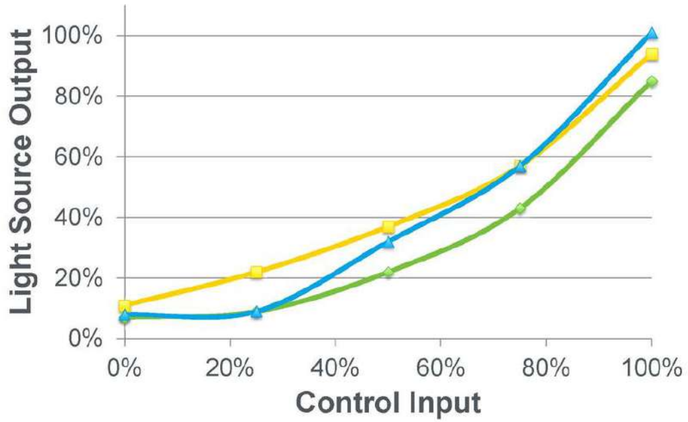
Examples

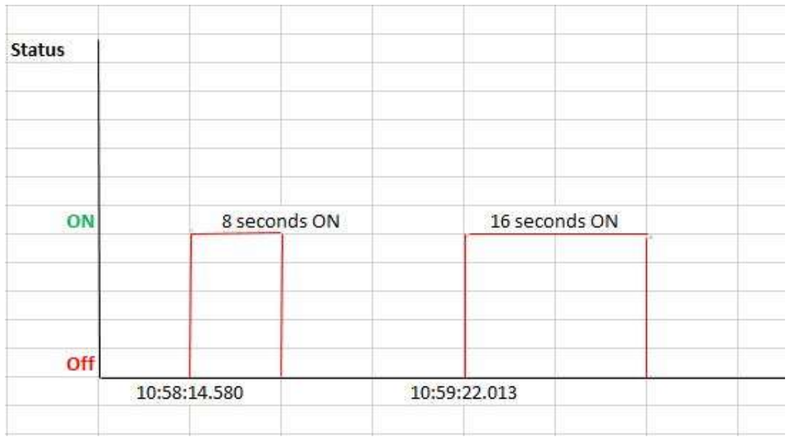
- Weight measured every month
- Temperature measured every hour
- Sound played every second

Continuous and discrete (on/off) stages



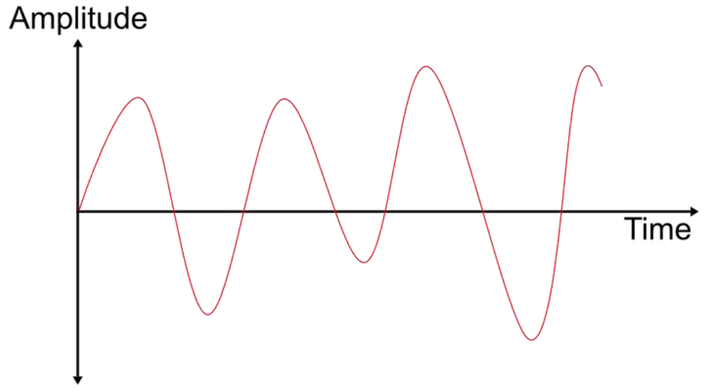


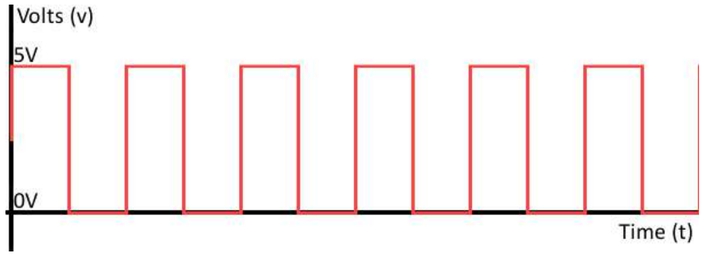




Analog and digital signals

Analog signal	Digital signal
Continuous-time data.	Discrete-time data.
Amplitude changes with time.	Amplitude changes with time.
Amplitude covers a wide range of real numbers.	Amplitude can have two possible values (on/off).
Almost all signals in nature are analog signals.	Digital signals are used in digital devices.





Examples

- Voice - Volume and frequency change continuously.
- AC current - Voltage changes alternately.

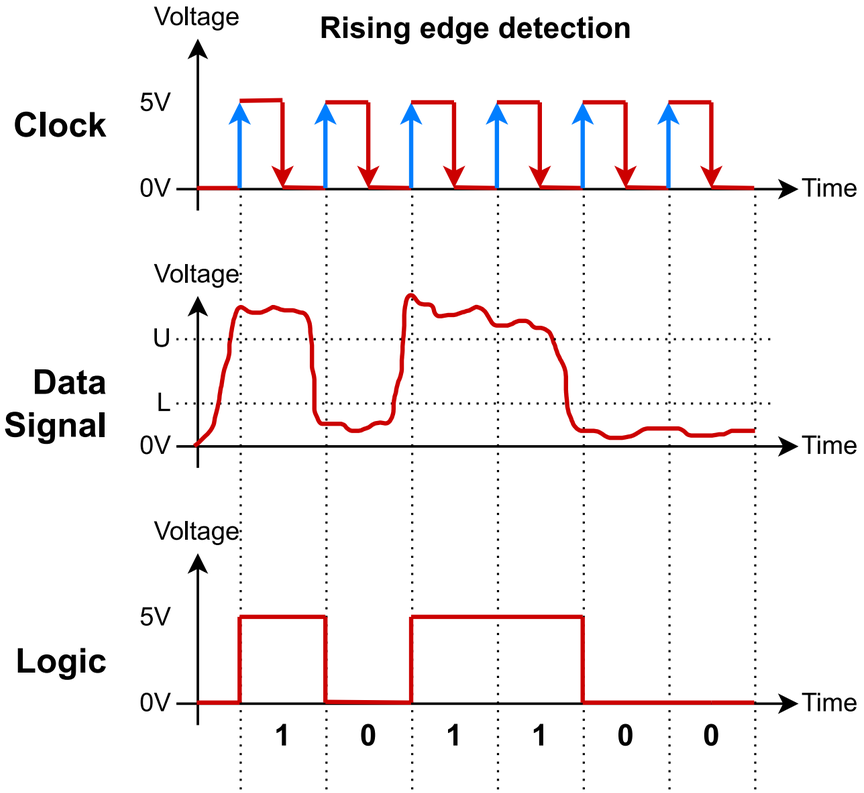
Examples

- Signal transmitted through a USB cable.
- Signal transmitted through an optical fiber network.

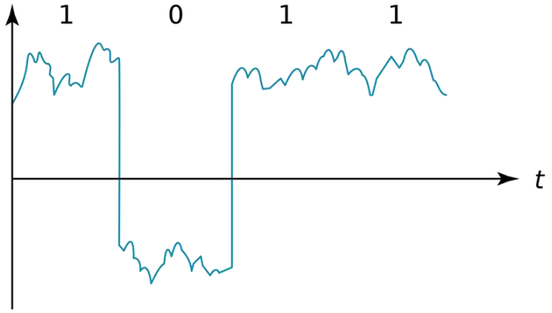
Logic *(in digital electronics and signal processing)*

Digital signal processing considers higher levels as 1 and lower levels as 0 which, in most cases, represents voltage levels 5V and 0V respectively.

The clock signal is used to synchronize digital signals. Logic changes are triggered either by the rising edge (0 to 1) or the falling edge (1 to 0) of the clock signal.



No real-world circuit can instantly change voltage levels. There will be small response time.



Digital signal is strong against noise and disturbance. A received digital signal may be impaired by noise and distortions without necessarily affecting the digits

Attempt a quiz

Quiz 1, Page 2, Question 5

Analog and digital media

Analog media keeps the entire record (continuous-time) with almost no data loss.

It is difficult to search or manipulate analog data.

Automation has to be done mechanically.

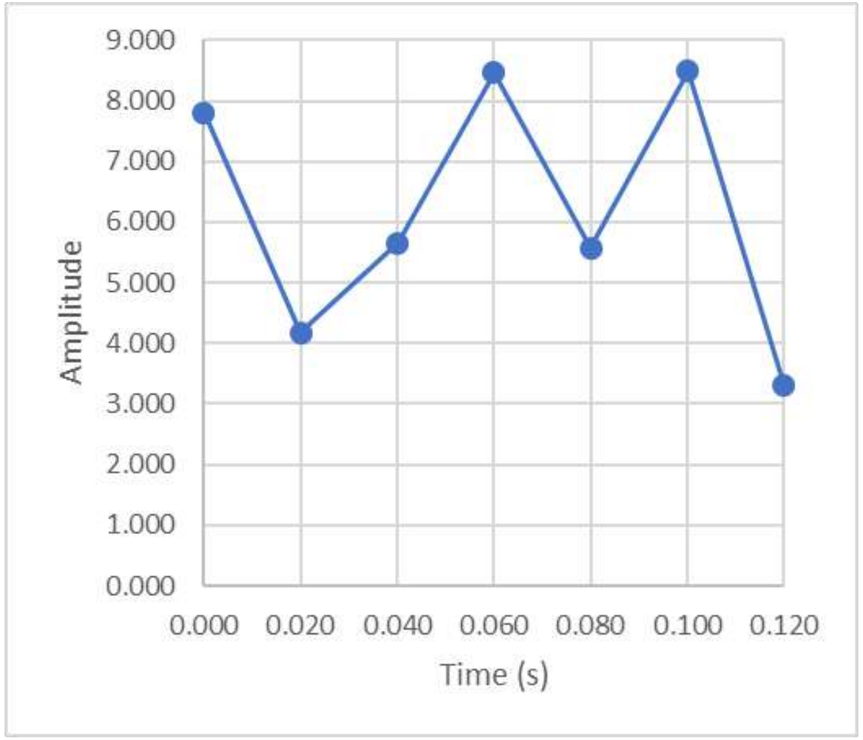
Example: Digital media

Digital media keep records at (time) intervals.

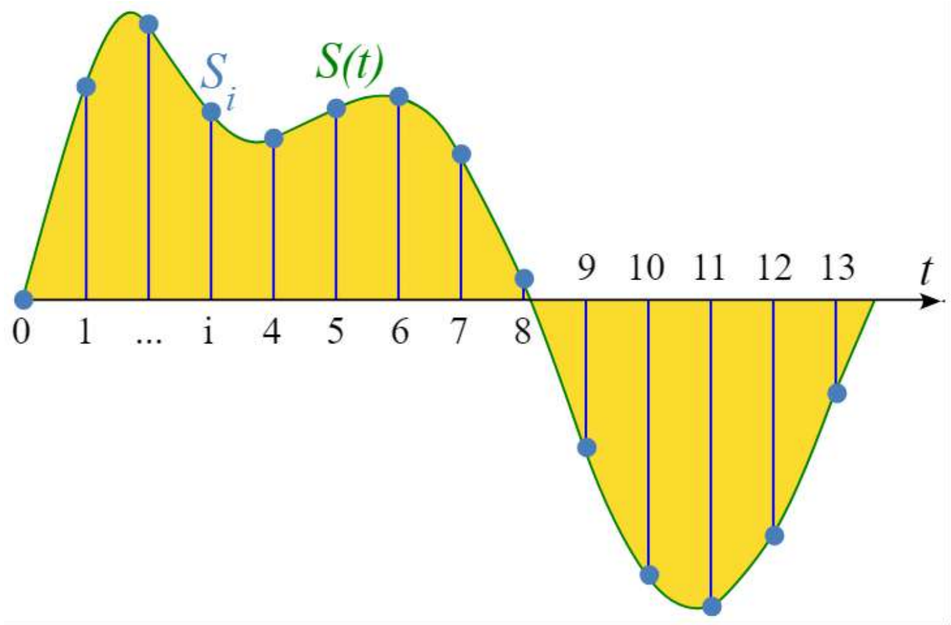
You will see that a digital signal is not that smooth.

Example

time	amplitude
0.000	7.810
0.020	4.180
0.040	5.660
0.060	8.460
0.080	5.570
0.100	8.490
0.120	3.300



Converting analog to digital (A/D) is done through a sampling process where the original analog data will be sampled at intervals.



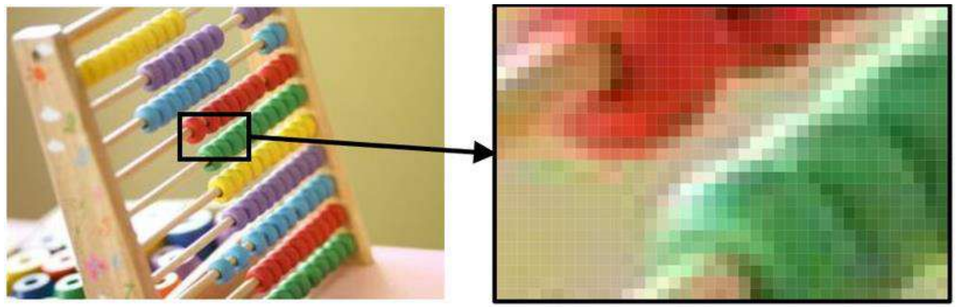
Example: Digital audio sampling

- 8 kHz - Telephone
- 44.1 kHz - CD quality
- 48 kHz - DVD quality

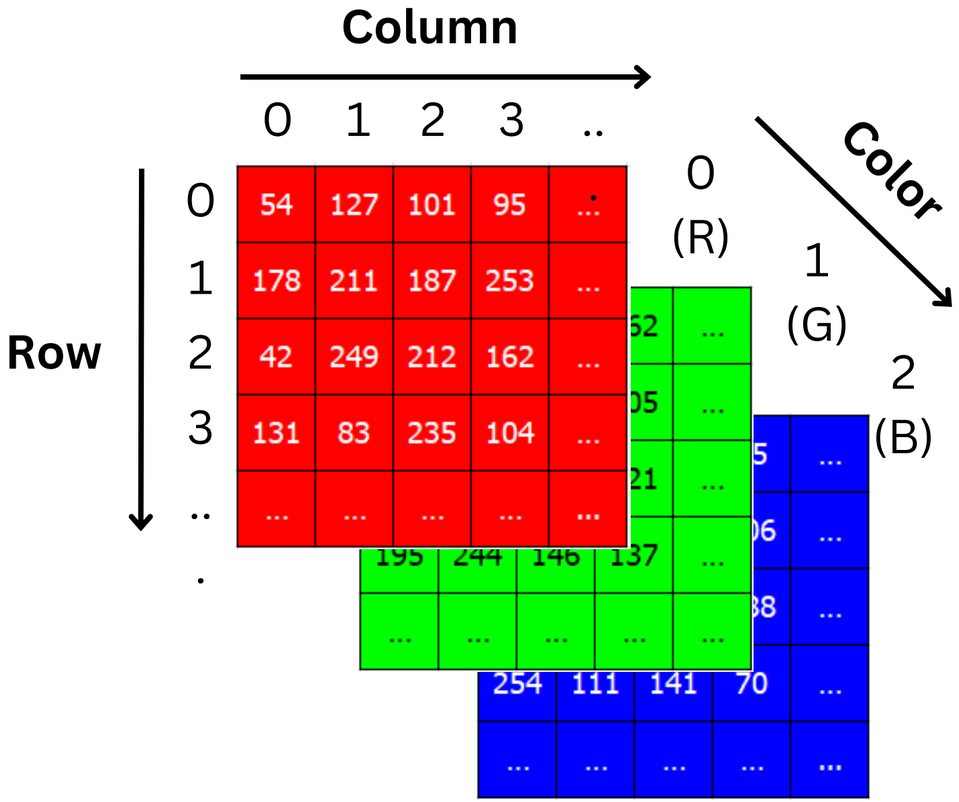
Digitally recording or digitizing analog media will always result in the loss of some of the original data.

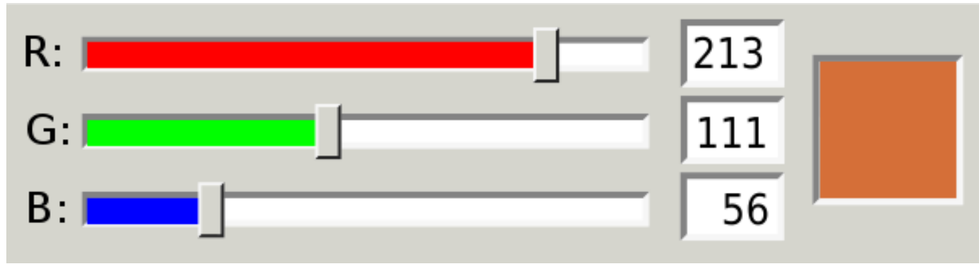
It is easy to search or manipulate digital data.

- Crop, copy, delete
- Change amplitude (volume)
- Limit maximum amplitude
- Change frequency (pitch)
- Band-pass filter



Raster graphics, a kind of digital images (such as JPG and PNG) keeps data as a pixel grid made of a 3-dimensional array.





Attempt a quiz

Quiz 1, Page 3, Question 6