Introduction

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Mathematics

- It's *not* just about numbers!
- Mathematics is *much* more than that:

> Mathematics is, most generally, the study of any and all *absolutely certain* truths about any and all *perfectly well-defined* concepts.

- These concepts can be *about* numbers, symbols, objects, images, sounds, *anything*!
- It is a way to interpret the world around you.

Discrete Mathematics

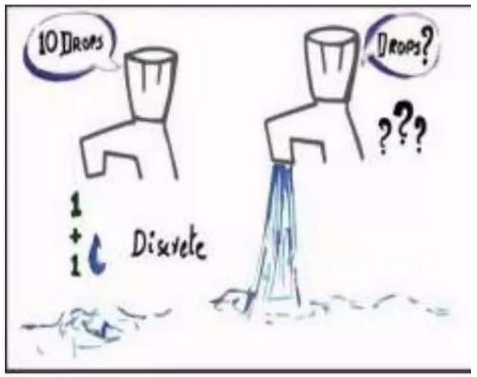
What are "discrete structures" anyway?

- "***Discrete***" - Composed of distinct, separable parts. (Opposite of *continuous*.)

  discrete:*continuous* :: *digital*:*analog*

- "***Structures***" - Objects built up from simpler objects according to some definite pattern.
- "***Discrete Mathematics***" - The study of discrete, mathematical (i.e. well-defined conceptual) objects and structures.

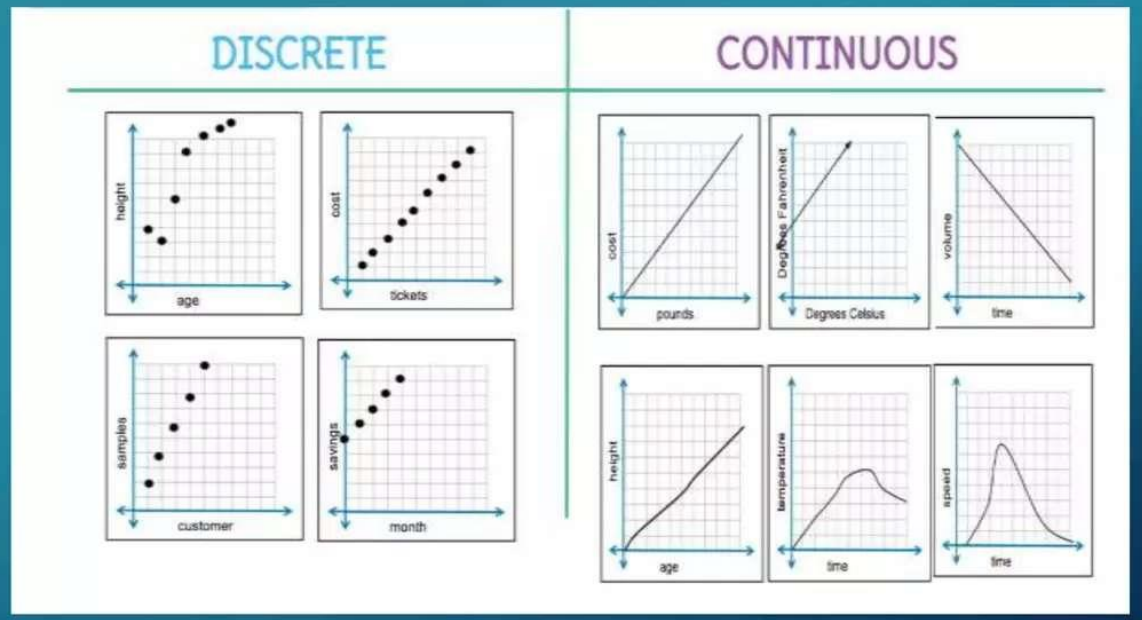
Discrete Mathematics

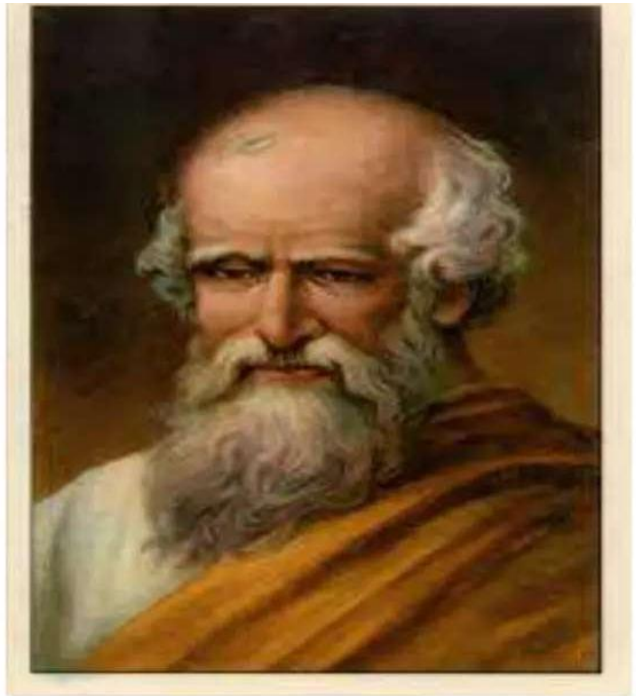


- **Discrete mathematics** deals with objects that come in discrete bundles, such as integers, graphs and statements in logics
  - e.g., 1 or 2 books
  - Topics include probability, set theory etc.
- **Continuous mathematics** deals with objects that vary continuously, such as real numbers-vary smoothly
  - e.g., 3.42 inches from a wall.
  - Topic include calculus
- *Think of **digital watches** versus **analog watches*** (ones where the second hand loops around continuously withoutstopping)

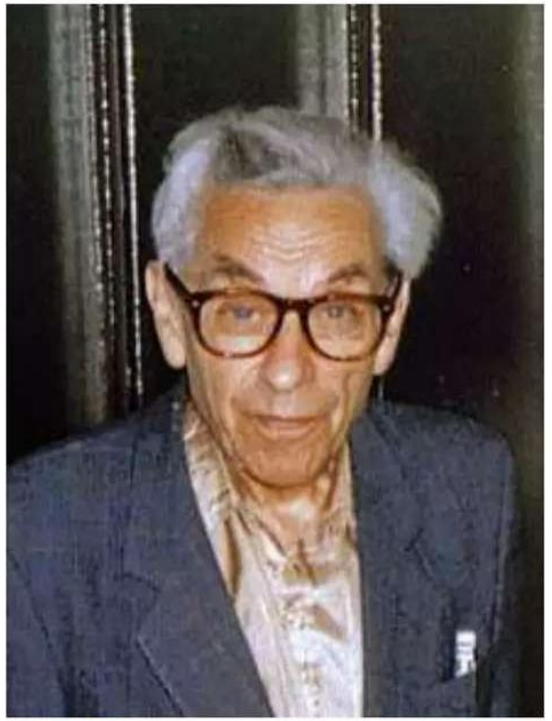
DISCREATE VS CONTINUES

- Examples of discrete Data
  - Number of boys in the class.
  - Number of candies in a packet.
  - Number of suitcases lost by an airline.
- Examples of continuous Data
  - Height of a person.
  - Time in a race.
  - Distance traveled by a car.





Montes Archimedes is known as the **Father of Mathematics.** Mathematics is one of the ancient sciences developed in time immemorial



Paul Erdos is known as the father of discrete mathematics.
In 1980s Discrete Mathematics was introduce as a computer science support course.

Why Discrete Mathematics?

- The basis of all of digital information processing is: *Discrete manipulations of discrete structures represented in memory.*
- It's the basic language and conceptual foundation for all of computer science.
- Discrete math concepts are also widely used throughout math, science, engineering, economics, biology, *etc.*, …
- A generally useful tool for rational thought!

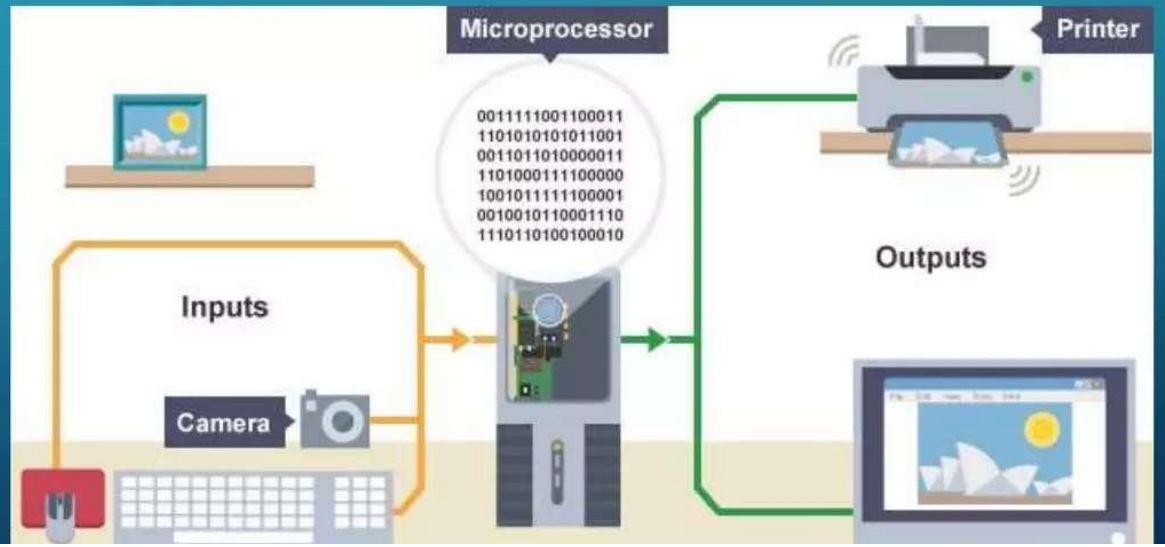
Uses of discrete mathematics in computer science

- Advanced algorithms & data structures
- Programming language compilers & interpreters
- Computer networks
- Operating systems
- Computer architecture
- Database management systems
- Cryptography
- Error correction codes
- Graphics & animation algorithms, game engines,

DISCRETE MATH IN COMPUTERS

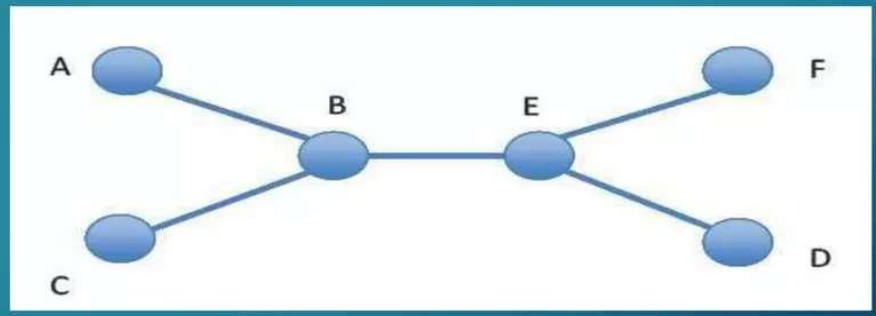
Computers run software and store files. The software and files are both stored as huge string of 1s and 0s Binary math is discrete mathematics. All computer data is represented using binary. Binary digits can be grouped together into bytes.

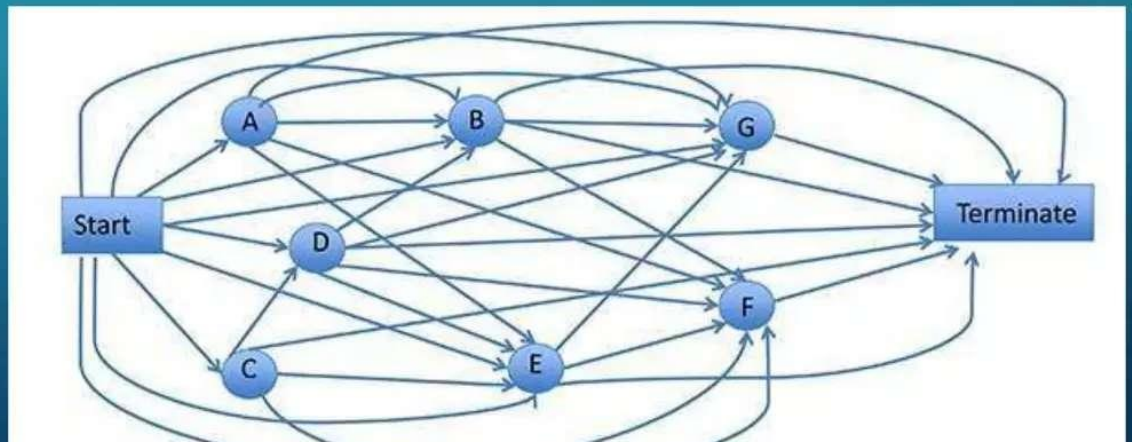
Case	A	+	B	Sum	Carry
1	0	+	0	0	0
2	0	+	1	1	0
3	1	+	0	1	0
4	1	+	1	0	1



DISCRETE MATH IN RAILWAY PLANNING

Railway planning uses discrete math deciding how to expand train rail lines, train timetable scheduling, and scheduling crews and equipment for train trips use both graph theory and linear algebra.



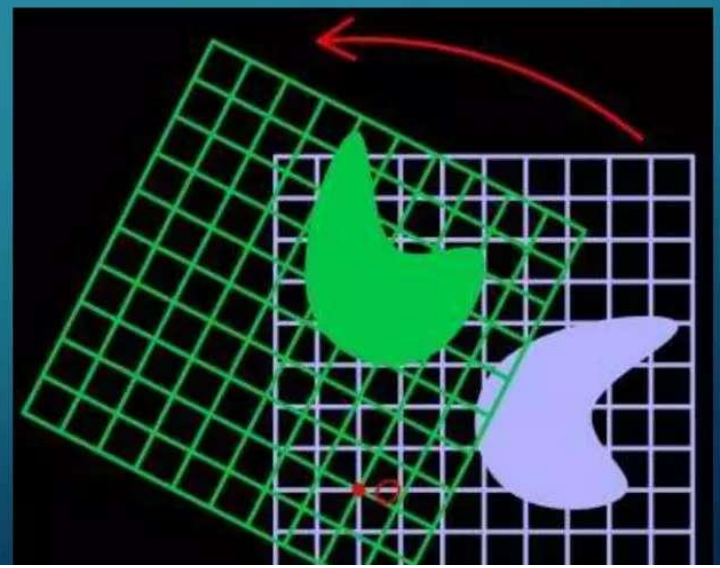


DISCRETE MATH IN COMPUTER GRAPHICS

Computer graphics (such as in video games) use linear algebra in order to transform (move, scale, change perspective) objects. That's true for both applications like game development, and for operating system

XY rotation matrix:

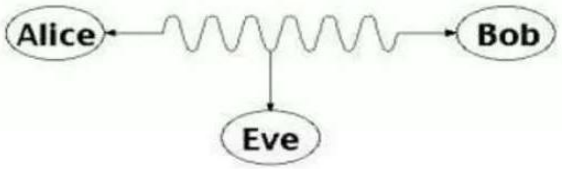
$$\begin{bmatrix} cos\theta & -sin\theta & 0 \\ sin\theta & cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$



DISCRETE MATH IN CRYPTOGRAPHY

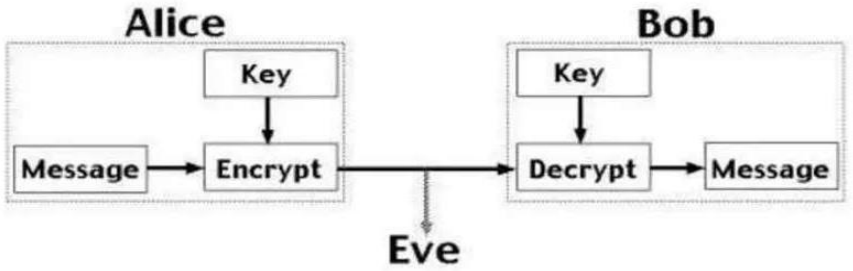
Cryptography is a method of storing and transmitting data in a particular form so that only those for whom it is intended can read and process it. Cryptography provide secure any data or passwords in encryption methods. computers send information in discrete -- or separate and distinct -- bits. Number theory, one important part of discrete math, allows cryptographers to create and break numerical passwords.

Example :



Alice and Bob have never met but they would like to exchange a message. Eve would like to eavesdrop.

E.g. between you and the Bank of America.

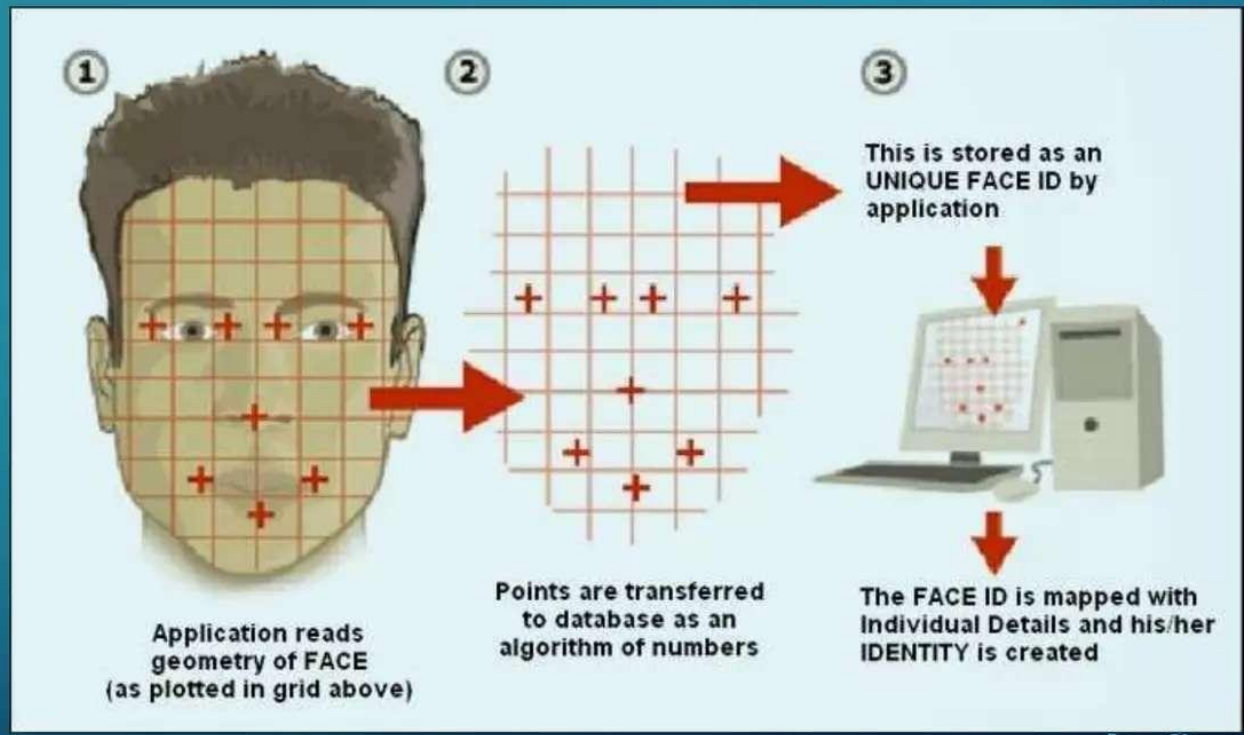


They could come up with a good encryption algorithm and exchange the encryption key – but how to do it without Eve getting it? (If Eve gets it, all security is lost.)

IMAGE PROCESSING

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It convert image as two dimensional signals.

- **Digital image processing** uses discrete mathematics to merge images or apply filters.



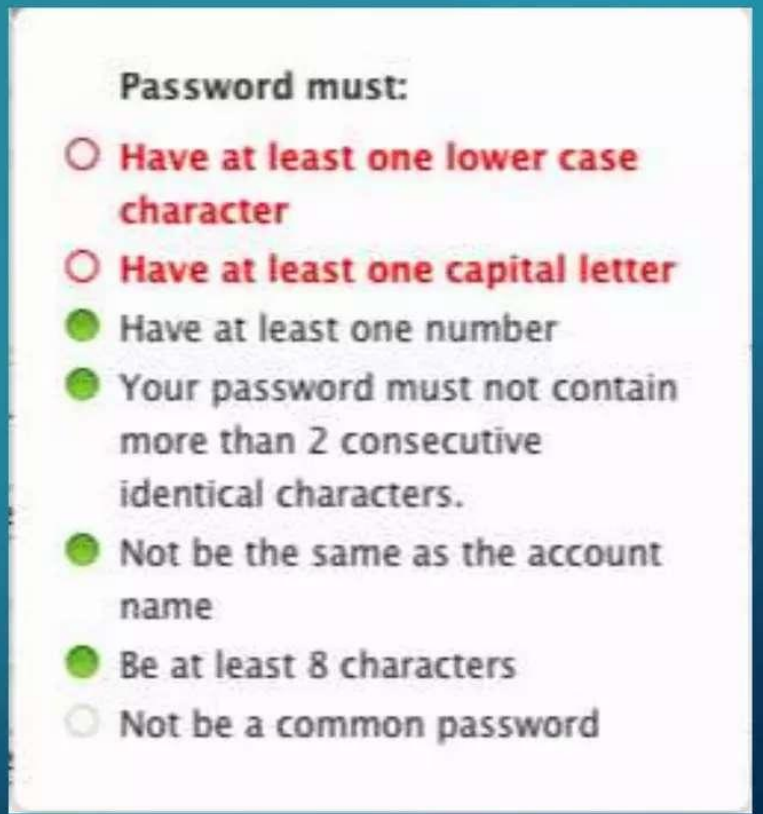
NETWORKS

Networks are, at base, discrete structures.
The routers that run the internet are connected by long cables.

- People are connected to each other by social media ("following" on Twitter, "friending" on Facebook, etc.).
- The US highway system connects with the roads.

DESIGNING PASSWORD CRITERIA

- Is the space of passwords chosen large enough that a hacker can't break into accounts just by trying all the possibilities.
- Discrete Math help decide how much possibilities are present to crack the password, so that we can make it more secure.

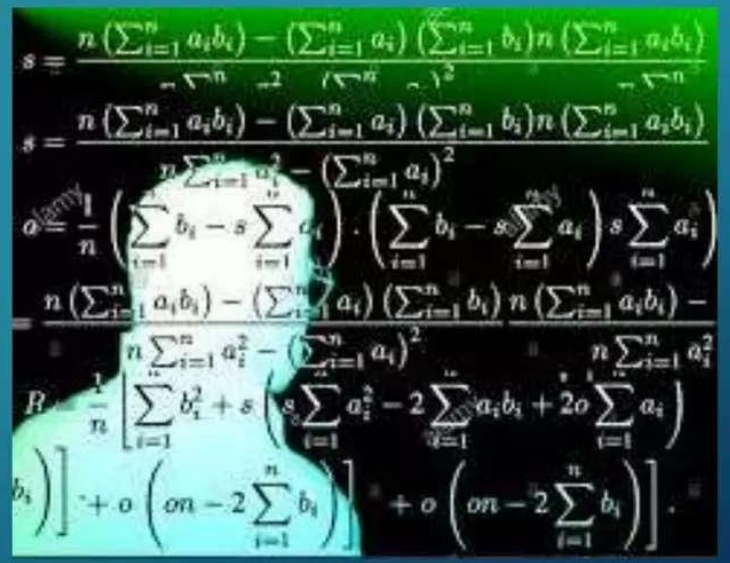


DISCRETE MATH IN LOGISTICS

- Logistics is the study of organizing the flow of information, goods and services.
- Without discrete mathematics, logistics would not exist.
- This is because logistics makes heavy use of graphs and graph theory, a sub-field of discrete math. Graph theory allows complex logistical problems to simplify into graphs consisting of nodes and lines.
- A mathematician can analyze these graphs according to the methods of graph theory to determine the best routes for shipping or solving other logistical problems.

COMPUTER ALGORITHMS

- Algorithms are the rules by which a computer operates. These rules are created through the laws of discrete mathematics.
- A computer programmer uses discrete math to design efficient algorithms.
- This design includes applying discrete math to determine the number of steps an algorithm needs to complete, which implies the speed of the algorithm.
- Because of discrete mathematical applications in algorithms, today's computers run faster than ever before.



RELATIONAL DATABASES

- Relational databases play a part in almost every organization that must keep track of employees, clients or resources.
- A relational database connects the traits of a certain piece of information.
- For example, in a database containing client information, the relational aspect of this database allows the computer system to know how to link the client's name, address, phone number and other pertinent information.
- This is all done through the discrete math concept of sets. Sets allow information to be grouped and put in order. Since each piece of information and each trait belonging to that piece of information is discrete, the organization of such information in a database requires discrete mathematical methods.

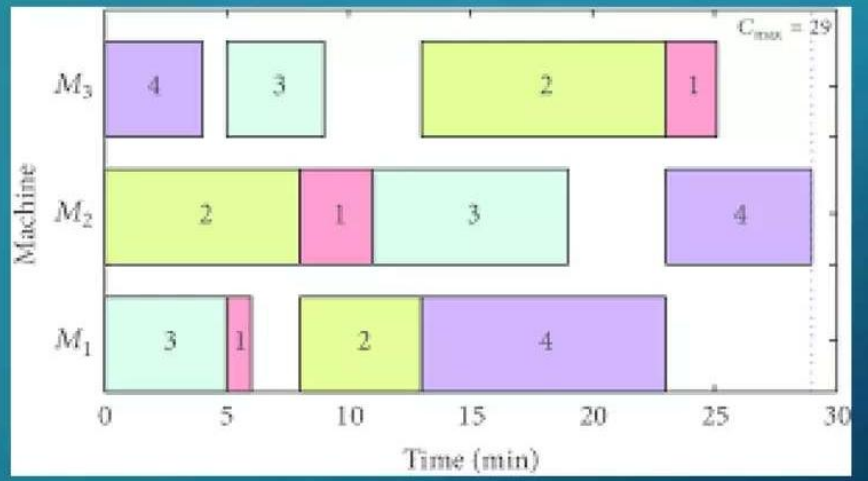
WEB SEARCHES.

Doing web searches in multiple languages at once, and returning a summary, uses linear algebra.

- Web search involves Various Algorithms, which are called “Web Crawlers”.
- There job is to search every online page on the web. They do that through Graph Theory.
- They find the shortest path to the required page to increase speed.

SCHEDULING PROBLEMS

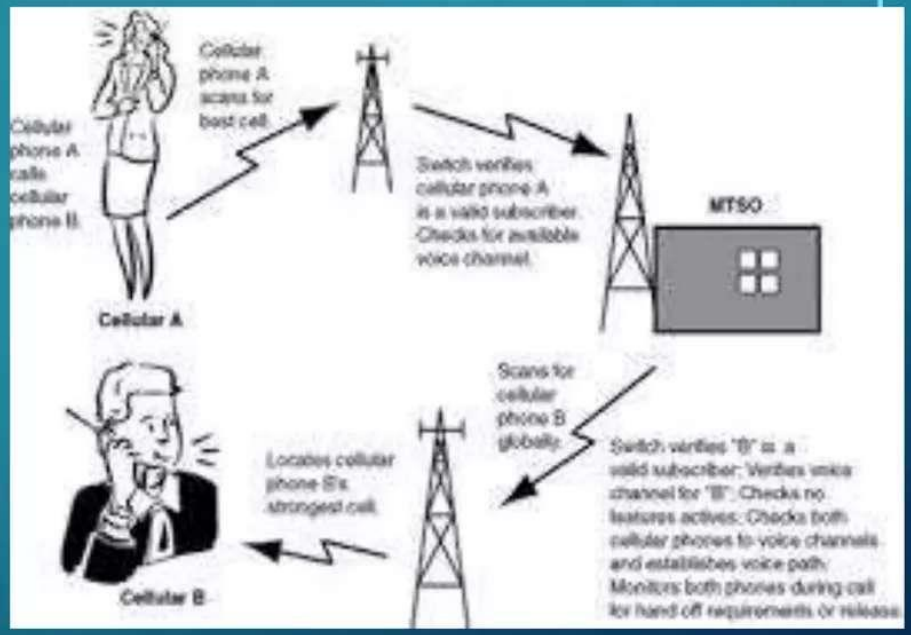
- Like deciding which nurses should work which shifts.
- Which airline pilots should be flying which routes. Scheduling rooms for an event
- Deciding timeslots for committee meetings
- Which chemicals can be stored in which parts of a warehouse
- All are solved either using graph coloring or using combinatorial optimization, both parts of discrete mathematics. One example is scheduling games for a professional sports league.



CELL PHONE COMMUNICATIONS

Cell phone communications:

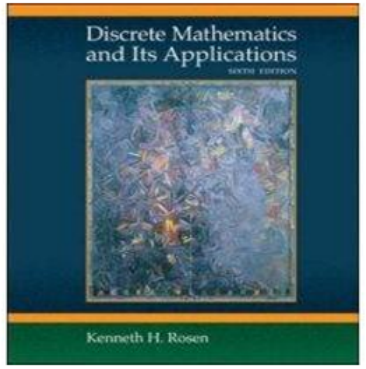
- Making efficient use of the broadcast spectrum for mobile phones uses linear algebra and information theory.
- Assigning frequencies so that there is no interference with nearby phones can use graph theory or can use discrete optimization.



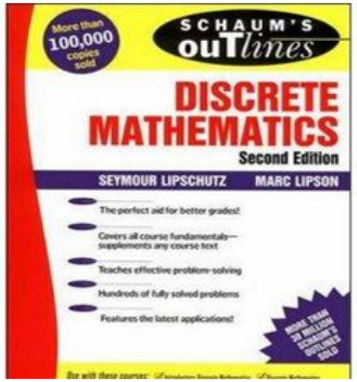
ARCHAEOLOGY

- It uses discrete math to construct 3D images from scans of archaeological sites.
- Archaeologists and engineers are using lasers to scan many ancient structures to create three-dimensional images.
- Areas of mathematics such as **vector analysis** and **linear algebra** help convert the billions of measurements from the laser beams into coordinates and then align readings from repeated scans to achieve images that are accurate to within a millimeter.

Textbook



Discrete Mathematics and Its Application
By Seymour Kenneth H. Rosen



Discrete Mathematics
By Seymour Lipschutz and Marc Lipson

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Any Question?