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CS39R - Write up for Presentation

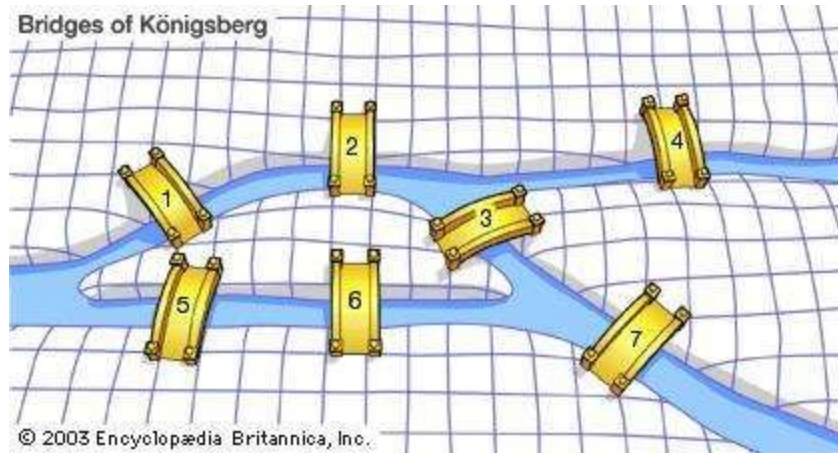
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Ecology and Graph Theory

Graph Theory is one of the major aspects of discrete mathematics. It involves graphical structures that visually represent the relationship between two or more items. The first mathematical paper that introduced the world to the possibility of using graphs, edges, and nodes beyond their usual applications was Leonhard Euler.

Euler was a Swiss mathematician who proposed a solution to the Seven Bridges of Königsberg problem. This problem stipulates the solver to find one path that covers all seven bridges of the city of Königsberg exactly once, does not go over the same bridge twice and returns to the point from which it started from. After much debate in the mathematical and scientific community about the answer to this problem, Euler finally published his own findings. He concluded that the problem of the Seven Bridges of Königsberg was unsolvable as it did not contain a Eulerian circuit. Published in 1735, his deduction based on this problem is

regarded as one of the primary theories of planar graph theory, a subfield within Graph Theory itself.

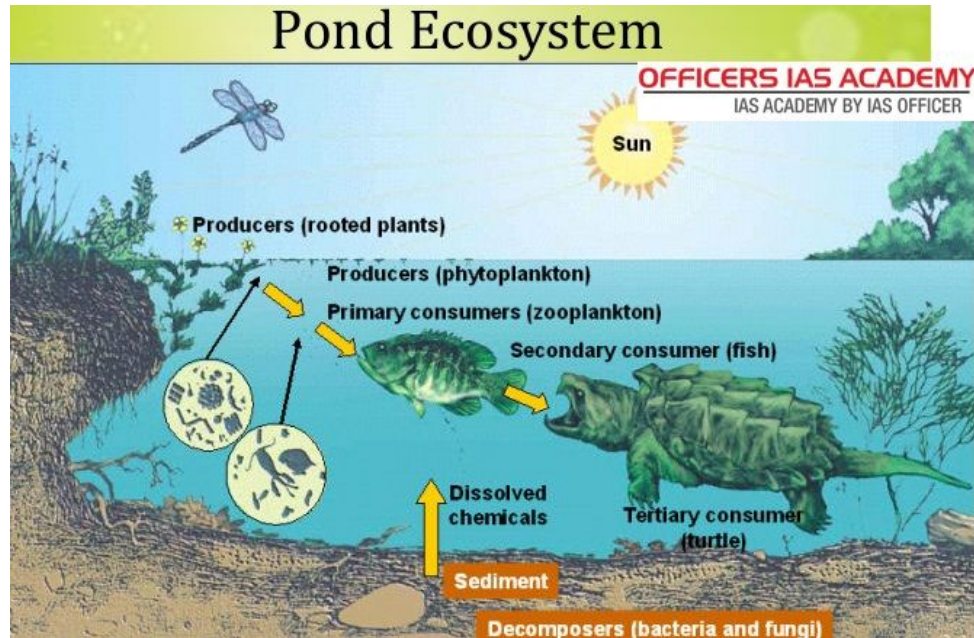


The Seven Bridges of Königsberg Problem

He also figured out the correlation between nodes, vertices, edges and faces of a convex polyhedron and came up with a formula for calculating any of the aforementioned variables through the formula. The Euler Formula helps us understand the genus of the object through Euler characteristic.

While Graph theory is used in many places when designing algorithms for softwares and programs, it has also started being a lot in ecology. Graph Theory in ecology helps visualize population densities, species richness, biodiversity, migration rates and patterns as well as energy flow. An ecosystem is a biological community of organisms interacting with the biotic and abiotic elements in the environment. Many ecosystems exist like terrestrial, aquatic, tree and so on. Any

ecosystem can also be seen as a network of interactions. The nodes are the species and the edges connecting them are the flow of energies as one organism is eaten by another. This is also how food webs and food chains can be organised.



A Pond Ecosystem showing Flow of Energy from Producers to Tertiary Consumers

Based on how interconnected one node is, the ecological importance of that species or animal in that particular ecosystem can be inferred. In other words, vertices of higher degree are more ecologically important than species with lesser degrees. The cardinality, or how many vertices there are in a plane is also of high importance. Cardinality is the number of nodes on any graph. So higher cardinality means that a large number of species are present in an ecosystem. This means that

the species richness is high and that the ecosystem is very diverse, or has high biodiversity.



A Graph Theory Approach to visualizing the ecosystem of an area

The importance of using Graph theory in helping measure the biodiversity of an area is really important. It helps quickly visualise information and helps point out which species are the most vulnerable in any ecosystem.