EWCE 205
NUMERICAL METHODS

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Course Content
Section A

- Basics of Numerical Methods
- Systems of Linear Algebraic Equations
- Finite Differences
- Numerical Differentiation
- Numerical Integration
- Initial Value Problems
- Two-point Boundary Value Problems

Reference Books

- ✓ Numerical Analysis: Goel & Mittal
- ✓ Introductory Methods of Numerical Analysis: Sastry
- ✓ Applied Numerical Analysis: Gerald & Wheatly
- ✓ Numerical Methods for Engineers: Chapra & Canale
- ✓ Introduction to Numerical Methods, Lecture notes for MATH 331, Jeffrey R. Chasnov

What is Numerical Analysis?

- Numerical analysis involves the development and evaluation of methods for computing numerical results from given numerical data.

- Input data ⟶ Algorithm ⟶ Output Result/Information

Algorithm:

- An algorithm in a particular problem is a step by step procedure that produces a solution in a finite number steps.

Numerical Methods

- A numerical method is an algorithm for solving the problem whose solution consists of one or more numerical values. Values obtained in this way are called numerical solutions.
- It is an approach for solving complex mathematical problems using the simple arithmetic operations (+,-,* and /)
- Numerical method is not needed if the exact answer is known. So, before using a numerical method, one must-

i. Examine the problem

ii. Determine how close to the exact value is needed

When used?

- The numerical methods are usually used when

i. A problem can not be solved analytically,

ii. When a problem can be solved analytically, but the analytical solution is so complex that it is difficult to apply and

iii. The functional relationship between the various parameters in a problem is not known.

Analytical and Numerical solutions

- There are two types of methods for solving the equations-

i. The analytical methods and

ii. The numerical methods

- For linear and some non-linear equations, it is sometimes possible to obtain an exact or direct solution by the analytical methods.
- On the other hand, any equation, whether linear or non-linear, can be solved numerically.

$$x^3 - 3x^2 + 3x - 1 = 0$$

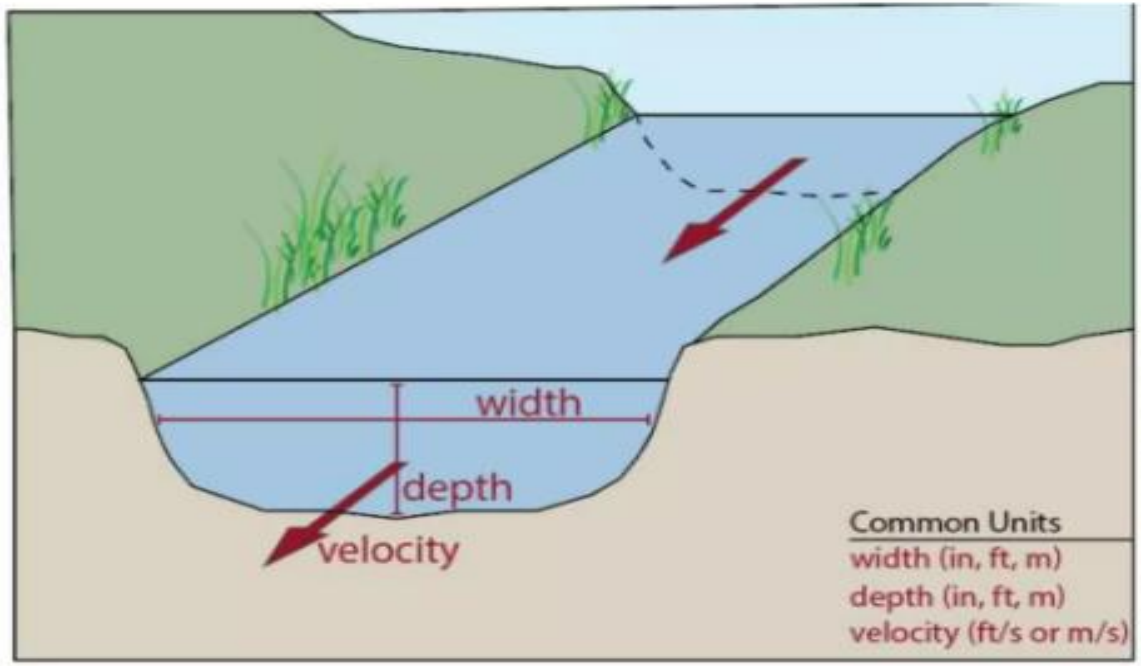
- This equation can be solved analytically.

$$x^5 + 3x^2 + 3x - 2 = 0$$

- This equation can not be solved analytically, however can be solved numerically.

Application of Numerical Method

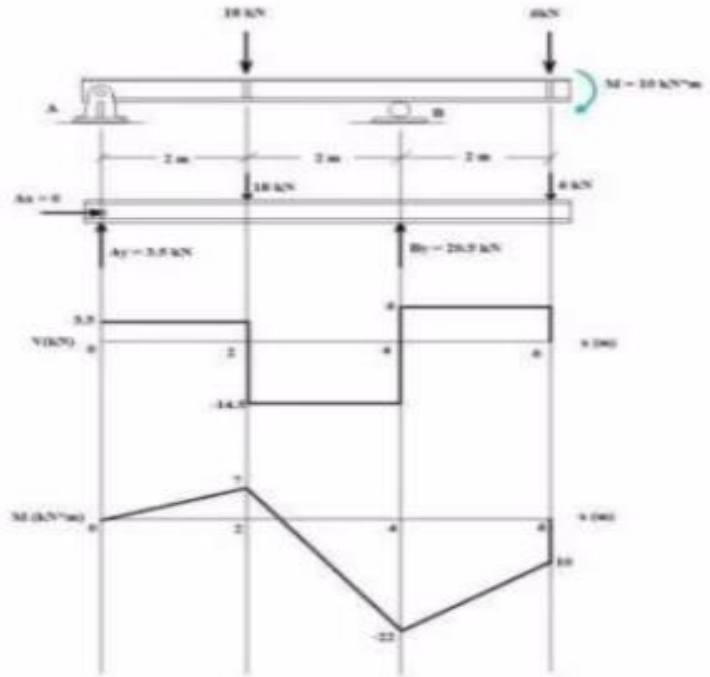
- **Estimation of the amount of water:** Numerical method is used to estimate the **amount of water that flows in a river, ocean current** during a year.

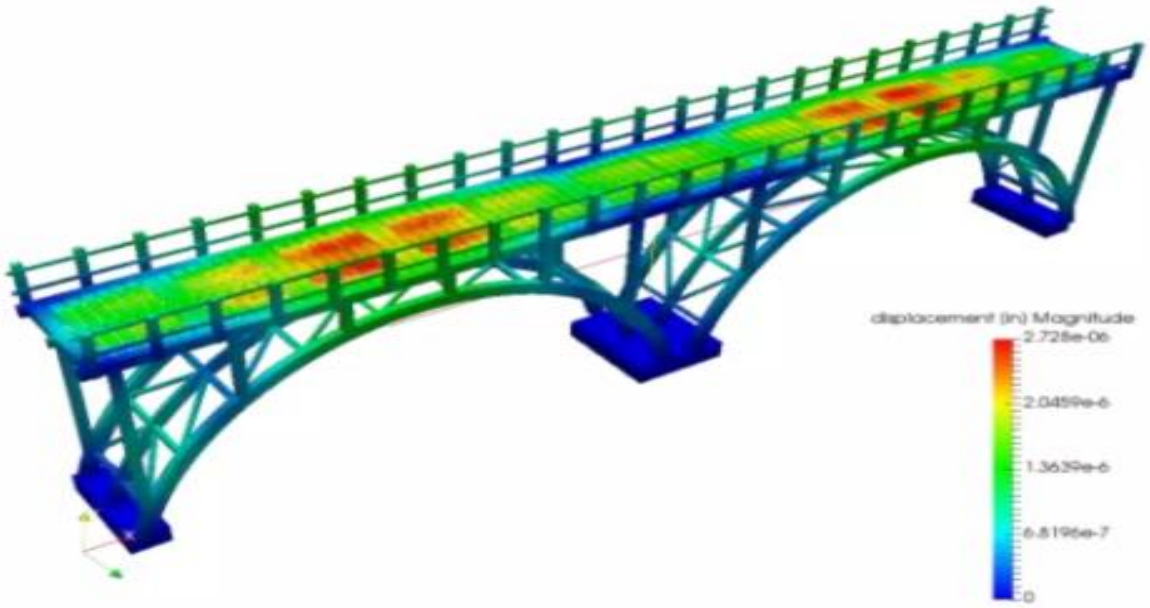




Application of Numerical Method

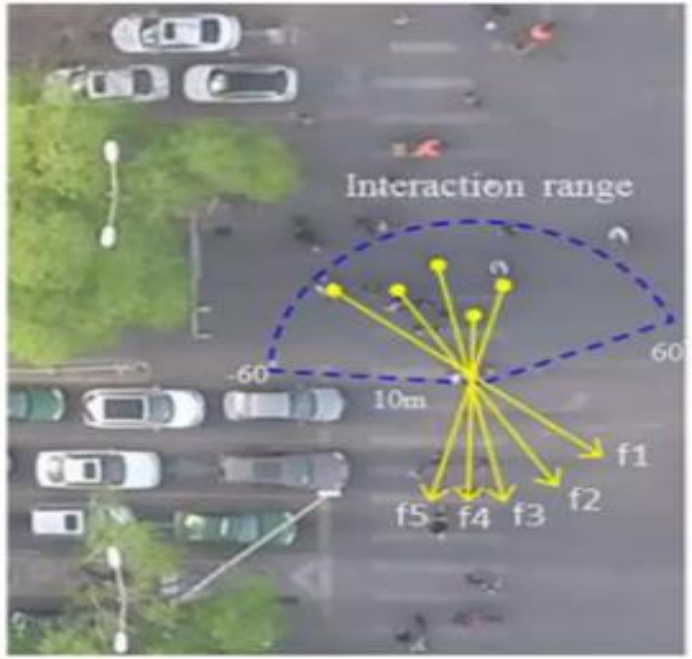
- **Structural Analysis:** Structural analysis deals with a calculation of **load** coming on the structure and analyzing them. It is a procedure followed to find and measure the effect of **external forces** on physical objects like built structure elements. Numerical method is used to calculate **strength, stiffness, stability and vibration of loads and beams.**





Application of Numerical Method

- **Traffic Simulations: Collision avoidance, exit position, entrance, turning point of vehicles** are solved by forming mathematical model. Numerical method is used to solve these mathematical models in traffic simulations.



(a)

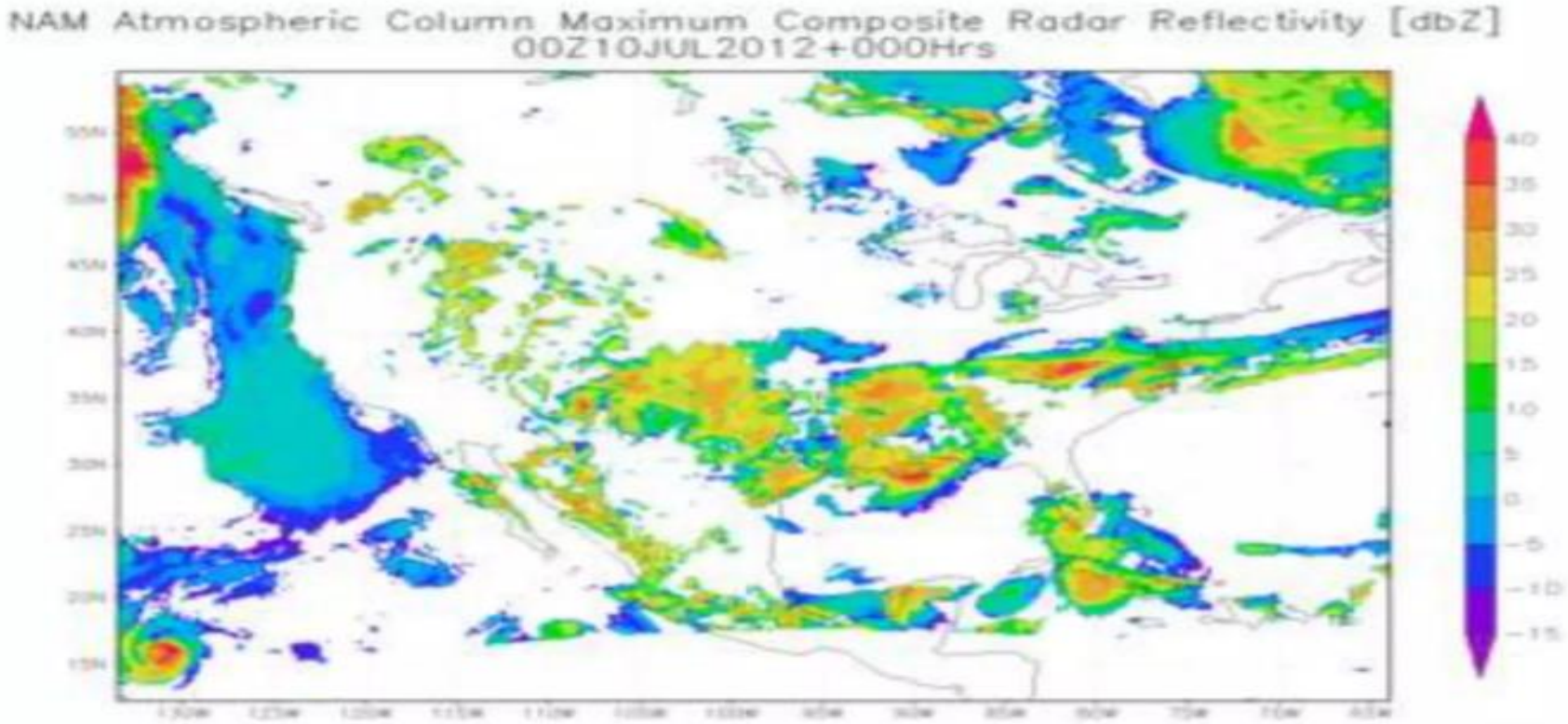


(b)



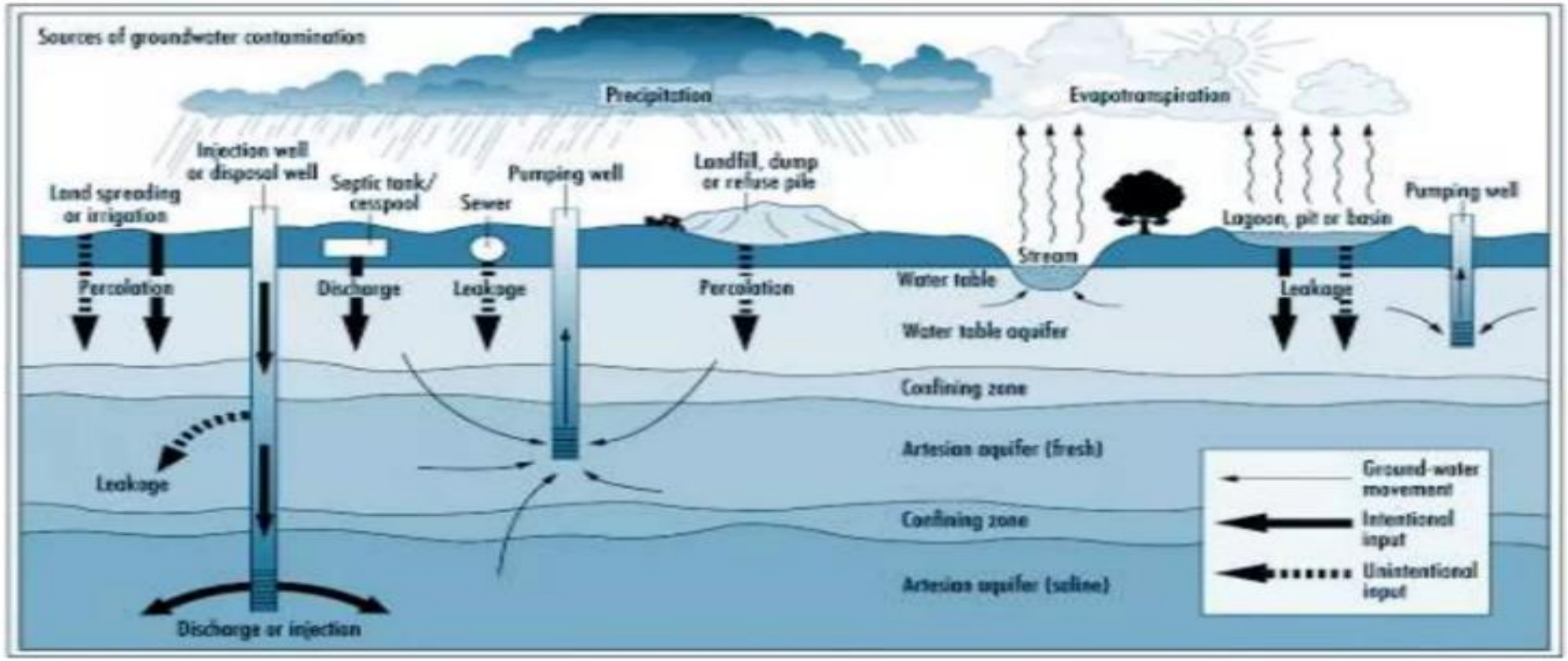
Application of Numerical Method

- **Weather prediction:** Numerical method is used to **predict weather** and **environmental simulations** by data assimilation to produce outputs of temperature, precipitation, and hundreds of other meteorological elements from the oceans to the top of the atmosphere.



Application of Numerical Method

- **Ground water & pollutant movement:** Ground water forms a part of the **hydrologic cycle**. Numerical method is used to analyze the movement of ground water and pollutants.



Application in Civil Engineering

- Finite Element Analysis (Structural analysis)
- Computational Fluid Dynamics (Flows in Spillways, canals etc)
- Pollutant dispersal (Statistical analysis)
- Artificial Neural Networks (Hydrological Forecasting)
- Systems Approach (Inventory management and queuing systems often found on construction sites)
- Transportation models

Application in Water Resources Engineering

- Flood propagation
- Sediments transport
- Water quality control
- Oil slick transport

Application in Environmental Engineering

- Air pollution box
- Gauss models emission
- Fate of pollutants in lower atmosphere

THANK YOU