

## Content beyond the Syllabus

- The eigenvalues are used to determine the natural frequencies (or eigenfrequencies) of vibration, and the eigenvectors determine the shapes of these vibrational modes. Most structures from buildings to bridges have a natural frequency of vibration. Eigenvalues can also be used to test for cracks or deformities in structural components used for construction. Model population growth using an age transition matrix and an age distribution vector, and find a stable age distribution vector. Use a matrix equation to solve a system of first-order linear differential equations. Find the matrix of a quadratic form and use the Principal Axes Theorem to perform a rotation of axes for a conic and a quadric surface.
  - There are many applications of sequences. To solve problems involving sequences, it is a good strategy to list the first few terms, and look for a pattern that aids in obtaining the general term. When the general term is found, then one can find any term in the sequence without writing all the preceding terms. Sequences are useful in our daily lives as well as in higher mathematics. For example, the interest portion of monthly payments made to pay off an automobile or home loan, and the list of maximum daily temperatures in one area for a month is sequences.
  - There was not a good enough understanding of how the Earth, stars and planets moved with respect to each other. Calculus (differentiation and integration) was developed to improve this understanding. We use the derivative to determine the maximum and minimum values of particular functions (e.g. cost, strength, amount of material used in a building, profit, loss, etc.).
1. Derivatives are met in many engineering and science problems, especially when modeling the behavior of moving objects.
  2. It is used ECONOMIC a lot, calculus is also a base of economics. In economics, calculus is used to compute marginal cost and marginal revenue, enabling economists to predict maximum profit in a specific setting.
  3. The **Petronas Towers** in Kuala Lumpur experience high forces due to winds. **Integration** was used to design the building for strength.



4. The **Sydney Opera House** is a very unusual design based on slices out of a ball. Many **differential equations** (one type of integration) were solved in the design of this building.



5. Historically, one of the first uses of integration was in finding the **volumes of wine-casks** (which have a curved surface).



6. It is used in history, for predicting the life of a stone.

7. The newbie, **PID controller** is a control loop feedback mechanism (controller) widely used in industrial control systems.

8. Applications of the Indefinite Integral shows how to find displacement (from velocity) and velocity (from acceleration) using the indefinite integral.

- Taylor's series is an essential theoretical tool in computational science and approximation. One application is to use series to approximate solutions to differential equations. In many cases, solving for a given variable outright can be very difficult or even impossible. Representing the variable as a Taylor Series, it is far easier to approximate a solution around a particular point.
- One of the major applications of multiple integrals in engineering, particularly structures and mechanics, is the determination of properties of plane (i.e. effectively 2-D) and solid (i.e. 3-D) bodies – their volume, mass, centre of gravity, moment of inertia, etc.
  1. In mechanics, the moment of Inertia is calculated as the volume integral (triple integral) of the density weighed with the square of the distance from the axis.
  2. In electromagnetism, Maxwell's equations can be written using multiple integrals to calculate the total magnetic and electric fields.