Mathematical and stochastic models usually tailored to fit into specific real world problems. A known fact is that it is difficult to conceive a model that reflects the reality as close as possible and simultaneously simple for analysis. During the past four decades, a substantial body of literature has been developed on maintenance policies.

This thesis is a contribution of mathematical model that leads to arriving at the best replacement strategies to determine the age at which the replacement is most economical instead of continuing at increased cost, and optimal design and maintenance strategies are developed for a type of capital equipment (Block of Air Conditioners). There are different conventional replacement models to suggest the replacement period for all categories of items. For capital equipment like machine tools, which deteriorate with time, models are available considering the running costs, resale value, depreciation costs etc. For items that fail completely, group replacement model is applicable. In this policy, all the items are replaced after predetermined time, irrespective of whether the items have failed or not. Failures are a way of life in the modern technological world and the penalties paid by people in terms of money, time and security are becoming more and more severe due to increasing application of complexities and automation. The novel approach of accounting secondary value of items replaced in a group, applying Financial Management techniques and applying Markov chains in block and group replacement decision is followed. Better understanding of failures, careful planning and designing of new systems and proper selection of components are some of the approaches which can be tried to reduce the level of unreliability of systems. A judiciously designed preventive maintenance policy can help in eliminating failures to a large extent. Replacement and reliability
goes hand in hand. To solve reliability models, non linear programming techniques are better applicable. The thesis is focused mainly to establish some replacement models under varying conditions to develop suitable mathematical models with their practical applications.

The thesis has been organized in seven chapters. A summary of the thesis follows in the sequel, describing contents chapter wise.

Chapter – I

This chapter has been broadly divided into Part-A and Part-B. Under part-A, the fundamentals, concepts and importance of maintenance in production environment are discussed. Also, the need, challenges in maintenance, and objectives of maintenance are discussed. The two broad types of maintenance namely, Breakdown maintenance and Planned maintenance are explained with their limitations. The objective of maintenance work should be to strike a balance between the availability and the overall running costs.

Part-B explains the replacement problem, objectives of replacement, failure mechanisms of equipments, the need for replacement, and the equipment renewal problems, various replacement models are explained. It covers two categories of techniques for determining the best replacement strategies for the items that deteriorate with time and those do not deteriorate but fail suddenly. The first category of models aims at determining the optimum time for replacement so that the sum of costs of maintenance and cost of new equipment is minimum. The second category-group replacement models- aim at finding which items to replace and whether or not to replace them in group and if so when. These models are discussed with respect to the parameters like maintenance cost, time and value of money.
Chapter – II

This chapter concentrates on the fundamentals of inflation, forecasting, and Markov Chains. Inflation, a macroeconomic variable, represents a situation in which too much money chasing too few commodities; in other words rise in prices of commodities. This chapter deals with the theories, causes, costs, and control of inflation. Also, the nature of inflation in a developing economy, measuring the rate of inflation, and the need for forecasting of inflation are discussed.

Forecasting is a technique of estimating the value of an identified parameter for future time periods. Various forecasting techniques - qualitative and quantitative; and the forecast errors are also discussed in this chapter.

This chapter mainly concentrates on Markov Process, a stochastic mathematical model that is used in decision-making in severe uncertainty environment. Markov process is based on the premise that the future state of the system depends on the current state but not on how it reaches the present state. The general characteristics of the Markov Process, different states of Markov process, order of Markov process, transition probability etc. are discussed in detail. Stochastic matrix, Eigen values and Eigen vectors of matrix, and spectral decomposition of a matrix are also discussed.

By defining the higher order Multi state Markov processes and the difficulties in estimating the corresponding transition probabilities, reasons for introducing the Weighted Moving Transition Probabilities (WMTP) technique are discussed in detail. Weighted Moving Transition Probabilities (WMTP) technique is a parsimonious model that approximates higher order Markov chains.
Chapter – III

This chapter deals with the survey of literature related to the present study. It furnishes the advanced studies and work carried out by various researchers in the areas of Macroeconomic studies, Forecasting Techniques, Replacement Models, and Markov Process. This helps in understanding the existing models, establishing the objectives for the present study and further for the development of solution.

Chapter – IV

This chapter discusses the replacement decision problem, objectives of the study and development of the corresponding mathematical models.

The objective of this study reported here is to develop a mathematical model using Markov process for block replacement problem that considers the influence of inflation and value of money on the optimal replacement policy. A special reference is given to the multi-state repairable system containing a block of similar items viz. Air Conditioners.

The formulation and development of the model is done as given below.

(a) Block Replacement Model Using First Order Markov Chain without considering the macroeconomic variable i.e. Inflation

(b) Influence of Inflation on Block Replacement decision using First order Markov Chain

(c) Influence of Inflation on Block Replacement decision using Higher (Second) order Markov Chain

Chapter – V

This chapter deals with the case study on a Block of Air Conditioners, mentioning various types of repairs and also the state transition diagram. In this case study the developed model is applied to evaluate the replacement strategies and
determine the age at which block replacement can be economically done for a block of Air Conditioners under. Influence of macroeconomic variables like inflation and time value of money are also considered on the models using First Order Markov Chain and Higher (Second) Order Markov Chain.

Chapter – VI

This chapter deals with the results obtained in the case study. In addition, few more observations about the behavior of the block replacement model under the influence of variable maintenance cost; and trends in inflation. Maintenance cost is varied in different situations viz. High initial maintenance cost and lower increments during later periods, and Low initial maintenance cost and higher increments during later periods. Inflation trends considered includes Gradual Uptrend and Gradual Down Trend for the above situations with hypothetical data.

Also, the influence of Rapid Uptrend, Rapid Down Trend, Sluggish Up trend, and sluggish downtrend in inflation with the fixed maintenance costs is studied.

Chapter – VII

Summary and conclusions of the work carried out, limitations of the present work and the further scope for future work are detailed in this chapter. The inferences regarding the model behavior considering variable maintenance costs and trends in inflation are detailed in this chapter.
BLOCK REPLACEMENT MODELING USING HIGHER ORDER MARKOV CHAINS

Study of Replacement Models

Study of Markov Chains

Study of Inflation

Prediction of Inflation

Development of Block Replacement Model using First Order Markov

Influence of inflation on Block Replacement decision using First Order Markov Chain

Study of Higher order Markov chains

Development of Model to Study the influence of inflation on decision making using Higher Order Markov Chain

Study of Forecasting Techniques