

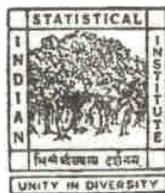
INDIAN STATISTICAL INSTITUTE

STUDENTS' BROCHURE

MASTER OF TECHNOLOGY (M. Tech.)

IN

QUALITY, RELIABILITY AND OPERATIONS RESEARCH



203, BARRACKPORE TRUNK ROAD
KOLKATA 700108

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GENERAL INFORMATION

1.1 SCOPE

The Master of Technology in Quality, Reliability and Operations Research is a full time programme. This programme is intended to produce specialists in Quality Management with emphasis on Statistical Quality Control, Reliability, Operations Research, Computer Software and Management Systems. The programme is designed to offer adequate instruction in the theory and practice of the above disciplines. The objective is to equip students with the basic practical skills with sufficient theory to understand the principles involved in the application and to develop in them the power of systematic thinking and reasoning, practical approach and exposition. Every student, besides undergoing classroom instruction, is required to do practical work by way of case studies, dissertation and project work on live problems in factory under the guidance of the expert faculty of ISI. On successful completion of this programme, the students may take up either

- a. a professional career in the field of quality engineering and management in departments of government, semi-government, public/private sector undertakings, industrial organisations, consultancy agencies, or
- b. an academic career for further study and research in theoretical and applied aspects of Quality, Reliability and Operations Research in organisations of higher learning and research institutions.

The programme is offered in two streams: **Statistics stream** and **Engineering stream**.

1.2 DURATION

The duration of the course is two years, inclusive of the period of project work at the end of the first year and a period of dissertation and project work in the second year of the programme. The classes are generally held, only on weekdays, between 10:15/11:10 AM and 5:50 PM. The time-table, prepared at the beginning of each semester, do not have an off day in the beginning or at the end of the week. Usually, there is a study break of

roughly one week before the semestral examinations in each of first, second and third semester.

1.3 CENTRE

The course is offered at the Kolkata centre of the Institute. However, during project works students may be placed to different SQC & OR Units of the Institute.

1.4 COURSE STRUCTURE

The two-year Master of Technology programme in Quality, Reliability and Operations Research, M. Tech. (QROR), is divided into four semesters, two semesters each in the first and second years. A student is required to take six courses in each of the first three semesters plus two project works and a dissertation study during the fourth semester. **All the courses in M. Tech. (QROR) are credit courses.**

1.5 EXAMINATIONS AND SCORES

For each course of the programme, there are two examinations, mid-semester and semester (final), except for the courses Dissertation, Project - I and Project - II. The calendar for the semester is announced in advance.

The composite score in a course is a weighted average of the scores in the mid-semester and semester or corresponding supplementary examinations, if any, home-assignments, practical record-book, etc. (announced at the beginning of the semester). For courses other than Dissertation, Project - I, Project - II, Workshop - I and Workshop - II, the minimum weight given to the semester examination is 50%.

There is a provision of backpaper examinations in all the courses, except Dissertation, Project - I and Project - II. If the **composite score** of a student falls short of 45% in any one of OR - I, SQC - I, Reliability - I, Workshop - I, Workshop - II, Dissertation, Project - I and Project - II, or 35% in any one of the other courses barring the exclusions, the student may take a backpaper examination to improve the score. At most one backpaper examination is allowed in a given course. The post-backpaper score in a course is equal to the maximum of backpaper examination score and composite score, subject to a maximum of 45%.

A student can take a maximum of 2 (two) backpaper examinations in any of the four semesters of the M.Tech.(QROR) programme subject to a ceiling of a maximum of 2 (two) in the first year and 2 (two) in the second year. However, a student may take more than the allotted quota of backpaper examinations in a given academic year and decide at the end of that academic year which of the backpaper examination score / scores

should be disregarded for computation of the post-backpaper score / scores. Such communication must reach the Class Teacher, in writing.

If a student gets less than 35% in at most one course after the back-paper examination, but gets 60% or more in average in other courses of that academic year excluding the course under consideration, the student can appear for a compensatory paper in the course under consideration. A student can appear in at most one compensatory paper every academic year. However, in the final year of the programme, the student can *either* appear in the compensatory paper, if the conditions stated above are met, *or* repeat the year if the existing rules so allow; and not do both. The student must inform the Dean of Studies or the In-Charge, Academic Affairs in writing in advance regarding his/her choice. No compensatory paper will be allowed in a course where backpaper is not allowed, e.g., Statistics Comprehensive in B. Stat. programme. The compensatory examinations for all subjects will be held once in an academic year. A student can score at most 35% in a compensatory paper. If a student scores more than 35% in a compensatory paper, the composite score in the course will be 35%. Any student who scores less than 35% in a compensatory paper will have to discontinue the programme regardless of the year of study in the academic programme.

There will be supplementary examination for mid-semester, semester, back-paper and compensatory examinations within a month of the examination missed by a student due to medical or family emergencies. The student should submit a written application to the Dean of Studies or the In-Charge, Academic Affairs for appearing in the supplementary examination, enclosing supporting documents. On receipt of such application from a student with supporting documents, the Dean of Studies or the In-Charge, Academic Affairs will decide, in consultation with the relevant Teachers' Committee, on whether such examination will be allowed. The student can score at most 60% in the supplementary examinations to mid-semester and semester examinations. For the back-paper or the compensatory papers, the maximum the student can score in the supplementary examination, is 45% or 35% respectively.

1.6 SATISFACTORY CONDUCT

A student is also required to maintain satisfactory conduct as a necessary condition for taking semestral examination, for promotion and award of degree. Unsatisfactory conduct will include copying in examination, rowdyism, other breach of discipline of the Institute, unlawful / unethical behaviour and the like. Violation of these is likely to attract punishments such as withholding promotion / award of degree, withdrawing stipend and / or expulsion from the hostel / Institute.

Ragging is banned in the Institute and any one found indulging in ragging will be given punishment such as expulsion from the Institute, or suspension from the Institute / classes for a limited period and fine. The punishment may also take the shape of (i) withholding Stipend / Fellowship or other benefits, (ii) withholding of results, (iii) suspension or expulsion from hostel and the likes. Local laws governing ragging are also applicable to the students of the Institute. Incidents of ragging may also be reported to the police.

The students are also required to follow the following guidelines during the examinations:

- a. Students are required to take their seats according to the seating arrangement displayed. If any student takes a seat not allotted to him/her, he/she may be asked by the invigilator to hand over the answer script (i.e., discontinue the examination) and leave the examination hall.
- b. Students are not allowed to carry inside the examination hall any mobile phone with them, even in switched-off mode. Calculators, books and notes will be allowed inside the examination hall only if these are so allowed by the teacher(s) concerned (i.e., the teacher(s) of the course), or if the question paper is an open-note/ book one. Even in such cases, these articles cannot be shared.
- c. No student is allowed to leave the examination hall without permission from the invigilator(s). Further, students cannot leave the examination hall during the first 30 minutes of any examination. Under no

circumstances, two or more students writing the same paper can go outside together.

- d. Students should ensure that the main answer booklet and any extra loose sheet bear the signature of the invigilator with date. Any discrepancy should be brought to the notice of the invigilator immediately. Presence of any unsigned or undated sheet in the answer script will render it (i.e., the unsigned or undated sheet) to be cancelled, and this may lead to charges of violation of the examination rules.

- e. **Any student caught cheating or violating examination rules for the first time will get 'Zero' in that examination. If the first offence is in a backpaper examination, the student will get 'Zero' in the backpaper.** (The other conditions for promotion, as mentioned in Section 1.7 of this brochure will continue to hold).

- f. **If any student is caught cheating or violating examination rules for the second / third time and he/ she**
 - (i) is in the final year of any programme and **not** already repeating, then he/she will have to repeat the final year without stipend;
 - (ii) is in the final year of any programme and already repeating, then he/she will have to discontinue the programme;
 - (iii) is **not** in the final year of any programme, then he/she will have to discontinue the programme even if he/she was not repeating that year.

Any student caught cheating or violating examination rules for the second/third time, will be denied further admission to any programme of the Institute.

Failing to follow the examination guidelines, copying in the examination, rowdiness or some other breach of discipline or unlawful/unethical behaviour etc. are regarded as **unsatisfactory conduct**.

The decisions regarding promotion, in Section 1.7, and final result, in Section 1.8, are arrived at taking into account the violations, if any, of the unsatisfactory conduct of the student as described in this section.

1.7 PROMOTION

A student is declared to have passed the semester if he/she

- i. maintains a satisfactory conduct;
- ii. does not obtain a score of less than 35% in any course;
- iii. does not obtain a score of less than 45% in more than one course;
- iv. does not obtain a score of less than 45% in OR - I, SQC - I, Workshop - I, Reliability - I, Workshop - II, Dissertation, Project - I and Project - II;
- v. secures an overall average percentage score of at least 45% taking into account all the courses of the semester.

A student is declared to have failed the examination if he / she fails to satisfy at least one of the above passing criteria as mentioned in (i) to (v).

If the number of backpaper examinations by any student, in any semester or any academic year, exceeds the ceiling specified in Section 1.5 of this brochure, the student is declared to have failed the semester.

A student admitted to the first year of the programme is allowed to attend the second semester of the programme if he / she passes the first semestral examinations, otherwise he / she is declared to have failed the semestral examination.

A student, who takes all the second semestral examinations, will be allowed to go for Project - I otherwise he/she has to discontinue the programme.

A student who passes the second semestral examination, completes the Project - I satisfactorily as certified by the supervisor and submits his/her report within the prescribed time limit is promoted to the third semester of the programme; otherwise, he/she is declared to have failed the semestral examination.

A student promoted to the third semester of the programme will be allowed to attend the fourth semester of the programme if only he / she passes the third semestral examinations.

A student who submits his / her Dissertation and report of Project – II within the prescribed time limit with proper certifications from his/her supervisors, does not obtain less than 45% in Dissertation and Projects (I and II) and passes the fourth semestral examination will be declared to have successfully completed the fourth semester of the programme.

If even after the compensatory paper, backpaper and supplementary examinations, as referred to in Section 1.5 of this brochure, the student fails to pass the first or the second semestral examinations, he/she has to discontinue the course. However, if he / she fails to pass the third or the fourth semestral examination, but has not opted for any compensatory examination, then at the discretion of the Teachers' Committee, he / she may be allowed to repeat the second year of the course without stipend. The scores obtained during the repetition of the final year are taken as final scores in the final year. A student is given only one chance to repeat a programme. A student will be asked to discontinue if he / she fails in the third or fourth semester of the repeating second year.

A student who is asked to discontinue the programme is not eligible for readmission to this programme even through the admission test.

1.8 FINAL RESULT

A student, who has successfully completed the fourth semester of the programme and whose conduct is satisfactory, gets M. Tech. (QROR) degree and is placed in the

- I. **First division with distinction**, if the student secures an overall average percentage score of at least 75% in all four semesters put together and at most 2 (two) scores less than 45%.
- II. **First division**, if the student secures an overall average percentage score of at least 60% and at most 4 (four) scores less than 45%.
- III. **Second division**, if the student passes all four semesters but fails to secure first division with distinction or first division.

1.9 AWARD OF CERTIFICATES

A student passing the M.Tech (QROR) degree examination is given a certificate of the degree and a mark-sheet mentioning.

- I. all the credit courses taken and the composite percentage score or the post-backpaper score in each course.
- II. the non-credit courses taken, if any, and the composite percentage score or post-backpaper percentage score in each, and
- III. the division in which placed.

The certificate is awarded in the Annual Convocation of the Institute following the fourth semester.

1.10 CLASS TEACHER

One of the teachers in a class is designated as the Class-Teacher. All students are required to meet their respective class-teacher periodically to get their academic performance reviewed and to discuss academic problems, if any.

1.11 ATTENDANCE

Every student is expected to attend all the classes. If he / she is absent, he / she must apply for leave to the Dean of Studies or Academic Coordinator. Failing to do so may result on disciplinary action.

1.12 STIPEND

All students, other than those sponsored by the employers, are awarded full stipend on admission initially for the first semester only. The present rate of stipend is Rs.5000.00 (Rupees five thousand only) per month. The first stipend is given two/three months after admission, with retrospective effect, provided the student continues the programme till that time. The students (other than those sponsored by the employers) are also eligible to receive a contingency grant of Rs.2500.00 (Rupees two thousand five hundred only) per semester in reimbursement of cost of text books and supplementary text books, photostat copies of required academic materials, a

scientific calculator and other required accessories for the practical classes. All such expenditure should first be approved by the respective class teachers. The payment of stipend and the reimbursement of contingency grant will, however, be governed by the following terms and conditions:

The contingency grant sanctioned will be treated as a limit and the student concerned will be reimbursed the actual expenditure incurred by him/her on the admissible items within the limit. The grant is not to be paid as an outright payment.

The books and nonconsumable items purchased or acquired out of the contingency grant will be the property of the Institute and the student will have to return them at the end of the program.

The following terms and conditions will govern the grant of the stipend:

- a. It will be obligatory for every student concerned to undertake 8 to 10 hours (per week) of work related to teaching and research activities as assigned to him/her by the Institute. This could include tutorials, laboratory classes, and development activities undertaken by faculty members, maintenance and operation of computers and other facilities, assistance in Library etc.
- b. Wherever Government of India/University Grants Commission/Council of Scientific and Industrial Research/Industry sponsored projects are undertaken, the services of the student may be used for providing assistance in projects funded by these agencies. In that event, a portion of stipend amount i.e., Rs.800.00 per month, for the time being may be charged to the project funds for the duration the student is engaged on these projects.
- c. The Institute will work out specific programmes of work and maintain the record of each student.
- d. A student shall be required to give an undertaking to the effect that he would not leave the course midway or appear in any competitive examinations, etc., not related to engineering and technology, statistics and related fields in order to be eligible to receive this stipend.
- e. During the course of studies, the student shall not receive any emoluments, salary, stipend, etc. from any other source.
- f. Suitable hostel type accommodation may be provided wherever available.
- g. No House Rent Allowance (HRA) is admissible to the M.Tech. Students.

For sponsored candidates: Sponsored candidates, if admitted to the course, will not receive any stipend or contingency grant. Their sponsors will have to pay a tuition fee of Rs.20, 000.00 only per candidate per year as course fee and provide facilities for carrying out project work on practical problems during normal working hours under the guidance of the faculty of the Institute. In addition to the course fee, the sponsoring organisations will have to reimburse the travelling expenses of the members of the faculty to guide the project work of their nominees.

The stipend rules for second, third and fourth semesters, following the declaration of results of the preceding semester is as follows:

- a. full stipend and contingency grant will be given to a student if he/she gets an overall percent score of at least 60%,
- b. 50% of the full stipend and 50% of the contingency grant will be given to a student who passes the preceding semester but fails to secure an overall percent score of at least 60%.
- c. No stipend is awarded to
 - i. A repeating student,
 - ii. A student whose attendance falls short of 75%, overall, in the preceding semester.

Stipend can be restored because of improved performance and/or attendance, but no stipend is restored with retrospective effect.

1.13 PRIZES AND MEDALS

Students are awarded prizes, in the form of books, for good academic performances in each semester as decided by the Teachers' Committee.

The best M.Tech (QROR) student of the Institute, as decided by the Teachers' Committee based on his/her academic performance, is awarded with the ISI Alumni Association – Mrs. M. R. Iyer Memorial Gold Medal.

1.14 LIBRARY RULES

Students are allowed to use the reading-room facilities in the library and are allowed access to the stacks. They have to pay Rs.500.00 as security

deposit in order to avail of the borrowing facility. At most four books can be borrowed at a time. Any book from the Text Book Library (TBL) may be issued to a student only for overnight or week-end provided at least two copies of that book are present in the TBL; only one book will be issued at a time to a student. *Fine will be charged if any book is not returned by the due date stamped* on the issue-slip. The library rules and other details are posted in the library.

1.15 PLACEMENT

Students who have successfully completed the M. Tech (QROR) programme are now well placed in government and semi-government departments, public and private sector undertakings, and industries/service organizations. Most of the students of the Institute get employment offers even before they complete the qualifying degree examinations.

There is a Placement Committee in Kolkata, which arranges campus interviews by prospective employers.

1.16 HOSTEL FACILITIES

The Institute has hostels for male and female students in its premises in Kolkata. However, it may not be possible to accommodate all students in the hostels. Limited medical facilities are available free of cost at Kolkata campus. Students, selected for stay in the hostels in Kolkata, have to pay Rs. 1500.00 as hostel deposit, whereas hostel rent of Rs 200.00 is deducted from their monthly stipend.

The Institute campus in Kolkata is about 12 km from the city centre.

1.17 CAUTION MONEY

Each student, whether sponsored or not, will have to make a refundable deposit of Rs.1,000.00 as caution money for use of department equipment and facilities.

1.18 PROJECT WORK

A student, who takes all the second semestral examinations, is allowed to go for Project – I of 12 weeks' duration. Also, after passing the third semestral examination, a student is required to work on Dissertation followed by Project – II of about 20 weeks' duration.

The practical training for the project is offered at different centres of the SQC and OR Division. During the practical training, the candidates are required to work on live plant problems and to submit project reports which form a part of the curriculum. The field trainings are, as far as possible, arranged in industrial establishments which are clients of the different SQC and OR Units of the Institute. However, where the Institute is not able to arrange training in such plants, the sponsoring organisations should provide training facilities for their nominees either in their own plants or in other plants approved by the Institute. The deputation of a candidate to any plant is at the sole discretion of the Institute.

A student who undergoes field training somewhere in India during the training period may receive his/her usual monthly stipend/remuneration/emolument either from the Institute (ISI) or from the host organization at his/her own discretion.

A student, who wishes to receive stipend from the Institute, will receive his/her usual monthly stipend. However, the students during field training will be paid an additional monthly allowance at the following rate:

- i. Fifteen percent (15 %) of the monthly stipend to those who are placed in Kolkata and its suburbs.
- ii. Thirty percent (30 %) of the monthly stipend to those who are placed outside Kolkata and its suburbs, but offered accommodation either in the ISI hostel or by the organization where they are placed.

- iii. Forty percent (40 %) of the monthly stipend to those who are placed outside Kolkata and its suburbs, but not offered accommodation as in (ii).
- iv. From travel from Kolkata to the city where the students are placed, and back, the students will be reimbursed second class (sleeper) to and fro train fare and allowance of Rs 50.00 for every 24 hours or part thereof during the train journey and incidental expenditure to cover the road travels/coolies to the extent of Rs 30.00 each way for the whole trip.

1.19 CHANGE OF RULES

The Institute reserves the right to incorporate changes in the above rules, course structure and the syllabi as and when needed.

CURRICULUM

The courses offered, for both Engineering and Statistics stream, in different semesters are as follows:

SEMESTER - I

Engineering Stream		Statistics Stream
Probability - I	16 weeks class	Electrical & Electronics Engineering
Statistical Methods - I		Workshop - I
SQC - I		SQC - I
Operations Research - I		Operations Research - I
Programming Techniques and Data Structure		Programming Techniques and Data Structure
Quality Management & Systems		Quality Management & Systems

SEMESTER - II

Engineering Stream		Statistics Stream
Probability - II	16 weeks class	Mechanical Engineering
Statistical Methods - II		Workshop - II
SQC - II		SQC - II
Reliability - I		Reliability - I
Instrumentation & Computer Engineering		Instrumentation & Computer Engineering
Industrial Engineering & Management		Industrial Engineering & Management

* Project I starts in May after second Semestral examinations and continues till Mid July. This is included in Semester IV.

SEMESTER - III

Engineering and Statistics Stream

Operations Research - II	16 weeks class	Elective Subjects **
Industrial Experimentation		1. Applied Stochastic Process
Reliability - II		2. Advanced Statistical Methods
Elective - I		3. Advanced Optimisation
Elective - II		4. Software Engineering
Elective - III		5. Data Base Management System
		6. Advance Reliability
		7. Game Theory & Decisions
	8. Other selected Subjects as suggested by the Faculty	

** From the above list of elective subjects, the teachers committee will decide on the subjects to be offered to the students in a particular semester and also the combination a student may take up.

SEMESTER - IV

Engineering and Statistics Stream

Project - I (at factory) 12 weeks	Starts on first week of May
Dissertation	Starts on first week of January
Project - II (at factory) - 20 weeks	Starts on first week of March

- Project I will have 100 marks, Dissertation 200 marks and Project II 300 marks
- Each semester consists of about 14 weeks of instruction (ordinarily 3 lectures of 50 minutes each except for workshop and one practical-cum-tutorial session per week).

BRIEF SYLLABI

SEMESTER - I

PROBABILITY - I

1. Concept of probability (10)

Historical introduction and citation of examples for application of probability. Definition of probability – classical, relative frequency and subjective approaches, their drawbacks, practical exercises on relative frequency approach. Sample space and events; calculus of events, examples of sample space. Concept of random experiment with examples. Axiomatic development of probability– discrete and general probability space, properties of probability. Conditional probability, Bayes' theorem, independence of events, pairwise and mutual independence.

2. Combinatorial probability (6)

Probability of occurrence of at least one and exactly m events, Birth day, Matching and. Occupancy etc. problems, exercises.

3. Concept of random variables and probability distribution (4)

Definition of random variable, cumulative distribution function. Discrete random variables and their p.m.f. and d.f. with some general examples. Continuous random variables and their p.d.f. and d.f. with some general examples

4. Discrete random variable and its distribution (10)

Bernoulli trials, binomial, poisson, geometric, negative binomial, hypergeometric distributions, their properties, relationship and simple approximations (Hypergeometric to binomial and binomial to poisson). Numerical examples and statistical tables for individual and cumulative probabilities. Discrete random vector and bivariate cases marginal and conditional density functions, independence of discrete random variables. Distribution of the sum of two or more discrete independent random variables. Probability generating function (p.g.f.), properties and exercise.

5. Continuous random variable and its distribution (10)

Uniform, normal, gamma, beta, exponential, weibull, cauchy, lognormal distribution, Relationship between gamma and poisson, beta and binomial. Cumulative probabilities. Bivariate distribution – marginal and conditional density, bivariate normal, independence of continuous random variables. Distribution of sum, product and ratio of two independent random variables. Some derived distributions such as χ^2 , t, F. Order statistics and distribution of range.

6. Expected values and moments (6)

Mathematical expectation and its properties; Moments, their properties and interpretation; moments through p.g.f.; variance of sum of independent random variables, conditional expectation, conditional variance. Correlation coefficient and its properties.

7. Moment generating and characteristic function (4)

Definition, properties and relationship. Statement of uniqueness theorem of characteristic function and its applications.

8. Limit Theorems (6)

Chebyshev's lemma, Chebyshev's inequality, weak law of large numbers (WLLN), Central limit theorem (Lindbergh & Levy) Demoivre's theorem, examples for application these limit theorems in Statistical Quality Control.

References:

1. Introduction of Probability Models, S.M. Ross, Academic Press, N.Y.
2. A first course in Probability, S.M. Ross.
3. An introduction of Probability, P.G. Hoel, S.C. Port, C.J. Stone, Universal, N.Delhi
4. An Introduction to Probability Theory and its application (Vol.I & II), W.Feller.
5. Probability Theory and Mathematical Statistics, M. Fisz.
6. Modern Probability Theory and its applications, E. Parzen, F.A.Graybill, D.C.Boes,
7. Introduction to the Theory of Statistics, A.M. Mood, F.A.Graybill, D.C. Bose.
McGraw-Hill
8. Mathematical Methods of Statistics, Harlod Cramav.
9. Elementary Probability Theory with Stochastic Processes, Kai Lai Chung

STATISTICAL METHODS - I

1. Introduction (2)

Definition of Statistics. Basic objectives. Applications in various branches of science with examples.

2. Collection of Data (3)

Internal and external data, Primary and secondary Data. Population and sample, Representative sample.

3. Descriptive Statistics (20)

Classification and tabulation of univariate data, graphical representation, Frequency curves. Descriptive measures – central tendency and dispersion.

Bivariate data. Summarisation, marginal and conditional frequency distribution. Scatter diagram. Linear regression and correlation. Least squares method. Rank correlation.

Multivariate data. Multiple linear regression, Multiple and partial correlation.

4. Simulation of Probability models (8)

Random Numbers, Simulation techniques.

5. Sampling Techniques (10)

Random sampling. Sampling from finite and infinite populations. Estimates and standard error (sampling with replacement and sampling without replacement).

Sampling distribution of sample mean, Stratified random sampling.

6. Sampling distribution (10)

Sampling distribution related to standard univariate probability models– Binomial, Poisson, Normal, Uniform, Exponential, Gamma, Beta etc.

References: Vide references given for **Statistical Methods II** under Semester–II

SQC - I

1. Introduction to SQC (2)

2. SPC Techniques (33)

Definition of quality, meaning of control, chance and assignable causes of variation, statistical process control (SPC), basis of SPC, expected benefits of SPC. Tools of SPC – Process capability Analysis, process capability and machine capability indices (C_p , C_{pk} , C_m , C_{mk}), Control charts– Classical

(Shewhart) control chart for variables and attributes- \bar{X} - R, \bar{X} - s, np. p, c, u charts. Sloping control chart, Median chart. Modified control (Shewhart) charts, Control charts with memory CUSUM chart, Moving sum/Moving average chart, EWMA chart, Pre control, Softwares for SPC.

3. Acceptance Sampling (20)

Introduction to acceptance sampling. Rejection and Rectification types. Sampling risks and parameters– consumer’s risk, producer’s risk. Operating characteristic curve, average sample number (ASN) curve, AQL, AOQL, ATI, LTPD, Single, Double, Multiple and Sequential sampling plans. Published sampling plans– Attribute (Dodge–Romig, Mil Std, IS–2500) and variable (AQL, LTPD stipulated plans, MIL std.414) type plans.

References:

1. Statistical Quality Control– 5th edition, E.L. Grant & R.S. Leavenworth, McGraw–Hill, N.Y.
2. Quality Control and Industrial Statistics – 5th edition. A.J. Duncan, Irwin, Homewood, Ill.
3. Quality Control and Statistical Methods– Edward M. Schrock, Asia Publishing House.
4. Statistical Process Control, Theory and Practice, –G.B. Wetherill & D.W. Brown, Chapman & Hall, N.Y.
5. Introduction to Statistical Quality Control– D.C.Montgomery, Wiley, N.Y.
6. Acceptance sampling in Quality Control, E.G. Shilling, Marcel Dekker, Inc. N.Y.

OPERATIONS RESEARCH - I

1. Introduction to OR : (2)

Origin of OR and its definitions– Operational Research with special emphasis on interdisciplinary and system approach, Orientation–iconic, Analogue and Mathematical models, Stages of an OR project: Formulation of the problem, Developing a model, Testing the adequacy of the model, Deriving a Solution and Evaluation of the solution and implementation.

2. Linear Programming : (32)

Linear programming Modelling and Examples. Geometric solution, Vector spaces, Basis, Linear transformations. Matrices, Partitioned matrices, Quadratic form. Convex sets, extreme points and convex polyhedral sets, Simplex Algorithm–its theory and computational details, resolution of

degeneracy. Duality theory, dual-simplex and primal-dual algorithms. Transportation, Assignment problems, Sensitivity Analysis.

Bounded variables algorithm and decomposition principle. Flows in network, max flow-min cut theorem and its application to transportation problems. Industrial applications of linear programming like product mix problems, blending problems, optimal allocation of resources etc.

3. Replacement and Maintenance Models : (6)

Replacement of items that deteriorate, Equipments that suddenly fail, chain of improving equipments, assuming (i) same life for each member in the chain and (ii) increasing life, equal to that of deterioration only at infinity. Replacement of items that fail stochastically- individual and common preventive replacements, Investment decision models.

4. Inventory Control : (10)

Inventory control problem; Concept of inventory and various costs, EOQ formula.

Single period models: Single period models, newspaper boy problems–provisioning of spares with or without salvage value.

Multi-period Models: Different models, Comparison of different models–evaluation of system consequences.

Inventory Control Project: Carrying out an inventory control study–relevant costs to be considered, estimation of costs by imputation or otherwise, ABC analysis and Selective inventory management, Decaying inventory.

5. Queuing Theory : (10)

Introduction to waiting line models steady state behaviour of M/M/1 and M/M/C queues–the problem of machine interference and use of finite queuing tables–introduction to M/G/1, and G/M/1.

References:

1. Principles of OR with Application to Managerial Decisions -H.M. Wagner, Prentice Hall.
2. Introduction to Operations Research - F.S. Hiller and G.J. Lieberman, Addison Wesley.
3. Linear Programming - G. Hadley, Addison Wesley.
4. Linear Programming & Network flows - M.S. Bazaraa, J J Jarvis and H D Sherali, John Wiley.
5. Linear Programming and Extensions - G.Dantzig, Princeton, N.J.
6. Linear Programming - K.G. Murthy, John Wiley
7. Modern Inventory Management - J.W. Prichard and R.H. Eagle, John Wiley.
8. Material Management in Inventory Systems - M.K. Starr and R.J. Tersine, North Holland.
9. Renewal Theory - D.R. Cox
10. Queues - D.R. Cox and W.L. Smith
11. Analysis of Queuing Systems - J.A. White, J.W. Schmidt and G.K. Bennet, Academic Press.
12. Elements of Queuing Theory - Thomas L. Saaty, McGraw Hill.
13. Introduction to Queuing Theory–B.V. Gnedenko and I.N. Kovalenko.
14. Operations Research - An Introduction– H.A. Taha, Macmillan, N.Y.

PROGRAMMING TECHNIQUES AND DATA STRUCTURES

1. Programming Techniques and Structures

C-language and structural programming concepts.

2. Data Structures

Formal definitions, operations, implementations and applications of basic data structures; array, stack, queue, dequeue, priority queue, doubly linked list, orthogonal list, binary tree-traversal algorithms, threaded binary tree, generalized list.

3. Search Techniques

Binary search, Fibonacci search, binary search tree, height balanced tree, heap, B-tree, B*-tree, digital search tree, tree, hashing techniques.

Three lectures and one two-hour tutorial per week.

60% for theory and 40% for programming assignments.

References:

1. Data Structures using C, - A.M. Tanenbaum and M.J. Augesestein, Y. Langsan
2. The Art of Computer programming, Vol. I - D.E. Kunth
3. Data structure techniques -T.A. Standish:
4. Fundamentals of Data Structures -E. Horowitz and S. Sahni :
5. Data Structure and Program Design.- R.J. Kruse :
6. Data Structures and Algorithm. -A. Aho, J. Hopcroft, and J. Ullman :

QUALITY MANAGEMENT SYSTEMS

1. Strategic quality Management : (5)

Basic concepts. Elements of strategic Management, Quality and Management cycles, Quality policies and Goals, Resources for Quality activities, Training, Obstacles to SQM.

2. Organising for Quality : (5)

Evolution of organisation for quality, co-ordination of quality activities, role of upper management, middle management, work force and teams. Self managing teams quality circles.

3. Developing quality culture :(5)

Culture, Motivation, Creating and maintaining quality awareness, Providing evidence of management leadership, Providing for self-development and Empowerment. Providing recognition and Rewards, time to change culture. Achieving total commitment to quality-various approaches.

4. Quality Management & Assurance systems : (20)

Developing and establishing quality management and assurance system. Basics of ISO 9000, QS 9000, ISO 14000 systems, Quality Audit, Accreditation systems.

5. Quality costs - Foundations of Quality Systems Economics : (5)

6. TQM and allied concepts : (10)

(i) TQM implementation process, Deming's 14 point

(ii) Six Sigma Process.

(iii) Kaizen.

References:

1. ISO 9000 : Quality Management and Quality systems element standards
2. ISO 8403 : Quality Management and Quality Assurance - Vocabulary
3. ISO 9001: Quality systems- Models for Quality assurance in design/development, production, installation and servicing.
4. Strategic Management, -A.A. Thompson and A.J. Strickland, R.D. Irwin, Illinois.
5. Quality planning and Analysis - J.M. Juran and F.M. Gryna, Tata McGraw Hill.
6. Total quality Control - A.V. Feigenbaum, McGraw Hill
7. Quality Handbook - J.M. Juran (Ed.), McGraw Hill.
8. Total Quality Management- A practical approach -H. All, Wiley Eastern.
9. Handbook of Quality Management.-D.Lock (Ed.), Jaico
10. QS 9000 Quality Assurance System Standard
11. ISO 14001 Environmental Management systems- specifications with guidance for use.

ELECTRICAL AND ELETRONICS ENGINEERING

1. Basic Electrical Systems & Control: (25)

D.C. and A.C. circuits (including three phase circuits), Electromagnetic induction, Principles of D.C. motors and generators, Transformers, Alternators and A.C. motors. Feedback and feed forward control, Stability of control systems.

2. Electronics: (25)

Kirchoff's law, analysis of RLC circuits, Network theorems.

Principles of semiconductor diodes and transistors, Transistor biasing and RC-coupled amplifiers, Operational amplifiers, Feedback amplifiers, Oscillators, Pulse and digital Circuits.

References:

1. Fundamentals of Electrical engineering and electronics – B.L. Theraja.
2. Electrical Technology - B.L. Theraja, A.K. Theraja
3. Network, lines and Fields -J.D. Ryder, Asia publishing.
4. Electronics Engineering Principle - J.D. Ryder, McGraw Hill.
5. Integrated Electronics : Analog and Digital Circuits and systems - S. Millman and C.C. Halkias, McGraw Hill
6. Analysis and Design of feedback control systems - G.J. Thaler and R.G. Brown, McGraw Hill.
7. Operational Amplifiers, design and applications– J.G. Graeme and T.E. Tobey, McGraw Hill.
8. Transistor Engineering - A.B. Phillips, McGraw Hill.
9. Digital Electronics with engineering applications– T.P. Sifferlen & V. Vartanian, Prentice Hall, N. Jercy

WORKSHOP - I

1. Engineering Drawing (25)

Basic concept of orthogonal projection, third angle and first angle projections, scale of drawing and dimensioning, theory of section and conventional sectional view, offset section, revolved section, auxiliary view.

Convention of representing screw threads in a drawing, diametral clearance in bolt holes and their spacing, standard bolt diameters, bolt circle diameter and flange diameter.

Concept of fitting boss and alignment, standard key, key ways and spline, dimensioning parts before assembly and after assembly, Duplication of dimensions and cumulative errors, representing gears by pitch circles in a drawings.

Computer aided graphics, sketch-pad concept, features drawing and simple topographical representation of product (practical demonstration with OMC drafting machine).

2. Basic workshop practices (15)

3. Exercises on Electrical and Electronics Engineering. (30)

SEMESTER - II

PROBABILITY - II

1. Concept of a stochastic process: (4)

State space and parameter space. Various types of Stochastic processes. Examples.

2. Markov processes and Markov chains: (5)

Definition and Examples

3. Discrete Time Parameter, Time Homogeneous Markov Processes: (36)

- a. Transition probabilities, Chapman-Kolmogorov equations, First passage time (8)
- b. Communication among states. Classification of states. Definition of recurrence, transience, positive and null recurrence, periodicity- (10)
- c. Stability of Markov chain. Limiting probabilities. (3)
- d. Absorption probabilities. (3)
- e. Examples of Markov chains-Birth and Death chain, Random walk, Ehrenfest chain, Gambler's ruin chain etc. (2)
- f. Modeling of common industrial and real life systems as Markov chains □ Examples of waiting line and inventory models (10)

4. Poisson process: (10)

Postulates for Poisson process. Properties of Poisson process.

Poisson process and related distributions. Examples.

References:

1. Elements of Applied Stochastic Process, 2nd ed., U.N. Bhatt, Wiley, N.Y.
2. An Introduction to Probability Theory and Its Applications, Vol.1, 3rd ed., W. Feller, Wiley N.Y.
3. Introduction to Stochastic Processes, P.G. Hoel, S.C. Port and C.J. Stone, Haughton Mifflin, Boston
4. Markov Chains–Theory and Applications, D.L. Isaacson and R.W. Madson, Wiley, N.Y
5. A First course in Stochastic Processes 2nd ed., S. Karlin and H.M. Taylor, Academic Press, N.Y
6. Stochastic Processes, J.Medhi ,Wiley eastern, N. Delhi
7. An Introduction to Probability Models, 2nd ed., S.M. Ross, Academic Press, N.Y.
8. Stochastic Processes, S.M. Ross, Wiley, N.Y.

STATISTICAL METHODS – II

1. Introduction (2)

Principles of Statistical Inference. Formulation of the problems with examples.

2. Estimation (8)

Point estimation. Estimator and estimate criteria for good estimates – unbiasedness, consistency, efficiency and sufficiency, Illustrations. Methods of estimation of Parameters of standard distributions. Interval estimation by examples– Confidence intervals of the parameters of the standard distributions, one-sided confidence interval.

3. Testing hypothesis (20)

Formulation of the problem and concepts for evaluation of tests, Illustrations.

Statistics Sampling distribution of statistic and its standard error.

Small sample tests associated with standard univariate probability distributions and corresponding sampling distributions (without derivations)

Large sample tests in one and two-sample problems of standard probability distributions, Statement of central limit theorem, Determination of sample size.

Small sample tests connected with Bivariate Normal population, Simple linear regression and correlation and corresponding confidence intervals. Transformation of statistics to stabilize the residual plots. Assessment of the model. Fitting of non-linear regression using transformation.

Analysis of categorical data. Pearsonian chi-square and its applications.

4. Linear Statistical Models (5)

Definition of linear model, interactions with illustrations. One way and two way analysis of variance.

5. Non-parametric Inference (10)

Comparison with parametric inference, Use of order statistics. Confidence interval for fractile. Sign test, Wilcoxon signed rank test, Mann-Whitney test,

Run test, Kolmogorov–Smirnov test. Spearman's and Kendall's test. Tolerance region.

6. Elements of Sequential Test and its Uses. (5)

Tests for Binomial and Normal population parameters.

References:

1. Probability and Statistics for Engineers (4th Edition) – I.R. Miller, J.E. Freund and R. Johnson.
2. Fundamentals of Statistics (vol. I and vol. II)– A. Goon, M. Gupta and B. Dasgupta.
3. Statistical Theory with Engineering Application – A. Hald.
4. Statistical Methods – G.W. Snedecor and W.G. Cochran.
5. Statistical Concepts & Methods – G.K. Bhattacharyya and R.A. Johnson.
6. Introduction to Linear Regression Analysis – D.C. Montgomery & E. Peck
7. Introduction to the Theory of Statistics – A.M. Mood, F.A. Graybill & D.C. Boes.
8. Practical Non-Parametric Statistics – W.J. Conover
9. Applied Regression Analysis – N. Draper & H. Smith

SQC – II

1. Advanced SPC Techniques (20)

Group control chart for multiple stream processes, Multivariate control chart. Control chart of process mean vector and process variability matrix, Control chart based on Run lengths. Control chart for short run process.

Process capability analysis under non-normal situation.

SPC with correlated quality characteristic. Interface and integration between SPC and EPC (Engineering process control). Selecting optimum target for a production process.

Economic design of control charts, economic models of X-R control chart. Economic design of p chart.

2. Taguchi's on-line QC Techniques (15)

Taguchi's loss function and quality level. Taguchi's on-line feedback quality control (variable and attribute characteristics), On-line process parameter control (variable and attribute types), On-line quality control and methods for process improvement.

3. Further topics in Acceptance Sampling (15)

Continuous sampling plans (CSP-1, CSP-2, CSP-3), Multilevel plans.
Special purpose plans - Chain sampling and Skip lot sampling plans.
Economic design of acceptance sampling plans.

References:

1. Introduction to statistical quality control, D.C. Montgomery 3rd Edition,
2. Multivariate QC" in Encyclopedia of statistical sciences, Vol. 6, edited by W.L. Johnson, S, Kotz, John Wiley, N.Y.
3. Quality Control and Industrial Statistics –A.J. Duncan .5th edition, Irwin, Homewood, Ille.
4. Principle of Quality Control, Jerry Banks, John Wiley.

RELIABILITY - I

1. Concept of Reliability (5)

Importance of reliability, definition of reliability and its measures, concept of failure. General provision of a reliability specification, Methods of achieving reliability, Broad functions of reliability.

2. Failure patterns (8)

Bath tub curve, causes of early failure and methods to avoid them, failure distributions: exponential, Weibull, truncated normal, log normal, gamma, inverse Gaussian, their properties and uses.

3. Combinatorial reliability (12)

Series, parallel and r-out of n configurations; their block diagram, reliability graph and determination of reliability through combinatorial methods of inspection, events space, cut set and tie set. Multistate models.

4. System reliability redundancy (15)

System reliability with exponential components in series, parallel and r-out-of-n system. Usefulness of redundancy and improvement factor. MTTF, MTBF, Equivalent MTBF of series and parallel system. Cold and hot redundancy, reliability of stand-by system. Weakest link model, chain model, stress-strength model, non-parametric estimation of reliability.

5. Reliability testing demonstration and acceptance (15)

Problem of life testing, estimation of parameters and reliability using standard probability models using complete and censored (type I, II and III) samples, properties of these estimators. Probability plotting and graphical

procedures for estimating the parameter and testing validity of model by some standard statistical tests. Life test acceptance sampling plans in exponential case. Sequential life test in exponential case, accelerated life tests.

Reference:

1. Methods for Statistical Analysis of Reliability and Life Data, Mann, N.R. Schofer R.E. & Singpurwalla, N.D., Wiley, New York
2. Statistical Analysis of Reliability and Life- Testing Models, Bain, L.J, Dekker, New York,
3. Statistical Models and Methods for Lifetime Data, Lawless, J.F., Wiley, New York
4. Bayesian Reliability Analysis, Martz, H.E. & Weller, A., Wiley New York,
5. Statistical Theory of Reliability and Life Testing Probability Models, Barlow R.E. & Proschan, F., Holt, Rinehart and Winston, New York.
6. Statistical Reliability Theory, Gertsbakh , I.B., Marcel Dekker Inc.
7. Reliability and Life Testing, Sinha, S.K., Wiley Eastern Limited.
8. Reliability Theory and Practice, Bazvosky, I., Prentice Hall, New Jersey
9. Fundamentals of Reliability Theory, Polvko, A.M., Academic press, New York.
10. Mathematical Theory of Reliability, Barlow, R.E. and Proschan, F, John Wiley, New York.
11. Mathematical Methods of Reliability Theory, Gnedenko, Yu, Belyayev K and Solovyev, A.D., Academic Press, New York.
12. Repairable system Reliability-Modeling, Inference, Misconception and their Causes, Ascher Harold and Feingold Harry, Marcel Dekker, Inc., New York,
13. Life Testing and Reliability Estimation, Sinha, S.K. and Kale, B.K., Wiley Eastern, New Delhi.
14. Software Engineering: Design, Reliability and Management, Shooman, M.L., McGraw - Hill, New York.
15. Reliability in Engineering Design, Kapur, K.C. and Lamberson, L.R., John Wiley, New York.
16. The Statistical Analysis of failure time data, Kalb Feisch, J.D. and Prentice, R.L., John Wiley, New York.
17. Reliability and Maintainability of Electronic System (edited), Arsenault and Roberts, J.A., PITMAN.

INSTRUMENTATION AND COMPUTER ENGINEERING

1. Instrumentation (25)

Primary sensing elements, Transducers, Signal conditioning and conversion, Telemetry, Process control.

2. Computer Engineering (30)

Boolean algebra, Switching functions and their minimization, Circuit realization.

Logic gates, Combinatorial and sequential circuits.

Number representation, Binary arithmetic, Fixed point and floating point arithmetic, Processor organisation, Memory organisation, Input–Output organisation, Process management, memory management, Input–Output management.

References:

1. Measurement Systems - Application and Design. E.O. Doebelin, McGraw Hill, Int.
2. Instrumentation Fundamentals and Applications, R. Marrison, John Willey
3. Electronics Measurement and Instrumentation, M.Oliver and J.M. cage, McGraw Hill
4. Instrumentation, Measurement and Feedback, B.E. Jones, McGraw Hill
5. Digital Computer Fundamentals, T.C. Bartee,
6. Computer Systems Architecture, M.M. Mano, Prentice Hall
7. Operating systems, J.J.Donovan and S.E. Madnick McGraw Hill.

INDUSTRIAL ENGINEERING AND MANAGEMENT

1. Industrial Engineering (30)

(a) Operations Management: (10)

Method:

Methods study: Recording techniques, critical examination, and development of alternative and implementation, Examples:

Estimation of task times by past data approach, direct time study approach, predetermined time standards approach, work sampling approach.

Machine:

Equipment selection, techniques and replacement strategies, Examples

Break– down, preventive and predictive maintenance, distribution of breakdown time, distribution of repair time, determination of crew sizes, Scheduling.

(b) Man Management: (5)

Incentive schemes, job specification, job evaluation, work & job design.

(c) Material & Management: (5)

Choice of materials, standardisation, value engineering and analysis.

(d) Plant Management: (5)

Plant location, plant layout, and materials handling.

(e) Ergonomics and Human engineering: (5)

Introduction, application in product and job design, Safety.

2. Industrial Management (15)

(a) Introduction to management and Systems (5)

Functions of management, Planning, Co-ordination, Motivation and Control, Decision making, Roles and role conflict, Organisation structure, Communication and information subsystem, Administration & management of change , Case studies.

(b) Management Accounting and Financial Management (10)

Introduction to financial Management, Scope & functions, structure & components of balance sheet, income statement, funding flow and cash flow, Ratio analysis, and interpretation of financial statements, Budgeting, standard budgeting and control, control and accounting of materials, control and accounting of labour, control and accounting of overhead, system of cost accounting with reference to historical predetermined cost, process cost and uniform cost accounting, cost accumulation systems, variance analysis, financial evaluation of alternatives, cost of capital and capital budgeting.

3. Marketing : (10)

Consumer, Demand, Marketing strategy (Segmentation, Pricing, Distribution channel), Product life cycle & product development, Market research (techniques of data collection & information processing), Brand Management, Advertising & Promotional activity.

References:

1. Industrial Engineering and Management Science, P.R. Banga, S.C. Sharma and N.K. Agrawal
2. Industrial Engineering and Operation research, D.M. Miller, J.W. Schmidt, John Wiley, N.Y.
3. Motion & Time study, W.N. Benjamin, Irwin, Homewood, IL.
4. Industrial Engineering Handbook, H.B. Maynard (Ed.) Mc Graw Hill. N.Y.
5. Job evaluation Methods, C.W. Lytle Ronald Press N.Y.
6. Industrial Engineering, R.B. Gupta, Satya Prakashan, N. Delhi
7. Introduction to Work Study (3rd edition), ILO, Geneva, Universal Book Corporation.
8. Industrial Engineering & Management, O.P. Khanna
9. Management: a system and contingency analysis of managerial functions—H. Koontz and C.O. Donnell.
10. Market Research, D.J. Luck and R.S. Rubin, Prentice Hall
11. Market research—Text and cases, H.W. Blyd, R. Westfall, S.F. Stasch, Richard Allwyn Inc, Illinois
12. Marketing Management, Analysis, Planning, Implementation and Control, Philip Kotler, Prentice Hall (India).
13. Financial Management & Policy (Ninth edition), J.C. Van Horne, Prentice Hall (India)
14. Financial Management—theory & practice (2nd edn), P. Chandra, Tata McGraw Hill (India)
15. Accounting Theory and Management Accountancy, S.P. Jain and K.L. Narang, Kalyani Publishers.

MECHANICAL ENGINEERING

1. Mechanical Properties of Materials. (15)

Brittleness, ductility, toughness, Engineering and true stress strain curves, Instability in tension, yielding criteria for ductile materials, tensile properties, anisotropy, Torsional properties, Hardness, Impact strength, Fatigue and Creep behaviours at low and elevated temperature.

2. Metrology (15)

Objectives of Metrology, Characteristics of measuring instruments, Functional elements of instruments, classification of methods of measurement.

Standards for measurement and standardising organisations

International system (SI) of units.

Measurement uncertainty/error, types of error, methods of estimating total uncertainty in a measurement process.

Linear measurement–steel rule, calipers, surface plates, straight edges, gauges, vernier calipers.

Limits, Fits and Tolerances.

Straightness, flatness, squareness, parallelism, roundness, circularity, runout.

Surface roughness measurement.

3. Machining (15)

Various machining methods and machine tools for metal cutting. Influence of various factors like speed, feed and depth of cut on tool life. Economic tool life, various angles and geometry of single point cutting tools (ISO standard). Design of single point cutting tool. Forces of turning, drilling and milling operations.

Non conventional machining.

NC/CNC Machines.

4. Mechanical working of Metals:(15)

Plastic deformation of metals - Hot and cold working, Forging, Rolling, Extrusion, Wire drawing, Deep drawing, Stretch forming, Blanking, Piercing, Bending. Hydroforming and explosive forming.

References:

1. Production Technology by HMT, Tata McGraw Hill
2. Manufacturing and Machine tool operation, H.W. Pollack, Prentice Hall, N.Y.
3. Manufacturing Analysis, N.H. Cook, Addison– Wesley
4. Structure and Properties of Engineering Materials, R.M. Brick, A.W. Pouse, R.B. Gorden, Mc Graw Hill
5. Mechanical Metallurgy, E.M. Dieter, McGraw Hill
6. Workshop Technology, Parts 1,2,3, W.A.J. Chapman, ELBS
7. Numerical Control of Machines, S.J. Martin, ELBS.
8. Principles of Machine tools, G.C. Sen and A. Bhattacharya.
9. Fundamental of Tool design, ASTME, Prentice Hall,

10. Fundamentals of Rolling, Z. Wusatowski, Pergamon Press, Oxford.
11. Nontraditional Machining Process, R.K. Springborn (Ed.), ASTM
12. Principles of Numerical Control, J.J. Childs, Ind. Press Inc, N.Y.
13. Engineering Metrology, R.K. Jain, Khanna, N.Delhi
14. Measurement Systems– Application & Design, E.O. Doebelin, McGraw Hill
15. Handbook of Industrial Metrology, ASTM, Prentine Hall
16. Engineering Metrology, K.J. Hume, Mc Donald
17. Engineering Dimensional Metrology, L. Miller, Arnold.

WORKSHOP - II

1. Instrumentation/ Digital Electronics (25)
2. Material Testing (20)
3. Metrology and Machining Practices (30)

SEMESTER - III

OPERATIONS RESEARCH - II

1. Integer Programming: (12)

Formulation of various industrial problems as integer and mixed integer programming Problems. Branch and bound algorithm. Cutting plane methods for pure and mixed Integer programming problems. Knap–sack, travelling salesman and shortest route problems.

2. Non-linear Programming : (25)

Constraint qualification and Kuhn–Tucker necessary conditions. Sufficiency of Kuhn–Tucker necessary conditions and convex programs. Linear Complementarity Problem (LCP) and Lemke’s complementary pivot algorithm. Copositive plus matrices and Lemke’s algorithm. Quadratic programming and use of LCP for solving quadratic programming problems. Separable Programming. Linear fractional Programming.

3. Dynamic Programming : (6)

Bellman’s principle of optimality and recursive relationship of dynamic programming for various optimization problems.

4. Sequencing Models : (7)

Two machine and n jobs (no passing) problem and three machine and n jobs (no passing) problems: different routing, 2 jobs and m machines, n jobs and m machines; branch and bound algorithms. Line balancing models.

5. PERT/CPM : (10)

Introduction to Network analysis, definition of a project, job and events, drawing of arrow diagrams, determination of critical paths and calculation of floats. Resource allocation and least cost planning. Use of network flows for least cost planning. Uncertain duration and PERT. PERT COST system and installation of Network system.

References:

1. Integer Programming - R.S. Garfinkel and G.L. Nemhauser, John Wiley.
2. Integer Programming: Theory, applications and Computations - H.M. Taha, Academic Press.
3. Non Linear Programming: Theory and Algorithms - M.S. Bazara and C.M. Shetty, John Wiley.
4. Non-linear Programming- W.I. Zangwill, Prentice Hall.
5. Practical Methods of constrained optimization - R. Fletcher, John Wiley.
6. The Art and Theory of Dynamic Programming - S.E. Dreyfus, Academic Press.
7. Theory of Scheduling - R. Conway, Addison Wesley.
8. Network based Management Systems -R.D. Archibald, John Wiley,
9. Network Analysis for Planning and Scheduling - A. Battersby, Macmillan.
10. Applied Dynamic Programming - R. Bellman and S. Dreyfus, Princeton, N.J.

INDUSTRIAL EXPERIMENTATION

1. Introduction : (2)

Role of experimental designs. Basic principles, use of statistical technique in experimentation.

2. Randomised Block, Latin Squares and Related Designs : (6)

Randomised complete block design, Latin square design, Graeco-Latin square design, Incomplete block designs-statistical analysis, Model adequacy checking, Problems.

3. Factorial Designs : (4)

2^k and 3^k factorial designs, Statistical Analysis, Model adequacy checking, Confounding – 2^k in two blocks, four blocks and in 2^p blocks, 3^k in 3, 9 and 3^p blocks. Partial confounding problems.

4. Nested/Hierarchical Designs : (4)

Two stage nested design, Statistical analysis, estimation of model parameters, diagnostic checking. General m-stage nested designs. Design with nested and crossed factors. Problems.

5. Multifactor Experiments with Randomisation Restrictions : (4)

Randomised block and Latin squares as multifactor designs, Split-plot design, Split-split plot design, Problems.

6. Orthogonal Arrays : (8)

Linear graphs and their applications, Different types of Orthogonal Arrays, Split unit design, Multilevel arrangement, Pseudo-factor designs, Statistical analysis, Problems.

7. Response Surface Methodology : (80)

Introduction, Method of steepest ascent, Analysis of quadratic models, Response surface designs for first order and second order models, rotatable and orthogonal -designs-Equiradial, simplex, central composite, Box Behnken designs, Problems.

8. Taguchi's Robust Designs : (6)

Taguchi's philosophy of quality engineering, Loss function, Three steps approach to robust design, Parameter designs, Inner array and outer array, Signal to noise ratios, Tolerance designs, Statistical analysis, Problems.

9. Mixture Designs: (8)

Introduction, Simplex lattice designs (Scheffe). Simplex centroid designs, Extreme vertices designs, Response surface designs with mixtures - first order and second order model for constrained mixture spaces, Problems.

Reference:

1. Design and Analysis of experiments, D.C. Montgomery, J. Wiley, N.Y.
2. Statistics for Experimenter: An Introduction to data analysis and model building, G.E.P. Box, W.G.Hunter, J. Wiley, N.Y.
3. Design of Experiments: A-No-Name-Approach, T.J. Lorenzer and V.L. Anderson, Marcel Dekker, N.Y.
4. Experimental Designs, W.G. Cochran and G.M. Cox, J. Wiley, N.Y.
5. Design of Experiments _ A realistic approach, V.L. Anderson and R.A. Mcelean, Marcel Dekker, N.Y.
6. Statistical Design and Analysis of Experiments, P.W.M. John, MacMillan.
7. The Design of Experiments, R.A. Fisher, Hafner N.Y.

8. Statistical Design and Analysis of Industrial Experiments, S.Ghosh, Marcel Dekker, N.Y.
9. Design and Analysis of Experiments, M .N. Das and N.C. Giri, Wiley Eastern, N. Delhi
10. Empirical Model Building and Response Surface, E.E.P. box and N.R. Draper, J. Wiley, N.Y.
11. Response Surface Methodology Process and Product Optimisation Using Designed Experiments, R.H. Myers and D.C. Montgomery
12. Response Surface Designs and Analysis, A.I. Khuri and J.A. Cornel, Marcel Dekker, N.Y.
13. Introduction to Quality Engineering, G. Taguchi, APO, UNIPUB, White Plains, N.Y.
14. Introduction to Off-line Quality Control, G. Taguchi, Central Japan Quality Control Association, Nagoya, Japan.
15. System of Experimental Designs Engineering Methods to Optimise Quality and Minimise Cost, UNIPUB/Kraus International, White Plains, N.Y.
16. Experiments with Mixtures –Design, Model and the Analysis of Mixture Data, J.A. Cornell, J. Wiley, N.Y.

RELIABILITY - II

1. Optimisation of System Reliability :

Optimal spare part allocation, Generalized Kette's algorithm, Optimisation of system reliability with redundancy through dynamic programming.

2. Bayesian life Test Acceptance Sampling Plan.

Problem of optimal design of plan under Bayesian consideration, turncation of number of failure and cost model based on cost of sampling, testing and decision of acceptance and rejection, sign regular function and monotone plan, posterior risk and minimisation of expected regret.

3. Markov Models for System Reliability:

(i) Non-Repairable System:

Single element-non repairable, two element-non-repairable system; solution through Laplace transform. Poisson process, Stand-by system.

(ii) Repairable System:

Reliability and availability function of one and two components system, up-time and down-time ratio, steady state probabilities, n equipment

and r repairmen ($r = n$ and $r < n$). Analysis of parallel and stand-by redundant configuration. Maintainability; Maintainability increment, Methods of achieving optimum maintainability, Availability in stand-by system. Practical considerations for maintenance management.

4. Coherent System and its Structural Properties :

Components and systems with independent components, coherent system, path sets and cut sets, reliability of coherent system, bounds on system reliability, Relative importance of components, Modular decomposition of coherent system and improved bounds for system reliability. Concept of associated random variables.

5. Fault Tree Analysis:

Event tree, simple fault tree and its construction, Mathematics of FTA, Efficiency of FTA formats, FTA, Event space method, Monte-Carlo technique, Min-cut set algorithm, FMEA, Carrying out FMEA with practical example.

References:

1. Theory of Reliability & life Testing, Probability models, R.E. Barlow and F. Proschan ,Holt, Riehort and Winston, N.Y.
2. Practical Method for Reliability Data Analysis, J.I. Ansell and M.J. Phillips, Clarendon, Oxford.
3. Repairable System Reliability , H. Ascher and H. Feingold, Marcel Dekker, N.Y.
4. Introduction to Reliability Analysis, S. Zacks, Springe Verlag, N.Y.
5. Statistical Reliability Theory, I.B. Gerstbakh, Marcel Dekker, N.Y.
6. Mathematical Methods of Reliability Theory, B.V. Gnedenko, B.V. Belyayev, K. Yu and A.D. Solovyev, Academic Press, N.Y.
7. Reliability Engineering and Risk Assessment, E.J. Henly and H. Kumamoto, Prentice Hall, N.Y.
8. Bayesian Reliability Analysis, H.F. Martzad, R.A. Waller, John Wiley, N.Y.
9. Reliability and Risk Analysis, N.J. McCormick, Academic Press, N.Y.
10. Stochastic Methods on Reliability Theory, N. Ravichandran, Wiley Eastern, N. Delhi
11. Reliability and Life Testing, S.K. Sinha, Wiley Eastern, N. Del

APPLIED STOCHASTIC PROCESSES

1. Introduction to ASP (2)

2. Types of Stochastic Process

Simple random walk and some extensions like, random walk with absorbing/reflecting barriers; A review of discrete time Markov chains, continuous time Markov Chains, Branching Process, Birth and Death process with industrial orientation; Poisson Processes, waiting time distribution and applications; Renewal Process, renewal equation, renewal theorem, Delayed and equilibrium renewal process, excess life distribution

3. Applications of SP (8)

Application to Dam, Replacement and other models

References:

1. Stochastic Process - S.Ross
2. First course in Stochastic Processes - S. Karlin & H. Taylor
3. Elements of Applied stochastic process, 2nd ed., - U.N. Bhatt.
4. Elements of Stochastic processes with applications to National Sciences - T.J. Bailey
5. Theory of Stochastic process - D.R. Cox & H.D. Miller
6. Stochastic process - E. Parzen
7. Stochastic process - N.U. Prabhu
8. Introduction to Stochastic Processes - E. Cinlar
9. Elements of the theory of Markov Processes and their applications - A.T. Bharucha
10. Introduction of Probability Theory and applications. Vol.I-W.Feller.

ADVANCED STATISTICAL METHODS

1. Multivariate Normal Distribution (7)

Multivariate Normal Distribution Functions, Conditional Distribution and its relation to regression model, Estimation of parameters.

2. Multiple Linear Regression Model (16)

Standard multiple regression models with emphasis on detection of collinearity, outliers, non-normality and autocorrelation, Validation of model assumptions.

3. Multivariate Regression (6)

Assumptions of Multivariate Regression Models, Parameter estimation, Multivariate Analysis of variance and covariance.

4. Discriminant Analysis (10)

Statistical background, Linear discriminant function analysis, Estimating linear discriminant functions and their properties.

5. Principal Component Analysis (6)

Principal components, Algorithm for conducting principal component analysis, Deciding on how many principal components to retain, H-plot.

6. Factor Analysis (5)

Factor analysis model, Extracting common factors, Determining number of factors, Transformation of factor analysis solutions, Factor scores.

7. Cluster Analysis (5)

Introduction, Types of clustering, Correlations and distances, clustering by partitioning methods, hierarchical clustering, overlapping clustering.

References:

1. An Introduction to Multivariate Statistical Analysis, T.W. Anderson, John Wiley, N.Y.
2. Applied Multivariate Data Analysis, Vol I & II, J.D. Jobson, Springer-Verlag, N.Y.
3. Statistical Tests for Multivariate Analysis, H. Kris, Springer-Verlag, Heidelberg.
4. Regression Diagnostics , Identifying Influential Data and Sources of Collinearity, D.A. Belsey, E. Kuh and R.E. Welsch
5. Residuals and Influence in Regression, R. Dennis Cook and S. Weisberg, Chapman & Hall. N.Y.
6. Applied Linear Regression Models, J. Neter, W. Wasserman and M.H. Kutner, Homewood, Illinois.
7. The Foundations of Factor Analysis, A.S. Mulaik, McGraw Hill, N.Y.
8. Introduction to Linear Regression Analysis, D.C. Montgomery and E.A. Peck, John Wiley, N.Y.
9. Cluster analysis for Applications, M.R. Anderberg, Academic Press, N.Y.
10. Cluster Analysis, B. Everitt, Halsted, N.Y.
11. Multivariate Statistical Analysis, D.F. Morrison, McGraw Hill, N.Y.
12. Introduction to Multivariate Analysis, G.H. Dunteman, Sage, London.

ADVANCED OPTIMISATION

1. Linear Programming: (15)

Computational Complexity of the simplex algorithm. Khachyan's Ellipsoid Algorithm Karmarkar's projective algorithm.

2. Non-Linear Programming: (20)

Kuhn-Tucker Theory, Unconstrained Optimisation: Line Search, Multi dimensional search and an outline of method of Hooke and Jeeves, Method of Rosenbrock, Method of steepest descent and method of Conjugate directions.

Methods of Feasible Direction: Method of Zoutendijk, Gradient Projection method of Rosen, Method of reduced gradient and the Convex Simplex method of Zangwill.

Penalty and Barrier function methods.

3. Goal Programming and Multicriteria Decision Making: (13)

Multicriteria decision. Multicriteria decision making models, Determination of set of feasible alternatives, Solution Techniques, Multicriteria simplex method.

Modeling Multiple objective problems, Goal programming approach. Goal programming models. Ranking and Weighting of multiple goals. Simplex method in goal programming. Post optimality analysis, Computer based goal programming. Applications.

4. Stochastic programming: (12)

Stochastic programming with one objective function. Stochastic linear programming. Two stage programming technique. Chance constrained programming technique, Stochastic dynamic programming.

References:

1. Linear Programming & Network flows : MS Bazaraa, J J Jarvis and H D Sherali, John Wiley.
2. Non Linear Programming; Theory and Algorithms - M.S. Bazaraa and C.M. Shetty, John Wiley.
3. Mathematical Programming Techniques - N.S. Kambo, Affiliated East-West Press.
4. Advanced Linear Programming - B.A. Murtagh, McGraw Hill.
5. Practical Method of Optimisation, Vol I and II, R. Fletcher, John Wiley.
6. Conflicting objectives in Decisions- D.E. Bell, R.L. Keenev and H. Raiffa (Eds.), John Wiley.
7. Multiple criteria Decision Making - M. Zeleny (ED.) Springer Verlag, N.Y.
8. Goal Programming For Decision Analysis - S.M. Lee. Auerback Publishers Inc., Philadelphia. (19720.
9. Goal programming and extensions - J.P. Ignizio, Laxington Books, Laxington, Massachusetts.
10. Stochastic Programming With Multiple Objective Functions - I.M. Stancu-Minasian, D. Reidel Publishing Company, Boston

SOFTWARE ENGINEERING

1. Software Engineering Concepts :

Introduction: Software project planning (basic concepts of life cycle model, milestone, cost models, successive version model, project structure, team structures), Requirements Analysis (Specifications, Algebraic axioms, Regular expressions, Decision tables, Event tables, Transition Tables, FS mechanism, Petri Nets), Software Design- Architectural and detailed Design (Abstraction, Information hiding, Modularity, Concurrency etc., coupling and cohesion, data flow diagrams, structure charts, Pseudo code, stepwise refinement, top-down and bottom-up programming etc.); test plan, Implementation issues (structured coding, recursion, documentation guidelines), modern programming language features (type less, Strong type and pseudo strong type checking, user-defined data types, data encapsulation, generic facilities, concurrency mechanism), program verification and validation (Unit testing, integration testing , acceptance testing, formal verification), Software maintenance (Source code metrics-halstead's effort equation, cyclomatic metric), Reliability and software assurance, software quality assurance, Software cost estimation (Delphi, COCOMO etc.)

2. Projects -Team-based term project.

- Three lectures and one two-hour tutorial per week.
- 50% for theory and 50% for project
- The project will be done in a group of 4 to 5.

Reference:

1. Software Engineering concepts, -R. Fairly :
2. An Integrated Approach to Software Engineering -P. Jalote
3. Software Engineering-A Practitioner's Approach, R.S. Pressman

DATA BASE MANAGEMENT SYSTEMS

1. Introduction :

Purpose of Database systems, Data abstraction and Modelling, Instances and schemes, Database manager, Database users and their interactions, Data Definition and manipulation language, Data Dictionary, Overall system structure

2. Entity relationship model :

Entities and entity sets, Relationship and relationship sets, Mapping constraints, E-R diagram, Primary keys, Strong and weak entities, Reducing E-R diagram to tables, trees or graphs, Generalization and Specialization, Aggregation, E-R language.

3. Files and Data-structure Revisited :

Sequential file organization, buffer management, mapping tables, trees or graphs to files, ISAM file, Use of B-tree for indexing, Hashing and Hash functions.

4. Relational Model

Structure of relational database, operations on relation Relational Algebra, Tuple

And Domain relational calculus, Sailable features of query language.

5. Hierarchical Model:

Information Management System (IMS), Database description and tree-structure diagram, DL/I language, data retrieval and update facility, Limitations of hierarchical systems, Virtual records.

6. Net Work Model:

Database task group (DBTG) model, Data-structure diagram, Record and Set constructs, Record retrieval and update facility, Set processing facility, Example of an actual network database implementation (DMS), Importance of network database.

7. Normalization in Relational System:

Pitfalls in RDBMs, Importance of normalization, Functional, multivalued and join dependencies, 1NF to 5NF, Limitations of RDBMS.

8. Description of an actual RDBMS and its Query language:

Involves extensive practice in computer centre to get an idea of an actual implementation.

9. Query Optimization:

Importance of query processing, Equivalence of queries, Cost estimation for processing a query, general strategies, bi-relational and multi-relational join algorithms, algebraic manipulations

10. Failure and Crash recovery in DBMS:

Failure classification, transactions, Long maintenance, check point implementation, Shadow paging, example of an actual implementation.

11. Security and Integrity:

Security and Integrity violations and constraints, Authorization and views, Encryption, Example of an actual implementation.

12. Special Topics:

Structure of a database machine, Distributed database, Present trends in Database technology.

- ❖ Three lecture and one two-hour tutorial per work
- ❖ 60% for theory and 40% for programming assignments
- ❖ Two to three assignments are to be given

References:

1. Database System Concepts,- H.F. Korth and S. Silberschatz :
2. Principles of Database System - J.D. Ullman
3. Introduction to Database System - C.L. Date
4. Fundamentals of Database System - Elmasri & Navthe :

ADVANCED RELIABILITY

1. Class of Life Distributions Based on Notions of Ageing :

Ageing properties. Families of probability distributions based on ageing properties: IFR, IFRA, NBU, NBUE, DMRI and HNBUE properties (and their

duals), interrelation among them; Closure under reliability operations of formation of coherent systems, mixtures and convolutions. Reliability bounds.

2. **Dependent components and their distributions :**

Bivariate exponential distribution and its properties. Fatal and non-fatal shock models and Bivariate exponential distribution derived from them.

3. **Maintenance and Replacement models :**

Block, age and random replacement policies, class of life distributions in replacement; NBU, NWU, NBUE, NWUE and their properties and relevant shockmodels. Renewal theory for replacement models.

4. **Mixture Distribution**

Mixture Distribution and Competing risk Mixtures of exponential, mixtures of Weibull, Competing risks.

5. **Reliability Growth Models**

NHPP reliability growth models, Alternative models.

6. **Probabilistic Modelling of Repairable Systems :**

Basic concepts for stochastic point process, Inter-arrival times between successive failures, ROCOF, Estimating Avg. ROCOF, ROCOF for stationary, transient and non-stationary point processes, Statistical analysis of part and system failure data, Trend testing, Plot of cumulative failure vs. cumulative time, Statistical tests, Homogeneous Poisson Process (HPP), Non homogeneous Poisson Process (NHPP), Renewal Process (RP), Superimposed Renewal Process (SRP) Branching Poisson Process (BPP)

References:

1. Renewal Theory, D.R. Cox, Methuen, London
2. Repairable System Reliability, H. Ascher and H. Feingold, Marcel Dekker, N.Y.
3. Practical Methods for Reliability Data Analysis, J.I. Ansell and M.J. Phillips, Clarendon, Oxford
4. Statistical Analysis of Reliability Data, M.J. Crowder, A.C. Kimber, R.L. Smith and T.J. Sweeting, Chapman and Hall, London.
5. Reliability Analysis for Complex Repairable System (L.H. Crow) in Reliability and Biometry (eds), F. Proschams and R.J. Serfling, SIAM, Philadelphia.

GAME THEORY AND DECISIONS

1. Games Types : (29)

Games in extensive form-normal form-coalitional form (3 hours); two person zero sum games Minimax throrem-Linear programming formulation (8 hours);Infinite games-games on unit square-duels-multistage games-stochastic games (4 hours); Bimatrix games-LCP formulation-Lemke's algorithm for solving bimatrix (6 hours); N-person games-core shapley (8 hours).

2. Elements of Decision Theory : (20-24) [16-20 hours]

- i. Randomization, Optimality, Bayes rules, Minimax rules Admissible rules, Invariance and sufficiency, Complete class and essential complete class of rules.
- ii. Minimax rules.
- iii. Complete class theorem.
- iv. Results on admissibility
- v. Elements of Multicriteria decision methods

References :

1. Game Theory - Guillermo Owen, Academic Press.
2. Games and Decisions-Introduction and Critical Survey - R.D. Luce and H. Raiffa, Chapman and Hall, London
3. Game Theory for Economists - Jurgen Eichberger, Academic Press.
4. Mathematical Statistics - T.S. Ferguson, Academic Press.
5. Statistical Decision Theory - James O. Berger, Springer Verlag.
6. Decision with Multiple Objective - R.Keeney and H. Raiffa, John Wiley.