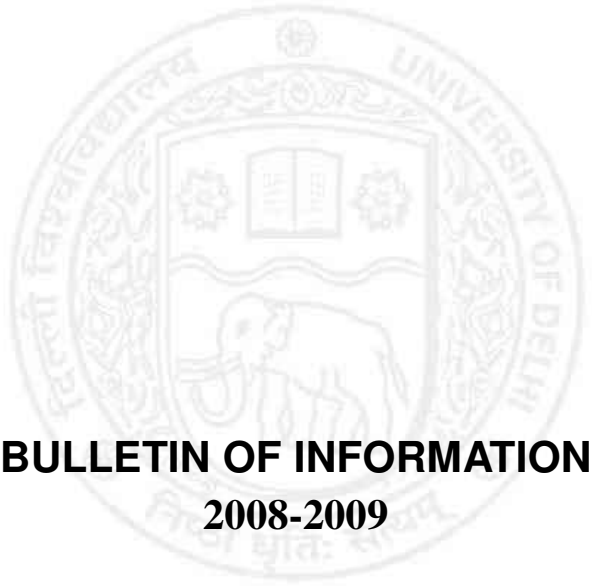
# UNIVERSITY OF DELHI
## DEPARTMENT OF OPERATIONAL RESEARCH

- **M.Sc. Operational Research**

- **M.A./ M.Sc. Applied Operational Research**
  **(SOUTH CAMPUS)**



# BULLETIN OF INFORMATION
## 2008-2009

**Prof. (Ms.) Manju Lata Agarwal**
Head of the Department

**Faculty Members**

| | |
|---|---|
| Dr. P.K. Kapur | Professor |
| Dr. (Mrs.) Davinder Bhatia | Professor |
| Dr. Chandra K. Jaggi | Reader |
| Dr. (Mrs.) Preeti Wanti Srivastava | Reader |
| Dr. Prakash C. Jha | Reader |
| Dr. Pankaj Gupta | Reader |
| Dr. K. K. Aggarwal | Lecturer |
| Dr. Ompal Singh | Lecturer |
| Dr. (Mrs.) Anu Gupta Aggarwal | Lecturer |
| Dr. A. K. Bardhan **(South Campus)** | Sr. Lecturer **(On lien upto June 28, 2008)** |

**Administrative Staff**

| | |
|---|---|
| Mrs. Seema Chauhan | Stenographer |
| Mr. Sehdev | Office Attendant |

**Technical Staff**

| | |
|---|---|
| Mr. Jaipal Singh | Lab Assistant |
| Ms. Aikta Bhatia | Sr. Technical Assistant |
| Mr. Sushil Kumar | Data Entry Operator |
| Mr. Tejvir Singh | Lab Attendant |

## INDEX

**M.Sc. Operational Research and M.A. / M.Sc. Applied Operational Research**

***Schedule of Admission***

| | | |
|---|---|---|
| 1 | (a) Starting date of obtaining Application Forms for the Common Entrance Test | **7th January, 2008**<br>**From the Department office on working days (Monday-Friday), 10:00AM-1:00PM** |
| | (b) Last date for receipt of completed Application Forms | **15th February, 2008**<br>**On working days (Monday-Friday)**<br>**10:00AM-1:00PM** |
| 2 | Dispatch of Admit Cards by Post | **22nd February, 2008** |
| 3 | Date of Common Entrance Test | **Sunday, 16th March, 2008** |
| 4 | Declaration of result of Common Entrance Test | **30th March, 2008*** |
| 5 | Group Discussions and Interviews | **Ist week of June, 2008*** |
| 6 | Admission List | **IInd week of June, 2008*** |

*Tentative Dates

***Notes:*** (1) The list of candidates selected for interview will be notified in the Department of Operational Research and on the Website (www.du.ac.in). It is, therefore, the responsibility of the candidates to contact the Department personally.

(2) The Common Entrance Test will be conducted at University of Delhi only.

## *I. Introduction*

University of Delhi, established in 1922, is the premier University of the country and is known for its high standards in teaching and research and attracts eminent scholars to its faculty.

Part of University of Delhi, the Department of **Operational Research (OR)** is the only of its kind in India. Its philosophy in both teaching and research is to combine intellectual rigour with a strong emphasis on practical applications. It has an international reputation for developing both quantitative and qualitative modeling methods. The alumni of the department hold important positions in the best of Indian as well as multinational companies.

**Operational Research** as a subject was introduced in the University of Delhi in 1963 with the introduction of a two year Post Graduate programme. A decade later the Department of Operational Research was independently set up under the Faculty of Mathematical Sciences. It is the first Department to start a Post Graduate programme of Operational Research in India.

In 1994, the Department also introduced Post Graduate programme in **Applied Operational Research (AOR)** at South Campus. Besides these courses, the Department also offers **M.Phil** and **Doctorate** programmes.

OR is the discipline of applying advanced analytical methods to help make better decisions, by using techniques such as mathematical modeling to analyze complex situations. It gives executives the power to make more effective decisions and build more productive systems.

OR has firmly embedded itself in a wide range of sectors, including manufacturing, transport, retailing, marketing, the financial and service sectors, defense, revenue management, consultancy, supply chain management, engineering etc..It also addresses a wide variety of issues in communication systems, computer operations, design and networking, inventory planning, manufacturing, distribution and many other topics that aim to improve business productivity.

World over many companies (IBM, AMR Corp. parent company of American Airlines, Proctor & Gamble, Hewlett Packard Corp., Merrill Lynch and Company, Taco Bell Corp., British Airways) are making extensive use of Operational Research techniques and have dedicated OR groups working for them. In India too, many companies like TISCO, Reliance Petrochemicals, JK Tyres, Hindustan Levers Limited, Asian Paints, GE Capital, Inductis, Progeon, Skytech Solutions etc. are applying OR for increasing their productivity gains.

The overall aim of the M.Sc. OR and M.A. /M.Sc AOR programmes is to produce good analysts who will be in high demand from OR groups in business, government and management consulting companies. This means that in addition to acquiring skills in formal techniques of OR, students learn to apply theories and concepts in a creative and practical way. They also develop the intellectual and personal skills needed to work on complex issues in an organization often as a part of team. The programme places heavy

emphasis on practical experiences for which extensive interaction with the industry is built into the curriculum. The final year students are required to engage themselves in industry oriented projects as a part of their regular course work. Students spend a lot of time working within an established **OR** (or related) group, gaining preliminary experience of how analysis is carried out in an organizational setting and submit their findings in the form of a project report for evaluation.

## *II. Courses Offered*

### M.Sc. Operational Research at University of Delhi, North Campus

M.Sc. Operational Research is a two-year post graduate course. The number of seats in this course is 60 (including all reservations)**.** This course includes a number of techniques of Operational Research: Linear, Nonlinear, Parametric and Network Optimization, Queueing, Inventory, Reliability, Marketing, Quality Control etc.. The curriculum emphasizes on formulation of OR models and algorithms. Students are encouraged to develop skills in setting up and analyzing Operational Research models. The course demonstrates factors and restrictions involved in building and using models for planning and management problems. Case studies, Projects and use of OR software are constituents of the course.

### M.A. / M.Sc. Applied Operational Research at University of Delhi, South Campus

M.A. / M.Sc. Applied Operational Research is a two-year post graduate course. The number of seats in this course is 30 (including all reservations)**.** This course was started in the year 1994. The curriculum lays heavy emphasis on experimental and process-oriented learning. The pedagogical tools include the use of case studies and industry oriented project work. Besides building up skills of individual decision making, lot of emphasis is laid on developing team skills and value focused decision making.

### M.Phil and Doctor of Philosophy (Ph.D) Programmes

The Department has strong research interest in different subject areas of OR and offers M.Phil and Doctor of Philosophy (Ph.D) programmes aimed at producing quality researchers.

## *III. Eligibility Conditions for Admission to M.Sc. Part-I in Operational Research and M.A. /M.Sc. Part-I in Applied Operational Research, 2008-2009*

| Examination passed | Percentage Required |
|---|---|
| (a) Any Master's Degree examination of the University of Delhi or an examination recognized as equivalent thereto with atleast two papers in Mathematics/ Computer Science/ Statistics/ Operational Research at graduation/ higher level. | 55% marks in aggregate |
| OR | |
| Any Bachelor's Degree examination under 10+2+3 scheme of examination of the University of Delhi or an examination recognized as equivalent thereto with atleast two papers in Mathematics/ Computer Science/ Operational Research/ Statistics. | 55% marks in aggregate |

**Note :**

1. The candidates who are appearing in the final year examination of the degree on the basis of which admission is sought are also eligible to apply.
2. Applicants who have graduated under 10+2+3 scheme or an equivalent scheme are eligible for admission.
3. Relaxation of 5% marks in the minimum eligibility conditions will also be allowed to candidates belonging to all the reserved categories.

## *IV. Age Requirement*

(i) No person shall be eligible for admissions to M.Sc. Part-I in Operational Research Course and M.A./ M.Sc. Part-I in Applied Operational Research Course in the University unless he / she is twenty years of age before the first day of October, 2008.

(ii) The Vice-Chancellor may relax the age limit up to the extent of one year on individual merit after a written request is made by the candidate.

## *V. Reservations*

(a) 15 % and 7½ % of total number of seats will be reserved for Scheduled Caste and Scheduled Tribe candidates respectively, subject to production of certificate as mentioned in VI(a).

(b) (i)5 % of the total number of seats will be reserved for the Children or Widows/ Wives of Officers and Men of the Armed Forces including Para Military Personnel killed or disabled in action.

(ii) The cases of the Wives/ Widows/ Children of Officers and Men of the Armed Forces including Para-Military Personnel who died/ were disabled while on duty will be considered for admission if any seat remains vacant after admission of persons mentioned above in category (i). Above reservation is subject to production of certificate as mentioned in VI (b).

(c) 3 % of seats will be reserved for the physically handicapped candidates, subject to production of a certificate as mentioned in VI (c).

(d) 5% of total number of seats will be reserved for admissions under Sports Category. Students seeking admission under the Sports Category shall apply directly to the Delhi University Sports Council.

In case sufficient numbers of eligible candidates mentioned at (a), (b), (c) and (d) above are not available, the vacancies will be treated as unreserved in the respective categories.

(e) Foreign students seeking admission in the Department and satisfying the eligibility criteria are required to apply directly to the Foreign Students' Advisor, Foreign Students Registry, c/o Faculty of Management Studies, University of Delhi, Delhi-110007 (India). No foreign student will be admitted directly by the Department. Foreign students studying in Indian Universities are required to appear in the Common Entrance Test. For foreign students there would be 5% additional seats over and above the sanctioned number of seats in both the Courses. Fee would be charged as per University rules.

**Note :** Reservation of Other Backward Classes (OBC) candidates as per the Government of India directives is currently being processed by the University. Percentage/number of seats and modalities of such reservation will be notified separately in due course.

***VI. Certificate Required for Reserved Categories:***

A candidate applying for any reserved seat as mentioned above in paragraph (a), (b) or (c) should submit the following certificate as the case may be:

**(a) SC/ST Certificate :** For admission to a seat reserved for Scheduled Castes/ Scheduled Tribes, attested copy of certificate should be submitted from an approved district authority stating the Scheduled Caste/Tribe to which the candidate belongs. A list of approved authorities is given below:

(i) District Magistrate/ Additional District Magistrate/ Collector/ Deputy Collector/ Deputy Commissioner/Additional Deputy Commissioner/ Ist Class Stipendiary Magistrate/City Magistrate, not below the rank of 1st Class Stipendiary Magistrate / Sub- Divisional Magistrate/ Taluka Magistrate/ Executive Magistrate/ Extra Assistant Commissioner.

(ii) Chief Presidency Magistrate/Additional Chief Presidency Magistrate/ Presidency Magistrate.

(iii) Revenue Officer not below the rank of Tehsildar.

(iv) Sub Divisional Officer of the area where the candidate and / or his/ her family resides.

(v) Administrator / Secretary to Administration / Development Officer (Lacadive and Minicoy Islands).

**(b)** **Entitlement Card/ Certificate:** The Children or Widows/ Wives of Officers and Men of the Armed Forces including Para Military Personnel killed or disabled in action, Wives/ Widows/ Children of Officers and Men of the Armed Forces including Para Military personnel who died/were disabled while on duty will be required to provide attested photocopy of Entitlement Card/ Certificate from the competent authority.

**(c)** **Certificate for Handicapped Candidates:** For admission to a seat reserved for handicapped candidate, the candidates should submit a medical certificate from competent medical authorities along with their application form for Entrance Examination. However, the admission of the physically handicapped candidates shall be subject to their medical examination and appropriate recommendations of the Chief Medical Officer, WUS Health Centre, University of Delhi (Main Campus). The recommendations of the above mentioned authority shall be final for all purposes.

However, the original certificate as mentioned above in (a), (b) and (c) would be required to be produced for verification at the time of admission.

## *VII. Admission Procedure*

### (a) Entrance Test fee

As the Eligibility Conditions are same for admission to both the Courses M.Sc. Operational Research Part-I at North Campus and M.A./M.Sc. Applied Operational Research Part-I at South Campus, the candidates may opt for admission to both the Courses. Accordingly, the Common Entrance Test fee would be as follows :

| Course Name | Entrance Test Fee | |
|---|---|---|
| | General Category | Scheduled Caste/ Scheduled Tribe Category |
| M.Sc. Operational Research and/or M.A./ M.Sc. Applied Operational Research | Rs. 600/- | Rs. 300/- |

**(b) Mode of Payment**

Payment should be made by crossed Bank Draft in favour of **"Registrar, University of Delhi"** payable at State Bank of India, New Delhi.

For obtaining the bulletin and application form by post, the Bank Draft only alongwith a self-addressed stamped (worth Rs.30/-) envelope (size 10''x7'') should be sent to the

**Office Incharge**
**Room No. 215**
**Department of Operational Research**
**II$^{nd}$ Floor, New Academic Block**
**University of Delhi**
**Delhi – 110007.**

The Department will not be responsible for any postal loss/ delay.

**(c) Common Entrance Test**

It will consist of written test, group discussion and interview.

(i) **Written Test** (80%) :

It will be of 3 hrs. duration with multiple choice questions. There will be negative marking for every wrong answer. It will consist of two parts :

**Part-I : General Aptitude** (20%) **:** General English, Comprehension, Logic, Analytical ability and Reasoning.

**Part-II :Quantitative Aptitude** (60%)**:** Questions from Mathematics, Statistics, Operational Research and Computer Science.

(ii) **Group Discussion** (10%)

(iii) **Interview** (10%)

Based on the performance in written test, a consolidated merit list consisting of 3 times of the number of seats available for admission in each course would be prepared for group discussion and interview.

**Note:** In all cases the decision of the Mathematical Sciences Courses Admission Committee will be final and binding on the candidates.

**(d)** ***Admission Ticket***

The Admission Tickets will be issued by post only. In case of non-receipt of the Admission Ticket, a request may be made to the Department with two copies of photograph and Serial Number of Application Form, not earlier than three days before the date of the Common Entrance Test date, for issue of a Duplicate Admission Ticket. The candidate will be required to show the Admission Ticket at the time of the test. No candidate will be admitted to the Examination Hall without the Admission Ticket.

## *VIII. List of Colleges offering M.Sc. Course in OR ,North Campus*

1. Hindu College
2. Hans Raj College
3. Indraprastha College (for Women)
4. Kirori Mal College
5. Ramjas College
6. St. Stephen's College

## *M.A./M.Sc. Course Offered in AOR*

***South Delhi Campus***

## *IX. Course Structure of the M.Sc. Operational Research Programme*

### Part-I Examination

| | | Duration Hours | Maximum Marks |
|---|---|---|---|
| **Course - I** | Basic Mathematics<br>(i) Numerical Analysis<br>(ii) Linear Algebra<br>(iii) Mathematical Analysis | 3 | 100 |
| **Course - II** | Statistical Methods | 3 | 100 |
| **Course – III** | Object Oriented Programming | | |
| | (a) Theory | 3 | 60 |
| | (b) Practical | 4 | 40 |
| **Course – IV** | Linear Programming | 3 | 100 |
| **Course – V** | Inventory Management | 3 | 100 |
| **Course – VI** | Queueing Theory | 3 | 100 |
| **Course – VII** | Theory of Reliability | 3 | 100 |
| **Course – VIII** | Nonlinear and Dynamic Programming | 3 | 100 |
| **Course – IX** | Marketing Management | 3 | 100 |
| **Course – X** | Network Analysis and Theory of Sequencing | 3 | 100 |

### Part-II Examination

| | | Duration Hours | Maximum Marks |
|---|---|---|---|
| **Course – XI** | Database Management System and Java Programming | | |
| | (a) Theory | 3 | 50 |
| | (b) Practical | 4 | 50 |
| **Course – XII** | Applied Statistics | 3 | 100 |
| **Course – XIII** | Mathematical Programming | 3 | 100 |

| | | | |
|---|---|---|---|
| **Course – XIV** | Financial Management | 3 | 100 |

**Course – XV to XVIII Optionals (Any four of the following)**

| | | | |
|---|---|---|---|
| (i) | Advanced Mathematical Programming | 3 | 100 |
| (ii) | Advanced Inventory Management | 3 | 100 |
| (iii) | Advanced Queueing Theory | 3 | 100 |
| (iv) | Control Theory | 3 | 100 |
| (v) | Advanced Dynamic Programming | 3 | 100 |
| (vi) | Queueing Networks | 3 | 100 |
| (vii) | Theory of Games | 3 | 100 |
| (viii) | Decision Theory | 3 | 100 |
| (ix) | Software Reliability | 3 | 100 |
| (x) | Portfolio Management | 3 | 100 |
| (xi) | Marketing Research | 3 | 100 |
| (xii) | Management Information and Decision Support Systems | 3 | 100 |

**Course – XIX** Project Work-

The project work will start in the beginning of M.Sc. Operational Research Part-II under approved supervisors from amongst the members of the faculty and the report is to be submitted for evaluation by 31st March. It will carry 200 marks.

| | |
|---|---|
| Project Report | 100 marks |
| Viva-voce | 50 marks |
| Internal Assessment | 50 marks |

**Note :** Course III (b) Practical, will be of four hours duration carrying 40 marks out of which 10 marks will be reserved for class records and 10 marks for oral test.

Course XI (b) Practical, will be of four hours duration carrying 50 marks out of which 10 marks will be reserved for class records and 10 marks for oral test.

**<u>Lectures & Internal Assessment</u>**

1. Attendance at lectures and practicals will be compulsory according to the existing provision of the University.

2. 25% of total marks in each course will be awarded for internal assessment on a continual basis; based on tutorial work/ class presentation/ mid-term examination, or a combination of the same; subject to the modalities worked out by the Department/ University. The internal assessment marks will be shown, separately in the Mark Sheet issued by the University and these marks shall be added to the Annual Examination Marks for determining the division of the student.

***Course Structure of the M.A./ M.Sc Applied Operational Research Programme***

**Part-I Examination**

| | | | Duration Hours | Maximum Marks |
|---|---|---|---|---|
| **Course – I** | **:** | Computer Programming and Numerical Methods | | |
| | | (a) Computer Programming | | 40 |
| | | (b) Numerical Methods | 3 | 40 |
| | | (c) Minor project using (a) | | 20 |
| **Course – II** | **:** | Statistical Methods | 3 | 100 |
| **Course – III** | **:** | Linear Programming | 3 | 100 |
| **Course – IV** | **:** | Inventory Management | 3 | 100 |
| **Course – V** | **:** | Queueing and Simulation | 3 | 100 |
| **Course – VI** | **:** | Marketing Management | 3 | 100 |
| **Course – VII** | **:** | Database Management System and Visual Programming | | |
| | | (a) Theory | 3 | 60 |
| | | (b) Practical | 4 | 40 |
| **Course – VIII** | **:** | Industrial Statistics | 3 | 100 |

**Part-II Examination**

| | | | Duration Hours | Maximum Marks |
|---|---|---|---|---|
| Course – IX | : | Network Analysis and Theory of Sequencing | 3 | 100 |
| **Course – X** | **:** | Theory of Reliability and Maintenance | 3 | 100 |
| **Course – XI** | **:** | Mathematical Programming | 3 | 100 |
| **Course – XII** | **:** | Software Engineering | 3 | 100 |

**Course - XIII and XIV : Optionals (Any two of the following)**

| | | | |
|---|---|---|---|
| (i) | Advanced Mathematical Programming | 3 | 100 |
| (ii) | Applied Queueing Systems | 3 | 100 |
| (iii) | Advanced Inventory Management | 3 | 100 |
| (iv) | Applied Reliability Methods | 3 | 100 |
| (v) | Marketing Research | 3 | 100 |
| (vi) | Financial Management | 3 | 100 |
| (vii) | Theory of Control | 3 | 100 |
| (viii) | WEB Programming using JAVA | | |
| | (a) Theory | 3 | 60 |
| | (b) Practical | 4 | 40 |
| (ix) | Data Warehousing and Data Mining | 3 | 100 |

**Course- XV : Industrial and Project Work** **200**

The work will start in the beginning of M.A./ M.Sc. Part-II under approved supervisors from amongst the members of the staff and the report is to be submitted for evaluation by March 31. It will carry 200 marks.

| | | |
|---|---|---|
| Project Report | : | 100 Marks |
| Viva-voce | : | 50 Marks |
| Internal Assessment | : | 50 Marks |

**Note:** (a) The students have to secure 50% marks in each course.
(b) In courses having minor project/ practical, students have to secure 50% marks separately in minor project/practical.
(c) In Course-VII Part-(b), Course- XIII and XIV(viii) Part-(b),10 marks are reserved for class record and 10 marks for viva-voce.
(d) In Course-I (C), 10 marks are reserved for project report and 10 marks for viva-voce.

**Lectures & Internal Assessment**

1. Attendance at lectures and practicals will be compulsory according to the existing provision of the University.

2. 25% of total marks in each course will be awarded for internal assessment on a continual basis; based on tutorial work/ class presentation/ mid-term examination, or a combination of the same; subject to the modalities worked out by the Department/ University. The internal assessment marks will be shown, separately in the Mark Sheet issued by the University and these marks shall be added to the Annual Examination Marks for determining the division of the student.

## *X. Infrastructure*

**Library:** Students have access to two main libraries, the Central Science Library and Mathematical Sciences Library. Both the libraries have a vast collection of resources on OR including over 50 journals and 10,000 books. The Central Science library also has an Internet Access Center to help students to consult online subject literature.

**Seminar Room:** The department has an ultra modern seminar room with seating capacity of 70 equipped with round table conference setup with the latest Audio-Visual teaching aids including an LCD Projector, visualizer and 20 microphone sets.

**Computer Lab :** The computer lab exclusively for OR students has over 30 systems (Pentium III & IV) with a switch based Local Area Network (LAN) operating under windows 2000 and Linux servers. The students can work on various platforms such as DOS, Linux, Windows 95, 98 and 2000 servers provided. The systems are supported by high speed Laser printers, scanners and CD writers. The lab is equipped with a variety of OR and statistical softwares such as SPSS 11.5, Mat Lab, Oracle 9i, Mini Tab, MAPPLE, QSB, MS Project, Hyper Lingo, MS Office, Visual Studio-6.0 and Turbo C++. Lab also has Internet connectivity through campus wide fiber optic network.

**Lecture Rooms:** The lecture rooms have seating capacity of 60 students and are equipped with the modern teaching aids like an LCD projector, visualizer, audio system. The internet facility is also available in all the lecture rooms to augment the teaching.

### *Infrastructure at University of Delhi South Campus*

**Computer Lab:** The computer lab exclusively for OR students has over 20 systems (Pentium IV) with a switch based Local Area Network (LAN) operating under windows 2000 and Linux servers. The lab is equipped with a variety of OR and statistical softwares such as SPSS 15.0, Hyper Lingo and Minitab. Lab also has Internet connectivity through campus wide fiber optic network.

## *XI. Departmental OR Society*

The Department has an active OR Society, a student elected body that regularly organizes various educational and cultural events. The society provides a platform for the students to interact with academicians and professionals from the industry. Workshops and seminars that are organized witness an active and enthusiastic participation of the students.

## *Placements*

The Placement Cell at the Department is headed by a Placement Coordinator. It assists the students in pursuing their career in the areas of their interest and facilitates their entry into the industry. In this work, student committees help the coordinator to maximize results of the efforts. The placement cell makes arrangements for organizations on the

campus recruitment. The campus recruitment programme ensures that all the students secure meaningful and challenging placement in keeping with the mission of the Department. A glance of the companies where our students have been placed in the past is as follows:

American Express Bank
Crane Software
GE Capital
Hewlett Packard Corp
India Bulls
Inductis
Market Rx
Absolute Data
Adventity
Mode Modellers
Progeon
Safe Express
Schneider Electric
SkyTech Corp.
Symphony Corp.
Cognizant
Dunn Humby

## *XII. Hostel Accommodation*

Limited hostel accommodation is available on the campus. Students should contact directly the following University Hostels for accommodation:

*For men:*

1. Gwyer Hall
2. P.G. Men's Hostel
3. Jubilee Hall
4. International Students House
5. Mansarovar Hostel
6. D.S. Kothari Hostel
7. V.K.R.V. Rao Hostel
8. Aravali P.G. Hostel (South Campus)
9. Saramati P.G. Hostel (South Campus)

*For women:*

1. University Hostel for women
2. Meghdoot Hostel
3. International Students House for Women
4. North East Students House
5. Ambedkar-Ganguli Students House for Women
6. Geetanjali Hostel (South Campus)

## *XIII.* *Syllabus for the Common Entrance Test*

### PART-I

This part is intended to test the candidate's vocabulary and analytical skills at a level essential for accurate comprehension and presentation of material appropriate for this degree. The language background expected will be of the level of English at Senior Secondary Examination. The paper will include passages for comprehension, test of vocabulary (synonyms and antonyms), elementary grammar and syntax.

The section on Analytical Ability and Reasoning will include standard questions on pattern recognition, logic, Venn diagrams etc. It is not intended to be subject-specific.

### PART-II

**Mathematics :**Vector Space, subspace and its properties, linear independence and dependence of vectors, matrices, rank of a matrix, reduction to normal forms, linear homogenous and non-homogenous equations, Cayley-Hamilton theorem, characteristic roots and vectors. De Moivre's theorem, relation between roots and coefficient of nth degree equation, solution to cubic and biquadratic equation, transformation of equations.

Calculus : Limit and continuity, differentiability of functions, successive differentiation, Leibnitz's theorem, partial differentiation, Euler's theorem on homogenous functions, tangents and normals, asymptotes, singular points, curve tracing, reduction formulae, integration and properties of definite integrals, quadrature, rectification of curves, volumes and surfaces of solids of revolution.

Differential Equations: Linear, homogenous, separable equations, first order higher degree equations, algebraic properties of solutions, linear homogenous equations with constant coefficients, solution of second order differential equations. Linear non-homogenous differential equations.

Real Analysis : Neighborhoods, open and closed sets, limit points and Bolzano Weiestrass theorem, continuous functions, sequences and their properties, limit superior and limit inferior of a sequence, infinite series and their convergence. Rolle's theorem, mean value theorem, Taylor's theorem, Taylor's series, Maclaurin's series, maxima amd minima, indeterminate forms.

**Statistics**

Measures of central tendency and dispersion and their properties, skewness and kurtosis, introduction to probability, theorems of total and compound probability, Bayes theorem, random variables, probability mass and density functions, mathematical expectation, moment generating functions, Binomial, Poisson, Geometric, Exponential and Normal distributions and their properties, method of least squares, correlation and regression, introduction to sampling, sampling distributions and tests of significance based on t, Chi-square and F-distributions.

**Operational Research**

Definition & scope of Operational Research, Formulation of simple Linear Programming Problems, Simplex method and basics of Duality.

Characteristics of Inventory System, Simple Economic Lot Size Inventory models, Reorder Level, Simple single period Stochastic Inventory Model.

Definition of Queues and their characteristics, Queueing Models with Markovian Input and Markovian Service, M/M/1 & M/M/C Queueing Models.

Definitions of Reliability, Availability, Reliability of multicomponent systems, failure time distributions: exponential and Weibull.

**Computer Science**

Flowcharts and algorithms, Number system : binary, octal, hexadecimal; Truth values, Logical operations, Logic functions and their evaluation.

Computer basics, Computer generations and classifications, Fundamentals of high level languages, Fundamentals of Operating System, C Programming Language.