JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech in GEOTECHNICAL ENGINEERING
Effective from Academic Year 2017- 18 admitted batch

COURSE STRUCTURE AND SYLLABUS

I Semester

Category	Course Title	Int. marks	Ext. marks	L	T	P	C
PC-1	Advanced Soil Mechanics	25	75	4	0	0	4
PC-2	Advanced Foundation Engineering	25	75	4	0	0	4
PC-3	Soil Dynamics and Machine Foundations	25	75	4	0	0	4
PE-1	Earth & Rockfill Dams Optimization Techniques Applied Statistics	25	75	**3**	0	0	3
PE-2	Soil - Structure Interaction Rock Mechanics and Engineering Physical Modeling in Geotechnical Engineering.	25	75	**3**	0	0	3
OE-1	***Open Elective – I**	25	75	3	0	0	3
Laboratory I	Advanced Geotechnical Engg. Lab-I	25	75	0	0	3	2
Seminar I	Seminar-I	100	0	0	0	3	2
Total		**275**	**525**	**21**	**0**	**6**	**25**

II Semester

Category	Course Title	Int. marks	Ext. marks	L	T	P	C
PC-4	Retaining Structures	25	75	4	0	0	4
PC-5	Geo-Environmental Engineering	25	75	4	0	0	4
PC-6	Ground Improvement Techniques	25	75	4	0	0	4
PE-3	Geotechnical Earthquake Engineering Design of Substructures Geotechnics for Infrastructure	25	75	**3**	0	0	3
PE4	Geosynthetics& Soil Reinforcement Material Characterization and Pavement Engineering. Offshore Geotechnical Engineering.	25	75	**3**	0	0	3
OE-2	***Open Elective – II**	25	75	3	0	0	3
Laboratory II	Advanced Geotechnical Engg. Lab-II	25	75	0	0	3	2
Seminar II	Seminar-II	100	0	0	0	3	2
Total		**275**	**525**	**21**	**0**	**6**	**25**

III Semester

Course Title	Int. marks	Ext. marks	L	T	P	C
Technical Paper Writing	100	0	0	3	0	2
Comprehensive Viva-Voce	0	100	0	0	0	4
Project work Review II	100	0	0	0	22	8
Total	**200**	**100**	0	**3**	22	**14**

IV Semester

Course Title	Int. marks	Ext. marks	L	T	P	C
Project work Review III	100	0	0	0	24	8
Project Evaluation (Viva-Voce)	0	100	0	0	0	16
Total	**100**	**100**	**0**	**0**	**24**	**24**

***Open Elective subjects must be chosen from the list of open electives offered by OTHER departments.**

 # For Project review I, please refer 7.10 in R17 Academic Regulations.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Geotechnical Engineering)

RETAINING STRUCTURES (PC - IV)

Course Objective: To design the earth retaining structures used in construction of road/railways/pipe lines/open excavations.

Course Outcome: Able to design conventional/Reinforced earth retaining walls, sheet pile walls, bracing system for open excavations

UNIT - I

Earth Pressure Theories: Rankine's and Coulomb's Earth pressure theories for cohesive and cohesion less soils, stresses due to compaction and surcharge loads.

UNIT - II

Conventional Retaining Wall: Types of retaining walls, Stability (sliding, overturning, bearing capacity & overall) of gravity and cantilever walls, Proportioning of retaining walls, Effect of backfill material and drainage, Static and pseudo-static analyses.

UNIT - III

Flexible Walls: Sheet pile walls, Construction methods**-** Cantilever and Anchored sheet pile wall.

UNIT - IV

Reinforced Soil Walls/Mechanically Stabilized Earth: - Failure mechanisms-
Pullout and rupture failures, Analysis methods, Limit equilibrium method- Internal and external stability, Static and seismic analyses.

UNIT - V

Braced Cuts: Lateral earth pressure in braced cuts, Design of various components, Stability of braced cuts, base heave and stability, yielding and settlement of ground surrounding excavation.

TEXT BOOKS:

1. Clayton, C.R.I., Woods, R.I., Bond, A.J., Milititsky, J. - Earth Pressure and Earth-retaining structures, CRC Press, Taylor and Francis group, 2013.
2. Budhu, M. – Foundations and Earth retaining structures, John Wiley & Sons, Inc., 2008.

REFERENCES:

1. Bowles, J.E. – Foundation Analysis and Design, 5th Edition, BBS Publisher, 2009.
2. Donald P Coduto – Foundation Design Principles and Practices, 2nd edition, Pearson, Indian edition, 2012.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Geotechnical Engineering)

GEOENVIRONMENTAL ENGINEERING (PC - V)

Course Objective: To understand various sources of contamination of ground and to characterize contaminated ground and to find extent of contamination and to get familiarize with various remediation methods.

Course Outcome: Able to characterize the contaminated ground and identify most appropriate method of remediation

UNIT- I

Sources and Site Characterization: Scope of Geoenvironmental Engineering, Various Sources of Contaminations, Need for contaminated site characterization; and Characterization methods.

UNIT- II

Solid and Hazardous Waste Management: Classification of waste, Characterization of solid Wastes, Environmental Concerns with waste, waste management strategies.

UNIT- III

Contaminant Transport: Transport process, Mass-transfer process, Modeling, Bioremediation, Phytoremediation.

UNIT- IV

Remediation Techniques: Objectives of site remediation, various active and passive methods, remediation of NAPL sites, Emerging Remediation Technologies.

UNIT- V

Landfills: Types oflandfills, Site Selection, Waste Containment Liners, Leachate collection system, Cover system, Gas collection system.

TEXT BOOKS:

1. Phillip B. Bedient, Refai, H. S. & Newell C. J. - Ground Water Contamination - Prentice Hall Publications, 4th Edition, 2008
2. Sharma, H. D. and Reddy, K. R. - Geoenvironmental Engineering, John Wiley & Sons (2004)

REFERENCES:

1. Rowe, R. K. - Geotechnical & Geoenvironmental Engineering Handbook, Kluwer Academic, 2001
2. Reddi, L. N. and Inyang, H. I. - Geoenvironmental Engineering Principles and Applications, Marcel. Dekker, Inc., New York (2000).
3. La Grega, M. D., Buckingham, P. L. and Evans, J. C. - Hazardous Waste Management, New York: McGraw-Hill, 2001

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Geotechnical Engineering)

GROUND IMPROVEMENT TECHNIQUES (PC - VI)

Course Objective: To understand the importance of ground improvement and know various ground improvement techniques available to date, and selecting and designing suitable ground improvement technique for given soil conditions.

Course Outcome: Depending on the site conditions, students will be able to identify suitable ground improvement technique for specific project and its implications

UNIT- I

Introduction to Engineering Ground Modification: Need and objectives, Identification of soil types, In-situ and laboratory tests to characterize problematic soils; Mechanical, Hydraulic, Physico-chemical, Electrical, Thermal methods, etc. and their applications.

UNIT- II

Mechanical Modification – Principles of soil densification – Properties of Compacted soil, Compaction control tests, Specification of compaction requirements, Blasting, Vibrocompaction, Dynamic Tamping and Compaction piles.

UNIT- III

Hydraulic Modification – Objectives and techniques, traditional dewatering methods and their choice, Design of dewatering system, Electro-osmosis, Filtration, Drainage and seepage control with Geosynthetics, sand drains, Preloading and vertical drains, Electro-kinetic dewatering.

UNIT- IV

Physical and Chemical Modification – Modification by admixtures, Shotcreting and Guniting Technology, Modification at depth by grouting, Crack Grouting and compaction grouting, Jet grouting, Thermal Modification, Ground freezing.

UNIT- V

Modification by Inclusions and Confinement - Soil reinforcement, reinforcement with strip, bar, mesh, sheet and grid reinforced soil. In-situ ground reinforcement, ground anchors, rock bolting and soil nailing, case studies.

TEXT BOOKS

1. Hausmann, M. R. (1990) –Engineering Principles of Ground Modification, McGraw Hill Publications, New York.
2. P. Purushothama Raj (1995) - Ground Improvement Techniques, Laxmi Publications, India.

REFERENCES:

1. M. P. Moseley and K. Krisch (2006) – Ground Improvement, II edition, Taylor and Francis.
2. Jones C. J. F. P. (1985) – Earth Reinforcement and soil structures – Butterworths, London.
3. K. Krisch & F. Krisch (2010) –Ground Control and Improvement, John Wiley & Sons, 1994.
4. Peter G. Nicholson (2015): Soil Improvement and Ground Modification Methods, Elsevier Publishers

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Geotechnical Engineering)

GEOTECHNICAL EARTHQUAKE ENGINEERING (PE - III)

Course Objective: To understand the effect of earthquake on soil structures and to design earthquake resistant geotechnical structures.

Course Outcome: Able to understand the behavior of ground during the earthquakes, so that geotechnical structures can be designed to resist/ sustain the earthquake loading.

UNIT- I
Earthquake Seismology – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Quantification of earthquake, Intensity and magnitudes, Earthquake source models.

UNIT- II
Earthquake Ground Motion – Seismograph, Characteristics of ground motion, Effect of local site conditions on ground motions, Design earthquake, Design spectra, code-based design, Earthquake maps

UNIT- III
Ground Response Analysis – One-dimensional and Two-dimensional ground response analysis: Linear approach, Nonlinear approach, Dynamic finite element analysis, Equivalent linear approach, Nonlinear approach, Comparison of two dimensional ground response analyses.

UNIT- IV
Liquefaction and Lateral Spreading - Liquefaction related phenomena, Liquefaction susceptibility: Historical, Geological, Compositional, and State criteria. Evaluation of liquefaction by cyclic stress and cyclic strain approaches, Lateral deformation and spreading, Criteria for mapping liquefaction hazard zones. Soil improvement for remediation of seismic hazards.

UNIT- V
Seismic Design of Foundations, Retaining Walls & Slopes - Seismic design requirements for shallow and pile foundation, Seismic bearing capacity, Seismic settlement, Design loads. Seismic slope stability analysis Seismic design of retaining walls.

TEXT BOOKS:

1. Kramer S. L - Geotechnical Earthquake Engineering, Prentice Hall, 1996.
2. Bharat Bushan Prasad- Advanced Soil Dynamics and Earthquake Engineering, PHI Learning Pvt. Ltd., New Delhi, 2011.

REFERENCES:

1. R. W. Day - Geotechnical Earthquake Engineering Handbook, McGraw-Hill, 2002.
2. Naeim, F. - The Seismic Design Handbook, Kluwer Academic Publication, 2nd Edition, 2001.
3. Bolt, B. A. - Earthquakes, W. H. Freeman and Company, 4th Edition, 1999.
4. Lourie, W. - Fundamentals of Geophysics, Cambridge University press, 1997.
5. Kamalesh Kumar - Basic Geotechnical Earthquake Engineering – New Age International Publishers, 1st Edition, 2008.
6. Dowrick - Earthquake Resistant Design, John Wiley & Sons.(2009)

JNTUH COLLEGE OF ENGINEERING HYDERABAD
M. Tech. I Year II-Sem (Geotechnical Engineering)

DESIGN OF SUBSTRUCTURES (PE - III)

Prerequisites: Geotechnical Engineering, Reinforced Concrete Design

Course Objectives: To impart knowledge on geotechnical and structural design of different types of foundation appropriate to the type of soil for different structures.

Course Outcome: The learner will be able to design shallow and deep foundations from both geotechnical and structural considerations.

UNIT – I
Shallow Foundations: Basic requirements of foundation –Types and selection of foundations. Bearing capacity of foundations, structural design of isolated, combined, eccentric, strip, and strap footings, Detailing of reinforcement.

UNIT – II
Raft Foundations: Types of rafts, SBC of raft foundation and structural design of different raft foundations, Detailing of reinforcement.

UNIT – III
Pile Foundations: Types of piles, Load carrying capacity of single and pile groups, structural design of piles, pile caps and pile-raft foundation, Detailing of reinforcement.

UNIT – IV
Design of Retaining walls: Stability Checks and structural design of gravity, Cantilever retaining walls, Detailing of reinforcement.

UNIT – V
Machine Foundations: Vibration analysis of machine foundation - Design of foundation for Reciprocating machines and Impact machines - as per I S Codes, Detailing of reinforcement.

TEXT BOOKS:

1. Bowles .J.E., “Foundation Analysis and Design”, McGraw Hill Publishing co., New York, 1986.
2. Varghese P.C. Design of RC foundations, PHI Learning Pvt. Ltd.
3. Unnikrishnana Pillai & Devadas Menon, Reinforces Concrete Design, McGraw Hill Publishing Pvt. Ltd.

REFERENCE:

1. Tomlinson. M.J, “Foundation Design and Construction”, Longman, Sixth Edition, New Delhi, 1995.
2. Das, B.M., Principles of Foundation Engineering, Design and Construction, Fourth Edition, PWS Publishing, 1999.
3. Varghese, P.C. Foundation Engineering, PHI Learning Pvt. Ltd.
4. Narayan V. Nayak, Foundation design manual, Dhanpat Rai & Sons, 2006.
5. Prakash Shamsher and Puri Vijay K, Foundations for Machines, Analysis and Design” John Wiley and Sons, USA, 1988.
6. IS 2911: Part 1: Sec 1: 1979 Code of practice for design and construction of pile foundations: Part 1 Concrete piles, Section 1 Driven cast in-situ concrete piles.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Geotechnical Engineering)

GEOTECHNICS FOR INFRASTRUCTURE (PE - III)

Course Objectives: To impart knowledge on site investigation and soil testing methods and design of different types of foundation appropriate to the type of soil for different structures.

Course Outcome: The learner will be able to design shallow and deep foundations for railway and highway bridges, and marine structures

UNIT – I

Site Investigation for Infrastructure Projects: methods of site investigation, types of soil samples and samplers- Geotechnical field testing – SPT, CPT, Plate Load Test, Pile Load Test.

UNIT – II

Shallow Foundations for Railway & Highway Bridges and Port &Harbour Structures: types of foundations, design forces, safe and allowable bearing capacity of shallow foundations, settlement computation;

UNIT – III

Pile Foundations for Railway & Highway Bridges and Port &Harbour Structures: Pile foundations – types, axial and lateral capacity of pile, pile group analysis and pile cap; Introduction to drilled piers, caissons, well foundations.

UNIT – IV

Foundations for Transmission Line, Radar Antenna, Microwave and TV Tower and Chimneys: Introduction, foundations for towers and chimneys, design forces, behaviour of pad and chimney foundations, design of chimney and pad foundations, anchor foundations (rock anchors), design of foundations for towers and chimneys, analysis of raft on pile foundations; design and construction of shallow foundations on rocks.

UNIT – V

Sheet Piles - introduction, types of sheet pile walls, cantilever sheet pile wall, anchored sheet pile wall, stability analysis of anchored bulkhead by free earth support and fixed earth support method, position of anchorage.

Expansive and Collapsible Soil: Difficult soils- loose granular soils, soft clays and shrinkable soils-identification, swell and swell pressure.

TEXT BOOKS:

1. Bowles, J. E. - Foundation Analysis & Design, 5th Edition McGraw-Hill Companies, Inc. (1996)
2. Coduto, D.P. – Foundation Design Principles and Practices, 2nd edition, Indian edition, 2012.

REFERENCE BOOKS:

1. Poulos, H. G., and Davis, E. H. - Pile Foundation Analysis and Design, 1980
2. Tomlinson, M. J. - Foundation Design and Construction - Prentice Hall (2003).
3. Das, B.M. - Principle of foundation engineering, CENGAGE Learning, Thomson, Brooks/Cole.
4. Kameswara Rao, N.S.V. - Dynamic soil tests and applications, Wheeler Publishing.
5. Relevant Indian and International Standard Codes of Practice

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Geotechnical Engineering)

GEOSYNTHETICS AND SOIL REINFORCEMENT (PE - IV)

Course Objective: To determine the properties, functions and applications of various geosynthetic materials and to design reinforced soil structures.

Course Outcome: Able to apply the appropriate geosynthetic material for improving ground for various Civil Engineering projects, and design of various reinforced soil structures.

UNIT- I

An Overview of Geosynthetics: Classification of Geosynthetics, Functions and applications, Properties of geotextiles, Geogrids and Geomembranes.

UNIT- II

Soil Reinforcement: Mechanism, improvement of Bearing capacity, Embankments on soft ground, Soil Nailing.

UNIT- III

Reinforced Embankments and Reinforced soil walls –Internal and External Stability

UNIT- IV

Geosynthetics for Highways: Roadway Reinforcement, applications for Separation, Filtration, Drainage, Reinforcement, Moisture Barrier, Membrane encapsulation.

Landfills: Geosynthetic applications for landfill liners, covers and other components

UNIT- V

Dewatering Systems: Sand drains, Prefabricated Vertical drains (PVD), French Drains.

TEXT BOOKS:

1. Koerner, R. M. - Designing with Geosynthetics, Prentice Hall; 2nd edition (1991)
2. Rao, G. V., & Raju G. V. S. S. - Engineering with Geosynthetics, Tata-McGraw Hill. Publication, New Delhi. (2004.)

REFERENCES:

1. Hausmann, M. R. - Engineering Principles of Ground Modifications, McGraw Hill Pub Co, 1989
2. Xianthakos, Abreimson and Bruce - Ground Control and Improvement, John Wiley & Sons, 1994.
3. M. P. Moseley and K. Krisch (2006) – Ground Improvement, II Edition, Taylor and Francis
4. Jones C. J. F. P. (1985) – Earth Reinforcement and soil structures – Butterworths, London.
5. Siva Kumar Babu .GL 2013-Introduction to Soil Reinforcement & Geosynthetics, University Press

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Geotechnical Engineering)

MATERIAL CHARACTERIZATION AND PAVEMENT ENGINEERING (PE - IV)

Course Objective: To evaluate the physical and mechanical properties of subgrade, and pavement materials, and design flexible and rigid pavements subjected to wheel loads.

Course Outcome: Student should be able to understand various pavement material characterization techniques, and able to design a suitable pavement for known wheel loading characteristics and subgrade soil conditions.

UNIT- I
Introduction: Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airport pavements, field CBR, field plate load test, modulus of subgrade reaction, resilient modulus, Suitability of soil, Compaction equipment and Compaction Control.

UNIT - II
Stresses and strains in flexible pavements: Stresses and strains in an infinite elastic half space use of Boussinesq's equations - Burmister's two layer and three layer theories; Wheel load stresses, various factors in traffic wheel loads; Equivalent single wheel load of multiple wheels. Repeated loads and EWL factors.

UNIT - III
Flexible pavement design methods for highways and airports: Empirical, semi-empirical and theoretical approaches; Development, principle, design steps of the different pavement design methods including AASHTO, Asphalt Institute, Shell Methods. IRC method of pavement design.

UNIT - IV
Stresses in rigid pavements: Types of stresses and causes; Introduction to Westergaard's equations for calculation of stresses in rigid pavement due to the influence of traffic and temperature; Considerations in rigid pavement analysis, EWL; wheel load stresses, warping stresses, frictional stresses, combined stresses.

UNIT - V
Rigid pavement design: Design of cement concrete pavement for highways and runways; Design of joints, reinforcements, tie bars, dowel bars. IRC method of design; Design of continuously reinforced concrete pavements.

TEXT BOOKS:

1. Atkins, N. Harold, Highway Materials, Soils and Concretes, Fourth Edition, 2002, Prentice-Hall.
2. Yang H Huang - Pavement Analysis and Design, 2nd Edition, Pearson Education
3. Yoder. J. & Witzorac Mathew, W. Principles of Pavement Design, John Wiley & Sons Inc

REFERENCES:

1. Kerbs Robert D. and Richard D. Walker, Highway Materials, McGraw-Hill, Design of Functional Pavements, Nai C. Yang, McGraw Hill Publications
2. Concrete Pavements, AF Stock, Elsevier, Applied Science Publishers
3. Pavement Analysis & Design, Yang H. Huang, Prentice Hall Inc.
4. Pavement and Surfacing for Highway & Airports, Micheal Sargious, Applied Science Publishers Limited.
5. IRC: 37 & 58 Codes for Flexible and Rigid Pavements Design.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. (Geotechnical Engineering)

OFFSHORE GEOTECHNICAL ENGINEERING (PE - IV)

Course Objective: To understand differences between the soil and loading conditions of on-shore and offshore structures, various types of offshore foundation systems, and to evaluate the performance of offshore structures.

Course Outcome: Students should be able to design and evaluate the performance of offshore foundations.

UNIT - I
The nature of Submarine Soils: origin, classification and distribution of marine sediments; insitu stress state in submarine deposits; inorganic clay deposits; calcareous sediments; siliceous sediments. Offshore Geotechnical Investigations: phases of the investigation, geophysical survey, drilling and sampling procedures, in-situ testing techniques, laboratory testing.

UNIT - II
Foundations for Offshore Gravity Structures: construction, installation, instrumentation of gravity platforms, stability analysis, deformation analysis based on elastic theory, piping and erosion.

UNIT - III
Foundations for Jack-up Rigs: foundations types and design loads, Prediction of individual footing performance, prediction of mat footing performance, seabed anchors, load capacity of anchors, breakout forces, anchor systems for floating structures.

UNIT - IV
Offshore Pile Foundations: types of offshore piles, temporary support of piled structures, dynamic analysis of pile driving, axial load capacity, axial deformation analysis, Lateral loading, and dynamic response.

UNIT - V
Seafloor Stability: causes of seafloor instability, geological features of submarine slides, mechanisms of instability, slope stability under gravity forces and wave forces, Effects of soil instability on piles, installation, and stability of submarine pipelines.

TEXT BOOKS:

1. Marine Geotechnics – H. G. Poulos (1988), Prentice Hall Inc.
2. Construction of marine and offshore structures – Ben C Gerwick, jr., CRC Press, Taylor and Francis Group.(2012)

REFERENCES:

1. Seabed Reconnaissance and Offshore Soil Mechanics (for the installation of petroleum structures) – Pierre LE Tirant (1979), Gulf Publishing Company, Houston, Texas.
2. API (2000) – Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – API, RP2A.
3. Pile design and construction practice – M J Tomlinson, View point Publications, Palladian Publications Limited.(1987)
4. Port Engineering planning, construction, maintenance and security – George P Tsinker, John Wiley & Sons, Inc. (2004)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. (Geotechnical Engineering)

ADVANCED GEOTECHNICAL ENGINEERING LABORATORY – II

Course Objective: To obtain the physical and mechanical properties of rocks and geosynthetic materials for civil engineering applications.

Course Outcome: Student should be able to evaluate engineering properties of rocks and to determine load carrying capacity and stability of rock slopes for various civil engineering structures. Determination of properties of geosynthetic materials, for use in the design of reinforced soil structure.

List of Experiments:

1. Preparation of Rock Specimen-Core drilling
2. Preparation of Rock Specimen-Cutting, Polishing
3. Slake Durability Test
4. Brazilian Test
5. Point Load Test
6. Unconfined Compression Test on rock samples
7. Interface Shear Behavior of Soils with Geosynthetics
8. Cone Drop Test on Geotextile
9. Tensile Tests (Wide Width, Narrow Width, etc. on Geotextiles)
10. CBR Push Through on Geotextiles
11. In-Plane and Cross-Plane Permeability of Geotextiles
12. Design of Slope, Embankment, Reinforced Soil Wall using Software

References: 1. Rao G. V & Goutham. P (2008), Geosynthetic testing – a laboratory manual, SAGES, Hyderabad.