Irrigation Engineering (3-2-0)

Evaluation:

	Theory	Practical	Total
Sessional	50	-	50
Final	50	-	50
Total	100	-	100

Course Objectives:

After completion of this course, student will be able to:

- design surface and groundwater irrigation systems
- operate and manage irrigation systems
- design infrastructure needs for acquisition, conveyance, distribution and control for regulated flow of water from the source to the farmers' fields
- design removal of excess water to maintain condition for crop production

Course Contents:

1. Introduction **(2 hrs)**

1.1 Definition of irrigation
1.2 Classification/types of irrigation systems
1.3 Functions and advantages of irrigation
1.4 Irrigation development in Nepal

2. Soil Moisture and Crop Relation **(4 hrs)**

2.1 Climate-soil-water-crop (CSWC) relationship
2.2 Soil moisture regimes; Crop water requirements
2.3 Factors affecting crop water requirements
2.4 Base period, Kor period, duty, delta and their relationships
2.5 Command area of irrigation system- GCA, CCA and NCA
2.6 Principal crops, their seasons and water requirements

3. **Methods of Irrigation** **(3 hrs)**

3.1 Different methods of irrigation
3.2 Hydraulics of irrigation distribution
3.3 Efficiency and suitability of different irrigation methods

4. **Canal Design** **(8 hrs)**

4.1 Components of surface gravity irrigation systems
4.2 Classification of canals
4.3 Types of permanent and inundation canals
4.4 Components of canal cross-section - side slope, berm, free board, banks, service roads, spoil banks
4.5 Alignment of canals
4.6 Canal seepage and evaporation and other losses
4.7 Use of Manning's equation in canal design

4.8 Tractive force approach in canal design
4.9 Silt theories- Kennedy's silt and Lacey's regime theories
4.10 Design of canals in alluvial formation
4.11 Options of canal lining
4.12 Advantages and economics of canal lining
4.13 Design of lined canals
4.14 Specific design considerations for canals in hill irrigation systems

5. Hydraulic Structures in Surface Gravity Irrigation System **(13 hrs)**

5.1 Headworks- types, functions and components, silt excluder, silt extractor
5.2 Conditions and causes of failure of hydraulic structures in alluvial formation
5.3 Bligh's, Lanes and Khosla's seepage theory
5.4 Cross drainage structures, conditions for their applications and designs
5.5 Canal Escapes
5.6 Types of canal drops and their design considerations
5.7 Functions of head and cross-regulators
5.8 Design considerations for head regulator
5.9 Types of canal outlets and their design considerations
5.10 Design of pipe outlets

6. Hill Irrigation **(3 hrs)**

6.1 Specific design considerations in hill irrigation
6.2 Choices of intake, control and regulation structures
6.3 Environmental protection measures in hill irrigation

7. River Control and Drainage **(4 hrs)**

7.1 Effect of water logging and their control
7.2 Considerations in the design of surface and sub-surface drainage systems
7.3 Objectives of river training
7.4 Types of river training works and their necessities
7.5 Design considerations of marginal banks, guide banks and spurs

8. Planning and Design of Groundwater Irrigation Schemes **(6 hrs)**

8.1 Exploration and development of groundwater
8.2 Types of wells- shallow and deep
8.3 Components of tube-wells
8.4 Design considerations of shallow and deep wells
8.5 Types and selection of pumps
8.6 Conveyance and distribution systems in groundwater irrigation schemes
8.7 Design of underground pipeline system
8.8 Conjunctive use of surface and groundwater

9. Planning and Management of Irrigation System **(2 hrs)**

9.1 Operation and management needs of surface and groundwater irrigation schemes
9.2 Canal operation plans
9.3 Participatory management

Tutorials:

1. Water requirement (crop and irrigation) and irrigation scheduling.
2. Design of lined canals and canal cross-section in alluvial formation.
3. Design of guide bund and marginal embankment.
4. Design of hydraulic structures based on Bligh's and Khosla's theory.
5. Design of cross and head regulators, aqueduct and canal drops.
6. Design of sub-surface drainage system and underground pipe line conveyance in tube wells.

Field Trip: A one-day field trip to an irrigation project in Nepal. Students need to submit individual report based on field trip.

Text Books:

1. Varshney, R.S., Gupta S.C. and Gupta R.L. *Theory and Design of Irrigation Structures(Vol. I and II).*Roorkee:Nem Chand and Brothers.
2. Garg, S.K. *Irrigation Engineering and Hydraulic Structures*.New Delhi:Khanna Publishers.
3. Arora, R.K.*Irrigation Water Power and Water Resources Engineering*.New Delhi:Standard Publication.

References:

1. WECS (1998).*Design Guidelines for Surface Irrigation in Terai and Hills of Nepal, (Vol. I and II).*
2. DoI(1990).*Design Manuals for Irrigation Projects in Nepal(Vol. I to XIII*). Planning and Design Strengthening Project, UNDP-NEP/85/013-World Bank: Sir M MacDonald and Partner Ltd.
3. Michael, A.M.(2011).*Irrigation Theory and Practice*.New Delhi: Vikash Publishing House.
4. FAO (1977). *Guidelines for Predicting Crop Water Requirements*. FAO Irrigation and Drainage Paper No. 24.

Foundation Engineering (3-2-1)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

After successful completion of this course, students will be able to:

- conduct site investigation for design of foundation
- calculate bearing capacity of soil
- select type of foundation for construction and design ofdeep foundations
- calculate earth pressure and design retaining wall and sheet piles
- design foundation soil improvement
- calculate pressure under mat foundation
- design pile and well foundation

Course Contents:

1. **Introduction** **(1 hr)**
   - 1.1 Purpose, importance and types of foundation
   - 1.2 Factors affecting choice of foundation

2. **Site Investigation** **(6 hrs)**
   - 2.1 Objectives and methodsof soil exploration
   - 2.2 Soil sampling, types of sample, soil samplers and its basic requirementsfor cohesive soil
   - 2.3 Planning of exploration, number of bore holes, depth of exploration
   - 2.4 Field penetration tests and their suitability
     - 2.4.1 Standard Penetration Test (SPT)
     - 2.4.2 Static Cone Penetration Test (SCPT)
     - 2.4.3 Dynamic Cone Penetration Test (DCPT)
   - 2.5 Methods of boring
   - 2.6 Groundwater observation
   - 2.7 Bore hole logs
   - 2.8 Site investigation report

3. **Lateral Earth Pressure Theories** **(7 hrs)**
   - 3.1 Definition and types of earth pressures
   - 3.2 Rankine's earth pressure theory for active and passive states
   - 3.3 Coulomb's earth pressure theory and its graphical solution
   - 3.4 Culmann's graphical construction of earth pressure
   - 3.5 Trial wedge method for earth pressure

4. **Earth Retaining Structure and Coffer Dam** **(5 hrs)**
   - 4.1 Flexible retaining structures
     - 4.1.1 Sheet pile wall and its classification

4.1.2 Analysis of sheet pile wall (cantilever sheet pile wall and anchored sheet pile wall)

4.1.3 Introduction to gabion wall

4.2 Types and proportioning of earth retaining structures

4.3 Stability analysis of earth retaining structures

4.4 Coffer dam

5. Arching in Soil and Braced Cuts **(3 hrs)**

5.1 Theory of arching in soils and its practical applications

5.2 Bracing for open cuts

5.3 Earth pressure against bracing in cuts

5.4 Strut loads

6. Bearing Capacity and Settlement of Shallow Foundation **(6 hrs)**

6.1 Introduction

6.2 Modes of soil failure

6.3 Terzaghi'stheory and its extension (Mayerhof, Handson and Vesic theory)

6.4 Effect of water table

6.5 Paukar and Bells theory of failure

6.6 Rankine's classical earth pressure theory

6.7 Use of various charts/formulae to find bearing capacity using N-value

6.8 Bearing capacity from in-situ tests (Plate Load Test).

6.9 Settlement and its type

6.10 Proportioning of spread footing for equal settlement

6.11 UBC on layered soil

6.11.1 Foundation on layered sand (dense sand over loose sand)

6.11.2 Foundation on dense sand overlying soft clay

7. Mat Foundations **(3 hrs)**

7.1 Introduction and types

7.2 Bearing capacity and settlement

7.3 Compensated foundation (Floating Foundation)

7.4 Conventional methods of analysis

8. Pile Foundations **(6 hrs)**

8.1 Introduction, classification and uses

8.2 Selection of pile type

8.3 Determination of pileload capacity

8.3.1 Static approach

8.3.2 Dynamic approach

8.4 Pile capacity by in-situ test

8.5 Pile load test (Progressive Loading)

8.6 Group action of piles

8.7 Efficiency of pile group

8.8 Negative skin friction

8.9 Construction of piles

9. Well Foundation **(4 hrs)**

9.1 Introduction, types and shapes
9.2 Components of well foundation
9.3 Depth of well foundation
9.4 Forces acting on well foundation
9.5 Construction and sinking of well
9.6 Lateral stability

10. Foundation Soil Improvements **(3 hrs)**

10.1 Introduction
10.2 Mechanical compaction
10.3 Preloading
10.4 Sand compaction piles and stone columns
10.5 Soil stabilization by the use of admixtures
10.6 Soil stabilization by injection of suitable grouts

11. Machine Foundation **(1 hr)**

11.1 Introduction
11.2 Types of machine foundation

Practical

1. Unconfined compression test
2. Triaxial tests
3. Standard penetration test
4. Dynamic cone penetration test

Text Books:

1. Murthy, V.N.S. *Text Book of Soil Mechanics and Foundation Engineering (Geotechnical Engineering Series)*. CBS Publishers and Distributors Pvt. Ltd.
2. Ranjan, G. and Rao, A.S.R. *Basic and Applied Soil Sciences*.India:New Age International Publishers.

References:

1. Terzaghi, Karl and Peck, R.B. John Wiley. (1967).*Soil Mechanics in Engineering Practice*, New York.
2. Das Braja M.*Principles of Geotechnical Engineering*. California State University Sacramento: Thomson/Brookdcole Publication.
3. Punmia B.C, Jain A.K. and Jain Arun K. (2005).*Soil Mechanics and Foundation engineering*, India: Laxmi Publication Pvt. Ltd.
4. Arora K.R. (1997).*Soil Mechanics and Foundation Engineering*, India: Standard Publisher Distribution.
5. Bowels Joseph E. (1997).*Foundation analysis and Design*. McGraw-Hill International Edition.
6. PoulsH.G. and Davis E.H.*Pile Foundation Analysis and Design*. John Wiley and sons.
7. Venkatramaiah C. *Geotechnical Engineering*. India: New Age International (P) Limited Publisher.

Concrete Technology and Masonry Structures (3-1-2)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

After completion of this course, students will be able to:

- inspect and supervise concreting works
- carry-out mix-design of concrete
- test various properties of fresh and hardened concrete
- analyze and design simple masonry structures
- conduct tests on masonry units and masonry structures

Course Contents:

Part I: Concrete Technology

1. Introduction **(3 hrs)**

1.1 Use of concrete in structure
1.2 Constituents of concrete
  1.2.1 Coarse and fine aggregate
  1.2.2 Cement
  1.2.3 Water
  1.2.4 Admixtures

2. Properties of Fresh Concrete **(6 hrs)**

2.1 Hydration of cement
2.2 W/C ratio
2.3 Mixing, handling, placing, compaction and curing of concrete
2.4 Workability and its tests (slump test, compaction factor test and flow test)
2.5 Segregation and bleeding
2.6 Types and functions of admixtures
2.7 Concreting in extreme temperatures
2.8 Quality control at site

3. Properties of Hardened Concrete **(5 hrs)**

3.1 Deformation of hardened concrete, moduli of elasticity
3.2 Creep, shrinkage and thermal expansion
3.3 Fatigue, impact and cyclic loading
3.4 Effect of porosity, water-cement ratio and aggregate size
3.5 Durability of concrete

4. Introduction to Special Types of Concretes **(3 hrs)**

4.1 Light weight concrete
4.2 Aerated concrete
4.3 No-fines concrete
4.4 High density concrete
4.5 Fibre reinforced concrete

4.6 Self compacting concrete
4.7 Shotcrete

5. Mix Design of Concrete **(5 hrs)**

5.1 Introduction to nominal mix
5.2 Probabilistic concept in mix design approach
5.3 Concrete mix design as perDOE and ISmethod

6. Testing of Concrete and Quality Control **(3 hrs)**

6.1 Various strength of concrete: Tensile, Compressive, Shear and Bond
6.2 Compressive, tensileand bond strength tests
6.3 Non-destructive tests
6.4 Variability of concrete strength and acceptance criteria
6.5 Quality control and quality assurance

Part II: Masonry Structures

7. Introduction to Masonry Structures **(4 hrs)**

7.1 Composition of masonry and different types masonry units
7.2 Types of masonry structures
  7.2.1 Load bearing and non-load bearing masonry
  7.2.2 Reinforced and unreinforced masonry
7.3 Properties and strength of cement-mortar

8. Design of Masonry Walls for Gravity Loads **(8 hrs)**

8.1 Introduction to codal provisions (NBC109) and guidelines(NBC202)
8.2 Design for gravity loads (solid wall, wall with opening, wall with eccentric loading and wall acting as column)
8.3 Bonding elementsinmasonry: bond-stones, bands and dowels

9. Masonry Walls Under Lateral Loads **(5 hrs)**

9.1 Elements of lateral load resisting masonry system
9.2 In-plane and out-of-plane behavior of masonry walls
9.3 Failure behavior of masonry wall in lateral loads
9.4 Analysis for stresses on masonry wallsunder lateral loads
9.5 Ductile behavior of reinforced and unreinforced masonry structures

10. Testing of Masonry Elements **(3 hrs)**

10.1 Compressive strength of masonry units and masonry walls
10.2 Diagonal shear test
10.3 Non-destructive tests(Elastic wave tomography, Flat-jack and Push shear test)

Laboratories:

1. Workability test of fresh concrete.
2. Mix-design and Compressive strength test of concrete using cubes/cylinders.
3. Bond-strength test of concrete.
4. Non-destructive test of concrete.
5. Determination of strength of masonry units:blocks.
6. Determination of strength of cement mortar.
7. Determination of strength of masonry.

Text Books:

1. Shetty M. S. *Concrete Technology.* New Delhi: S. Chand and Company Ltd.
2. Arya, A.S. *Masonry and Timber Structures including Earthquake Resistant Design.* Nem Chand & Bros.

References:

1. Neville, A. M. *Properties of Concrete.*England: Pearson Education Limited.
2. Neville, A. M. & Brooks J.J. *Concrete Technology.* England: Pearson Education Ltd.
3. Dayaratnam, P. *Brick and reinforced brick structures.*
4. Hendry, A.W., Sinha, B.P. & Davies, S.R. *Design of Masonry Structure.* London: E & FN Spon.
5. DUDBC. *NBC109– Masonry: Unreinforced.*
6. DUDBC. *NBC202 – Load Bearing Masonry.*
7. BIS. *IS456:2000 – Plain and Reinforced Conctere – Code of Practice.*
8. BIS. *IS383:1970 – Specification for Coarse and Fine Aggregates from Natural Sources for Concrete.*

Design of Steel and Timber Structures (3-2-0)

Evaluation:

	Theory	Practical	Total
Sessional	50	-	50
Final	50	-	50
Total	100		100

Course Objectives:

After completion of this course, student will be able to:

- design various types of joints, tension and compression members, beams and roofs of steel structures,
- design simple timber structural members.

Course Contents:

1. Introduction **(2 hrs)**

1.1 Structural behavior of steel
1.2 Advantages and disadvantages of steel structures.
1.3 Methods of design of steel structure (WSM andLSM)
1.4 Plastic method of design of steel structure

2. Analysis and Design of Joints **(5 hrs)**

2.1 Types of riveted joints
2.2 Types of welded joints
2.3 Axially and eccentrically loaded riveted joints (bracket connection)
2.4 Axially and eccentrically loaded welded joints
2.5 Codal provisions

3. Design of Tension Members (LSM) **(4 hrs)**

3.1 Net cross sectional area of tension members
3.2 Design of structural members in tension (I, angle and channel)
3.3 Design of steel ties
3.4 Design of lug angles

4. Design of Compression Members (LSM) **(6 hrs)**

4.1 Computation of permissible stress for compression members
4.2 Design of standard steel sections for compressive loads
4.3 Design of built up members
4.4 Design of lacing and battens
4.5 Design of eccentrically loaded columns
4.6 Design of column splices

5. Design of Column Bases (LSM) **(6 hrs)**

5.1 Design of base for axially loaded columns

5.2 Design of base for eccentrically loaded columns

6. Design of Steel Beam (LSM) **(8 hrs)**

6.1 Design of stiffened beams

6.2 Web crippling effect and buckling of beams

6.3 Design of unstiffened beams

6.4 Design of built up beams

6.5 Curtailment and design of rivets connecting cover plate

6.6 Design of stiffened and unstiffened connection in steel beams

7. Design of Plate Girders (LSM) **(5 hrs)**

7.1 Elements of plate girders

7.2 Design of flanges, webs and curtailment of flanges

7.3 Design of web stiffeners and load bearing stiffeners

8. Design of Roof Trusses (LSM) **(5 hrs)**

8.1 Types of roof trusses and their selection

8.2 Load calculation in roof trusses

8.3 Design of purlins

8.4 Design of bracings

9. Timber Structures **(4 hrs)**

9.1 Allowable stresses in timber

9.2 Design of solid, built-up and spaced columns

9.3 Designof timber beams

9.4 Types of joints and their detailing

9.5 Analysis and design of composite beams of steel and timber

Text Book:

1. Duggal, S.K.,Limit State *Design of Steel Structures*. Tata McGraw-Hill Education.

References:

1. Arya, Chanakya.*Design of structuralelements: concrete, steelwork, masonry and timber.*
2. Punmia, B.C. *Comprehensive Design of Steel structures*. New Delhi: Tata McGraw.
3. IS 800-2008.

Sanitary Engineering (3-2-1)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

After completion of this course, student will be able to:

- describe sources of waste, their collection, conveyance, treatment and disposal system
- specify or calculate quantity and quality of waste water along with its disposal methods

Course Contents:

1. Introduction **(2 hrs)**

1.1. Definitions of common terms: sewer, sewerage, sewage/waste water, domestic sewage, industrial sewage, sanitary sewage, storm water, sullage , rubbish, garbage, refuse/solid waste

1.2. Historical development of waste water and solid waste management

1.3. Systems of sanitation

1.3.1. Conservancy system

1.3.2. Water carryingsystem

1.3.3. Merits and demerits of each system and their differentiation

1.4. Systems of sewerage:

1.4.1. Separate system,

1.4.2. Combined system and

1.4.3. Partially combined system

1.4.4. Merits and demerits of each system and their differentiation

2. Quantity of Waste Water **(3 hrs)**

2.1. Introduction to sources and types of waste water

2.2. Description of sanitary sewage, its sources, calculation of discharge of sanitary sewage, factors affecting quantity of sanitary sewage, peak flow

2.3. Description of storm water, factors affecting quantity of storm water, calculation of discharge of sanitary sewage by rational method and its limitations

2.4. Concept of time of concentration and time area graph

2.5. Numerical exercises on calculation of quantity of sanitary sewage and storm water

3. Quality of Waste Water **(5 hrs)**

3.1. Constituents of waste water

3.2. Properties of waste water

3.3. Aerobic and anaerobic decomposition

3.4. Cycles of decomposition: nitrogen cycle, carbon cycle and sulfur cycle

3.5. Biochemical oxygen demand (BOD), derivation of BOD equation, introduction to first and second stage BOD, Ultimate BOD, relative stability, population equivalent

3.6. Numerical exercises on calculation of BOD, relative stability and population equivalent

3.7. Examination of waste water

3.7.1. Sampling of waste water

3.7.1.1. Grab and composite samplers

3.7.1.2. Preservatives and storage

3.7.1.3. DO, BOD and COD sampling

3.7.2. Characteristics of waste water

3.7.2.1. Physical analysis: tests for color, odor, temperature and turbidity

3.7.2.2. Chemical analysis: tests for ammonical-nitrogen, DO, BOD, COD and chlorine

3.7.2.3. Introduction to biological analysis: membrane filter test

4. Design and Construction of Sewer (6 hrs)

4.1. Hydraulic formula for sewer design: Manning's formula, Manning's roughness coefficient, Chezy's formula, Bazin's formula, Kutter's formula, Hazen William's formula

4.2. Self cleansing velocity, minimum velocity and maximum velocity

4.3. Shapes of sewer: rectangular, horse shoe,circular and non-circular with their applications

4.4. Requirements of sewer materials, types of sewer materials: CI, concrete, PPR, PVC, DI, stainless steel, salt glazed stoneware.

4.5. Derivation of hydraulic elements of circular sewer

4.6. Derivation of proportionate variables for partial flow in circular sewer, partial flow diagrams

4.7. Stages of construction of sewer

4.8. Sewer appurtenances: manhole and its types, street inlets, catch basins, flushing devices, inverted siphon, ventilation in shaft, sewer outlets

4.9. Numerical exercises on sewer design for full flow and partial flow conditions

5. Disposal of Waste Water (4 hrs)

5.1. Objectives of sewage disposal

5.2. Natural methods of sewage disposal: dilution, land treatment

5.2.1. Dilution method: essential condition, self purification process of streams,

5.2.2. Factors affecting self purification of stream, oxygen sag curve and Streeter-Phelps equation (expressions only)

5.2.3. Land treatment method: essential conditions, merits, demerits

5.2.4. Methods of land treatment: broad irrigation, overland run-off, rapid filtration

5.2.5. Sewage sickness and preventive measures

5.3. Numerical exercises on calculation of critical DO deficit and plotting of oxygen sag curve

6. Waste Water Treatment (16 hrs)

6.1. Objectives of waste water treatment

6.2. Types of waste water treatment processes and typical layout of waste water treatment plant

6.3. Preliminary and primary treatment of waste water and their designs:
  6.3.1. screening
  6.3.2. skimming tank / flotation tank
  6.3.3. grit chamber
  6.3.4. sedimentation tank
  6.3.5. description of chemical precipitation and coagulation
6.4. Secondary treatment of waste water
  6.4.1. Sewage filtration: introduction of intermittent sand filter and contact beds, concepts, construction and design of trickling filter
  6.4.2. Activated sludge process: concept, construction and design
  6.4.3. Oxidation pond: concept, construction, design
  6.4.4. Introduction of membrane technology, GAC treatment in waste water treatment
  6.4.5. Introduction of membrane bio-reactors for waste water treatment
6.5. Numerical exercises on design of screening, skimming tank, grit chamber, sedimentation tank, trickling filter, activated sludge process and oxidation pond(till dimension calculation)

7. Treatment of Sludge and Disposal **(5 hrs)**

7.1. Sources of sludge and necessity of sludge treatment
7.2. Aerobic and anaerobic digestion process
7.3. Methods of sludge treatment
  7.3.1. Thickening: concept of volume moisture content relationship
  7.3.2. Dewatering: types and process
  7.3.3. Digestion: types, design processes
  7.3.4. Other methods: drying andcomposting
7.4. Methods of sludge disposal
  7.4.1. Sludge drying bed
  7.4.2. Lagooning
  7.4.3. Land filling
  7.4.4. Incineration
7.5. Numerical exercises on volume moisture content relationship, design of sludge digester

8. Disposal of Waste Water in Unsewered Area **(2 hrs)**

8.1. Brief description of pit privy, ventilated improved pit latrine (types and design), pour-flush latrine, compost latrine
8.2. Concept, construction, maintenance, working and design of septic tank
8.3. Disposal of septic tank effluent: soak pit (design), drain field, evapo-transpiration mound,
8.4. Leaching cesspool
8.5. Numerical exercises on design of VIP latrine, septic tank and soak pit

9. Disposal of Solid Waste **(2 hrs)**

9.1. Types and characteristics of solid waste
9.2. Composition of solid waste

9.3. Methods of solid waste collection
9.4. Disposal of solid waste by dumping, incineration, composting and sanitary landfill

Field Visit

One local field visit at components of waste water treatment system and landfill.

Tutorials:

Minimum 6 tutorials to be submitted by students covering major theoretical and numerical exercises in the course.

Laboratories:

1. Determination of turbidity, pH, total solids and dissolved solids of waste water sample.
2. Determination of chlorine in waste water sample by Starch Iodide method.
3. Determination of dissolved oxygen of waste water sample from Winkler's Method and BOD test.

Text Book:

1. Punmia, B. C., Jain, Ashok & Jain,Arun.Environmental Engineering - II: Waste Water *Engineering*. New Delhi: Laxmi Publications.

Reference:

1. Modi, P. N. *Environmental Engineering, Volume II: Waste Water Treatment, Disposal and Air Pollution Engineering*. Delhi: Standard Book House.
2. Garg,S. K. *Environmental Engineering (Vol. II): Waste water Engineering*.Delhi:Khanna Publishers.