STRUCTURAL DYNAMICS
ENCE 365

Lecture : 3 — **Year : III**
Tutorial : 2 — **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to equip students with an understanding of the basic concepts of structural dynamics and the dynamic behavior of structures, along with the underlying principles required to analyze and solve dynamic problems of structures.

1 Introduction (6 hours)

1.1 Structural dynamics (Dynamic loading, structural behavior and response)
1.2 Essential characteristics of a dynamic problem
1.3 Equation of motion (Newton's second law of motion and D'Alembert's principle) and dynamic degrees of freedom
1.4 Types of vibrations (Free, forced, damped and undamped)
1.5 Types of dynamic loading (Simple harmonic, periodic, transient, impulsive, and random)
1.6 Damping: Definition, characteristics, and types (Viscous, coulomb, structural, aerodynamic, magnetic, viscoelastic, and active)
1.7 Dynamic response of structures
1.8 Time-domain and frequency-domain analysis

2 Single-degree-of-freedom System (20 hours)

2.1 Equations of motion: Modeling of single-degree-of-freedom system, response parameters, effect of gravity, effect of support excitation, combination of stiffness (Parallel and series)
2.2 Free vibration response: Undamped system; Damped system (Under critically, critically, and over critically)
2.3 Logarithmic decrement of response
2.4 Forced vibration response to harmonic loading: Undamped system; Damped systems (Transient response, steady-state response, general response, and resonance response)
2.5 Energy dissipated by damping (Viscous damping)
2.6 Forced vibration response to periodic loading: Undamped system (Transformation of loading and response using Fourier series)
2.7 Forced vibration response to impulsive load (Half-sine wave pulse, rectangular pulse, ramp pulse, triangular pulse)

2.8 Forced vibration response to general dynamic loading: Unit-impulse and Dirac-delta function; Unit-impulse response function; Duhamel integral and Convolution integral; Numerical evaluation of Duhamel integral
2.9 Vibration measuring instruments (Displacement meter and accelerometer)
2.10 Vibration isolation (Vertical oscillating force, harmonic motion of the base, force transmissibility, unbalanced mass amplitude of rotating unbalanced system)
2.11 Computer simulation of dynamic responses of single-degree-of-freedom system: Free; Forced; Undamped damped (Under critical, critical, and over critical); Resonance effect

3 Multi-degrees-of-freedom System (8 hours)

3.1 Simple system (Basic concept, uses and limitations)
3.2 Generalized coordinate and reduction of degrees of freedom (Kinematic constraints and static condensation)
3.3 Dynamic equilibrium: Mathematical modeling and dynamic equilibrium equation; influence coefficients (Stiffness influence coefficients, damping influence coefficients, and mass influence coefficients)
3.4 Free vibration analysis of undamped system: Eigen value problem (natural frequencies and mode shapes)
3.5 Free vibration response of undamped system: Modal expansion; Orthogonality conditions; Normalization; Normal coordinates; Uncoupled equations of motion; Mode superposition method
3.6 Modal response analysis of damped systems
3.7 Forced vibration response of damped and undamped system
3.8 Dynamic analysis of linear multi-degrees-of-freedom system: Response spectrum analysis; Element forces; Modal contribution factors and minimum number of modes; Base shear; Modal mass
3.9 Evaluation of natural frequencies and mode shapes (Iterative methods): Rayleigh's method; Stodola's method; Holzer's method
3.10 Support excitation (Influence vector, synchronous support motion of a planar system, and structure with multiple support motions)

4 Continuous Systems (4 hours)

4.1 Partial differential equations of motion (Transverse vibration of a string and beam; axial vibration of a bar)
4.2 Evaluation of natural frequencies and mode shapes (Transverse vibration of a string and beam)

5 Application of Finite Element Method in Structural Dynamics (7 hours)

5.1 Basic concept of finite element method: Node and element; types and characteristics of finite element, local and global coordinate system; Discretization and meshing; shape functions; Nodal forces, Nodal displacements, Elemental stiffness matrix and structural (Global) stiffness matrix

5.2 Formulation of shape function and stiffness matrix (Bar and beam elements)

5.3 Convergence and compatibility

Tutorial **(30 hours)**

1. Evaluation of equivalent stiffness and fundamental frequency for structural systems with lateral-load-resisting elements in parallel and series combinations
2. Evaluation and plotting of vibration responses for an single-degree-of-freedom system (Undamped free vibration, undamped forced vibration, damped free vibration damped forced vibration, periodic and impulse loading)
3. Determination of the vibration response due to general dynamic loading using Duhamel's integral by applying both the analytical approach and numerical integration methods
4. Evaluation of the modal frequencies and mode shapes using the Eigen value method including sketches of the mode shapes
5. Determination of displacements and velocities of the free and forced vibration with damped and undamped system for the given initial conditions
6. Determination of displacements and velocities of the undamped and damped free vibration system for given initial conditions
7. Determination of several parameters of damped free vibration system of realistic problems (Such as elevated water tank, portal frame, and others): Damping ratio, natural period, equivalent stiffness, weight, damped natural frequency, damping coefficient, number of cycles required for the targeted reduced displacement amplitude, logarithmic decrement, and others
8. Determination of force transmissibility ratio and force due to rotation unbalance of machine
9. Determination of responses due to several types of periodic and impulsive loading (Half-sine wave, triangular, step or rectangular, ramp, and blast)
10. Evaluation of responses due to general dynamic loading: (General integration and numerical evaluation approach)
11. Determination of modal frequencies and mode shape vector and plotting the mode shapes of Eigen value problem of MDOF system
12. Evaluation and plotting of vibration responses for multi-degrees-of-freedom system using modal superposition method
13. Determination of modal frequencies of multi-degrees-of-freedom system using iterative methods (Rayleigh's method, Stodola's method, and Holzer's method)
14. Evaluation of the natural frequencies and plotting the mode shapes of vibrations (Transverse or axial) for continuous structural systems (String, bar and beam)

15. Evaluation of the nodal displacements of 1D bar problem and simple truss under point load and UDL

Practical **(15 hours)**

1. Free vibration of a simple cantilever beam
2. Mass-spring system: Determination of natural frequency
3. Damping in a simple pendulum
4. Dynamic response of a multi-story frame model
5. Modal analysis of MDOF system using FEM-based software

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	6
2	20	30
3	8	10
4	4	6
5	7	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Clough, R. W., Penzien, J. (2015). Dynamics of structures. CBS Publishers & Distributors.
2. Paultre, P. (2013). Dynamics of structures. John Wiley & Sons.
3. Jain, A.K. (2016). Dynamics of structures with MATLAB applications. Pearson.
4. Chopra, A.K. (2017). Dynamics of structures: Theory and applications to earthquake engineering. Pearson.
5. Paz, M., Leigh, W. (2010). Dynamics of structures: Theory and computation. Springer.
6. Thompson, W.T., Dahleh, M. D. (1998). Theory of vibration with applications (Latest Edition). Prentice Hall.
7. Cook, R.D. (1981). Finite element analysis (Latest Edition). John Wiley & Sons.
8. Belegundu, A. D., Chandrupatla, T. R. (2011). Introduction to finite elements in engineering. Pearson.

TRAIL SUSPENSION BRIDGES
ENCE 366

Lecture : 3 **Year : III**
Tutorial : 2 **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to provide students the theoretical and practical background required for planning, survey, design, execution and maintenance of trail bridges.

1 Introduction (4 hours)

1.1 Historical background
1.2 Development of trail bridges
1.3 Classification of trail bridges
1.4 Types of trail bridges
1.5 Components of trail Bridges
1.6 Specification of materials: Wire rope; Reinforcement; Structural steel; Wire mesh netting; Bulldog grip; Thimble; Nuts and bolts
1.7 Planning procedures: Socio-economical assessments; Preliminary site investigations

2 Trail Bridge Survey (4 hours)

2.1 Desk study
2.2 Preparation for survey
2.3 Site reconnaissance
2.4 Site selection
2.5 Preliminary design
2.6 Bridge axis survey
2.7 Bridge site survey
2.8 Geotechnical and geological assessment: Design parameters
2.9 Site photographs

3 Analysis and Design of Cable Structure (8 hours)

3.1 Loads on trail bridges
3.2 Cable properties
3.3 Cable geometry
3.4 Sag calculation for D-type and N-type bridges
3.5 Design of main and hand rail cables for D-type bridges
3.6 Design of main cables for N-type bridges
3.7 Design of spanning cables

4 Design of Short Span Trail Bridges (SSTB) (5 hours)

- 4.1 SSTB: D-type and N-type steel and construction drawing manuals
- 4.2 Determination of bridge span of SSTB D-type and N-type bridges
- 4.3 Selection of cable combination for D-type and N-type bridges
- 4.4 Selection of foundation block for D-type and N-type bridges
- 4.5 Selection of tower for N-type bridge

5 Long Span Trail Bridges (LSTB) (14 hours)

- 5.1 LSTB: D-type and N-type steel and construction drawing manuals
- 5.2 Design of the trail bridge cable: Cable design for suspended bridges; Cable design for suspension bridges
- 5.3 Wind effect and bridge stability
- 5.4 Wind loads on bridges
- 5.5 Design of wind-guy and Wind-ties cables
- 5.6 Design of tower for suspension bridges
- 5.7 Design of suspenders for suspension bridges
- 5.8 Design of bridge foundations
- 5.9 Drawings, cost estimating and reports

6 Construction of Trail Bridges (7 Hours)

- 6.1 Transportation and handling of bridge parts
- 6.2 Storage of bridge parts
- 6.3 Fabrication: Specification of materials, quality check and fabrication plant requirement
- 6.4 Galvanization: Introduction, galvanization process, quality check and specification for different bridge parts
- 6.5 Layout: SSTB D/N–type bridges, LSTB D/N-type bridges with/without wind guy cable
- 6.6 Earth works and civil works
- 6.7 Bridge erection: Tower erection; Cable hoisting (D-type and N-type bridges)
- 6.8 Fitting of bridge parts
- 6.9 Quality control and finishing works

7 Maintenance of Trail Bridges (3 hours)

- 7.1 Importance of maintenance
- 7.2 Routine maintenance
- 7.3 Major maintenance
- 7.4 Survey and design of maintenance works
- 7.5 Rehabilitation of bridges

Tutorial **(30 hours)**

1. Calculation of hoisting and full load sag
2. Design of cable for D and N type bridges
3. Design of suspenders
4. Design of all types of foundation for D and N types bridges

Practical/Assignment **(15 hours)**

1. SSTB D-type bridge
2. SSTB N-type bridge
3. LSTB D-type bridge
4. LSTB N-type bridge
5. Visual presentation/demonstration/observation of trail suspension bridges

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	6
2	4	6
3	8	12
4	5	6
5	14	16
6	7	10
7	3	4
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Suspension Bridge Division, Department of Roads, Institute of Engineering. (2003). A course manual on trail bridges.
2. Department of Local Infrastructure Development and Agricultural Roads, Trail Bridge Section. (2003). Short span trail bridge standard: Technical handbook: How to build a short span trail suspended bridge (Vol. I and II).
3. Department of Local Infrastructure Development and Agricultural Roads, Trail Bridge Section. (2003). Short span trail bridge standard: Steel and construction drawings.
4. Department of Local Infrastructure Development and Agricultural Roads, Trail Bridge Section. (2004). Long span trail bridge standard: Technical manual.
5. Swiss Centre for Development and Cooperation. (2003). Short span trail suspended bridge: Technical handbook.
6. Swiss Centre for Development and Cooperation. (1992). Long-span trail bridge standard: Technical manual.

SEISMIC RESISTANT DESIGN OF MASONRY STRUCTURES

ENCE 367

Lecture	**: 3**	**Year : III**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to provide students the theoretical and practical knowledge on earthquake and its effect on masonry structures, mainly failure mechanism and design of earthquake resistant masonry structures using codes. Students will be able to understand how masonry structures respond to earthquakes, effects on structure due to earthquake forces such as bending, and shear. Students will also learn to apply building codes to design safe and durable masonry buildings capable of withstanding earthquakes.

1 Earthquakes and Seismic Ground Motion (6 hours)

1.1 Origin of earthquake
1.2 Seismic waves, earthquake ground motion, magnitude and intensity
1.3 Occurrence of earthquakes; loss and damages
1.4 Time history, frequency spectra, and response spectra of earthquake force
1.5 Effects of earthquake on building

2 Masonry Structures (8 hours)

2.1 History of masonry structures in ancient and modern times
2.2 Nature of masonry structures
2.3 Mechanical and physical properties of masonry; Masonry materials (Units, mortar, and walls)
2.4 Types of masonry structures (Load bearing masonry, confined masonry, and infill masonry); Types of walls
2.5 Lateral force resisting elements (Walls, piers, and arches)
2.6 Structural system of historical masonry structures; Review on design of masonry walls for static force
2.7 Emerging materials and technologies in masonry structures

3 Seismic Behavior of Masonry Structures (10 hours)

3.1 Basic concept of seismic effect in masonry structure; Failure mechanism
3.2 Historical buildings with seismic resisting features
3.3 Lateral force resisting systems
3.4 In-plane and out-of-plane behavior of walls
3.5 Box-integrity-action of masonry structures

3.6 Modes of failure of masonry structures
3.7 Typical damages to masonry buildings in earthquakes
3.8 Seismic performance due to various factors (Geometrical and mass irregularities; Opening size and location; Eccentrically acted gravity load; eccentrically lateral force; Rigid and flexible floor diaphragm; Slender wall; horizontal and vertical bands; Material properties; Construction quality)
3.9 Seismic performance of masonry building during past earthquakes

4 Seismic Analysis and Design of Masonry Buildings (12 hours)

4.1 Principle of seismic design of masonry structures
4.2 Historical perspective on seismic design of masonry structures
4.3 Code provisions and calculation of seismic forces
4.4 Determination and distribution of lateral forces based on flexibility of diaphragms (IS 1893: 2016 or NBC 105: 2020)
4.5 Rigidity of shear wall considering opening effects
4.6 Direct and torsional shear force in shear walls
4.7 Increase in axial load in piers due to overturning
4.8 Wall subjected to out of plane bending
4.9 Stability check of flexural wall for out-of-plane forces
4.10 Additional forces due to arching action (Rigid and gapped arching)

5 Reinforced Masonry (5 hours)

5.1 Basic concept
5.2 Vertical and horizontal one-way flexural behavior
5.3 Two-way flexural behavior
5.4 Flexural and shear strength
5.5 Reinforced masonry column, beam, and bands

6 Repair and Strengthening Methods for Existing Masonry Buildings (4 hours)

6.1 Basic concept of repair, rehabilitation and retrofitting
6.2 Vulnerability assessment and methods
6.3 Retrofitting materials
6.4 Retrofitting techniques and various methods/approaches for masonry structures based on failure mechanism
6.5 Existing retrofitting practice of masonry structures in Nepal
6.6 Existing retrofitting practice in Nepal

Tutorial (30 hours)

1. Design of walls for gravity load
2. Calculation of center of mass, center of rigidity and eccentricity of lateral force
3. Calculation and distribution of lateral loads using IS 1893 and NBC 105
4. Distribution of seismic force on shear wall connected with rigid and flexible floor

5. Determination of rigidity of shear wall considering opening
6. Determination of direct shear force and torsional shear force
7. Determination of increase in axial load due to overturning
8. Determination of nominal allowable load carrying capacity of the wall subjected to out of plane bending
9. Stability check of flexural wall for out-of-plane forces
10. Determination of additional force due to arching action
11. Design of reinforced masonry walls (Flexure and shear capacity)
12. Design of reinforced concrete bands along with corner stiches

Practical **(15 hours)**

1. Survey and selection of a two storey masonry building
2. Preparation of asbuilt drawing
3. Calculation of loads: Dead, live and earthquake, calculate and analyze effects on building elements
4. Analysis and seismic resistant design and preparation of design report

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	8
2	8	8
3	10	14
4	12	18
5	5	6
6	4	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Tomazevic, M. (1999). Earthquake-resistant design of masonry buildings (Latest Edition). Imperial College Press.
2. Drysdale, R., Hamid, A. A. (2018). Masonry structures: Behavior and design. The Masonry Society.
3. Paulay, T., Priestley, M. J. N. (1992). Seismic design of reinforced concrete and masonry buildings (Latest Edition). John Wiley & Sons.
4. Hendry, A. W., Sinha, B. P., Davies, S. R. (2017). Design of masonry structures. CRC Press.
5. Sahlin, S. (1971). Structural masonry (Latest Edition). Prentice-Hall.
6. Hendry, A. W. (1998). Structural masonry (Latest Edition). Macmillan.
7. Arya, A., Boen, T., Ishiyama, Y., Martemianov, A., Meli, R., Scawthorn, C., Vargas, J., Yaoxian, Y. (2010). Guidelines for earthquake resistant non-engineered construction.

WATERSHED ENGINEERING AND MANAGEMENT
ENCE 368

Lecture : 3 **Year : III**
Tutorial : 2 **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to make students competent to apply agronomic, vegetative and engineering measures for soil and water conservation in a watershed with required management plan. After completion of the course the students will be able to design soil and water conservation structures like contour bunds, graded bunds, grassed waterways, terraces, gully control structures, water retaining and storage structures, sediment retention and flood control structures after estimating runoff and soil loss from a watershed.

1 Introduction (2 hours)

1.1 Soil erosion and landslide problems; Need of soil and water conservation
1.2 Concept and approaches of watershed engineering and management
1.3 Watershed operations: Physiography; Rainfall-runoff and soil loss analyses; Measures and operations
1.4 Condition of watersheds in Nepal and their future development

2 Runoff and Soil Loss (5 hours)

2.1 Soil and water: Soil characteristics (Composition, profile, texture and structure); Infiltration and soil moisture conditions; Surface runoff and ground water; Mechanics of soil erosion
2.2 Types of soil erosion and landslides: Surface erosion (Splash, sheet and rill); Gully erosion; Stream bank erosion; Landslides and movement
2.3 Estimation of peak runoff (Design flood): Rational method; Regional methods (WECS, DHM, MHSP, Dickens, PCJ)
2.4 Estimation of soil loss: Soil loss factors; Universal soil loss equation (USLE)

3 Land Capability Classification for Watershed Management (2 hours)

3.1 Land capability classification of Nepal
3.2 Characteristics of land capability classes (LCC)
3.3 Land use and soil conservation practices of LCC

4 Agronomic Measures for Soil and Water Conservation (4 hours)

4.1 Contour farming and cultivation
4.2 Strip cropping

4.3 Conservation farming: Tillage conservation; Crop rotation; Multiple cropping; Cover crop; Farm yard manure; Micro irrigation methods
4.4 Grassland farming
4.5 Agro-forestry
4.6 Horticulture

5 Bioengineering Measures for Soil and Water Conservation (4 hours)

5.1 Vegetative conservation techniques: Fascines; Palisades; Grass planting; Watling; Bamboo Planting; Live Fencing; Brush Layering
5.2 Natural hazard prevention: Gully treatment; Landslide treatment; Stream bank protection; Degraded land rehabilitation
5.3 Protection of developed infrastructures: Irrigation channel stabilization; Trail improvements; Road slope stabilization; Water source protection

6 Engineering Measures for Conservation of Agricultural Land (8 hours)

6.1 Bunding
 6.1.1 Contour bunding (Design criteria, specification and design)
 6.1.2 Graded bunding (Design criteria, specification and design)
 6.1.3 Construction and maintenance of contour and graded bunds
6.2 Terracing
 6.2.1 Bench terraces (Design, construction and maintenance)
 6.2.2 Broad base terraces (Design, construction and maintenance)
6.3 Drainage structures and grassed waterways
 6.3.1 Drainage structures (Types, design of surplus weir and pipe outlet)
 6.3.2 Grassed waterways (Types, design, construction and maintenance)

7 Engineering Measures for Conservation of Non-Agricultural Land (8 hours)

7.1 Contour and staggered trenching
7.2 Gully control structures (Types and application)
 7.2.1 Temporary and semi-permanent check dams
 7.2.2 Permanent spillway structures: Types; Design of straight drop, drop inlet and chute spillways
7.3 Design of sediment retention structure
7.4 Design of soil retaining wall

8 Water Harvesting and Conservation (6 hours)

8.1 Water conservation for cropland
8.2 Broad bed and furrow system; Conservation bench terraces; Tied ridging or furrow damming; Contour furrows; Catch Pits
8.3 Small storage structures: Conservation ponds; Small weirs; Small earthen and masonry dams; Sand dams
8.4 Design of conservation pond and small earthen dam
8.5 Recharge and use of ground water

9 Watershed Management (6 hours)

9.1 Causes and consequences of watershed deterioration
9.2 Objectives and steps of watershed management
9.3 People's participation in watershed management
9.4 Watershed management plan (WMP)
9.5 Formulation of project proposal

Tutorial (30 hours)

1. Estimation of design flood by Rational and Regional (WECS, DHM, MHSP, Dickens and PCJ) methods
2. Estimation of soil loss by universal soil loss equation (USLE)
3. Design of contour and graded bunds
4. Design of bench and broad base terraces
5. Design of surplus weir and pipe outlet
6. Design of trapezoidal and parabolic grassed waterways
7. Design of straight drop, drop inlet and chute spillways
8. Design of sediment retention structure
9. Design of soil retaining wall
10. Design of conservation pond and small earthen dam

Practical/Assignment (15 hours)

1. Visual presentation/demonstration/observation on soil erosion/landslide processes and watershed structures
2. Individual assignment on delineation of a catchment and estimation of design floods by different methods of a selected river with report submission

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	2	3
2	5	8
3	2	3
4	4	6
5	4	6
6	8	10
7	8	10
8	6	8
9	6	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Tiedeman, E. M. (1996). Watershed management: Guidelines for Indian conditions (Latest Edition). Omega Scientific Publishers.
2. Suresh, R. (1997). Soil and water conservation engineering (Latest Edition). Standard Publishers Distributors.
3. Schwab, G. O., Fangmeier, D. D., Elliot, W. J., Frevert, R. K. (2018). Soil and water conservation engineering. John Wiley & Sons, Inc.
4. NARMSAP NEPAL and Department of Soil Conservation and Watershed Management (2004). Soil Conservation and Watershed Management Measures and Low Cost Techniques. Kathmandu.
5. Department of Soil Conservation and Watershed Management. (1987). Watershed Planning Manual no. 4, Land Capability Classification.
6. Singh, G., Sastry, G., Joshi, B. P. (2023). Manual of soil and water conservation practices. CBS Publishers & Distributors.
7. Jha, P. C., Devkota, N. (2024). A textbook of irrigation and drainage engineering. Heritage Publishers & Distributors.
8. Suresh, R. (2017). Watershed planning management. Standard Publishers.

RIVER AND SEDIMENT ENGINEERING
ENCE 369

Lecture : 3 | **Year: III**
Tutorial : 2 | **Part: II**
Practical : 1

Course Objectives:
The objective of this course is to develop fundamental skills for collecting sediment related data in the field, essential for sedimentation studies and river engineering projects. Upon successful completion, students will also be able to design basic sediment management, as well as river training and protection works.

1 Introduction (3 hours)

1.1 History of sediment transport and river engineering
1.2 Rivers and the water-rock cycle link
1.3 Key water infrastructures projects in rivers
1.4 Sediment induced problems in water infrastructure projects
1.5 Spatial and temporal scales in sedimentation and river engineering

2 Properties of Sediment (2 hours)

2.1 Characteristics of sediment grains: Size, shape and classifications
2.2 Sampling of bed deposits
2.3 Density, porosity and their measurements
2.4 Particle fall velocity, measurement and estimation
2.5 Angle of repose

3 Sediment Erosion and Yield (4 hours)

3.1 Weathering, erosion and sediment yield
3.2 Inter-rill and rill erosion
3.3 Gully erosion
3.4 Channel erosion
3.5 Mass wasting
3.6 Sediment delivery ratio (SDR)
3.7 Erosion modelling using universal soil loss equation (USLE)
3.8 Erosion modelling using erosion potential model (EPM)

4 Sediment Transport (6 hours)

4.1 Roughness in river bed: form and skin drag
4.2 Initiation of motion and transport modes
4.2.1 Critical velocity

4.2.2 Critical bed-shear stress
4.2.3 Initiation of suspension
4.2.4 Sediment transport modes

4.3 Bed-load transport
4.3.1 Deterministic methods
4.3.2 Stochastic methods
4.3.3 Bed-load transport of non-uniform material

4.4 Suspended load transport
4.4.1 Concentration profiles
4.4.2 Reference concentration and levels
4.4.3 Suspended load transport rates

5 Monitoring of Suspended Sediments (4 hours)

5.1 Iso-kinetic sampling
5.1.1 Sampling methods
5.1.2 Samplers

5.2 Sampling location and handling of samples

5.3 Laboratory analysis
5.3.1 Concentration analysis
5.3.2 Particle size distribution
5.3.3 Mineral content analysis
5.3.4 Organic content analysis

5.4 Surrogate methods of suspended sediment measurements

5.5 Data analysis

6 Sediment Handling in Run-of-River and Storage Projects (12 hours)

6.1 Sediment handling in run-of-river projects
6.1.1 Sediment handling strategies
6.1.2 Bed-load handling
6.1.3 Suspended sediment handling

6.2 Operation of peaking reservoir

6.3 Sediment transport and deposition in reservoir

6.4 Trap efficiency and life of reservoir

6.5 Design paradigm of storage projects

6.6 Sediment handling in storage projects
6.6.1 Reducing sediment yield
6.6.2 Sediment routing
6.6.3 Redistributing or removing sediment deposits
6.6.4 Adaptive strategies

7 Fundamentals of River Engineering (6 hours)

7.1 River planform

7.2 Flow in river bends

7.3 Bank-full and formative discharge concept

7.4 Sediment continuity and river bed changes
7.5 Stable channels and regime theories
7.6 Propagation of bed perturbations
7.7 Short-term development of shoals and trenches
7.8 Analytical model for reach scale equilibrium
  7.8.1 Response to permanent flow abstraction
  7.8.2 Response to sediment mining

8 Bank Erosion and River Training Works (4 hours)

8.1 Mechanics of bank erosion
8.2 Design of groynes
8.3 Design of embankments
8.4 Indigenous river training and protection methods

9 Bridge Foundation Scour and Protection (4 hours)

9.1 Bridge foundation scour
9.2 Approach flow and morphological consideration
9.3 Estimation and modelling of bridge foundation scour
9.4 Scour protection measures

Tutorial (30 hours)

1. Computation of particle size distribution and size related parameters of sediment mixture
2. Determination of fall velocity of natural sediment using different formulas
3. Estimation of sediment yield using USLE and EPM methods
4. Estimation of bed-load transport using various equations
5. Estimation of suspended load transport using various equations
6. Computation of sediment load using various methods
7. Derivation of discharge versus suspended sediment concentration rating curve from the observed sediment concentration and discharge data
8. Estimation of dimension of channels based on different regime theories
9. Derivation of equations for the propagation of small bed perturbations
10. Derivation of developments of shoals and trenches
11. Determination of short-term and long-term river response to discharge and sediment abstraction
12. Design of groynes and embankments
13. Estimation of bridge scour

Practical/Assignment (15 hours)

1. Visual presentation/demonstration of river-sediment transport processes
2. Determination of sediment concentration in a water-sediment mixture using the filtration method in laboratory
3. Individual assignment on erosion modelling by USLE and EPM

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	3	3
2	2	4
3	4	6
4	6	8
5	4	6
6	12	12
7	6	10
8	4	6
9	4	5
Total	**45**	**60**

* There may be minor deviation in marks distribution.

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1. Dey, S. (2014). Fluvial Hydraulics: Hydrodynamic and Sediment Transport Phenomena. Springer-Verlag.
2. Garcia, M. (Ed.). (2008). Sedimentation Engineering. American Society of Civil Engineers.
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5. Van Rijn, L. (1993). Principles of Sediment Transport in River, Estuaries and Coastal Areas (Latest Edition). Aqua Publication.

COMPUTATIONAL TECHNIQUES IN WATER RESOURCES ENGINEERING

ENCE 370

Lecture	**: 3**	**Year : III**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to equip students with computational techniques for solving complex problems in water resources engineering. The course emphasizes the application of numerical methods to simulate and analyze open channel flow, groundwater seepage, and unsteady flow in pipe systems, alongside the use of optimization approaches for water resources management. By the end of the course, students will be able to apply computational tools to effectively model, evaluate, and optimize water resources systems for practical engineering decision-making.

1 Computational Techniques (6 hours)

- 1.1 Role of computational techniques in water resources
- 1.2 Types of models: Deterministic, stochastic, data-driven
- 1.3 Methods of computation: Finite difference method (FDM); Finite element method (FEM); Finite volume method (FVM)
- 1.4 Initial and boundary conditions
- 1.5 Software overview related to water resources
- 1.6 Saint Venant equations: Assumptions, equations in conservative and non-conservative forms

2 Finite Difference Method (9 hours)

- 2.1 Mathematical theory of FDM: Forward difference approximation; Backward difference approximation; Central difference approximation; Steps in FDM
- 2.2 Order of accuracy; Truncation error
- 2.3 Concept of consistency, convergence and stability
- 2.4 Explicit and implicit schemes
- 2.5 Kinematic and dynamic wave celerity
- 2.6 Finite difference solution of kinematic wave model (Explicit only)
- 2.7 Finite difference solution of dynamic wave model (Explicit and implicit)

3 Method of Characteristics (MOC) (12 Hours)

- 3.1 Characteristics; Solution requirements; Advantages; Limitations
- 3.2 Characteristics equations to open channel and pipe flow
- 3.3 Finite difference solution of characteristics equations of unsteady pipe flow
- 3.4 Algorithm for solving water hammer problem using rectangular grid

3.5 Stability of MOC solution
3.6 Boundary conditions for unsteady pipe flow problem
3.7 MOC for 1D gradually varied unsteady open channel flow
3.8 Numerical (FDM) solution of MOC for 1D unsteady open channel flow

4 Simulation of Groundwater Flow (9 Hours)

4.1 Basic equation of groundwater flow and flow-net analysis: Darcy's Law; Steady continuity equation for incompressible flow; Equipotential line; Stream line; Flow potential; Flow-net; Rules for constructing flow-net in isotropic medium
4.2 Finite difference scheme for 2D groundwater simulation
4.3 Simulation of seepage under a dam based on steady state 2D model
4.4 1D implicit model for simulating river stage and groundwater table interaction

5 Optimization Techniques in Water Resources (9 Hours)

5.1 Introduction: Role and importance of optimization in water resources planning and management; Types of optimization problems (single-objective, multi-objective, deterministic and stochastic)
5.2 Linear programming (LP): Formulation of LP problems (objective function, constraints, and decision variables); Application in reservoir operation and canal scheduling
5.3 Nonlinear programming (NLP): Overview of NLP problems and solution approaches; Applications in groundwater remediation, water allocation, and hydropower scheduling
5.4 Dynamic programming (DP): Principle of optimality; Recursive solution approach; Application to multi-period reservoir operation problems

Tutorial (30 hours)

1. Methods and techniques of computation
2. Solution of water resources problems by numerical methods
3. Finite difference method
4. Kinematic wave model
5. Dynamic wave model
6. Method of characteristics
7. Simulation of groundwater flow
8. Optimization techniques in water resources

Practical/Assignment (15 hours)

1. Simulation of rainfall-runoff process in a sloped channel using the kinematic wave approximation
2. Model an unsteady flow scenario (e.g., gate opening or dam break) using HEC-RAS
3. Solution of transient flow problem (e.g., sudden valve closure) in a pipeline using the Method of Characteristics (MOC) in MATLAB or Python

4. Development of MATLAB or Python program to solve 1D steady-state groundwater flow in a confined aquifer using the finite difference method (FDM) with Dirichlet boundary conditions
5. Creation of 2D steady-state groundwater model to simulate seepage under an earthen dam using MODFLOW and ModelMuse GUI
6. Formulation of linear programming model to optimize the monthly operation of a single reservoir for irrigation and hydropower using Excel Solver or Python

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	8
2	9	12
3	12	16
4	9	12
5	9	12
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Cheng, A. H.-D., Cheng, D. T. (2005). Applied Hydrology with Remote Sensing. Springer.
2. Anderson, M. P., Woessner, W. W. (1992). Applied Groundwater Modeling: Simulation of Flow and Advective Transport. Academic Press.
3. Chapra, S. C., Canale, R. P. (2015). Numerical Methods for Engineers. McGraw-Hill.
4. Loucks, D. P., van Beek, E. (2017). Water Resource Systems Planning and Management: An Introduction to Methods, Models, and Applications. Springer.
5. Wurbs, R. A., James, W. P. (2002). Water Resources Engineering. Prentice Hall.
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TRANSPORTATION PLANNING AND MODELING

ENCE 371

Lecture : 3 | **Year : III**
Tutorial : 2 | **Part : II**
Practical : 1

Course Objectives:

The objective of this course is to provide students principles of transportation planning and the use of mathematical models for transport demand forecasting. It covers the role and functions of models in system analysis, the different types of models and their applications. It emphases on aggregated models for trip generation, trip distribution, modal split, and network assignment, along with estimation of model parameters with calibration, enabling student to analyze and forecast transportation demand effectively.

1 Introduction (7 hours)

1.1 Concept of transportation planning
1.2 Existing planning process in Nepal
1.3 Rational decision-making process
1.4 System engineering concept and application in transport planning
1.5 Models and model developing process
1.6 Issues in transportation planning and modeling

2 Statistics in Transportation Planning (7 hours)

2.1 Statistics in transportation (Binomial, Poisson, negative binomial, negative exponential and normal distributions)
2.2 Hypothesis tests
2.3 Regression analysis

3 Transportation Survey (4 hours)

3.1 Basic sampling theory
3.2 Data collection methods in transportation
3.3 Home interview survey
3.4 Roadside interview survey
3.5 Inventory of transport facilities, land-use and economic activities
3.6 Network and zoning system

4 Traffic Forecasting (6 hours)

4.1 Need for traffic forecasting
4.2 Forecasting based on past trends

4.3 Mathematical models for traffic forecasting
4.4 Econometric method for traffic forecasting
4.5 Land use forecasting model (Lowry model)

5 Trip Generation Modeling (5 hours)

5.1 Trip classification
5.2 Concept of trip generation and factors affecting trip generation
5.3 Trip generation analysis: Growth factor modeling; Regression analysis; Category analysis

6 Trip Distribution Modeling (6 hours)

6.1 Concept of trip distribution and factors affecting trip distribution
6.2 Growth factor methods: Uniform; Average growth factor; Fratar method; Furness method
6.3 Gravity models

7 Modal Split Model (4 hours)

7.1 Concept of mode choice modeling and factors affecting mode choice
7.2 Types of modal split models; Logit model and its application

8 Trip Assignment (6 hours)

8.1 Basic concepts and factors affecting trip assignment
8.2 Procedure of trip assignment (Minimum path technique; Minimum path with capacity restraint; BPR Method; Diversion curves; User equilibrium assignment; System optimization assignment

Tutorial (30 hours)

1. Use of probability distributions and regression analysis
2. Sampling theory and estimation of sample size
3. Analysis of trip generation
4. Analysis of trip distribution
5. Application of modal split model
6. Trip assignment

Practical/Assignment (15 hours)

1. Review of previous transportation study reports
2. Application of geo-informatics in transportation planning
3. Traffic and transport study using recent macro simulation packages

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	7	8
2	7	8
3	4	6
4	6	8
5	5	8
6	6	8
7	4	6
8	6	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Kadiyali, L. R. (2024). Traffic engineering and transport planning. Khanna Publishers.
2. Papacostas, C. S., Prevedouros, P. D. (2000). Transportation engineering and planning. Pearson.
3. Meyer, M. D., Miller, E. J. (2001). Urban transportation planning: A decision-oriented approach. McGraw-Hill.
4. Ortúzar, J. de D., Willumsen, L. G. (2024). Modelling transport. John Wiley & Sons.

RAILWAY ENGINEERING
ENCE 372

Lecture : 3 | **Year : III**
Tutorial : 2 | **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to provide basic knowledge of railway engineering, covering the key components, design principles of railway track and geometry, signal systems and train control mechanisms, and operational aspects of railway systems. It aims to equip students with the technical understanding necessary for planning, designing, and managing railway infrastructure and operations.

1 Introduction (4 hours)

1.1 History of railways
1.2 Characteristics of railways
1.3 Classification of railways
1.4 Advantages of railways
1.5 Scope and development of railways in Nepal

2 Train Resistance and Rolling Stock (5 hours)

2.1 Train resistances and tractive effort
2.2 Rolling stock
2.3 Locomotives (Definition, types and essential parts)
2.4 Coaches and wagons
2.5 Train braking system

3 Railway Track (5 hours)

3.1 Definition of track gauge and its types
3.2 Types of gauges used in different countries
3.3 Permanent way and its requirements
3.4 Functions and requirements of ideal rails
3.5 Types of rails
3.6 Rail wear and methods to reduce

4 Sleepers (4 hours)

4.1 Functions of sleepers
4.2 Types of sleepers
4.3 Requirements of an ideal material for sleepers
4.4 Materials for cross-sleepers

5 Ballast **(4 hours)**

- 5.1 Functions and Ideal requirements of ballast
- 5.2 Types of ballast
- 5.3 Ballast-less track

6 Rail Fastenings **(4 hours)**

- 6.1 Rail joints
- 6.2 Avoidance of rail joints
- 6.3 Types of rail joints
- 6.4 Fish-plates
- 6.5 Rail welding

7 Geometric Design of Railway Track **(8 hours)**

- 7.1 Objections to track curvature
- 7.2 Designation of a curve
- 7.3 Types of curves and limiting radius or degree of curvature
- 7.4 Design of transition curves
- 7.5 Super elevation and negative super elevation
- 7.6 Different types of speed of trains on curves
- 7.7 Design of vertical alignment
- 7.8 Grade compensation on curves
- 7.9 Bending of rails on curves

8 Stations and Yards **(6 hours)**

- 8.1 Definition and purposes of a railway station
- 8.2 Site selection for a railway station
- 8.3 Key features of a railway station
- 8.4 Types of stations
- 8.5 Platforms
- 8.6 Railway yard and types
- 8.7 Level crossings

9 Signaling **(5 hours)**

- 9.1 Definition and objectives of railway signaling
- 9.2 Types of signals
  - 9.2.1 Classification according to function
  - 9.2.2 Classification according to location
  - 9.2.3 Special signals
- 9.3 Modern signaling systems
- 9.4 Typical signal layouts
- 9.5 Train movement control
- 9.6 Railway telecommunication

Tutorial **(30 hours)**

1. Geometric design of a railway track
2. Design of railway track structure
3. Designation of a railway curve
4. Design of curves (Limiting radius or degree of curvature)
5. Design of transition curves
6. Design of super elevation and negative super elevation
7. Design speed of trains on curves
8. Design of vertical alignment
9. Grade compensation on curves

Practical/Assignment **(15 hours)**

1. Visual presentation/demonstration/observation of components of railways
2. Individual assignment with report submission on “Planning and design of a railway track alignment with components for a selected area of Nepal”

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	4
2	5	4
3	5	8
4	4	4
5	4	4
6	4	4
7	8	12
8	6	12
9	5	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Profillidis, V. A. (2006). Railway management and engineering. Ashgate Publishing.
2. Mundrey, J. S. (2009). Railway track engineering. Tata McGraw-Hill.
3. Bonnett, C. F. (2005). Practical Railway Engineering. Imperial College Press.
4. Chandra, S., Agarwal, M. M. (2013). Railway Engineering. Oxford University Press.
5. Rangwala, S. C. (2012). Railway engineering. Charotar Publishing House.

ROCK MECHANICS AND ENGINEERING

ENCE 373

Lecture : 3 **Year : III**
Tutorial : 2 **Part : II**
Practical : 1

Course Objectives:

The objective of this course is to provide students the knowledge of overall behavior of rocks and rock masses and the safe and economic designs of excavation and embankments in hilly areas. It delivers to determine the slope sensitivity to different triggering mechanism and to test and compare different support and stabilization options. At the end of this course students will be able to acquire basics of analysis and design of tunnels, caverns, slopes, and foundations on rocks.

1 Rock Engineering and Its Development (4 hours)

1.1 Introduction and basic concepts
1.2 Historical perspective and uses in civil engineering
1.3 Rock engineering problems and application area
1.4 Rock engineering principles
1.5 Rock engineering and Nepal Himalayas scenario

2 Rock Properties (9 hours)

2.1 Rock coring and logging
2.2 Physical properties
2.3 Mechanical properties
2.4 Failure in rocks: Hydrostatic compression; Deviatoric compression and effect of confining pressure
2.5 Failure modes in rocks; Complete stress-strain curve
2.6 Failure criteria for rocks; Mohr-coulomb criterion; Effect of water pressure and principle stress ratio; Hoek and Brown criterion; Empirical Rock failure criterion; Griffith failure criterion; Hyperbolic model and Bieniawski-Yudhbir criterion
2.7 Weakness joint and faults

3 Stresses around Underground Openings (8 hours)

3.1 Origin of rock stress
3.2 Stresses surrounding underground opening, Kirsch equation
3.3 Circular hole in an elasto-plastic infinite medium under hydrostatic loading
3.4 Plastic behavior around tunnels; Zone of influence

3.5 Excavation shape and boundary stress
3.6 Stress distribution due to development of fractured zone
3.7 Tunneling in stratified rock and blocky rock
3.8 Rock fractures and scale/size effect
3.9 Numerical modelling for stresses around underground opening
3.10 Effect of width to height (W/H) ratio
3.11 Tunneling in weak rock
3.12 Effects of planes of weakness on stress distribution

4 Tests on Rock and Rock Masses (5 hours)

4.1 Tests on rock: Uniaxial, tensile, point load, triaxial and direct shear test
4.2 In-situ direct shear test
4.3 In-situ tests for deformability (Plate, uniaxial and pressure meter test)
4.4 In-situ stress and their determination (Hydraulic, fracture and stress relief)
4.5 Geophysical investigation

5 Groundwater in Rock Masses (4 hours)

5.1 Permeability and hydraulic conductivity
5.2 Estimation of water leakages
5.3 Groundwater effects on slope stability
5.4 Groundwater pressure models
5.5 Problems caused by water

6 Geological Investigation for Underground Structures (4 hours)

6.1 Scope and importance
6.2 Investigation stages
6.3 Pre-construction phase investigations
6.4 Construction phase investigations
6.5 The engineering geological report

7 Rock Mass Classification and Improvement of Rock Mass (6 hours)

7.1 The RMR system, Q-system, GSI system and RMi system of classifications
7.2 Correlation between RMR, Q and GSI values
7.3 Rock reinforcement, rock bolting-suspension, beam building and keying theory
7.4 Underground supports
7.5 Evaluation of support requirements

8 Rock Engineering and its Applications in Slope Stability (5 hours)

8.1 Importance of rock slope stability in Nepal (Himalayan geology, fragile mountains, major incidents in the Himalayas, infrastructure needs)
8.2 Roadside slopes stability

8.3 Slopes around dams, tunnels, and reservoirs
8.4 Stone quarry and mining-related slope failures
8.5 Lessons from recent earthquakes
8.6 Engineering best practice for Nepalese terrain

Tutorial **(30 hours)**

1. Analysis of stress distribution around underground openings for structural stability assessment
2. Quantitative estimation of water leakage in rock masses using permeability and flow models
3. Graphical analysis of geological data using joint rosettes, rose diagrams, and stereonets
4. Interpretation of joint patterns and failure modes for slope and tunnel design
5. Stress analysis around underground openings using Kirsch equations and elasto-plastic models
6. Design of rock support systems using RMR, Q-system, and GSI-based empirical methods
7. Estimation and design of preventive measures for unstable slopes including drainage and reinforcement
8. Graphical analysis of geological data using joint rosettes, rose diagrams, and stereonets. Interpret the spatial orientation of discontinuities
9. Stress analysis around underground openings using Kirsch equations and elasto-plastic models. Assess stress concentration zones
10. Design of rock support systems using RMR, Q-system, and GSI-based empirical methods. Recommend suitable reinforcement strategies
11. Stability analysis and design of rock slopes using limit equilibrium and numerical modeling approaches; Calculation of factors of safety for various failure modes
12. Estimation and design of preventive measures for unstable slopes, including drainage systems and rock reinforcement; Optimization based on slope geometry and rock mass properties

Practical/Assignment/Observation **(15 hours)**

1. Preparation and submission of a detailed report on a nearby rock engineering project by examining the practical applications of rock engineering principles and identifying the key challenges encountered during the project
2. Analysis of rock properties using available laboratory data (Uniaxial compressive strength, tensile strength, point load test); Plotting of stress-strain curves and identification of different failure types
3. Assessment of a rock slope to analyze its stability and design appropriate mitigation measures for slope stabilization

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	6
2	9	12
3	8	10
4	5	6
5	4	6
6	4	6
7	6	8
8	5	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Goodman, R. E. (1989). Introduction to rock mechanics (Latest Edition). John Wiley & Sons.
2. Ramamurthy, T. (2014). Engineering in rocks for slopes, foundations and tunnels. Prentice Hall India.
3. Jaeger, J.C., Cook, N.G.W., Zimmerman, R.W. (2007). Fundamentals of rock mechanics. Wiley-Blackwell.
4. Nilsen, B., Thidemann, A. (1993). Rock engineering. Norwegian Institute of Technology, Division of Hydraulic Engineering.
5. Nilsen, B., Palmström, A. (2000). Engineering geology and rock engineering (Handbook No. 2). Norwegian Group for Rock Mechanics (NBG).
6. Dhakal, B. B., Shrestha, K. P. (2023). A textbook of rock slope engineering. Heritage Publishers & Distributors

PILE FOUNDATION ENGINEERING FOR BRIDGES
ENCE 374

Lecture : 3 | **Year : III**
Tutorial : 2 | **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to produce engineers having skills for investigation, design and construction of bridge foundation on piles. It provides understanding of soil properties and load transfer mechanisms for the structural design of piles and pile caps, and the construction aspects of pile installation. It also explores specific types of piles, design considerations for various bridge conditions, and relevant codes and standards.

1 Introduction (6 hours)

- 1.1 Classification and components of bridges
- 1.2 Types of bridge foundation
- 1.3 Topographic and river characteristics
- 1.4 Selection of pile foundation for bridges
- 1.5 Load analysis (Dead load, live load, earth pressure, impact load, seismic load, wind load and other loads)
- 1.6 Foundation design philosophy

2 Engineering Investigations and Study (6 hours)

- 2.1 Investigations and data collection at different stages of a bridge project
- 2.2 Geological and geophysical investigations
  - 2.2.1 Regional and local geology, geological structures and significance
  - 2.2.2 Geophysical investigations and types; Advantages and applications
- 2.3 Geotechnical investigation
  - 2.3.1 Field investigations (Boring, sampling, in-situ tests, ground water observation)
  - 2.3.2 Laboratory tests and data interpretation specific to pile foundation
- 2.4 Hydrological and hydraulic study for bridges
  - 2.4.1 Hydrological and hydraulic parameters for bridge design
  - 2.4.2 Estimation of design flood by suitable methods; Choice of method
  - 2.4.3 Bridge design discharge and foundation design discharge
  - 2.4.4 Linear waterway and effective linear waterway; Bridge length
  - 2.4.5 Afflux, high flood level and rating curve; Water surface profile
  - 2.4.6 Scour depth calculation by suitable methods; Depth of foundation

3 Geotechnical Design of Piles for Bridges (8 hours)

3.1 Types of pile: Driven and bored piles, driven concrete piles, their advantages and disadvantages; Factors affecting the selection of pile type; Soil properties relevant to pile design
3.2 Selection of pile materials and sizes based on load and soil conditions
3.3 Load transfer mechanism: End bearing and skin friction
3.4 Ultimate axial load capacity
  3.4.1 Single vertical pile by static method
  3.4.2 Single vertical pile by in-situ tests
  3.4.3 Pile in cohesive, cohesion less and stratified c-Ø soil, intermediate geo-material and rock by IS and IRC code of practice
  3.4.4 Pile capacity by field tests
3.5 Ultimate axial load capacity of under-reamed pile
3.6 Group efficiency and pile group capacity
3.7 Settlement of single and group piles (Consolidation, elastic and approximate methods)
3.8 Analysis of laterally loaded piles: Elastic methods (Wrinkler's, p-y curve and modulus of subgrade reaction methods); Empirical and semi-empirical methods; Codal provisions
3.9 Uplift capacity
3.10 Negative skin friction
3.11 Liquefaction and evaluation of liquefaction potential
3.12 Geotechnical design considerations, design steps and requirements

4 Structural Design of Piles for Bridges (8 hours)

4.1 Structural behavior of pile: Axial, bending and lateral resistance
4.2 Design of piles for axial compression, bending and shear
4.3 Spacing and arrangements for pile groups, considering interaction effects
4.4 Design of pile cap ensuring adequate reinforcement and shear capacity
4.5 Design of piles to resist lateral loads (Hydrodynamic, wind and seismic loads considering soil liquefaction and ground shaking)
4.6 Design with down drag loads from consolidating soil layers
4.7 Relevant codes and standards for pile design
4.8 Structural design of pile and pile cap by limit state method

5 Tests on Pile (4 hours)

5.1 Pile load tests and its significance
5.2 Static load test (IS:2911)
  5.2.1 Objectives of load test, types of test
  5.2.2 Vertical, lateral and pull-out test, safe load, bi-directional load test
5.3 Dynamic load test
  5.3.1 High strain dynamic test (PDA Test)); Pile integrity test
  5.3.2 Ultimate load from load-settlement curve by different methods

6 Construction of Piles and Pile Cap (6 hours)

- 6.1 Preconstruction planning based on filed and laboratory investigations
- 6.2 Project scheduling and monitoring tools and techniques
- 6.3 Fixing of bridge alignment and piles
- 6.4 Pile installation procedure and piling methods
  - 6.4.1 Driven pile: Driving, quality control and monitoring; Construction safety and environmental protection
  - 6.4.2 Bored pile: Boring, concreting, quality control and monitoring; Construction safety and environmental protection
- 6.5 Pile construction problems and remedial measures
- 6.6 Construction of pile cap
- 6.7 Causes of pile failure
- 6.8 Pile protection from corrosion particularly in aggressive soil environments
- 6.9 Bridge construction contract model practiced in Nepal

7 Maintenance and Rehabilitation of Bridges (7 hours)

- 7.1 Bridge maintenance
  - 7.1.1 Purpose of maintenance, cycle of maintenance
  - 7.1.2 Bridge maintenance management system, bridge components for maintenance
  - 7.1.3 Objectives, types, and time and frequency of inspection
  - 7.1.4 Prioritization of maintenance, maintenance operations
  - 7.1.5 Maintenance organization of bridge building agency in Nepal
- 7.2 Bridge rehabilitation
  - 7.2.1 Rehabilitation plan, testing methods for assessment of existing bridge
  - 7.2.2 Commonly occurred distress of foundation; Remedial measures of pile foundation; Repair and rehabilitation of damaged piles
  - 7.2.3 Methods of increasing lateral resistance and capacity of existing pile
  - 7.2.4 Bridge failure reasons and monitoring

Tutorial (30 hours)

1. Estimation of design flood discharge at bridge site by different methods
2. Estimation of waterway, high flood level, afflux and free board
3. Calculation of scouring discharge and depth by different methods; depth of foundation
4. Selection of pile materials and sizes based on load requirements and soil conditions
5. Determination of pile load capacity
6. Determination of ultimate axial load capacity of single vertical pile by static method
7. Determination of pile group capacity
8. Evaluation of liquefaction potential of soil
9. Bridge load analysis including dead load, live load and seismic loads

10. Design of piles for axial compression, bending and shear
11. Design of pile caps to distribute loads from the bridge structure to the piles
12. Design of piles to resist lateral loads
13. Structural design of pile and pile cap by Limit State Method

Practical/Assignment **(15 hours)**

1. Visual presentation/demonstration/ observation of bridge components, soil exploration, investigations for bridge and construction of piles and pile caps
2. Individual assignment with report submission on design of pile foundation for a bridge crossing in a selected river based on hydrological and geotechnical investigations and analysis

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	8
2	6	8
3	8	10
4	8	12
5	4	6
6	6	8
7	7	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Saran, S. (2018). Analysis & design of substructures: Limit state design. Oxford & IBH Publishing.
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3. Bowles, J.E. (1996). Foundation analysis and design (Latest Edition). McGraw-Hill.
4. Guo, W.D. (2024). Advanced design of pile foundations under lateral loading. CRC Press.
5. Mittal, S. (2023). Pile foundation design and construction (3rd ed.). CBS Publishers & Distributors.
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EARTH HAZARD
ENCE 375

Lecture : 3 **Year : III**
Tutorial : 2 **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to provide students a comprehensive understanding of earth hazards, their causes, processes, effects on infrastructure, and techniques for hazard assessment and mitigation. The course enables students to integrate earth hazard considerations into engineering design and planning.

1 Introduction (6 hours)

1.1 Hazard, vulnerability, risk and disaster
1.2 Geomorphological and geological sub-division and associated hazards
1.3 Key controlling factors of hazard: Geology; Climate; Hydrology; Land use patterns; Groundwater
1.4 Impact of earth hazards on civil engineering infrastructures

2 Geological Hazards (8 hours)

2.1 Earthquakes: Causes, seismic waters, magnitude and intensity
2.2 Earth mass movements: Classification, triggers, and mechanics
2.3 Soil and rock mechanics basics related to hazards

3 Hydrological Hazards (7 hours)

3.1 Floods: Types, causes and flood frequency analysis
3.2 Cryosphere hazards: Snow avalanche, glacial lakes and glacial lake outburst floods (GLOF)
3.3 Groundwater-related hazards: Springs, erosion

4 Atmospheric Hazards (5 hours)

4.1 Storms, cyclones, tornados, and hail
4.2 Drought: Causes and impacts
4.3 Climate change and its effect on hazard patterns
4.4 Air pollution and acid rain and their effects on structures

5 Hazard Assessment and Mapping (9 hours)

5.1 Remote sensing and GIS application in hazard mapping
5.2 Hazard zonation and vulnerability mapping

5.3 Hazard modelling and prediction tools
5.4 Multi-hazard risk assessment methods

6 Hazard Mitigation and Management **(10 hours)**

6.1 Engineering approaches: Slope stabilization, retaining structures, drainage
6.2 Bioengineering and natural methods of hazard control
6.3 Multi-hazard early warning systems (EWS) and disaster preparedness
6.4 Policy, planning and community involvement in hazard management

Tutorial **(30 hours)**

1. Analysis of relationship between geological, climatic, and land-use factors to determine hazard, vulnerability and risk in a selected area of Himalaya
2. Flood frequency analysis to estimate flood risk in a selected river basin
3. Evaluation of causes and impacts of drought in Nepal and propose mitigation strategies based on climatic and agricultural data
4. Application of GIS tools to create a hazard zonation map identifying areas of varying vulnerability to earth hazards
5. Design of a comprehensive slope stabilization and EWS plan for landslide-prone regions integrating engineering and community-based approaches

Practical **(15 hours)**

1. Analysis of spatial distribution of landslide occurrences in Nepal Himalaya using GIS data and correlate with geological and climatic factors
2. Evaluation of seismic hazard by analyzing ground shaking intensity maps and historic earthquake catalogs for a Nepalese region
3. Execution of statistical frequency analysis of historical landslide-triggering rainfall events to determine rainfall thresholds for slope failure
4. Application of remote sensing and GIS to create a multi-hazard zonation map highlighting earthquake, landslide, and flood-prone areas
5. Review of engineering case studies of slope stabilization structures and model their performance under different geotechnical conditions

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	8
2	8	10
3	7	10
4	5	8
5	9	12
6	10	12
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

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BIOENGINEERING
ENCE 376

Lecture : 3 **Year : III**
Tutorial : 2 **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to provide students with comprehensive knowledge of vegetation types, their functions, and integration with small scale civil engineering structures for landslide protection, mitigation, and management. By the end of the course, students will be able to assess and investigate landslide and plan, design, and implement appropriate bioengineering measures for slope stabilization.

1 Introduction (4 hours)

1.1 Landslides and soil erosion scenario in Nepal
1.2 Conventional approaches for slope protection and stabilization and their engineering functions
1.3 Vegetation as a slope stabilizing material and its engineering functions
1.4 Scope, advantages, limitations and sustainability of bioengineering techniques

2 Mass Movement (6 hours)

2.1 Mass movements and its classification
2.2 Erosion: Types, causes and effects
2.3 Landslides: Types, causes (Geological, geomorphological, topographical, anthropogenic) and their impacts
2.4 Landslide triggers; Rainfall induced landslides
2.5 Landslide assessments and investigations
2.6 Landslide mapping, assessment of seriousness, and repair priorities

3 Vegetation: Structure, Propagation and Function (10 hours)

3.1 Plant types, forms, and structures
3.2 Plant community
3.3 Basic plant requirements
3.4 Plant propagation: Sexual and asexual methods
3.5 Distribution of plants in Nepal
3.6 Hydrological and hydraulic functions of vegetation
3.7 Engineering functions of vegetation
3.8 Slope stability by vegetation
    3.8.1 Soil root model: Principles and derivation

3.8.2 Different root architecture and their impact on slope stability

3.9 Environmental functions

4 Vegetative Techniques (10 hours)

4.1 Classification of vegetative systems: Based on plant types, propagation, and purpose

4.2 Design consideration of major vegetative techniques

4.2.1 Grass seeding and plantation

4.2.2 Bamboo plantation

4.2.3 Shrubs and tree seeding and plantation

4.2.4 Cuttings based techniques: Brush-layering, palisades, fascines, checkdams

4.2.5 Other methods: Jute net and grass plantation, live crib wall, vegetated riprap

4.3 Species selection

4.3.1 Site categorization: Topographic, slope material, climatic

4.3.2 Native vs exotic species

4.3.3 Socio-economic consideration

4.3.4 Drought factor

4.4 Selection of optimal vegetative technique

5 Civil Engineering Techniques (10 hours)

5.1 Conventional and emerging techniques

5.2 Small scale civil engineering systems, their selection and design considerations

5.2.1 Slope work

5.2.2 Retaining, revetment, dentition, frame, crib walls

5.2.3 Check dams

5.2.4 Surface and sub-surface drainage; Drainage network planning

5.2.5 Cross-drainage and energy dissipation structures

5.3 Integration of vegetative and civil engineering systems

6 Nursery (3 hours)

6.1 Nursery and its components

6.2 Site selection and components design

6.3 Materials are resources

6.4 Nursery management

7 Bioengineering Implementation and Management (2 hours)

7.1 Cost estimation: Quantity estimation and rate analysis

7.2 Seasonal planning of bioengineering systems

7.3 Maintenance, monitoring and performance evaluation

Tutorial **(30 hours)**

1. Preparation landslide investigation planning for a given case
2. Landslide mapping and hazard zonation
3. Evaluation of soil reinforcement model for grass-based systems
4. Evaluation of soil reinforcement model for shrub- based systems
5. Evaluation of soil reinforcement model for Tree- based systems
6. Design of vegetative systems
7. Design of retaining/revetment walls
8. Design of drainage system for a landslide mitigation

Practical **(15 hours)**

1. Visual presentation/demonstration/observation of species identification, site assessment/investigation and real-case observation and data collection
2. Design of landslide mitigation with vegetative and civil engineering systems
3. Preparation of drawing, cost estimation and implementation plan

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	6
2	6	8
3	10	12
4 and 7	12	16
5	10	12
6	3	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Department of Roads. (1999). Roadside bio-engineering: Reference manual and Site handbook. Government of Nepal.
2. Department of Roads. (2007). Roadside geotechnical problems: A practice guide to their solutions. Government of Nepal.
3. Department of Soil Conservation and Watershed Management. (2016). Guideline on landslide treatment and mitigation, Government of Nepal.
4. International Centre for Integrated Mountain Development. (1991). Mountain risk engineering handbook.
5. Transport Research Laboratory. (1997). Overseas road notes 16: Principles of low-cost road engineering in mountainous regions.
6. National Reconstruction Authority and National Disaster Risk Reduction & Management Authority. (2021). Manual for hands-on training to engineers on slope stabilization techniques.

INTEGRATED SOLID WASTE MANAGEMENT
ENCE 377

Lecture : 3 | **Year : III**
Tutorial : 2 | **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to provide comprehensive understanding of solid waste management, including the properties of different waste types, key considerations, and evaluation of emerging wastes. Students will be able to analyze and manage municipal solid waste operations, encompassing collection, transfer systems, and landfills, while applying fundamental technologies to ensure environmentally sound practices. Additionally, students will learn to classify hazardous wastes according to international standards and develop strategies for their proper management.

1 Introduction (4 hours)

1.1 Definition, types, and sources of solid waste
1.2 Elements of solid waste management (Waste generation to disposal)
1.3 Solid waste management hierarchy and guiding principles
1.4 Introduction to integrated solid waste management (ISWM)
1.5 Refuse, reduce, reuse, recycle and recovery (5Rs) approaches for solid waste management
1.6 Solid waste management related acts, regulations, and guidelines in Nepal
1.7 History and current practice of municipal solid waste management in Nepal

2 Waste Generation, Quantification and Characterization (4 hours)

2.1 Waste generation (Residential, commercial, institutional and industrial); Methods of quantification (Source-specific approach, materials flow methodology); Factors affecting waste generation
2.2 Composition of solid waste and their characterization, sampling protocols
2.3 Properties of waste: Physical properties (Specific weight, density, moisture content, particle size distribution, filed capacity, permeability of compacted waste, solid contents, porosity); Chemical properties (Ultimate analysis, proximate analysis, energy content, fusion point of ash, content of nutrients and other constituents); Biological properties and biodegradability factors

3 Solid Waste Collection, Storage and Transportation (6 hours)

3.1 Types of collection system: Combined waste collection system and separate waste collection system; Stationary waste collection and mobile waste collection; Public and private waste collection system

3.2 Collection vehicles/tools and their types: Waste storage container requirement, set out requirements, waste separation, collection equipment
3.3 Collection/transportation route optimization
3.4 Temporary storage, transfer and secondary transport system
3.5 Site selection and conceptual design of transfer stations: Small to medium transfer stations, large transfer station
3.6 Requirements of collection and transportation vehicles: Trucks and semitrailers, rail cars

4 Waste Processing Techniques (4 hours)

4.1 Processing methodologies and waste minimization
4.2 Waste segregation and waste minimization at source
4.3 Sorting and mechanical methods for solid waste volume reduction
4.4 Various methods of waste disposal: Landfills, sanitary landfills, combustors, composting

5 Land Filling Method of Solid Waste Disposal (8 hours)

5.1 Classification of landfills (Hazardous waste, designated waste, municipal solid waste, and uncontrolled waste disposal sites)
5.2 Landfill site selection and environmental considerations
5.3 Concept of using multi-criteria evaluation method using geographic information system (GIS) and remote sensing (RS) for Landfill Site Selection
5.4 Landfill design considerations and basic components
5.5 Formation and composition of leachate (Variation in leachate composition, movement of leachate, and leachate collection system)
5.6 Generation and composition of landfill gases (Principal landfill gas constituents, quantity of gas produced, variation in gas production with time)
5.7 Monitoring and post-closure plan (Intermediate and final landfill cover; Leachate management and control; Active and passive control of landfill gases)

6 Organic Waste Treatment Methods and Energy Recovery (6 hours)

6.1 Organic solid waste treatment methods: Aerobic and anaerobic; Mesophilic and thermophilic
6.2 Types of composting and use of compost
6.3 Factors affecting composting process (Nutrient and substrate; Temperature; Particle size; C/N ratio; pH level)
6.4 Anaerobic digestion (Biogas) methods and energy recovery
6.5 Advantages of co-composting and co-digestion

7 Thermal Treatment Methods and Energy Recovery (5 hours)

- 7.1 High thermal treatment method: Incineration and waste to energy
- 7.2 Advanced waste treatment methods: Gasification, pyrolysis and energy recovery
- 7.3 Co-incineration of refuse derived fuels (RDFs)
- 7.4 Selection of thermal treatment methods

8 Recycling and Resource Recovery of Solid Waste (5 hours)

- 8.1 Principles of material recovery and recycling
- 8.2 Informal and formal recycling of solid waste
- 8.3 Mechanical and chemical recycling process
- 8.4 Sorting, processing, and storage of recyclable materials
- 8.5 Solid waste sorting and packaging system
- 8.6 Conceptual design of material recovery facility (MRF) and solid waste sorting system

9 Hazardous Waste (3 hours)

- 9.1 Introduction to hazardous waste
- 9.2 Identification criteria for hazardous waste from solid waste
- 9.3 Hazardous and toxicity characteristics of waste; Introduction to toxicity characteristic leaching procedure (TCLP)
- 9.4 Classification, treatment and disposal techniques of:
  - 9.4.1 Healthcare waste
  - 9.4.2 Radioactive and waste from chemical industries
  - 9.4.3 Plastic wastes
- 9.5 Introduction to e-waste
- 9.6 International hazardous waste convention and national guidelines

Tutorial (30 hours)

1. Quantity calculation and material flow analysis of solid waste
2. Computation method of estimating waste generation; Proximate analysis; Ultimate analysis; Approximate chemical (Energy) formula; Computation of physical properties; Energy value using Dulong's formula
3. Design of optimized waste collection route for a mid-sized city considering environmental and economic factors; Computation of vehicle size, container size, number required, and location
4. Design of waste management strategies including 5R for a given locality
5. Sanitary land filling design criteria and design example; Numerical on gas and leachate generation; Triangular model of leachate computation
6. Composting criteria and design example
7. Volume reduction principles (Mechanical and thermal)
8. Design example of material recovery
9. Design example of central treatment facility (CTF) for healthcare waste; Recent development and practices

Practical/Assignment **(15 hours)**

1. Sampling methods and waste characterization of municipal solid waste (Ultimate and proximate analysis)
2. Determination of physical and chemical properties of municipal waste such as bulk density and moisture content in municipal solid waste
3. Determination of heating value with bomb calorimeter
4. Visual presentation/demonstration/observation of collection, transfer station and community participation practices of solid waste management of the nearest municipalities

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	2
2	4	8
3	6	6
4	4	8
5	8	10
6	6	12
7	5	6
8	5	4
9	3	4
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Tchobanoglous, G., Kreith, F. (2002). Handbook of solid waste management. McGraw-Hill.
2. Pichtel, J. (2014). Waste management practices: municipal, hazardous, and industrial. Taylor & Francis / CRC Press.
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ENVIRONMENTAL BIOTECHNOLOGY
ENCE 378

Lecture : 3 **Year : III**
Tutorial : 2 **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to provide understanding of theory, modeling and role of environmental biotechnology in wastewater engineering. It includes knowledge of microorganisms and their kinetics use in several treatment processes. The basics of methane gas formation to nitrification and de-nitrification of waste by respective bacteria can be studied thoroughly. Emphasis is placed on practical examples and experiments to enhance students' understanding of the course content.

1 Fundamentals of Environmental Biotechnology (2 hours)

1.1 Introduction to biotechnology: Renewable sources and its classification
1.2 Role of environmental biotechnology: Scope for use
1.3 Importance of environmental biotechnology in environmental engineering
1.4 Integrated approach in environmental biotechnology

2 Microbiology (5 hours)

2.1 Composition and classification of microorganisms
2.2 Microorganisms found in surface waters and wastewater
2.3 Introduction to microbial metabolism; Metabolic pathways of particular relevance to environmental biotechnology
2.4 Bacterial growth and biomass yield
2.5 Microbial ecology and tools to study microbial ecology
2.6 Stoichiometry of biological reactions

3 Microbial Kinetics (8 hours)

3.1 Definitions and scope of microbial kinetics; Types of microbial growth; Kinetics terminology
3.2 Microbial products; Rate of utilization of soluble substrates
3.3 Design parameters; Applications in bioreactor design
3.4 Basic mass balances; Mass balance on inert bio-mass and volatile suspended solids
3.5 Rate of biomass growth with soluble substrate; Microbial growth kinetics and yield constant: Monod equations
3.6 Input of active biomass
3.7 Aerobic suspended growth processes

4 Biofilm Kinetics (8 hours)

4.1 Definition, formation, and significance of biofilm
4.2 The biofilm mass balance
4.3 Concept of the idealized biofilm
4.4 The steady state biofilm and its solutions
4.5 Non-steady state biofilm
4.6 Introduction to biofilm modeling, numerical modelling of biofilms; Mathematical models of biofilm growth
4.7 Aerobic biofilm processes; Biofilm process configurations; Special biofilm solutions
4.8 Completely mixed biofilm reactor
4.9 Hybrid biofilm: Suspended growth process
4.10 Granular media filters

5 Reactor Kinetics (8 hours)

5.1 Reactors used for the treatment of wastewater: Types and application
5.2 Hydraulic characteristics of reactors
5.3 Factors considered in engineering design of reactors
5.4 Mass balance analysis and principle (Batch, continuous flow and plug type reactors)
5.5 Modeling of ideal flow in reactors: Ideal flow in complete-mix reactor and plug-flow reactor
5.6 Modeling of non-ideal flow in reactors
5.7 Concept of reactions, reaction rates, reaction order and reaction rate coefficients and its analysis
5.8 Reactor arrangements: Reactors in series and in dispersion
5.9 Linking stoichiometric and mass balance equations
5.10 Process selection; Factor's affecting process selection; Process selection based on reaction kinetics; Mass transfer and loading criteria

6 Methanogenesis (3 hours)

6.1 Use of methanogenic treatment
6.2 Anaerobic membrane reactors
6.3 Reactor configuration
6.4 Process kinetics (Reaction kinetics for CSTR and biofilm processes)
6.5 Design of anaerobic bio-solids digesters and factors affecting
6.6 Design of anaerobic treatment of dilute wastewater
6.7 Quantity of methane gas produced
6.8 Gas collection methods and special care during gas collection

7 Nitrification and De-Nitrification (8 hours)

7.1 Nitrogen forms, effects, and transformations
7.2 Nitrogen's transformation reactions and nitrogen cycle
7.3 Meaning of nitrification and de-nitrification
7.4 Biochemistry, physiology, and kinetics of nitrifying bacteria
7.5 Physiology of denitrifying bacteria, de-nitrification systems
7.6 Stoichiometry of biological nitrification and de-nitrification
7.7 Growth kinetics of biological nitrification and de-nitrification
7.8 Biofilm nitrification
7.9 Nitrous oxide formation

8 Biological Treatment of Drinking Water (3 hours)

8.1 Needs of biological treatment of water
8.2 Treatment process reliability and selection of design values
8.3 Aerobic biofilm processes to eliminate biological instability
8.4 Anaerobic biofilm processes to reduce oxidized contaminants
8.5 Introduction to automatic treatment control

Tutorial (30 hours)

1. Application of environmental biotechnology in environmental engineering
2. Classification of microorganisms and tools for the study of microbial ecology; Microorganisms found in surface water and wastewaters
3. Meaning of microbial kinetics, mass balance, design parameters, rate expressions, meaning of aerobic suspended growth processes and its uses
4. Meaning of biofilm kinetics, concept of biofilm processes, steady state biofilm, non-steady state biofilm, numerical modelling of biofilms
5. Types of reactor used in waste water treatment, factors to be considered in engineering design of reactors, modeling of ideal flow in reactors, modeling of non-ideal flows in reactors, concepts of mass balances, reactors in series
6. Use of methanogenic treatment, reactor configuration, numerical on quantity estimation of methane gas produced, and various gas collection methods
7. Meaning of nitrification and de-nitrification, physiology and kinetics of nitrifying and de-nitrifying bacteria's, concepts of growth kinetics, formation mechanisms of nitrous oxide
8. Need of biological treatment of water, treatment process reliability and selection of design values, automatic treatment control

Practical/Assignment (15 hours)

1. Determination of biological oxygen demand (BOD) and chemical oxygen demand (COD) of any wastewater sample
2. Determination of microbial degradation of textile dyes, pesticides, hydrocarbons and oils

3. Determination and counting the colonies of E-Coli and total coliform bacteria's in any wastewater sample
4. Preparation of compost from vegetable/ leaf/ fruit wastes - Checking NPK
5. Visual presentation/demonstration/observation of working principle, operation and maintenance of the biological units of an effluent treatment plant
6. Visual presentation/demonstration/observation of the micro-organisms role in wastewater in microbiological laboratories
7. A complete modeling of waste water treatment plant showing necessary biological units and processes involved

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	**Hours**	**Marks distribution***
1	2	3
2	5	7
3	8	10
4	8	10
5	8	10
6	3	5
7	8	10
8	3	5
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Rittmann, B.E., McCarty, P.L. (2020). Environmental biotechnology: Principles and applications. McGraw-Hill Education.
2. Evans, G., Furlong, J. (2010). Environmental biotechnology: Theory and application. Wiley-Blackwell.
3. Metcalf, L., Eddy, H. P. (2014). Wastewater engineering: Treatment and resource recovery. McGraw-Hill Education.
4. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. (1985). Environmental engineering (Latest Edition). McGraw-Hill.

AIR POLLUTION AND CONTROL
ENCE 379

Lecture : 3 **Year : III**
Tutorial : 2 **Part : II**
Practical : 1

Course Objectives:
The objective of this course is to provide fundamental knowledge about the atmosphere and air pollution, exploring the causes, effects, and impacts on public health, the environment, and climate. The course focuses on air quality standards, regulations, rules and policies; and covers control technologies and mitigation strategies. It aims to equip students with the scientific knowledge and analytical skills necessary to evaluate and design effective air pollution management solutions.

1 Introduction to Air Pollution (2 hours)

1.1 Definitions and classification of air pollutants
1.2 Primary versus secondary pollutants
1.3 Source of air pollutants: Natural and anthropogenic sources

2 Atmospheric Chemistry and Meteorological Process (12 hours)

2.1 Atmosphere and atmospheric chemistry
  2.1.1 Atmosphere and its concept
  2.1.2 Different layers of atmosphere
  2.1.3 Composition of air
2.2 Atmospheric thermodynamics
2.3 Atmospheric stability
2.4 Effect of meteorological process on plume dispersion
2.5 Inversions
2.6 Air quality (AQ) modeling
  2.6.1 Types of AQ models
  2.6.2 Fixed box model
  2.6.3 Gaussian dispersion model

3 Basic Concept of Air Pollutants (4 hours)

3.1 Air pollutants
3.2 Sources of pollutants
3.3 Types of pollutants as per forms, class and sources
3.4 Unit of measurements of different pollutants

4 Criteria Pollutants (7 hours)

4.1 Introduction to criteria pollutants
4.2 Definition, source, impacts of various criteria pollutants: CO, NO_2, SO_2, SPM, O_3, lead, hydrocarbons
4.3 Introduction to atmospheric aerosols
  4.3.1 Definition and characteristics: Physical, chemical and biological
  4.3.2 Source and sinks of aerosols and forms of aerosol
  4.3.3 Introduction and composition of particulate matter
  4.3.4 Impacts of aerosol and particle removal processes

5 Impacts of Pollutants (6 hours)

5.1 Introduction of impacts of pollution
  5.1.1 Health effects as acute and chronic
  5.1.2 Effects on vegetation, animals, materials, and visibility
5.2 Climate change and air quality interlinkages
5.3 Indoor air pollution and its health implications

6 Air Quality Standards and Monitoring (6 hours)

6.1 Introduction of air control philosophies
6.2 Types of air pollution control philosophies
  6.2.1 Emission standards
  6.2.2 Air quality standards: National ambient air quality standards (NAAQS); Air quality indices (AQI)
  6.2.3 Emission taxes
  6.2.4 Cost-benefit standard
6.3 Introduction to "The intergovernmental panel on climate change (IPCC)"

7 Air Pollution Control Technologies and Air Quality Standards (8 hours)

7.1 Control of particulate pollutants: Cyclones, bag filters, electrostatic precipitators, scrubbers
7.2 Control of Gaseous pollutant: Absorption, adsorption, condensation, combustion, catalytic converters
7.3 Ambient air quality standard
7.4 Integrated air quality management

Tutorial (30 hours)

1. Effect of meteorological process on plume dispersion
2. Numerical on fixed box model and Gaussian plume model for air quality modeling
3. Criteria pollutants and particulate matters, their sources, impacts on environment and public health, standards, and control measures
4. Greenhouse gases and its global effects on climate change

5. Global initiations for air pollution and climate change actions, protocols and global agreements
6. Air quality standards and present context of Nepal in types, quantity, sources, measurements and control measures adopted for major pollutants

Practical **(15 hours)**

1. Use of air quality monitoring instrument to determine the pollution levels
2. Visual presentation/demonstration/observation of ambient air quality monitoring stations and preparation of report on the workings and parameters that are to be measured by the instruments
3. Analysis of data of air quality monitoring stations for a short period (Over a week) and preparation of report accounting standards, impacts and recommendation of remedies

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	2	2
2	12	16
3	4	6
4	7	10
5	6	8
6	6	8
7	8	10
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. De Nevers, N. (2016). Air Pollution Control Engineering. Waveland Press, Inc.
2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. (1985). Solutions manual to accompany: environmental engineering. Mcgraw-Hill.
3. Environmental Protection Agency. (https://www.epa.gov/environmental-topics/air-topics)

ENVIRONMENTAL MONITORING AND ASSESSMENT
ENCE 380

Lecture : 3 | **Year : III**
Tutorial : 2 | **Part : II**
Practical : 1

Course Objectives:

The objective of this course is to develop a comprehensive understanding of the principles, methodologies, and tools used for monitoring key environmental components, including air, water, wastewater, soil, sludge, and solid waste. It aims to equip students with practical knowledge and skills in the collection, analysis, and interpretation of environmental data, enabling them to critically evaluate results, draw meaningful conclusions, and make informed decisions in environmental management and policy-making.

1 Introduction (5 hours)

1.1 Environmental monitoring and assessment and their needs
1.2 Types of environmental monitoring and their significance: Air, water, soil, waste, biodiversity, remote sensing, and enterprise monitoring
1.3 Objectives and benefits of environmental monitoring and assessment
1.4 Environmental pollution and issues, their source, effect, and prevention: Air pollution, water pollution, soil pollution, noise pollution, radioactive pollution, solid waste, flooding, droughts, forest fires, acid rain, climate change
1.5 Environmental pollution and issues in developing countries, environmental pollution at regional and local levels in Nepal
1.6 Root causes of pollution: Population, consumption, and technology
1.7 Environmental legislations and standards: Environmental criteria and standards, drinking water quality, surface water quality, national effluents discharge, standards, air quality standards, equipment-based and vehicular exhaust emissions standards, noise standards, legislative and constitutional provisions, environmental protection acts and regulations
1.8 Roles of different governmental and non-governmental agencies in preserving the environment

2 Water Quality Monitoring and Assessment (5 hours)

2.1 Needs for water quality monitoring, water pollution: Conventional and emerging pollutants
2.2 Types of water sampling, process of sampling, their prevention, factors associated with water sampling from various sources, volume of samples

2.3 Water quality management: Needs; Actual concentration versus desired concentrations; Extent of treatment for different uses (Domestic, industrial, recreational, and agricultural)

2.4 Raw water characteristics: Physical, chemical, and biological characteristics

2.5 Physical characteristics, parameters, and their significance (Temperature, pH, electrical conductivity, solids, turbidity); Equipment uses of and their working principles

2.6 Chemical characteristics: Alkalinity and acidity, their types and quantification; Hardness, their types and measurements; Organic content in wastewater (Total organic carbon, biochemical oxygen demand, quantification - principle and equipment); Chemical oxygen demand (Significance and quantification); Optimal coagulant doses and its significance

2.7 Biological characteristics and their significance: Types of coliform and their quantification

2.8 Water quality indices, needs, and importance, various WQI indices: National sanitation foundation; Canadian council of ministers of the environment water quality index; Weighted arithmetic water quality index

3 Air Quality Monitoring and Assessment (5 hours)

3.1 Needs for air quality monitoring and assessment; Types of air quality monitoring: Direct and indirect monitoring and their significance

3.2 Air pollutants measurement: Ambient and source measurements, stacks monitoring, sampling arrangements, sampling systems for particulate matters, steps involved in sampling and analysis of air pollutants

3.3 Gaseous sampling and its components; Ambient sampling and their system; Types of sampling and their significance (Extractive, in situ, and passive; Continuous emission monitoring system)

3.4 Quantification of various air quality parameters, instruments used, and their working principles: Carbon monoxide, ozone, nitrous oxides, sulfur dioxides, non-methane volatile organics and hydrocarbons, particulate matters

3.5 Analysis and measurement of visibility, acidic deposition and their significance

3.6 Measurement of other air toxics and their significance

3.7 Air quality indices, importance, national breakpoint values, and computation of air quality index (AQI) values

4 Soil Quality Monitoring and Assessment (5 hours)

4.1 Basic function of soils; Needs of soil quality monitoring; Soil quality: Innate and dynamic quality; Factors affecting soil quality; Soil health

4.2 Need for soil quality indicators; Soil quality index; Methods of assessment: Farmers, statistical and conventional techniques

4.3 Soil sampling: Quantitative and semi quantitative measurements; Factors affecting soil sampling; Field equipment used in soil sampling; Soil samplers; Soil sampler's storage and prevention; Soil pore water sampling, samplers

4.4 Soil quality parameters (Physical, chemical, and biological parameters), their measurements and significance

5 Municipal Solid Waste and Fecal Sludge Monitoring (5 hours)

5.1 Municipal solid waste, waste generation, factors affecting waste generation

5.2 Solid waste sample collection and preservation: Coning and quartering

5.3 Solid waste characterization: Physical (Specific weight, particle size, and distribution, dry and wet density); Chemical (Moisture content, proximate analysis, fusing point of ash, ultimate analysis, energy content, elemental analyzer, bomb calorimeter, their working principles and uses); Biological (Organic fraction, biodegradability, odors)

5.4 Faecal sludge, sample collection methods, characterization and their environmental significance

6 Measurement of Meteorological Parameters (5 hours)

6.1 Importance, needs and applications of meteorology; Meteorological principles: Boundary layer and dynamic meteorology; Components and layers of the atmosphere

6.2 Solar radiation, heat balance, transport of heat and their significance; Urban heat islands and boundaries

6.3 Atmospheric circulation (Horizontal and vertical); Wind (Coriolis force, pressure gradient force, localized temperature effects)

6.4 Inversions, topographical effects (Flat terrains, valleys, hills); Mountain and valley breezes

6.5 Meteorological parameters (Temperature, humidity, pressure, wind speed, precipitation wind direction, mixing height, stability - atmospheric stability and their types); Their measurements, instrument used, and significance; Wind rose diagram preparation

7 Environmental Quality Monitoring (5 hours)

7.1 Objectives and types of environmental monitoring (Source and ambient)

7.2 Water quality monitoring system, purposes, and monitoring cycles

7.3 Methods of field monitoring: In situ measurements, manual or automated measurements, continuous monitoring or snapshot monitoring, grab sampling, integrated depth sampling, time proportional sampling, space composite sampling, water quality kits, vacuum pumping, remote sensing, mobile monitoring network for water quality, continuous ambient air quality monitoring system and their components

7.4 Sampling techniques for environmental data: Simple random, stratified, systematic random sampling, cluster, multistage sampling
7.5 Air quality monitoring: Stationary and mobile monitoring and management, their purposes, advantages and disadvantages, national monitoring stations, criteria for selecting stationary stations
7.6 Design of monitoring station for air quality; Background information; Development of air quality monitoring program
7.7 Comprehensive environmental pollution index (CEPI) and framework for industries: Source pathway and receptor, calculation of CEPI for industries

8 Role of Remote Sensing and GIS in Environmental Monitoring (5 hours)

8.1 Remote sensing, principle, basic components, types and advantages
8.2 Application of remote sensing in air, water, soil quality monitoring and deforestation
8.3 Application of remote sensing in the prediction of environmental events: Snow and glacier mapping, floods, landslides
8.4 Geographical information system (GIS): Introduction, application of GIS in environmental monitoring data analysis of water, air and soil

9 Environmental Data Acquisition and Analysis (5 hours)

9.1 Objective of data acquisition and analysis, data quality
9.2 Errors during data analysis: Systematic and random errors, data quality control and assurance, environmental data acquisition process, data acquisition system and component, data acquisition software, advantages and disadvantages
9.3 Quality controls and quality assurance for environmental monitoring: Internal checks (Field blanks, lab replicates, spike samples, calibration blanks, calibration standards); External checks (External field duplicates, split samples, external labs involvements); Knowns, unknowns
9.4 Quality controls and assurance plans for environmental monitoring of water, air, and soil
9.5 Data quality objective processes; Basic statistics (Descriptive, graphical, probabilistic statistics in environmental monitoring); Statistical errors and types

Tutorial (30 hours)

1. Study of environmental pollution at regional and local levels in Nepal; Use of national environmental legislations
2. Numerical on pH, alkalinity, BOD and determination of water quality index (WQI); Methods of water sampling
3. Sampling and analysis of air pollutants; National ambient air quality standards; Computation of air quality indices (AQI) values
4. Monitoring of soil quality; Study of field equipment for soil sampling; Measurement of soil quality parameters

5. Quantity estimation of municipal solid waste; Development of chemical formula; Energy estimation using empirical formulae (Dulong's equation, Khan formula); Methods of sample collection of fecal sludge; Collection and preservation of solid waste
6. Numerical on developing wind rose diagram
7. Environmental monitoring; Study of sampling techniques for measuring environmental data; Methods of water and air quality monitoring systems
8. Application of remote sensing in quality monitoring of air, water, soil, deforestation and use of GIS in environmental monitoring data analysis of water, air and soil
9. Use of data acquisition software, quality controls and assurance plans for environmental monitoring of water, air and soil

Practical/Assignment **(15 hours)**

1. Sampling and characterization of water samples for various parameters
2. Sampling of soils and characterization for various parameters
3. CEPI assessment for an industry of nearby locations
4. Design of station for surface water and air quality monitoring systems at nearby localities and development of monitoring plans in accordance with national legislation
5. Visual presentation/demonstration/observation of monitoring stations of air and water quality; Meteorological station

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	5	6
2	5	7
3	5	7
4	5	7
5	5	7
6	5	7
7	5	7
8	5	6
9	5	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

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2. Manly, B.F.J. (2008). Statistics for environmental science and management. Chapman & Hall/CRC.

3. Hinds, W.C. (1999). Aerosol technology: Properties, behavior, and measurement of airborne particles (Latest Edition). Wiley.
4. Coleman, H.W., Steele, W.G. (1999). Experimentation and uncertainty analysis for engineers (Latest Edition). John Wiley & Sons.
5. Metcalf & Eddy, Inc. (1991). Wastewater engineering: Treatment, disposal, and reuse (Latest Edition). McGraw-Hill.
6. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. (1985). Environmental engineering (Latest Edition). McGraw-Hill.
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8. Seinfeld, J.H., Pandis, S.N. (2006). Atmospheric chemistry and physics: From air pollution to climate change. Wiley.
9. American Public Health Association. (2017). Standard methods for the examination of water and wastewater. American Public Health A.