# COURSE STRUCTURE AND SYLLABUS

**for**

**JUNIOR RESEARCH FELLOW**

**in**

**MINING MACHINERY ENGINEERING**


DEPARTMENT OF MINING MACHINERY ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES)

DHANBAD-826004


*(Recommended to be effective from Academic Session 2019-20 onwards)*

# Course Structure & Syllabus for
# JRF Programme in MINING MACHINERY ENGINEERING

## SEMESTER-I

| Sl. No. | Designation | Course No. | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | DC-1 | MMC520 | Research Methodology and Statistics | 3 | 0 | 0 | 9 |
| 2. | DC-2 | MMC503 | Application of MATLAB in Engineering | 3 | 0 | 0 | 9 |
| 3. | DC-3 | MMC501 | Opencast Mining Equipment | 3 | 0 | 0 | 9 |
| 4. | DC-4 | MMC502 | Underground Mining Equipment | 3 | 0 | 0 | 9 |
| 5. | IC | HSI500 | Research and Technical Communication | 3 | 0 | 0 | S/X |
| | | | **Total Credit** | | | | **36** |

## SEMESTER-II

| Sl. No. | Designation | Course No. | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | DE-1 | | Any four/two DE out of Table 1 | 3 | 0 | 0 | 9 |
| 2. | DE-2 | | | 3 | 0 | 0 | 9 |
| 3. | DE-3/OE-1 | | | 3 | 0 | 0 | 9 |
| 4. | DE-4/OE-2 | | Any two OE out of Table 2 | 3 | 0 | 0 | 9 |
| | | | **Total Credit** | | | | **36** |

** Students with B. Tech degree or M. Tech in non-relevant field require two additional DC courses.

**TABLE-1**

| Sl. No. | Designation | Subject Code | Subject Name |
|---|---|---|---|
| 1. | DE-1 | MMD501 | Mineral Processing Equipment |
| 2. | | MMD502 | Finite Element Analysis |
| 3 | | MMD510 | Mine Electrical Safety |
| 4. | DE-2 | MMD503 | Computational Fluid Dynamics |
| 5. | | MMD504 | Advanced Fluid Power Systems and Control |
| 6. | | MMD513 | Mine Power System |
| 7. | DE-3 | MMD 505 | Fluid Flow Machines in Mines |
| 8 | | MMD 506 | Vehicle Dynamics |
| 9. | | MMD 507 | Contact Mechanics |
| 10. | | MMD512 | Mine Electrical Drives |
| 11. | DE-4 | MMD 508 | Mechatronics |
| 12. | | MMD 509 | Composite Materials |
| 13. | | MMD514 | Mine Automation |
| 14. | | MMD515 | Failure Analysis of Industrial Equipment Component |

**TABLE-2**

| Sl. No. | Subject Code | Subject Name |
|---|---|---|
| **1.** | MMO 501 | Mining Machinery |
| **2.** | MMO 502 | Bulk Material Handling Equipment |
| **3.** | MMO 503 | Mine Electrical Technology |

**Third Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1.** | TU-1 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

**Fourth Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1** | TU-2 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

**Fifth Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1** | TU-3 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

**Sixth Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1** | TU-4 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

**Seventh Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1** | TU-5 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

**Eighth Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1** | TU-6 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

**Nineth Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1** | TU-7 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

**Tenth Semester**

| Sl. No. | Designation | Course Code | Subject Name | L-T-P | Credit |
|---|---|---|---|---|---|
| **1** | TU-8 | MMC599 | Thesis Unit | 0-0-0 | 36 |
| | | | | **Total Credit** | **36** |

## 1. Course Name: Research Methodology and Statistics

**Course Code: MMC 520**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Methods of Data Collection, Reliability & Validity of data, Introduction to Qualitative Research Methods. Concepts, Purpose, Frequency Distribution, Presentation of Data, Measures of Central Tendency, Measures of Dispersion, Skewness, Kurtosis and Moments, Correlation and Regression, Probability Distributions – Binomial. Poisson, Normal, Sampling and Estimation, Hypotheses testing – t test, z test, Chi-square test, Analysis of Variance; Power Hydraulics; Simulation and Modelling; Finite Element Analysis; | 20 |
| **2.** | Tribology; Underground and open pit mining equipment, Mine Electrical. | 15 |
| **3.** | Report writing, Literature Review Techniques; Emerging areas of research pertaining to Mining Equipment, Accessories and Maintenance. | 5 |
| | **Total Classes =** | **40** |

**Text Books:**

1. C.R. Kothari (1985). Research Methodology: Methods and Techniques, New Age Publication

**References:**

1. Geoffrey R. Marczyk, David DeMatteo, David Festinger (2005). Essentials of Research Design and Methodology. John Wiley & Sons

**Course Goal / Learning Outcome:**

Students will be able to know the methodology of doing research.

**Learning Objectives**

To impart the concept of modelling, mathematical and statistical tools for performing research.

## 2. Course Name: Application of MATLAB in Engineering

**Course Code: MMC 503**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Understanding MATLAB Desktop, command window and graph window; Plotting of graph; Best fit operation; Multiple graph in single window; creation of .m file; creating functions, saving of data. | 8 |
| **2.** | Simple and complex calculation using MATLAB- Calculus; solving equations; matrix operation; determinant operations; | 8 |
| **3.** | Basic System Models; MATLAB programming environment; Developing simulation modelling of dynamic system; Dynamic Response and System Transfer Function; Block diagram/Signal flow diagram/State Space formulation and Frequency response; | 10 |
| **4.** | Parameter Estimation, System Identification and Optimization. | 6 |
| **5.** | Introduction to control tool boxes and tools that are essential in solving | 8 |

| | | |
|---|---|---|
| | engineering problems; development of a MATLAB programming of an engineering problem; Logical operators and loop functions; | |
| | **Total Classes =** | **40** |

**Text Books:**


1. Jaan, K. (2009). Numerical methods in engineering with MATLAB, Cambridge University Press.


**References:**


1. Close, C. M., Frederick, D. K., & Newell, J. C. (2002). Modelling and analysis of dynamic systems, Wiley India Pvt Ltd.
2. Klee, H., & Allen, R. (2018). Simulation of dynamic systems with MATLAB® and Simulink®. CRC Press.
3. Layer, E., & Tomczyk, K. (2009). Measurements, modelling and simulation of dynamic systems. Springer Science & Business Media.
4. Karris, S. T. (2007). Numerical analysis using MATLAB and Excel. Orchard Publications.


**Course Goal / Learning Outcome:**

Students will be able to do modelling and simulation of different system using different modules of MATLAB.

**Learning Objectives**

To impart the concept of modelling and simulation of different system using different modules of MATLAB.

## 3. Course Name: Opencast Mining Equipment

**Course Code: MMC 501**

**L-T-P = 3-0-0**

**Credit = 9**

**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Introduction to Opencast mining equipment | 2 |
| **2.** | Hydraulic Transmission system, Suspension System, Tyres, Wheels and Axle assembly. | 5 |
| **3.** | Braking and Steering system, Under Carriage unit of Crawler mounted machine; Hydraulic systems used in Heavy Earth Moving Equipment | 6 |
| **4.** | Classification of equipment; System with different combination of excavator and transport equipment. Applicability of different surface mining equipment, Mechanics of rock cutting / loading by excavator bucket | 5 |
| **5.** | Classification, construction, operation and maintenance of various sub-systems of HEMM: Shovel, Dragline, Bucket wheel excavator, Scraper, Surface Miner, Dumper, Dozer, Ripper, Grader, Loader, Drills and High-wall miner. | 6 |
| **6.** | Drilling Machine: Classification, construction, operation and maintenance of Rotary Blast Hole Drill, Jack Hammer Drill, DTH Drill; Drill Bits and Tubes / Rods, Drilling Fluids. | 6 |
| **7.** | Recent trends and development of surface mining equipment: Automation and control in HEMM. | 5 |
| **8.** | Selection criteria of open cast mining equipment. Safety aspects related to open cast mining equipment: Fire protection system used in HEMM. | 5 |
| | **Total Classes =** | **40** |

**Text Books:**


1. De, A. (2015). Latest Development of Heavy Earth Moving Machineries, Lovely Prakashan.

**References:**


1. Nichols, H. L. (1976). Moving the earth-the workbook of excavation.
2. Chugh, C. P. (1977). Drilling technology handbook. Oxford & IBH Publishing Company.


**Course Goal / Learning Outcome:**

At the end of the course

1. Student will be able to learn about the Classification, construction, operation and maintenance of various sub-systems of Shovel, Dragline, Bucket wheel excavator, Scraper, Surface Miner, Dumper, Dozer, Ripper, Grader, Loader, Drills and Highwall miner; Construction and Operations of subsystems of HEMM.
2. The student will be able to understand the Hydraulic Transmission system, Suspension System, Tyres, Wheels and Axle assembly.
3. The students will learn the Braking and Steering system, Under Carriage unit of Crawler mounted machine; Hydraulic systems used in Heavy Earth Moving Equipment.
4. Students will learn the recent trends and development of surface mining equipment: Automation and control in HEMM. Selection criteria of open cast mining equipment. Safety aspects related to open cast mining equipment: Fire protection system used in HEMM.

**Learning Objectives**

- To impart the knowledge of basic features, selection, trouble shooting, performance analysis, cost analysis, environmental issues, safety features, relevant regulations and design features of Opencast mining equipment.

## 4. Course Name: Underground Mining Equipment

**Course Code: MMC 502**

**L-T-P = 3-0-0**

**Credit = 9**

**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Mine winder: Drum winder, Friction winder, Blair winder, shaft fittings, rope fittings, rope capping, winder breaks, electric drives and control, duty cycle, steel wire ropes, Automatic contrivance, headgear structures, cages, skips, capacity and power calculations, statutory provisions, maintenance practices. | 8 |
| **2.** | Rock Drill: Types of rock drills used in underground mines, drill ability of rock, rock properties influencing selection of drills, rock drilling principle, construction, operation, maintenance practices of electric drills, pneumatic drills, electro hydraulic jumbo drills, Down-the-Hole drills, drill bits, drill rods, flushing arrangement, dust collectors, drilling cost analysis. | 5 |
| **3.** | Coal Cutting Machine: Construction, operation, application of shearer, plough, continuous miners, drives, control systems, theory of rock cutting, maintenance, safety regulations, productivity calculation. | 5 |
| **4.** | Roof Supports: Classifications of roof supports, constructional features, nomenclature, selection and operation, hydraulic circuits, hydraulic oil and properties, theory and practice of hydraulic control, safety features, power pack unit, roof bolts, roof bolting machines, maintenance. | 3 |
| 5. | Tunnelling Equipment: Construction, operation, application of road header, tunnel boring machines, cutting heads, bits, safety features and regulations. | 3 |

| | | |
|---|---|---|
| 6. | Loading and transporting equipment: Construction, operation and maintenance of Load Haul Dump machine, Side Discharge Loader, Low Profile Dump Truck, shuttle cars, Free steered vehicles; selection, safety features and regulations. | 5 |
| 7. | Rope Haulage: Classification, constructional features, drives, selection, capacity and power calculation, maintenance, safety features and regulations. | 3 |
| 8. | Mine Locomotive: Classification, constructional features, drives, selection, capacity and power calculation, maintenance, safety features and regulations. | 3 |
| | **Total Classes =** | **40** |

**Text Books:**

1. Tatiya, R. R. (2005). Surface and underground excavations: methods, techniques and equipment. CRC Press.

**References:**

1. Peng, S. S., & Chiang, H. S. (1984). Longwall mining, Wiley Publisher.
2. Deshmukh, D. J. (1982). Elements of mining technology. Vidyasewa Prakashan.
3. Mukharjee, S. N. (1993), Longwall Machinery and Mechanisation, Lovely Prakashan.
4. Kaku, L. C. (2000). The Coal Mines Regulations. 1957. Dhanbad: Lovely Prakashan.
5. Kaku, L. C., (1961), Metalliferous Mines Regulations, Lovely Prakashan.
6. Chakraborty, P. K., Mine Winder, CMPDI, Ranchi.
7. Stathan, I C F, Coal Mining Practices, London Publisher.
8. Das, S K., Modern Coal Mining Technology, Lovely Prakashan.

**Course Goal / Learning Outcome:**

Students will understand basic features of equipment, their selection, trouble shooting, performance analysis, cost analysis, environmental issues, safety features, relevant regulations and design features.

**Learning Objectives**

To impart conceptual knowledge on constructional and design features, operational detail, selection, safety features of different type of underground mining equipment

## 5. Course Name: Mineral Processing Equipment

**Course Code: MMD 501**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Milling Equipment: Construction, operation, selection, classification of ball mills, rod mills, autogenous mill, semi-autogenous mill, pebble mill, principle of milling process, grinding media, ore feeding and discharge arrangements, drives, accessories and controls, capacity estimation, associated terminologies. | 7 |
| **2.** | Jigs: Construction, operation, selection, classification of jigs, theory of jigging, jigging efficiency, design features, feeding and discharge principles, drives, accessories and controls, capacity estimation, associated terminologies, trouble shooting. | 7 |
| **3.** | Flotation Machines: Theory of flotation, construction, operation, maintenance, selection of different type of flotation machines, flotation cells, floating media, reagents, capacity calculation, terminologies, accessories, drive arrangements, trouble shooting. | 6 |

| | | |
|---|---|---|
| **4.** | Classifiers: Constructional features, working principle and selection of different type of classifiers, classifier efficiency, maintenance and trouble shooting. | 4 |
| **5.** | Magnetic separators: Constructional features, working principle, selection of different type of magnetic separators, accessories, feeding and discharging arrangements, evaluation of efficiency, maintenance and trouble shooting. | 4 |
| **6.** | Thickeners: Principle of thickening, classification, construction, design features, operation, drive arrangements, feeding and discharging methods, operational problems and maintenance. | 4 |
| **7.** | Filters: Theory of filtration, operating principle, types, constructional features, filter cloth, accessories, maintenance, terminologies, selection, operational difficulties. | 4 |
| **8.** | Cyclones and Centrifuges: Theory, construction, operating principle of pneumatic cyclone, hydro-cyclone, centrifuges, performance study, trouble shooting. | 2 |
| **9.** | Slurry Pumps: General concept constructional features, selection, trouble shooting and pump layout. | 2 |
| | **Total Classes =** | **40** |

**Text Books/:**


1. Wills, B. A., & Finch, J. (2015). Wills' mineral processing technology: an introduction to the practical aspects of ore treatment and mineral recovery. Butterworth-Heinemann.


**References**


1. Colijn, H. (1985). Mechanical conveyors for bulk solids (Vol. 4). Elsevier Science Ltd.
2. Alexandrov, M. P. (1981). Materials Handling Equipment: MP Alexandrov. Mir Publishers.
3. Hetzel, F. V. (1922). Belt conveyors and belt elevators. J. Wiley and Sons.
4. Stoess, H. A. (1983). Pneumatic conveying. Wiley-Interscience.
5. Handbook, C. E. M. A. (1997). Belt Conveyors for Bulk Materials. Conveyor Equipment Manufacturer's Assoc., USA.
6. Mular, A. L., Halbe, D. N., & Barratt, D. J. (Eds.). (2002). Mineral processing plant design, practice, and control: proceedings (Vol. 1). SME.


**Course Goal / Learning Outcome:**

To impart conceptual knowledge on constructional features, operational detail, selection, safety features, efficiency, capacity calculation, operational difficulties faced in industries of different type of mineral processing equipment.

**Learning Objectives**

Students will understand basic design features of equipment, their selection, trouble shooting, performance analysis, environmental issues and safety features.

## 6. Course Name: Finite Element Analysis

**Course Code: MMD 502**

**L-T-P = 3-0-0**

**Credit = 9**

**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Finite Element Formulations starting from Governing Differential Equations: Weighted Residual Method, General Weighted Residual Statement, Weak (Variational) form of the WR statement, Piece wise Continuous Trail Function Solution of the Weak Form, One-dimensional | 8 |

| | | |
|---|---|---|
| | Bar Element, One-dimensional Heat Transfer Element, Functional and Differential Equation forms, Rayleigh-Ritz method, Piece-wise continuous Trial Functions. | |
| **2.** | One Dimensional FEA: General form of the Total Potential for 1-D problems, Generic form of Finite Element Equations, Linear Bar FEM, Quadratic Bar Element, Beam Element, Plane Trusses, Frame Element, One-Dimensional Heat Transfer Problems. | 6 |
| **3.** | Two Dimensional FEA: Dimensionality of a problem, Approximation of Geometry and Field variable :3-noded triangular element, 4-noded rectangular element, 6-noded triangular element, Natural Coordinates and Coordinate Transformation, 2-D Elements for Structural mechanics, Numerical Integration, Incorporation of Boundary conditions, Solution of Static Equilibrium Equations, 2D Fluid flow problems, Beams and Frames: Shear force and Bending Moments, Beams on Elastic Supports, Plane Frames, Three-dimensional Frames. | 7 |
| **4.** | Three Dimensional FEA: Finite Element Formulation: Element stiffness, Force Terms, Stress Calculations, Mesh Patterns, Hexahedral Elements and Higher order elements, Three-dimensional Problem modelling. | 7 |
| **5.** | Dynamic Analysis using Finite Elements: Equations of motion based on Weak form, Equations of Motion using Lagrange's Approach, Consistent and Lumped Mass matrices, From of Finite Element Equations for Vibration Problems, Properties of Eigen pairs, Solution of Eigenvalue Problems, Transient Vibration Analysis, Thermal Transients. | 8 |
| **6.** | FEA of Structural systems: Unsteady Heat Transfer in a Pin-Fin, FEA of Crankshaft Torsional Vibrations, Axisymmetric FEA of a Pressure Vessel, FEA of an Automotive Chassis Dynamics, Stress concentration Problems, Analysis of cracked structures. | 4 |
| | **Total Classes =** | **40** |

**Text Books:**


1. JN Reddy. (2019), An introduction to The Finite Element Method, McGraw.
2. Bathe, K. J. (2006). Finite element procedures. Klaus-Jurgen Bathe.


**References**


1. Webber, J. P. H. (1984). An Introduction to the Finite Element Method.
2. Huebner, K. H., Dewhirst, D. L., Smith, D. E., &Byrom, T. G. (2008). The finite element method for engineers. John Wiley & Sons.
3. Segerlind, L. J. (1976). Applied finite element analysis (Vol. 316). New York: Wiley.
4. Rao, S. S. (2013). The Finite Element Method in Engineering: Pergamon International Library of Science, Technology, Engineering and Social Studies. Elsevier.
5. Chandrupatla, T. R., &Belegundu, A. D. (2011). Introduction to Finite Elements in Engineering, PHI Learning Pvt. Limited, New Delhi.
6. Seshu, P. (2003). Textbook of finite element analysis. PHI Learning Pvt.Ltd..


**Course Goal / Learning Outcome:**

Upon successful completion of this course a student should be able to:

- Understand FEM as a general tool for finding approximate solutions to governing differential equations of many natural phenomena.
- Understand the concepts behind variational methods and weighted residual methods in FEM.
- Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3-D element.
- Develop element characteristic equation procedure and generation of global stiffness equation will be applied.

- Able to apply Suitable boundary conditions to a global structural equation, and reduce it to a solvable form.
- Identify how the finite element method expands beyond the structural domain, for problems involving dynamics, heat transfer, fluid flow and Fracture analysis of Engineering components

**Learning Objectives**

- To learn basic principles of finite element analysis procedure.
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses performed by others.
- Learn to model complex geometry problems and solution techniques.

## 7. Course Name: Mine Electrical Safety

**Course Code: MMD 510**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Neutral Grounding practices for safe operation of underground and open pit equipment - Concept of earth fault current limitation in underground (UG) and open pit mine power systems, Solidly earthed, restricted-neutral and insulated neutral systems of power supply - their comparison. | 08 |
| **2.** | Earth fault protection techniques for various types of mine power supply systems, Earthing practice for underground and open pit equipment. | 05 |
| **3.** | Safety aspects of pilot circuit-operated underground coal face machines. Protection of underground and surface mine power distribution network, | 05 |
| **4.** | Mine Winder safety devices – Winder depth and speed indicator, Automatic Contrivances – over speed, over wind, slack rope and rope slip detection systems. | 06 |
| **5.** | Electrical equipment in explosive atmosphere – Principle of Flame proof enclosure (FLP), construction, testing and maintenance of FLP enclosure, | 06 |
| **6.** | Principle of Intrinsically safe circuit, Design, Testing of intrinsically safe circuit, Intrinsically safe mining apparatus. | 06 |
| **7.** | Safety requirement for mines as per CEA regulations. | 04 |
| | **Total Classes** | **40** |

**Text Books:**

1. SME Mining Engineering Handbook, 3rd edition

**References**


1. CEA Regulations, Ministry of Power, Govt of India.
2. DGMS Annual Report, 2009


**Course Goal / Learning Outcome:**

Upon successful completion of this course a student should be able to:

1. Understand the specifics of Earthing in Mines.
2. Understand the different safety and protection of equipment.
3. Understand the different probable mine winder safety.
4. Determine the specifics of mine illumination .
5. Understand the operation of Electrical equipment in explosive atmosphere.
6. Understand Safety requirement for mines as per CEA regulations.

**Learning Objectives**

The course objectives are to train students to be able to

1. Select and design Electrical equipment in explosive atmosphere
2. Get acquainted with safety and protection of equipment in mines
3. Get familiar with the safety in mines.

## 8. Course Name: Computational Fluid Dynamics

**Course Code: MMD 503**

**L-T-P = 3-0-0**

**Credit = 9**

**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Introduction to Computational Fluid Dynamics: Principles of conservation of mass, momentum and energy, classification of partial differential equations and physical behaviour, overview of finite difference, finite element and finite volume methods. | 5 |
| **2.** | Finite volume method: fundamental concepts, discretization of 1-D steady state and unsteady state diffusion problems, explicit and implicit schemes, consistency, stability and convergence, discretization of 2-D and 3-D diffusion problems. | 6 |
| **3.** | Numerical solution of systems of linear algebraic equations: general concepts of elimination and iterative methods, Gaussian elimination, tri-diagonal matrix algorithm, Gauss-Seidel iterations, conditions for convergence of iterative schemes, overrelaxation and underrelaxation. | 6 |
| **4.** | Convection diffusion problems: Central difference, upwind, exponential, hybrid and power law schemes, concept of false diffusion, QUICK scheme. | 6 |
| **5.** | Numerical solution of the flow field: SIMPLE, SIMPLEC and SIMPLER algorithms. | 8 |
| **6.** | Turbulent flow modelling: Reynolds Average Navier-Stokes equation, RANS turbulence Models, Large Eddy Simulation. | 4 |
| **7.** | Introduction to use of commercial CFD software | 5 |
| | **Total Classes =** | **40** |

**Text Books:**

1. Anderson, D., Tannehill, J. C., & Pletcher, R. H. (2016). Computational fluid mechanics and heat transfer. CRC Press.
2. Patankar, S. (1980). Numerical heat transfer and fluid flow. CRC press.

**References**

1. Versteeg, H. K., & Malalasekera, W. (2007). An introduction to computational fluid dynamics: the finite volume method. Pearson Education.
2. Muralidhar, K., & Sundarajan, T. (2003). Computational fluid flow and heat transfer. Alpha Science International.
3. Chung, T. J. (2010). Computational fluid dynamics. Cambridge university press.

**Course Goal / Learning Outcome:**

At the end of this course students will be able to

- Explain and calculate the governing equations of fluid flow.
- Numerically solve steady and unsteady diffusion problems, and convection-diffusion problems.
- Compute the flow field of an incompressible flow using different numerical methods.
- Numerically simulate turbulent flow using RANS and LES methods.
- Simulate different fluid flow and heat transfer problems using commercial CFD software.

**Learning Objectives**

- The course will introduce the governing equations, discretisation schemes, numerical methods, turbulence modelling, mesh quality and independence test, numerical errors, and boundary conditions to the students.
- The course will equip the students with the necessary knowledge to use computational techniques to solve problems related to flow mechanics.
- The course will provide the students with hands-on experience in using computational fluid dynamics to solve engineering problems.
- The course will develop students' skills of using a commercial CFD software package

## 9. Course Name: Advanced Fluid Power Systems and Control

**Course Code: MMD 504**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Steady-state characteristics of the system components: Direction control valve, Pressure relief valve, Flow through gaps, Flow between axial piston pump slipper pad and swash plate; Flapper Nozzle valve; Flow characteristics of the under lap and overlap spools; Flow and Torque losses of the pump and the motor; Determination of the performance parameters, e.g slip and efficiency of the hydrostatic pumps and motors. Sizing of the accumulator | 7 |
| **2.** | Steady-state performance of the systems: Meter-in and meter-out control systems; Counter-balance valve circuit and Over-center valve circuit; Hydrostatic drive: Closed loop and open loop drives; Servo-valve with linear actuator; Open-loop valve controlled drive: Intelligent control. | 7 |
| **3.** | System dynamics: Mathematical modelling of the hydraulic systems and | 8 |

| | | |
|---|---|---|
| | components; Computer simulation using software; System equations; Transfer functions of the hydraulic system; Time and Frequency responses of the hydraulic systems. | |
| **4.** | Control of displacement machines: Pressure control, Flow control, Power control and torque control, Load sensing systems. | 4 |
| **5.** | Hydrostatic Transmission: Basic design; Sizing of the components; Loss analysis; Dynamic analysis of Hydrostatic Transmission; Hydrostatic linear actuator; Split Power Transmission | 5 |
| **6.** | Fault diagnosis of hydraulic system and components. | 4 |
| **7.** | PLC controlled hydraulic and Pneumatic drives. P, PI and PID control used in Fluid Power systems for controlling the actuators. Application Labview software and DAQ software in fluid power systems. | 5 |
| | **Total Classes =** | **40** |

**Text Books:**


1. Watton, J. (2009). Fundamentals of fluid power control (Vol. 10). Cambridge University Press.


**References**


1. Merritt, H., Merritt, H. E., & Merritt, H. E. (1967). Hydraulic control systems. John Wiley & Sons.
2. Manring, N. D. Hydraulic Control Systems. 2005. John Wiley & Sons, ed, 1, 279-301.
3. Cundiff, J. S. (2001). Fluid power circuits and controls: fundamentals and applications. CRC Press.
4. Ivantysyn, J., & Ivantysynova, M. (2001). Hydrostatic pumps and motors.
5. Watton, J. (2007). Modelling, monitoring and diagnostic techniques for fluid power systems. Springer Science & Business Media.


**Course Goal / Learning Outcome:**

The students will get aware of the different types of Fluid Power components, systems used in mining applications. Their constructional and operational aspects of the machines; Analysis related with them.

**Learning Objectives**

To impart knowledge related to the Fluid Power components and systems; Control of fluid power systems, Fault diagnosis of fluid power systems, Simulation and modelling of fluid power systems using MATLAB; Design of hydraulic systems, Selection of components.

## 10. Course Name: Mine Power System

**Course Code: MMD 513**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Transmission and distribution of Electrical Power in Mines. Mining type switchgears and protective devices. | 05 |
| **2.** | Principle of Sub-station design, Types of Sub-station, Bus bar systems and layout, Design of Bus bars | 05 |
| **3.** | Design of Sub-station grounding system, Power Cables | 07 |
| **4.** | Testing and maintenance of Sub-station equipment | 07 |
| **5.** | Basic Principles – CTs, PTs. Static relay. Modern circuit breakers. | 06 |

| | | |
|---|---|---|
| **6.** | Protection of power transformers, alternators, transmission lines, cables, reactors and capacitors | 05 |
| **7.** | Protection of motors | 05 |
| | **Total Classes** | **40** |

**Text Books:**

1. Electrical Power System Protection by A. Wright, C. Christopoulos

**References**

1. Practical Power System Protection by L. G. Hewitson, Mark Brown, Ramesh Balakrishnan
2. Power System Protection & Switchgear by Oza
3. Substation Structure Design Guide by Leon Kempner Jr.
4. Electric Power Substations Engineering by John D. McDonald
5. Electrical Transmission and Substation Structures by Marlon W. Vogt

**Course Goal / Learning Outcome:**

Upon successful completion of this course a student should be able to:

1. Understand the specifics of Sub-station.
2. Understand the different Sub-station grounding system.
3. Understand the different probable power management.
4. Determine the specifics of relay and circuit breaker .
5. Understand the protection of equipmets.

**Learning Objectives**

The course objectives are to train students to be able to

1. Select and design mine sub-station
2. Get acquainted with Sub-station grounding system
3. Get familiar with the power management.

## 11. Course Name: Fluid Flow machines in mines

**Course Code: MMD 505**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | General: Classification and application of fluid flow machineries used in Mines and their basic theories. | 2 |
| **2.** | Non-positive displacement Pumps and Fans: Principle of operation; construction of impeller, multistage centrifugal pumps, axial thrust balancing, performance characteristics, parallel and series operations of pumps, capacity regulations; basic calculations; selection of mine pumps; Pumping system layout for mines. | 5 |
| **3.** | Axial Flow fan: Cascade of profiles; basic theoretical equations, head, energy, losses, efficiency; Multistage machines: Capacity regulation; Fan drive, calculations, selection procedure with special reference to mining applications; Parallel and series operation of Mine fans; Fan installation layout; Maintenance of axial flow fan. | 6 |
| **4.** | Centrifugal Fan: Principle of operation; construction of impeller, performance characteristics, capacity regulations; selection of mine fan; Centrifugal Fan drive; Centrifugal Fan installation layout. | 6 |
| **5.** | Other Mine Pumps and Fans: Construction and operation of slurry, | 6 |

| | | |
|---|---|---|
| | submersible, Screw / Mono pump; Main features of auxiliary and booster fans. Installation and maintenance of auxiliary and booster fan; Series and parallel operations of them. | |
| **6.** | Compressors and Blowers (Non-positive displacement type):Compressors used in Mining industries; Brief discussion on reciprocating compressor; Construction and operation of single and multi-stage non-positive Centrifugal compressors Capacity estimation and power calculation, Performance characteristics of compressors; Capacity regulation; Selection of compressors for mining application. | 6 |
| **7.** | Compressors (Positive displacement type): Construction and operation of single and multi-stage positive displacement compressors (Roots blower, Vane compressor and Screw compressor); Capacity estimation and power calculation, Performance characteristics of compressors; Capacity estimation and power calculation, Performance characteristics of positive displacement compressors; Capacity regulation; Selection of compressors for mining application. | 7 |
| **8.** | Maintenance of Pumps, Fans and Compressors used in mining industries | 2 |
| | | **40** |

**Text Books:**

1. Cherkassky, V. M. Pumps, Fans, and Compressors [in Russian], Energoatomizdat, Moscow (1984). Google Scholar, 29-35.
2. Khadzhikov, R., &Butakov, S. (1988). Mining Mechanical Engineering: R. Khadzhikov; S. Butakov. Mir Publishers.

**References**

1. Eck, B. (1973). Fans. 1st English ed., Pergamon Press, Oxford, 139-153.
2. Mine Fans, Dr. P. K. Chackroborty, CMPDIL – Ranchi
3. Mine Pumps, Dr. P. K. Chackroborty, CMPDIL – Ranchi
4. Fluid Mechanics & Fluid Machines, S. K. Som, G. Biswas, Tata-McGraw Hill

**Course Goal / Learning Outcome:**

The students will get aware of the different types of fluid flow machines used in mining applications. Their constructional and operational aspects of the machines; Analysis related with them.

**Learning Objectives**

To impart knowledge related to the Fluid Flow Machines used in Mining operations; such as Pumps, Fans and Compressors. Selection of them and their maintenance and trouble-shooting. Calculation with regard to their capacity estimation, power calculation etc.

## 12. Course Name: Vehicle Dynamics

**Course Code: MMD 506**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | CONCEPT OF VIBRATION: Definitions, Modeling And Simulation, Global And Vehicle Coordinate System, Free, Forced, Undamped And Damped Vibration, Response Analysis Of Single DOF, Two DOF, Multi DOF, Magnification Factor, Transmissibility, Vibration Absorber, Vibration Measuring Instruments, Torsional Vibration, Critical Speed. | 7 |
| **2.** | TIRES: Tire Forces and Moments, Tire Structure, Longitudinal and Lateral Force At Various Slip Angles, Rolling Resistance, Tractive And | 7 |

| | | |
|---|---|---|
| | Cornering Property of Tire. Performance of Tire on Wet Surface. Ride Property of Tires. Magic Formulae Tire Model, Estimation of Tire Road Friction. Test on Various Road Surfaces. Tire Vibration. | |
| **3.** | VERTICAL DYNAMICS: Human Response to Vibration, Sources of Vibration. Design and Analysis of Passive, Semi-Active and Active Suspension Using Quarter Car, Half Car and Full Car Model. Influence of Suspension Stiffness, Suspension Damping, and Tire Stiffness. Control Law For LQR, H-Infinite, Skyhook Damping. Air Suspension System and Their Properties. | 7 |
| **4.** | LONGITUDINAL DYNAMICS AND CONTROL: Aerodynamic Forces and Moments. Equation of Motion. Tire Forces, Rolling Resistance, Load Distribution for Three-Wheeler and Four-Wheeler. Calculation of Maximum Acceleration, Reaction Forces for Different Drives. Braking and Driving Torque. Prediction of Vehicle Performance. ABS, Stability Control, Traction Control. | 7 |
| **5.** | LATERAL DYNAMICS: Steady State Handling Characteristics. Steady State Response to Steering Input. Testing of Handling Characteristics. Transient Response Characteristics, Direction Control of Vehicles. Roll Center, Roll Axis, Vehicle Under Side Forces. Stability of Vehicle on Banked Road, During Turn. Effect of Suspension on Cornering. | 7 |
| **6.** | Noise, Vibration and Harshness – Random Processes | 5 |
| | **Total Classes =** | **40** |

**Text Books:**

1. Gillespie, T. D. (1992). Fundamentals of Vehicle Dynamics. Warrendale, PA: Society of Automotive Engineers.

**References**


1. Wong, J. Y. (2008). Theory of ground vehicles. John Wiley & Sons.
2. Rajamani, R. (2011). Vehicle dynamics and control. Springer Science & Business Media.
3. Karnopp, D. (2004). Vehicle stability. CRC Press.
4. Jazar, R. N. (2017). Vehicle dynamics: theory and application. Springer.
5. Blundell, M., & Harty, D. (2004). Multibody systems approach to vehicle dynamics. Elsevier.


**Course Goal / Learning Outcome:**

- Clear understanding of vehicle in different conditions of operations.
- Develop mathematical models, simulate, and evaluate problems with vehicular dynamics.
- Establish the fundamental knowledge of vehicle dynamics to improve vehicle performance.

**Learning Objectives**

The importance of this course is importing the basic understanding of the dynamics of the vehicle in different loads, speed and road conditions to improve the comfort for the passengers and life of the various components of the vehicle.

## 13. Course Name: Contact Mechanics

**Course Code: MMD 507**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1** | Introduction: concepts of friction and contact mechanics and their practical examples, relationship between friction and fracture, surface | 8 |

| | | |
|---|---|---|
| | energy, thermodynamics of surfaces, soft and hard solids friction, surface roughness, static, dynamic and stick-slip process and its significance. | |
| **2** | Stress analysis of contact problems: hertzian, jkr, and dmt contact mechanics, fracture mechanics of adhesion, adhesion of particles. | 8 |
| **3** | Surface characterization techniques: linear velocity tribometer, hardness testers. | 5 |
| **4** | Dynamics of frictional sliding: static and dynamic stability analysis of sliding surfaces, linear and non-linear analysis of stability, friction induced self-excited vibrations etc. | 8 |
| **5** | Contact Mechanics considerations in the analysis of surface fatigue failures. | 6 |
| **6** | Recent advances in adhesion and friction: Nano and bio-tribology, application of chaos and fractals, geophysical applications. | 5 |
| | **Total Classes =** | **40** |

**Text Books:**

1. Popov, V. L. (2010). Contact mechanics and friction. Berlin: Springer Berlin Heidelberg.

**References:**

1. Persson, B. N. (2000). Sliding Friction, Physical Principles and Applications. International Journal for Numerical and Analytical Methods in Geomechanics.
2. Johnson, K. L., & Johnson, K. L. (1987). Contact mechanics. Cambridge university press.

**Course Goal / Learning Outcome:**

- Student will be able to understand characterization techniques to visualize/image, describe, and analyse rough surfaces.
- Student will be able to understand and apply classic tribology and contact mechanics theory to solve engineering problems that involve contacting rough surfaces.
- Students will be able to analyse the fatigue life of the components under sliding contact as well as they learn about new advances going in the field of contact mechanics.

**Learning Objectives**

To impart the knowledge of designing tribological systems.

## 14. Course Name: Mine Electrical Drives

**Course Code: MMD 512**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Dynamics of Electrical Drives: Types of loads, Quadrantile diagram of speed-torque characteristics, Dynamics of motor-load combination. | 07 |
| **2.** | Selection of Electric Drives for Mining Equipment, Selection of Motor Power Rating, Characteristic of Drives used for Mines | 08 |
| **3.** | Drives used in Electric Rope Shovel and Dragline –Electrical drives arrangement and functions, Methods of drive control: Ward Leonard, Static DC Drive, AC Drive. | 08 |

| | | |
|---|---|---|
| **4.** | Mine Winder Drives – Selection, AC and DC drives and their control, Solid state DC winder, Electrical braking for AC and DC winders. | 08 |
| **5.** | Type of drives used for underground mine equipment : Ventilation Fan, Pump, Compressor, mine transport, coal-cutting machines. | 07 |
| **6.** | Gearless Drive for mining equipment | 02 |
| | **Total Classes** | **40** |

**Text Books:**

1. Mine winders and Drive System, P. K. Chakrabarti

**References**

6. Mine winding and transportation, M. A. Ramulu

**Course Goal / Learning Outcome:**

Upon successful completion of this course a student should be able to:

1. Understand the various electric drives used for mine equipment.
2. Understand the purpose and selection of electric drives.
3. Understand the characteristic, advantages of different drives.
4. Understand the operation of various drives in underground explosive atmosphere.
5. Understand the drives and its operation for HEMM in surface mines.

**Learning Objectives**

The course objectives are to train students to be able to

1. Select and design electrical drives in mining application both for underground and surface mining.
2. Get familiar with typical use of electrical drives in mining equipment.
3. Get familiar with the conventional and future drives application in mines.

**15. Course Name: Mechatronics**
**Course Code: MMD 508**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1** | Introduction to Mechatronics: Definition, Comparison between traditional and mechatronic approach, Microprocessor-Based Controllers and Microelectronics. | 6 |
| **2** | Measurement systems: Static and dynamic performance characteristics of measurement devices. Principle of calibration, errors in measuring instruments, sources of errors, types of errors and quantification of different types errors in measurement. Sensing elements: Working principles of resistive, capacitive, inductive, thermoelectric, piezoelectric, piezo-resistive, Hall Effect sensors, optical sensors and encoders, charge coupled devices. | 8 |
| **3** | Principle of measurement of pressure, strain, force, temperature. Introduction to virtual instrumentation. | 7 |
| **4** | Drives: Stepper motors, servo drives. Control Systems: Open loop and closed loop control, Time domain and state space analysis of control systems. | 6 |
| **5** | Mathematical modelling of physical systems: PI, PD and PID controllers. | 5 |

| | | |
|---|---|---|
| **6** | Introduction to discrete-time systems and Z-transform; A/D and D/A Conversion. Microprocessor architecture and programming. | 8 |
| | **Total Classes =** | **40** |

**Text Books:**

1. Ogata, K. (2009). *Modern control engineering*. Upper Saddle River, NJ: Prentice Hall.
2. Alciatore, D. G. (2007). *Introduction to mechatronics and measurement systems*. Tata McGraw-Hill Education.

**References:**

1. Kuo, B. C. (1987). *Automatic control systems*. Prentice Hall PTR.
2. Smaili, A., & Mrad, F. (2008). *Mechatronics: Integrated technologies for intelligent machines*. Oxford University Press.
3. Pearson, R. S. G. P. H. (2002). *Microprocessor Architecture Programming and Applications with the 8085, Atilim University Library, 2002: Microprocessor Architecture Programming and Applications with the 8085*. Bukupedia.

**Course Goal / Learning Outcome:**

- Students will understand the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes.
- Students will also understand the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structures and its overall control.

**Learning Objectives**

To impart the knowledge of design, instrumentation, manufacturing methods, computer integration and process and device control.

## 16. Course Name: Composite Materials

**Course Code: MMD 509**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Fabrication of Composite materials: Definition, Characteristics, Classification, Particulate composites, Advanced Fibers, Matrix materials, Hand Lay-up Technique, Bag Molding Process, Resin Transfer Molding, Filament Winding, Applications of Fiber Composites | 04 |
| **2.** | Defects and Damages in Composite materials: Defect Types, Description, Classification of Defect types, Defect occurrence, Defect size, Defect Location | 03 |
| **3.** | Analysis of Unidirectional Composites: Longitudinal behaviour of Unidirectional composites, Transverse stiffness and Strength, Prediction of Shear Modulus and Poisson's ratio, Failure modes, Expansion coefficients and Transport Properties, | 06 |
| **4.** | Analysis of an Orthotropic lamina: Stress ~ Strain Relations and Engineering constants: Specially orthotropic materials, Generally orthotropic materials; Transformation of Engineering constants; Hooke's law, stiffness and compliance matrices: General Anisotropic materials, Specially orthotropic materials, Transversely Isotropic materials, Isotropic materials, Specially orthotropic materials under plane stress, Compliance Tensor and Compliance matrix, Relations between Engineering constants and Elements of Stiffness and | 10 |

| | | |
|---|---|---|
| | Compliance matrices, Transformations of Stiffness and compliance matrices, Invariant forms of Stiffness and Compliance Matrices; Strengths of an orthotropic lamina: Maximum Stress Theory, Maximum Strain Theory, Maximum Work Theory | |
| **5.** | Analysis of laminated Composites: Introduction, Laminate Strains, Variation of Stresses in a Laminate, Resultant Forces and Moments: Synthesis of Stiffness Matrix; Laminate Description System, Construction and Properties of Special Laminates: Symmetric laminates, Unidirectional, Cross-Ply and Angle Ply laminates; Determination of Laminae Stresses and Strains, Analysis of laminates after Initial Failure, Hygrothermal Stresses in Laminates. | 07 |
| **6.** | Analysis of Laminated Plates and Beams: Governing Equations for Plates, Application of Plate Theory: Bending, Buckling, Free Vibrations; Deformations due to Transverse Shear, analysis of laminated Beams, Governing Equations of Laminated Beams, Application of Beam Theory: Bending, Buckling, Free Vibrations | 07 |
| **7.** | Performance of Composite materials: Fatigue damage, Impact induced behaviour of composites, Environmental Interaction Effects | 03 |
| | **Total Classes =** | **40** |

## Text Books:


1. Jones, R. M. (2014). Mechanics of composite materials. CRC press.


## References


1. Daniel, I. M., Ishai, O., Daniel, I. M., & Daniel, I. (1994). Engineering mechanics of composite materials (Vol. 3, pp. 256-256). New York: Oxford university press.
2. Heslehurst, R. B. (2014). Defects and damage in composite materials and structures. CRC Press.
3. Mukhopadhyay, M. (2005). Mechanics of composite materials and structures. Universities press.
4. Agarwal, B. D., Broutman, L. J., & Chandrashekhara, K. (2017). Analysis and performance of fiber composites. John Wiley & Sons.
5. Chawla, K. K. (2012). Composite materials: science and engineering. Springer Science & Business Media.


## Course Goal / Learning Outcome:

Upon successful completion of this course a student should be able to:

1. Understand the specifics of mechanical behaviour of layered composites compared to isotropic materials.
2. Understand the different laboratory based methods for manufacturing Fibre reinforced Composite materials.
3. Understand the different probable modes of defects in composite materials.
4. Apply constitutive equations of composite materials and understand mechanical behaviour at micro, macro and meso level.
5. Determine stresses and strains in composites structures.
6. Apply failure criteria and critically evaluate the results in composite materials.
7. Understand mechanical behaviour of composites due to variation in temperature and moisture.

## Learning Objectives

The course objectives are to train students to be able to

1. Select and design composite structures for specific Engineering Applications
2. Conduct stress analyses of selected practical applications using laminated plate theories and appropriate strength criteria.

3. Get acquainted with different types of Defects which are prone to occur in composite materials.
4. Get familiar with the properties and response of composite structures subjected to mechanical loading under static and cyclic conditions.

## 17. Course Name: Mine Automation

**Course Code: MMD 514**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Scope and role of automation in mining operation. Basic foundations for automation of mining equipment | 02 |
| **2.** | Programmable Logic Controller (PLC): operating principle, concept of ladder logic, use of Timer, Counter. Application of PLC in mines. | 10 |
| **3.** | Automation in monitoring of mine environments: Monitoring of methane, carbon monoxide, oxygen, temperature, humidity. | 04 |
| **4.** | Different methods of continuous monitoring, data transmission and Tracking | 02 |
| **5.** | Underground Voice communication, Leaky feeder and Fiber optic based systems. Applicability of Wireless communication systems. RFID-based communication. TTE Messaging. Underground mine roof subsidence monitoring | 08 |
| **6.** | Condition monitoring for HEMM | 02 |
| **7.** | GPS based Positional and Dispatch Management System in surface mine. Surface Slope Stability Monitoring. Anti-collision devices. | 05 |
| **8.** | Introduction to the application of robotics in mines, remote controlled and manless mining. | 03 |
| **9.** | Expert systems: concept and applications in mining. Artificial Intelligence: concept and applications in mining. | 04 |
| | **Total Classes** | **40** |

**Text Books:**

1. The Gas Monitoring Handbook, G. L. Anderson, D. M. Hadden

**References**

1. SME Mining Engineering Handbook, 3rd Edition
2. Programmable Logic Controllers, W. Bolton

**Course Goal / Learning Outcome:**

Upon successful completion of this course a student should be able to:

1. Understand the necessity of automation in mining industry.
2. Understand the operation and application of PLC in mines.
3. Understand the monitoring and data communication for underground mine environment for better productivity and safety
4. Understand the different existing and modern communication techniques for mines.
5. Understand the application possibility of robotics, AI in mining industry

**Learning Objectives**

The course objectives are to train students to be able to

1. Get familiar with new generation controller

2. Get acquainted with machines and other areas of mining automation
3. Get familiar with the PLC.
4. Get familiar with the application of modern communication techniques in mines

**18. Course Name: Failure Analysis of Industrial Equipment Component**
**Course Code: MMD 515**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Introduction to Failure analysis: Engineering aspects of failure & failure analysis ;Defects: Types and characteristics, Effects of defects on service properties; General Procedures for Failure Analysis Basic Failure Mechanisms: Distortion Failures, Overload Failures, Fatigue Failures, Wear Failures, Corrosion Failures, Elevated Temperature Failures, Fractures. Failure Analysis Techniques and Failure preventive measures: Preventive Measures: Non-Destructive Testing Techniques, Condition Monitoring and Reliability analysis. | 04 |
| **2.** | Introduction to Fracture analysis: Mechanisms of Fracture, Brittle and Ductile fracture, Modes of Fracture Failure, Damage tolerant design, | 02 |
| **3.** | Fracture growth parameters: Griffith's criteria, Concept of Strain Energy Release Rate, Anelastic deformation at crack tip, crack resistance, R-curve, Concept of Stress intensity factor, Linear Elastic fracture Mechanics, Westergaard's approach, Edge cracks, embedded cracks, Critical SIF, Relationship between G and K,J-integral, Path independence, Stress strain relations, Crack tip opening Displacement, Relationship among CTOD, $K_I$ and $G_I$ for small scale yielding, Equivalence between CTOD and J-integral | 15 |
| **4.** | Computation of fracture parameters: Experimental & Numerical (FEM) determination of SERR, SIF and J-integral | 07 |
| **5.** | Reliability analysis: Use of reliability and maintenance to prevent failure, Maintenance concept; Maintenance objectives; Different types of maintenance to prevent failure; Components of reliability: Mean, Median, Variance, Deviation; Probability; Failure rate; Failure pattern; Series, parallel and series-parallel reliability models; Normal distribution, lognormal distribution, Gamma distribution, Weibull distribution, Poisson distribution Exponential distribution Reliability Models; | 06 |

| | | |
|---|---|---|
| | Reliability Evaluation; Case study. | |
| **6.** | Condition monitoring: Condition monitoring use to prevent failure; Levels of condition monitoring; Condition Monitoring techniques; Vibration, noise, Wear debris, temperature monitoring; Thermography; Condition monitoring instrumentation; Online and off-line condition monitoring techniques; Data analysis; Non-destructive testing, principle methods such as dye-penetrant, magnetic particle testing and ultrasonic tests etc. | 06 |
| | **Total Classes =** | **40** |

**Text Books:**

1. An Introduction to Reliability and Maintainability Engineering, by Charles Ebeling, Tata McGraw-Hill, 2009.
2. Industrial Maintenance by H.P. Garg, S. Chand Publishing, 2010.

**References**

1. Elements of Fracture mechanics, Prashant Kumar, TMH Publication, 2009
2. Fracture Mechanics, C.T. Sun and Z.-H. Jin, Elsevier Publication, 2012
3. Industrial Maintenance Management by S.K. Srivastava, S.Chand (G/L) & Company Ltd 2002.
4. Practical Reliability Engineering, 5th edition by Patrick O'Connor and Andre Kleyner, Wiley, 2012.
5. Reliability Evaluation of Engineering Systems by Roy Billinton and Ronald N. Allan,
6. Reprinted in India B. S. Publications, 2007

**Course Goal / Learning Outcome:**

To provide an understanding about different types of failures and fracture in industrial components, their analysis and preventive techniques used in industries.

**Learning Objectives**

The objective of this course is to introduce the mathematical and physical principles of failure and fracture analysis and their applications to engineering design to develop the ability in students to compute the stress intensity factor, strain energy release rate, and the stress and strain fields around a crack tip for linear and non-linear materials. It will also expand the student's knowledge on experimental methods to determine the fracture parameters and develop their understanding towards a damage tolerant design of industrial equipment components.

**19. Course Name: Mining Machinery**
**Course Code: MMO 501**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Transportation - Haulage & Hoisting in Underground Mines:<br>Mine winders: Drum, Friction, Blair winders; Rope attachments; Shaft fittings; Safety devices; Hoisting cycle; Productivity calculation; Cages; Skips; Wire ropes<br>Rope haulages: Classifications; Operation; Productivity calculation; Mine cars; Rope fittings; Scope and application<br>Locomotive haulages: Electric, Battery, Diesel locomotives; Tractive effort; Drawbar pull; Ideal gradient; Optimum gradient; Neutral gradient; Super elevation; Track layouts & safety devices; Locomotive calculations; Scope & application<br>Trackless haulage system: LHD; Shuttle cars, LPDT, SDL<br>Man riding systems | 8 |
| **2.** | Ore Transporting Equipment in Surface Mines:<br>Dumpers: Classifications; System components and functions | 6 |

| | | |
|---|---|---|
| | Belt conveyors: System components and functions; Maintenance, Capacity & power calculations; Scope & application<br>High Angle Conveyor: Constructional features; Operation; Scope & application<br>Cable belt conveyor: Constructional features; Operation; Scope & application<br>Pipe belt conveyor: System components and functions; Scope & application<br>Aerial ropeways: Classifications; Operation; Angle stations; Loading & discharging stations; Buckets; Scope & application | |
| **3.** | Rock Drills: Types of rock drills, Constructional features and operation of electric and hydraulic coal drills; Jack hammers, Hydraulically operated drill machines, Electro hydraulic jumbo drills, Top hammer drills, DTH drills, Wagon drills, Blast hole drills, Drill bits, Drill rods, Flushing mechanisms, Dust collectors, Scope & application | 6 |
| **4.** | Roof Supports: Friction supports; Hydraulic supports; Power supports; Nomenclatures; Hydraulic circuits: Hydraulic oil & properties; Power pack unit, Roof bolts, Scope & applications | 6 |
| **5.** | Production Machines in Underground Mines :<br>Construction and operation of shearer, plough, continuous miner; Scope & application; Cutting picks; Cutting heads; Dust control; AFC; Stage loader. | 6 |
| **6.** | Excavating Equipment in Surface Mines :<br>Construction and operation of Surface miners, Electric rope shovels, Hydraulic shovels, Draglines, Bucket wheel excavators; Scope & application | 8 |
| **7.** | Ancillary Equipment: Road header; Dintheader; Dozers, Motor graders. | 2 |
| | **Total Classes =** | **42** |

**Text Books:**


1. De, A. (2015). Latest Development of Heavy Earth Moving Machineries, Lovely Prakashan.
2. Tatiya, R. R. (2005). Surface and underground excavations: methods, techniques and equipment. CRC Press.


**References**


1. Nichols, H. L. (1976). Moving the earth-the workbook of excavation.
2. Chugh, C. P. (1977). Drilling technology handbook. Oxford & IBH Publishing Company.
3. Peng, S. S., & Chiang, H. S. (1984). Longwall mining, Wiley Publisher.
4. Deshmukh, D. J. (1982). Elements of mining technology. Vidyasewa Prakashan.
5. Mukharjee, S. N. (1993), Longwall Machinery and Mechanisation, Lovely Prakashan.
6. Kaku, L. C. (2000). The Coal Mines Regulations. 1957. Dhanbad: Lovely Prakashan.
7. Kaku, L. C., (1961), Metalliferous Mines Regulations, Lovely Prakashan.
8. Chakraborty, P. K., Mine Winder, CMPDI, Ranchi.
9. Stathan, I C F, Coal Mining Practices, London Publisher.
10. Das, S K., Modern Coal Mining Technology, Lovely Prakashan.


**Course Goal / Learning Outcome:**

To features, operational detail, selection of different type of inderground mining equipment.impart conceptual knowledge on constructional

**Learning Objectives**

Students will understand basic features of equipment, selection, environmental issues and design features.

**20. Course Name: Bulk Material Handling Equipment**
**Course Code: MMO 502**
**L-T-P = 3-0-0**
**Credit = 9**
**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1** | Rock Crushers: Construction, operation, selection and classifications of jaw crusher, gyratory crusher, cone crusher, roll crusher, hammer crusher, ring granulator, feeder breaker, rotary breaker, inpit crusher, drives, accessories and controls, capacity estimation, loading and discharge arrangements, associated terminologies, crushing circuits flow sheets. | 11 |
| **2** | Conveyors, Feeders and Screens: Construction, operation, selection and classifications of conventional belt conveyors, high angle conveyors, cable belt conveyors, pipe conveyors, chain conveyors, AFC, feeders, screens, bucket elevators, theory and practices of hydraulic and pneumatic conveying systems, drives, accessories and controls, capacity and power calculations, general thoughts on loading transfer and unloading, idlers, pulleys, belt take-ups. | 11 |
| **3** | Stacking, Reclaiming and Spreading Equipment: Construction, operation, classification, maintenance, selection of stackers, reclaimers, spreaders, layouts, capacity calculation, | 6 |
| **4** | Tippler and Wagon Loader: Constructional features, working principles | 4 |
| **5** | Aerial Ropeway: Classifications, layout, constructional features, loading, unloading arrangements, angle stations, ropes, selection, advantages, disadvantages, capacity and power calculations | 4 |
| **6** | Storages Vessel: Construction, design features, operation of bins, bunkers, silos, storage and discharge methods, and problems encountered during loading and discharge, maintenance, capacity calculation. | 4 |
| | **Total Classes =** | **40** |

**Text Books:**


1. Wills, B. A., & Finch, J. (2015). Wills' mineral processing technology: an introduction to the practical aspects of ore treatment and mineral recovery. Butterworth-Heinemann.


**References:**


1. Colijn, H. (1985). Mechanical conveyors for bulk solids (Vol. 4). Elsevier Science Ltd.
2. Alexandrov, M. P. (1981). Materials Handling Equipment: MP Alexandrov. Mir Publishers.
3. Hetzel, F. V. (1922). Belt conveyors and belt elevators. J. Wiley and Sons.
4. Stoess, H. A. (1983). Pneumatic conveying. Wiley-Interscience.
5. Mineral Processing- G Trazon
6. Amer, M. M., & Awad, G. H. (Eds.). (2015). Handbook of Arab American psychology. Routledge.
7. Mular, A. L., Halbe, D. N., & Barratt, D. J. (Eds.). (2002). Mineral processing plant design, practice, and control: proceedings (Vol. 1). SME.


**Course Goal / Learning Outcome:**

To impart conceptual knowledge on constructional features, operational detail, selection, safety features of different type of bulk material handling equipment.

**Learning Objectives**

Students will understand basic design features of equipment, their selection, trouble shooting, performance analysis, cost analysis, environmental issues, safety features and industry regulations.

## 21. Course Name: Mine Electrical Technology

**Course Code: MMO 503**

**L-T-P = 3-0-0**

**Credit = 9**

**Syllabus & Lecture Plan:**

| Unit | Description | No. of Classes |
|---|---|---|
| **1.** | Layout and different components of a typical Mine Sub-station. Electrical power supply layout for UG coal mines. Purpose of electrical substation Earthing. Causes and disadvantages of low power factor and common methods of power factor improvement. | 7 |
| **2.** | Introduction of mining type circuit breaker - Transwitch unit, Gate-end box. Principle of flame-proof enclosure, intrinsically safe circuit. Introduction to Indian electricity rules as applied to mines. | 4 |
| **3.** | DC Motors and DC Generators – basic construction, emf and torque equation, starting of DC motors, speed control of DC motors. Application as mine drives. | 6 |
| **4.** | Three-phase ac motors: Induction motor – basic construction and types, basic principle of operation, Torque-speed characteristics. Starting and Speed control. Synchronous Motor – basic construction, basic theory of operation, starting. Application as mine drives. | 7 |
| **5.** | Semiconductor switches: Thyristor, IGBT, GTO. Application in AC to DC conversion: controlled rectifier, DC to DC Conversion and DC to AC Conversion: Inverter. Dynamics of Electrical Drives. | 6 |
| **6.** | Introduction to electrical drives used in mine winder, underground mining equipment and HEMM. Introduction to microcontroller and modern control schemes. | 10 |

**Total Classes = 40**

**Text Books:**

1. Kothari, D. P., & Nagrath, I. J. (2004). Electric machines. Tata McGraw-Hill Education.
2. Pillai, S. K. (1990). A first course on electrical drives. New Age International.

**References**

1. Dubey, G. K. (2002). Fundamentals of electrical drives. CRC Press.
2. Rashid, M. H. (Ed.). (2017). Power electronics handbook. Butterworth-Heinemann.

**Course Goal / Learning Outcome:**

The students will understand:

- The overview and basic layout of substation arrangements for open pit and underground mines, distribution of electrical power in mines.
- The concept and use of various types of circuit breakers, Gate end box, Drill Panel, Transwitch used in mines. They will learn the basic electrical safety rules in mines.
- Different type of motors used in underground and open-pit mines. Also, will learn main power semiconductor devices used in modern AC and DC drives for mining applications.

**Learning Objectives**

- Students will have an overall basic idea about the electrical system used in mines and mining equipment.