Shri Rawatpura Sarkar University, Raipur

Examination Scheme & Syllabus

for

M.Tech.(Mining Engineering)

Semester-I

(Effective from the session: 2019-20)

Faculty of Engineering,
Shri Rawatpura Sarkar University, Raipur

M.Tech.(Mining Engineering)
Semester-I
Examination Scheme
(Effective from the session: 2019-20)

S.N	Course Code	Th/ Pr	Subject	Type of Course	Teaching hours per week			TC	Examination Scheme				Total Marks
					L	T	P		Theory		Practical		
									EX	IN	EX	IN	
1	MSCCP101	Th	Advanced Computational Methodology	Core	4	-	-	4	70	30	-	-	100
2	MENMN102	Th	Advanced Rock Mechanics and Ground Control	Core	4	-	-	4	70	30	-	-	100
3	MENMN103	Th	Mine Planning and Design	Core	4	-	-	4	70	30	-	-	100
	MENMN104	Th	Elective –I	Core	4	-	-	4	70	30	-	-	100
5	MENMN105	Th	Elective –II	Core	4	-	-	4	70	30	-	-	100
6	MENMN102P	Pr	Rock Mechanics Lab	Core	-	-	4	2	-	-	35	15	50
7	MENMN103P	Pr	Mine Planning and Design Lab	Core	-	-	4	2	-	-	35	15	50
	Total Contact hr per week: 28			**Total Credit: 24**					**Grand Total Marks:**				**600**

L: Lecture T: Tutorial P: Practical

Elective-I

S.NO.	Subject Name	Subject Code
1	Ground Improvement Techniques	MENMN104A
2	Tunneling and Underground Space Technology	MENMN104B
3	Modern Surveying Techniques	MENMN104C

Elective-II

S.NO.	Subject Name	Subject Code
1	Instrumentation In Mining	MENMN105A
2	Introduction to Robotics and Application to Mining	MENMN105B
3	Remote Sensing & Geographical Information Systems	MENMN105C

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<table>
<tr><td>Course Title</td><td colspan="5">ADVANCED COMPUTATIONAL METHODOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="5">MSCCP101</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>4</td><td>-</td><td>-</td><td>4</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Engineering Mathematics –I & II</td></tr>
<tr><td>Course objectives</td><td colspan="5">This course will enable students to:
Represent the problems mathematically.
Optimize the solutions.
Analyze the result numerically and linguistically by fuzzy theory.
EmphasizethemeaningandpurposeofthesetechniquesandtheiruseinsolvingEngineering Problems.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT – I
Graph Theory and Its Application
Basic Terminology. Simple graph. Multi graph, Types of graphs. Path. Cycles. Eulerian and Hamiltonian graph. Shortest path problem Representation of graph. Trees and their properties. Spanning Tree. Binary Tree. Tree traversal.
UNIT - II
Fuzzy Set and Its Applications
Fuzzy sets-Basic definitions, α-level sets. Convex fuzzy sets. Basic operations on fuzzy sets. Types of fuzzy sets. Cartesian products, Algebraic products. Bounded sum and difference, t-norms and t-conorms. The Extension Principle- The Zadeh’s extension principle. Image and inverse image of fuzzy sets. Fuzzy numbers. Elements of fuzzy arithmetic.
UNIT – III
Cryptography and Its Application
Introduction to the Concepts of Security: The need for security, Security Approaches, Principles of Security, Types of Attacks. Cryptographic Techniques: Plain Text and Cipher Text, Substitution Techniques, Transposition TechniquesEncryption and Decryption, Symmetric and Asymmetric Key Cryptography, Steganography, Key Range and Key Size, Possible Types of Attacks. DES, RSA, Digital Signature.
UNIT - IV
Statistical Analysis
Expectation and variance of random variable. Sampling Distribution. Testing a Hypothesis. Level of significance. Confidence limits. Test of significance for large sample. Central limit theorem. Test of significance for means of two large</td></tr>
</table>

	samples. Sampling Variables-small samples. Student t-distribution, Chi-square test. **UNIT - V** **Optimization Techniques** Dynamic Programming-Deterministic and Probabilistic Dynamic programming. Inventory- Basic characteristics of an inventory system. The Economic order quantity. Deterministic models. Network analysis (PERT/ CPM).
Course Outcomes	**After the completion of course:** • This is the foundation of research and development in the computational domain of engineering and technology. • As the prerequisite, this will be traced the thought and ideas to design the behavioral tools over the engineering range. • This is a transformation from theory to application through measuring theory of natural problems and its applications.
Text Books	1. CalculusofVariationswithApplications, Gupta,A.S.PrenticeHallofIndia(P)Ltd.,New Delhi, 6th print,2006 2. Introduction to Partial Differential Equations, Sankar Rao., K Prentice Hall ofIndia(P) Ltd., New Delhi, 5th print,2004 3. Advanced Engineering Mathematics, Jain. R.K., Iyengar S.R.K. Narosa publications2nd Edition,2006 4. NumericalMethodsinScienceandEngineering,Grewal,B.S-KhannaPublications,New Delhi. 5. Numerical Methods, Kandasamy. P. Thilagavathy. K and Ganapathy, S. Chandand Co., Ltd., New Delhi, 5th Edition,2007 6. TheoryandproblemsofComplexVariableswithanIntroductiontoConformal MappingandItsapplications,Schaum'soutlineseries,Spiegel,M.R-McGrawHillBookCo.,1987.
Reference Books	1. Multi - Objective Optimization Using Evolutionary Algorithms, K. Deb (2003) John Wiley 2. Applied Statistics & Probability for Engineers: Montgomery, Douglas C. & Runger, George C. (2007), 3/e,Wiley India. 3. Parallel distributed processing Vol.1 (1986) Rumelhart, D.E and McClelland, J.L., M I T Press, 1986. 4. Fuzzy logic implementation and applications (1996), Patyra, M.J. and Mlynek Wiley

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<table>
<tr><td>Course Title</td><td colspan="5">ADVANCED ROCK MECHANICS AND GROUND CONTROL</td></tr>
<tr><td>Course Code</td><td colspan="5">MENMN102</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>4</td><td>-</td><td>-</td><td>4</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5">Rock Mechanics</td></tr>
<tr><td>Course Objectives</td><td colspan="5">This course will enable students to:
To study about application of Rock Mechanics, Physico-Mechanical properties of rocks, non-destructive testing methods, time dependent properties of rocks.
Design of different types of underground supports, etc.
To study the theories of failure and approaches used for open pit and underground designs.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT – I
Stress Analysis: Stress analysis in 2D and 3D, equations of equilibrium, Mohr's Circles, plane stress and plane strain condition, stress distribution in simple structures, Flexure of beams and rectangular plates

UNIT – II
Properties of Rocks:
Physico-mechanical properties of rocks including tri-axial strengths and in-situ strengths and their application in the design of different types of excavations, rock indices viz. drillability index, caving index, etc. Time dependent properties of rocks and their application in structural design, static and dynamic elastic constants of rocks, rock mass classification methods. Selection excavator based on rock properties.
UNIT – III
In-Situ Stresses and Theories of Failure:
In-situ stresses and instrumentation, drilling and blasting, measurement of stresses, strains, deformations, in-situ stress determination, strata monitoring in underground and opencast mines, mechanics a of drilling and blasting, blast vibration and its monitoring. Different theories of rock failure and their applications in design of mining structures.
UNIT IV
Design of Underground Openings, Subsidence, Rock Burst and Slope Stability:
Design of single and multiple underground openings, pillars including shaft pillar, scaling factors, mining subsidence, rock burst, design of slopes and</td></tr>
</table>

	spoil banks, slope stability in rock & soil and its analysis, slope monitoring and stabilization techniques. Design of pillars including barrier and shaft pillars. **UNIT V -Design of Mine Supports:** Advances of mine supports, supports and bord and pillar and longwall workings, rock load assessment, design of different types of supports like conventional and non-conventional supports like shotcrete, fiber reinforced shotcrete, strata grouting, rock bolting, supports in tunnels and shafts,
Course Outcomes	**After the completion of course:** • The students will have detailed knowledge on application of rock mechanics. • Design of different types of underground openings and supports. • Design, stabilization and monitoring of slopes, theories of subsidence and failure of rocks.
Text Books	1. Obert, L. and Duvall, W.I., Rock Mechanics and Design of Structure in Rock John Wiley and Sons Inc., New York, 1967. 2. Vutukuri, V.S., and Lama, R.D., Handbook on Mechanical Properties of Rocks, Vol. I, II, III and IV, Transtech Publication, Berlin, 1974/78
Reference Books	1. Peng, S.S., Ground Control, Wiley Inter science, New York, 1987. 2. Brady, B.H.G. and Brown, S.T., Rock Mechanics, Wiley Inter science, 1985. 3. Hoek, E., and Brown, S.T., Underground Excavations in Rocks, Institute of Mining Metallurgy, London, 1980.

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Course Title	**MINE PLANNING AND DESIGN**				
Course Code	**MENMN103**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	**Mining Methods**				
Course Objectives	**This course will enable students to:** • To introduce the various techniques for mine planning. • Study geotechnical investigation and equipment management. • To appreciate the modern trends in opencast mines, safety and environment.				
Course Contents	**UNIT – I** **Introduction:** Technical factors in mine planning, methodology of mine planning, short range & long range, mine modelling, mine simulation systems approach to mine planning based on mine subsystem and their elements, mine plan generation. **UNIT – II** **Open Pit Mining:** Selection of initial mine cuts, location of surface structures, division of mining area into blocks, mine design, bench drainage, geometry, haul roads, slope stability; open pit limits and optimization, calendar plan, production planning, production scheduling, economic productivity indices. **UNIT – III** **Underground Mining:** Location of mine entries, mine and auxiliary, optimization of mine parameters, design of shaft pillars and protective pillars, planning of production capacity, layout of development drives / raises / winzes etc, length of faces, size of panels, etc, planning of support systems, ventilation, lay out of drainage system, planning production schedule and monitoring, selection of depillaring / stopping method, manpower management, economic/ productivity indices, techno economic analysis, mine reclamation design. **UNIT – IV** **Equipment Planning:** Latest technological developments in increase in both types and capacities of equipment used in mining operations. Planning and selection of equipment for different mining conditions. Equipment design for optimum drilling and blasting operations. Equipment information – performance, monitoring and expert systems. Innovative mining systems. **UNIT – V**				

	Project Implementation and Monitoring: Pre-project activities – feasibility report, environment clearance, detailed project, report, sources of funds, import of technology, selection of contracts and contract administration, time management, cost control material management system, project quality assurance, social responsibility, government orders and guidelines. Environmental impact assessment and preparation of environmental management plan. Mine closure plan.
Course Outcomes	**After the completion of course:** • The students will have insight about the advanced techniques for mine planning. • Geotechnical investigation and equipment management. • Understand the modern trends in opencast mines safety and environment.
Text Books	1. Jayanth Bhattacharya, Principles of Mine Planning-Allied Publishers, Delhi 2003. 2. Hustrulid, W. and Kuchta, M., (eds)., Fundamentals of Open pit Mine Planning and Design, Elsevier, 1995.
Reference Books	1. Ehrenburger, V and Fajkos, A., Mining Modelling, Elsevier, 1995. 2. Bawden, W.F., and Archibald., J.F., Innovative Mine Design for the 21st Century Elsevier,1993. 3. Passamehtoglu, A.G., Karpuz, C., Eskikaya, S. and Hizal, T., (Eds), Mine Planning and Equipment Selection, Elsevier, 1994. 4. Pazdziora, J., Design of Underground Hard Coal Mines, Elsevier, 1988. 5. Swilski, and Richards, Underground Hard Coal Mines, Elsevier, 1986. Singh, B. and Pal Roy, P., Blasting in Underground excavations and mines, CMR Dhanbad, 1993

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Course Title	**GROUND IMPROVEMENT TECHNIQUES**				
Course Code	**MENMN104A**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites					
Course Objectives	**This course will enable students to:** • To understand the objectives, necessity and scope of ground improvement techniques • To learn different methods of insitu densification of cohesive, cohesionless soils. • To learn the classification, functions and applications of Geosynthetics in ground improvement. • To learn the process of identification of necessity for ground improvement, finding alternative methods and recommendation of the ideal technique through case studies.				
Course Contents	**UNIT–I** **General:** Formation of rock, soils and soil profiles, soil distribution in India and other countries - marine, black cotton soils (expansive)., lateritic, alluvial, desert soils peat etc., factors affecting the alteration of ground after formation – natural and man-made – reclaimed soils – methods of geotechnical processes. **UNIT-II** **Compaction methods:** moisture density relations – compactive efforts – field methods – surface compaction, deep compactions- vigor compaction methods, vibro-probes, stone columns, sand compaction, stone column piles, selection of methods – quality control – specifications for compaction process for solving field problems. **UNIT-III** **Drainage methods:** seepage, ground water seepage control – filter requirements methods of dewatering – well point methods of discharge computations – design of steps for dewatering – design of well screens – selection of pumps and accessories – deep bored wells. Pre compression methods: compressibility and consolidation properties of soils estimation of rate of consolidation settlements – accelerating methods – monitoring compressions – design of vertical drains – consolidation by electro osmosis and vacuum compression methods. **UNIT –IV**				

	Grouting and injection methods: principles, design methods, selection of methods and requirements. Aspects of grouts, types of grouts and chemical applications, seepage control, solidification and stabilization – equipment and accessories used – quality control – specifications for achieving satisfactory results. **UNIT- V** **Stabilization methods:** mechanical, cement, lime, chemical methods of stabilization of soils – use of admixtures – polymers – geo synthesis – reinforcements thermal slurry trenches, void filling – prewetting – improving rock stability methods – exercise quality control to achieve desired results.
Course Outcomes	**After the completion of course:** 1. Ability to understand the necessity of ground improvement and potential of a ground for improvement. 2. To gain comprehensive understanding about the improvement of in-situ cohesive soils as well as Cohesion less soils. 3. Competence to analyse an in-situ ground, identification of ground improvement techniques feasible, selection of the ideal method, its planning , design, implementation and evaluation of improvement level.
Text Books	1. J.E. Bowles – Foundation Design &Analysis. McGraw-Hill Edition 1995. 2. Ground improvement techniques by P. Purushottam Raj, Laxmi Pub., 1999.
Reference Books	1. F. S. Fang Handbook of Foundation Engg. CBS Pub., 1985.

<table>
<tr><td>Course Title</td><td colspan="5">TUNNELING AND UNDERGROUND SPACE TECHNOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="5">MENMN104B</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>4</td><td>-</td><td>-</td><td>4</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5"></td></tr>
<tr><td>Course Objectives</td><td colspan="5">This course will enable students to:
To study various design methods of tunnels, underground spaces and their supports.
To study various methods of driving tunnels, underground spaces and their surveying related.
To study about various machinery used in driving tunnels and underground spaces.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT-I
Introduction: Congestion in cities and its impact on development of social infrastructure for transport, water and power supply, separation of pedestrian and motorized vehicles and its movements, storage of materials, defence facilities including civil shelters. Parameters influencing location, shape and size; geological aspects; planning and site investigations. Natural caves, archaeological caves and their construction; Scope and application, historical developments, art of tunnelling, tunnel engineering, Tunnels for various purposes like road, rail, hydropower tunnels and caverns, Underground storage for LPG and crude oil, nuclear waste disposal, Metro tunnels, future tunnelling considerations. Planning and design, Assessment of behavior of tunnelling media, deformation modulus and rock pressure assessment; determination of appropriate size and shape; Design of openings in rocks with the help of field data; Instrumentation and monitoring; Numerical modelling to assess the stability.
UNIT-II
Tunnelling Methods: Types and purpose of tunnels; factors affecting choice of excavation techniques; soil and rock sampling and testing, Methods - soft ground tunnelling, hard rock tunnelling, shallow tunnelling, deep tunnelling; Shallow tunnels – cut and cover, cover and cut, pipe jacking, jacked box excavation techniques, methods of muck disposal, supporting, problems encountered and remedial measures.

UNIT-III
Tunnelling by Drilling and Blasting: Unit operations in conventional tunnelling; Drilling - drilling principles, drilling equipment, drilling tools, drill selection, specific drilling, rock drillability factors; Blasting - explosives, initiators, blasting mechanics, blast holes nomenclature; types of cuts - fan, wedge and others; blast design, tunnel blast performance - powder factor,</td></tr>
</table>

	parameters influencing, models for prediction; mucking and transportation equipment selection. **UNIT-IV** **Tunnelling by Road headers, Impact Hammers and Tunnel Boring Machines:** Cutting principles, method of excavation, selection, performance, limitations and problems. Boring principles, method of excavation, selection, performance, limitations and problems; Road headers, Impact Hammers, Tunnel Boring Machines and applications. **UNIT-V** **Tunnel Surveying, Supports and Services:** Surveying in Tunnels: Topographic and geological survey, Methods of surveying and different instruments used for surveying in tunnels, Supports in Tunnels: Principal types of supports, their design and applicability. Steel supports, rock bolts, shotcrete, wire mesh, chain link fabric and fibre reinforced shotcrete and other ground consolidation/grouting techniques. Ground Treatment in Tunnelling: Adverse ground conditions and its effect on tunnelling; introduction to ground control. Supports in Metro tunnels, Tunnel Services and Hazards: Ventilation, drainage and pumping. Explosion, flooding, chimney formation, squeezing ground.
Course Outcomes	**After the completion of course:** • The students will acquire knowledge relating to design of underground tunnels and spaces including their supports. • Distinguish the methods of driving and their comparison machinery used in underground tunneling and spaces.
Text Books	1. Hudson, J.A., Rock Engineering Systems Theory and Practice, Ellis Horwood, England. 2. Clark G.B., (1987), Principles of Rock Fragmentation, john Wiley and Sons, New York.
Reference Books	1. Lohanson, John and Mathiesen, C.F., Modern trends in Tunnelling and Blast Design, AA Balkima, 154 P, 2000. 2. Bickel J.O., Kuesel T.R. and King E.H., Tunnel Engineering Hand Book, Chapmen & Hill Inc., New York and CBS Publishers, New Delhi 2nd addition.

Course Title	**MODERN SURVEYING TECHNIQUES**				
Course Code	**MENMN104C**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	**Mine Surveying- I & II**				
Course Objectives	**This course will enable students to:** • To understand the working of Total Station equipment and solve the surveying problems. • To introduce the concepts of Space Borne, Air Borne and Terrestrial LASER. • Scanners for Topographic Mapping.				
Course Contents	**UNIT-I** **Fundamentals of Total Station and Electromagnetic Waves:** Types and working principles of Machines, Methods of Measuring Distance, Basic Principles of Total Station, Historical Development, Classifications, applications and comparison with conventional surveying. Classification - applications of Electromagnetic waves, Propagation properties, wave propagation at lower and higher frequencies- Refractive index (RI) - factors affecting RI. Care and Maintenance of total stations. Electro-optical system: working principle, Sources of Error, Infrared and Laser Total Station instruments. COGO functions, offsets and stake out-land survey applications. **UNIT-II** **Satellite, GPS System and Data Processing:** Basic concepts of GPS, GNSS, IRNSS and GAGAN - Different segments - space, control and user segments - satellite configuration – GPS signal structure, Anti Spoofing and Selective Availability - GPS receivers. Concepts of rapid, static methods with GPS - semi-Kinematicand pure Kinematic methods -satellite geometry & accuracy measures - applications. **UNIT-III** **Mine and Cadastral Surveying:** Reconnaissance – Route surveys for highways, railways and tunnels –Mine surveying Equipment – Weisbeck triangle – Tunnel alignment and setting out – Transfer of azimuth – Gyro Theodolite – Shafts and audits - Cadastral survey- Legal – Real – Tax cadaster – Land record system – Settlement procedure – deformation studies. Mine plan preparation - mapping process - use of mapping software's, VAVIks mapping. Route surveys of water ways, Hydrographic survey Tides – MSL – Sounding methods – Three-point problem – River surveys – Measurement of current and discharge. **UNIT-IV** **Airborne Laser Scanners:** Airborne Topographic Laser Scanner – Ranging Principle – Pulse Laser and Continuous Wave Laser – First Return and Last				

	Return – Ellipsoidal and Geoidal Height - Typical parameters of a Airborne Laser Scanner (ALS) – Specifications of Commercial ALS –- Components of ALS - GPS, IMU, LASER Scanner, Imaging Device, Hardware and Software. Merits of ALS in comparison to Levelling, echo sounding, GPS levelling, Photogrammetry and Interferometry. **UNIT-V** **Data Acquisition, Pre and Post Processing:** Various Scanning Mechanism – Synchronization of GPS, IMU and ALS Data - Reflectivity of terrain objects – Laser Classification – Class I to Class IV Laser – Eye Safety. Ground Point filtering – Digital Surface Model and Digital Elevation Model. Overview of LIDAR Applications in various domains - 3D models – Corridor Mapping Applications – Forestry Applications. Terrestrial Laser Scanners (TLS) – Working Principle – Commercial TLS Specifications – Applications of TLS, Drone based Mapping - derivatives from drone surveying.
Course Outcomes	**After the completion of course:** • Various techniques available for surveying and mapping along with working principles, functioning and applications of total station and GPS instruments. • Propagation of EMR through atmosphere and corrections for its effects. • Concepts of ALTM and working principle. • Available types of ATLM sensors and components of ALTM system. Process of data acquisition, data processing and possible applications. The fundamentals of terrestrial scanners and their applications.
Text Books	1. Satheesh Gopi, Rasathish kumar, N. Madhu, – Advanced Surveying, Total Station GPS and Remote Sensing – Pearson education, 2007 ISBN: 978-81317 00679 52. 2. Alfred Leick, GPS satellite surveying, John Wiley & Sons Inc., 3rd Edition, 2004.
Reference Books	1. Jie Shan and Charles K. Toth, Topographic Laser Ranging and Scanning – Principles and Processing, CRC Press, Taylor & Francis Group, 2009. 2. Rueger, J.M. Electronic Distance Measurement, Springer-Verlag, Berlin, 1996. 3. Michael Renslow, Manual of Airborne Topographic LiDAR, The American Society for Photogrammetry and Remote Sensing , 2013. 4. R.Subramanian, Surveying and Levelling, Oxford University Press, Second Edition, 2012.

<table>
<tr><td>Course Title</td><td colspan="5">INSTRUMENTATION IN MINING</td></tr>
<tr><td>Course Code</td><td colspan="5">MENMN105A</td></tr>
<tr><td rowspan="2">Course Credits</td><td>L</td><td>T</td><td>P</td><td>TC</td><td></td></tr>
<tr><td>4</td><td>-</td><td>-</td><td>4</td><td></td></tr>
<tr><td>Prerequisites</td><td colspan="5"></td></tr>
<tr><td>Course Objectives</td><td colspan="5">This course will enable students to:
Learn about Electrical instruments.
Learn about Pressure and flow measurements.
Learn about Temperature and Environmental parameters measuring instruments.
Learn about Rock mechanics and ground control instruments.</td></tr>
<tr><td>Course Contents</td><td colspan="5">UNIT-I
Electrical Instruments: Basic Concepts: Sensitivity, range, reproducibility and accuracy, drift, absolute and relative measurements, error, environmental factors and planning for instrumentation. Accuracy, precision, resolution, sensitivity, linearity, span and range -Dynamic characteristics. Ammeters (MI & MC), Volt meters, Watt meters (Dynamic), Energy Meters, Megger, Power Factor meters, Earth resistance measurement. and thermocouples, Inclinometers

UINT II
Pressure Measurements and Flow Measurements: Unit of Pressure – Manometers- Different types, - Elastic type pressure gauges and sensors– Bourdon tube – Bellows – Diaphragm – Elastic elements with LVDT and strain gauge, deformation gauge – Capacitive type pressure gauge – Measurement of vacuum – McLeod gauge – Thermal conductivity gauge – Ionisation gauge. Piezometer, Flow meters – Variable head type flow meter – Orifice plate – Venture tube – Positive displacement flow meter: Nutating disc, Reciprocating piston, oval gear and helix type flow meter – Rotameter – Mass flow meters.

UNIT III
Vibration, Humidity, Velocity and Level Measurements: Mechanical type vibration measuring instruments – Seismic instruments as an accelerometer – Vibrometers – Geo-phones. Humidity – Hot wire electro type hygrometer – Dew cell – Electrolysis type hygrometer. Anemometer, Velometer, Pitot static tube, Sound level meter, microphone, Lux meter; Level measurements: – Float gauges - Displacer type – D/P methods -Bubbler System-Load cell – Electrical types – Conductivity sensors – Capacitive sensors – Nucleonic gauge - Ultrasonic gauge – Boiler drum level measurement: – Differential pressure method and Hydra step method -Solid level measurement.

UNIT IV
Analysers: Dissolved Analyzer: Conductivity meter – pH meter – Dissolved oxygen</td></tr>
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	analyser – Sodium analyser – Silica analyser – Turbidity meter – Gas analyser – O_2, NO_x – H_2S analyser – CO and CO_2 monitor, Dust & Smoke measurement. IR analysers, thermal conductivity analysers, analysis based on ionization of gases. hydrocarbons, nitrogen oxides, sulphur dioxide estimation - Calibration methods. **UNIT V** **Rock Mechanics Instrumentation:** Different types of Load cells, stress capsules, Flat jack, tape extensor meters, convergence indicators and recorders, borehole deformation gauges of different types, depth indicators. Seismic measurements, Applications in Mining**:** Coal mining – bord and pillar development, depillaring and longwall, Metal mining and opencast mining applications, rock slope instrumentation.
Course Outcomes	**After the completion of course:** • Students can able to explain different types of Electrical Instruments. • Design the Mechanical type vibration measuring instruments. • Analyse the defects in pressure measurements and flow measurements.
Text Books	1. De, N.K. and Sen, P.K. 'Electric Drives' Prentice Hall of India Private Ltd, 2002. 2. Subramaniam, V. 'Electric Drives' Tata McGraw Hill, New Delhi,2007
Reference Books	1. Dubey, G.K. 'Fundamentals of Electrical Drives' Narosa, Second Edition. 2. Morrris, A.S. Principles of Measurement and Instrumentation, Print ice-Hall of India Pvt., Ltd. New Delhi, 1999. 3. Doeblin, E.O. Measurement Systems Application & Design, Tata McGraw Hill Publishing Co., New. Delhi, 1999.

Course Title	**INTRODUCTION TO ROBOTICS AND APPLICATION TO MINING**				
Course Code	**MENMN105B**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites					
Course Objectives	**This course will enable students to:** • Learn about design, construction, operation, and use of robots. • To design machines that can help and assist humans. • To help in the acceptance of robots in certain replicative behaviors which are usually performed by people.				
Course Contents	**UNIT-I** **Introduction:** Automation and Robotics, CAD/CAM and Robotics – An over view of Robotics – present and future applications. Components of the Industrial Robotics: common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Design of end effectors, Precision of Movement: Resolution, Accuracy and Repeatability, Speed of Response and Load Carrying Capacity. **UINT II** **Motion Analysis:** Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation – problems. Manipulator Kinematics-H notation-H method of Assignment of frames-H Transformation Matrix, joint coordinates and world coordinates, Forward and inverse kinematics – problems on Industrial Robotic Manipulation. **UNIT III** Differential transformation of manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formations – Problems. Trajectory planning and avoidance of obstacles, path planning, Slew motion, joint interpolated motion – straight line motion. **UNIT IV** **Robot actuators and Feedback components:** Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and Torque sensors. **UNIT V** **Robot Application in Mining:** Mining cycles such as drilling, blasting, loading, transportation in opencast mines; and its application in underground mining					

	methods board and pillar, blasting gallery, continuous miner and long wall, Mine ventilation: mine gas monitoring, ventilation survey and others. Rescue and recovery works.
Course Outcomes	**After the completion of course:** • Design machines that can help and assist humans. • Design robotics develops machines that can substitute for humans and replicate human actions.
Text Books	1. Mikell PG, Mitchel W, Roger NN, Nicholas GO and Ashish D. Industrial Robotics: Technology, Programming and Applications. Pearson Edu. 2. Mittal R K and Nagrath I J. Robotics and Control. Tata McGraw-Hill Education Pvt Ltd. 2003.
Reference Books	1. Richard DK, Thomas AC and Michael N. Robotic Engineering: An Integrated Approach. Prentice Hall. 1989.

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Course Title	**REMOTE SENSING & GEOGRAPHICAL INFORMATION SYSTEM**				
Course Code	**MENMN105C**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	GIS & Remote Sensing in Mining				
Course Objectives	**This course will enable students to:** • To improve knowledge about remote sensing, Hardware's and Software's related to mines. • Understand about Remote Sensing, Raster based GIS, Vector based GIS, Data Capture and Basic Operations of Spatial Analysis.				
Course Contents	**UNIT-I** **Basic principles of Remote Sensing:** Definition and components, Electro Magnetic Radiation; Wavelength regions of electro-magnetic radiation; Types of remote sensing with respect to wavelength regions; Black body radiation; Reflectance; spectral reflectance of land covers. **UINT II** **Sensors and platforms:** Types of sensors: Multispectral, Hyper-spectral, Microwave, scanners-along track and across track; Platform and their types-Geostationary and Polar orbiting, platforms based on altitudes. Satellite missions–MODIS, IRS, LANDSAT, SPOT, marine/ocean observation satellites. **UNIT III** **Digital Image Processing (DIP):** Interpretation of Images; Registration: Transfer of Information from Imagery to Base Map; Classification; Exposure to various Image Processing Techniques and Generation of digitally processed outputs. **UNIT IV** **Geographical Information System (GIS):** Definitions, History and development of GIS, components of GIS, applications of GIS; Coordinate Systems - Geographical Coordinate Systems, Projected Coordinate System, map projections; Geospatial data - Data input-existing GIS data, creating new data; attribute data query, spatial data query, raster data query. **UNIT V** **Applications:** Recent trends in RS&GIS and Environmental assessment & monitoring, Land Use and Land cover classification, Vehicle tracking system, Application of Geo-statistical methods and GIS in mineral prospecting and ore reserve estimation, Applications of GPS in Mineral Resource Surveys, Mapping and Navigation. Role of DGPS surveys in mining leases and identifying illegalities.				

Course Outcomes	**After the completion of course:** • Learners know about, Electromagnetic Radiation, Remote, Sensing Data Product, Spatial Filtering, Band Rationings Image. • Classification GIS-Project Planning, Management and Implementation.
Text Books	1. Anji Redddy M. Remote sensing and geographical information systems. 3rd edition. 2008. 2. Kaplan ED. Understanding GPS: principles and application. British Library Catalogue. 2006
Reference Books	1. Lillesand TM and Kiefer RW. Remote sensing and image interpretation. John Wiley and Sons, New York, 2004. 2. ML and Chouhan TS. Remote sensing and photogrammetry: principles and applications. Vigyan Prakashan, Jodhpur. 1998.

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Course Title	**ROCK MECHANICS LAB**				
Course Code	**MENMN102P**				
Course Credits	**L**	**T**	**P**	**TC**	
	-	**-**	**4**	**2**	
Prerequisites	**Rock Mechanics**				
Course Objectives	**This course will enable students to:** • To study about application of Rock Mechanics, Physico-Mechanical properties of rocks, non-destructive testing methods, time dependent properties of rocks. • Design of different types of underground supports, etc. • To study the theories of failure and approaches used for open pit and underground designs.				
Course Contents	1. Sample collection and Specimen preparation. 2. Determination of moisture content, density, voids ratio and porosity of rocks. 3. Determination of compressive strength, modulus of elasticity and Poisson's ratio of rocks. 4. Determination of tensile strength of rocks. 5. Determination of shear strength, angle of internal friction and cohesion of soil. 6. Determination of point load strength index of rocks. 7. Determination of Protodyknov's strength index of rocks. 8. Determination of slake durability index of rocks. 9. Determination of cohesion and angle of internal friction of rocks using triaxial test. 10. Determination of hydraulic conductivity of sand.				
Course Outcomes	**After the completion of course:** • The students will have detailed knowledge on application of rock mechanics. • Design of different types of underground openings and supports. • Design, stabilization and monitoring of slopes, theories of subsidence and failure of rocks.				
Text Books	1. Obert, L. and Duvall, W.I., Rock Mechanics and Design of Structure in Rock John Wiley and Sons Inc., New York, 1967.				
Reference Books	1. Vutukuri, V.S., and Lama, R.D., Handbook on Mechanical Properties of Rocks, Vol. I, II, III and IV, Transtech Publication, Berlin, 1974/78				

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Course Title	**MINE PLANNING AND DESIGN LAB**				
Course Code	**MENMN103P**				
Course Credits	**L**	**T**	**P**	**TC**	
	-	**-**	**4**	**2**	
Prerequisites	**Mine Planning**				
Course Objectives	**This course will enable students to:** • To introduce the various techniques for mine planning. • To appreciate the modern trends in opencast mines, safety and environment.				
Course Contents	1. Estimation of reserves of coal and metalliferous deposits. 2. Design of the haul roadway of open pit mines. 3. Design of the surface mine. 4. Design of underground coal mine. 5. Design of mine ventilation system for board and pillar method. 6. Design of mine ventilation system for long wall panel. 7. Design of blast for open pit workings. 8. Design of blast for cast blasting technique.				
Course Outcomes	**After the completion of course:** • The students will have insight about the advanced techniques for mine planning. • Geotechnical investigation and equipment management. • Understand the modern trends in opencast mines safety and environment.				
Text Books	1. Jayanth Bhattacharya, Principles of Mine Planning-Allied Publishers, Delhi 2003. 2. Hustrulid, W. and Kuchta, M., (eds)., Fundamentals of Open pit Mine Planning and Design, Elsevier, 1995.				
Reference Books	1. Ehrenburger, V and Fajkos, A., Mining Modelling, Elsevier, 1995. 2. Bawden, W.F., and Archibald., J.F., Innovative Mine Design for the 21st Century Elsevier,1993.				