POSTGRADUATE INSTITUTE OF SCIENCE
UNIVERSITY OF PERADENIYA

M.Sc. Programme in Gemmology/Industrial Minerals (Course work – SLQF Level 9)

M.Sc. Programme in Gemmology/Industrial Minerals (Course work and Research – SLQF Level 10)

1. INTRODUCTION

Sri Lanka has produced some of the most valued gemstones and possesses some of the best quality mineral deposits known to the mankind. Although the gem and mineral based industries are established in Sri Lanka, considerable proportion of this mineral wealth is exported at very low prices without adequate processing and value addition. Due to self-insufficiency or inadequate technology to exploit and process its own mineral resources, some of the mineral-based industries in Sri Lanka have to import certain raw materials at extremely high costs. In this regard, creation of opportunities for postgraduate training and research in the fields of gemmology and industrial minerals has been a long-felt need.

Having recognised this need, an M.Sc Programme in Gemmology was on offer since 1997/1998. Although two batches of students opted for this course, due to extremely limited number of graduates embarking on a gemmology-related field, this offer is currently not adequately made use of. On the contrary, the number of science graduates entering other mineral-based industries is rising, but presently they lack opportunities for training and research in the field of industrial minerals. Therefore, the present M.Sc. Programmes have been designed to cater to these fluctuating demands for postgraduate training and research in the fields of Gemmology and Industrial Minerals.

This M.Sc. programme will thus prepare the candidate to take the challenge of meeting not only national needs in diverse areas, but also to continue toward a higher degree anywhere in the world.

2. OBJECTIVES OF THE PROGRAMME

- To train personnel in the fields of gemology and industrial minerals and on related aspects at postgraduate level.
- To provide an opportunity to (i) improve the skills in mineral exploration with emphasis on gem minerals, gemmology and management of gem and jewellery industry **or** (ii) exploit and process industrial minerals to use as industrial raw materials.
- To provide necessary background knowledge for research in gemmology/industrial minerals.

3. PROGRAMME ELIGIBILITY

The minimum requirement for either of the M.Sc. Programmes is a B.Sc. General or Special Degree in Science or B.Sc. in Engineering/Agriculture from a recognized university or any other equivalent

qualification/s acceptable to the Postgraduate Institute of Science (PGIS), University of Peradeniya. A limited number of students could be accommodated in both programmes each year. Candidates who meet the eligibility requirement will be required to sit an aptitude test and/or a subject related examination. The successful candidates will be called for an interview and the selected candidates will be admitted to their desired programme.

4. PROGRAMME FEE

Category	Programme Fee	
	M.Sc. by Course work	M.Sc. by Research
Local candidates	Rs 150,000/-	Rs 180,000/-
Foreign candidates	Rs 300,000/-	Rs 360,000/-

Students registered for the M.Sc. degree by course work shall pay the Programme fee in full or in two *(1/2 at the registration and the balance at the end of the first semester)* or three *(1/3rd at the registration, another 1/3rd after 4 months from the date of registration and the balance after 8 months from the date of registration)* instalments. An additional payment of Rs. 30,000/- should be made at the end of the first year to continue for the M.Sc. degree by research. Other payments including registration fee, medical fee, library subscription, examination fee and deposits (science and library) should be paid according to the procedure stipulated by the PGIS. (N.B. The Programme fees given above may be revised from time to time.)

5. THE PROGRAMME STRUCTURE AND DURATION

This programme consists of three options for completion.

5.1 Masters Degree with Course Work

The M.Sc. degree (Course work) can be obtained by completing course work only (without conducting any research project).

Course work, comprising of theory courses, and laboratory and/or fieldwork, shall be conducted over a period of two semesters of 15 weeks each. The total duration of the degree, including examinations, shall be about 12 months. Satisfactory completion of a minimum of 30 credits of course work with a GPA of not less than 3.00 is required for the successful completion of the degree (Students who do not satisfy the above criteria but obtain a GPA in the range 2.75 to 2.99 for course work of 25 credits is eligible for the Postgraduate Diploma in Gemmology/Industrial Minerals, and those who obtain a GPA in the range 2.75 to 2.99 for course work of 20 credits is eligible for Postgraduate Certificate).

5.2 Masters Degree

In addition to Masters Degree with course work (5.1), the Masters Degree (Research) requires a research project. The duration of the entire programme will be 24 months inclusive of 5.1. Completion of all the requirements of 5.1 with a GPA of not less than 3.00 is a prerequisite for the Masters Degree (Research). The research project for this degree should be conducted on full-time basis, and completed during the second year. The research component is allocated 30 credits, totalling 60 credits for the entire programme. After successful completion of the research project, the student shall be eligible for the award of the M.Sc. Degree in Gemmology/Industrial Minerals (Students who do not complete the research project within the stipulated time period shall be awarded the M.Sc. Degree in course work in Gemmology/Industrial Minerals).

5.3 Extension of the programme for M.Phil. or Ph.D.

After completion of six months of research in the M.Sc. degree (research) programme, students who have demonstrated exceptional progress may apply for upgrading the degree status to M.Phil. The student should continue the research project and any additional research work/assignments recommended by the PGIS for a total of two years (60 credits of research) to qualify for the award of the M.Phil. degree.

During the second year of research, students who have demonstrated exceptional and continuous progress, may apply for upgrading the degree status from M.Phil. to Ph.D. The student should continue the research project and any additional research work/assignments recommended by the PGIS for another year on full-time basis (additional 30 credits) to qualify for the award of the Ph.D. degree.

M.Sc. Programme in Gemmology/Industrial Minerals
(Course work – SLQF Level 9)/(Course work and Research – SLQF Level 10)

Programme Summary

Course Code	Course	Lect. hrs.	Practical hrs.	No. of Credits
	Semester I			
Common Courses for M.Sc. Programme in Gemmology/Industrial Minerals				
ETS 501	Basic Geology and Geology of Sri Lanka	30	30	3
ETS 502	Mineral and Crystal Chemistry & Elementary Crystallography	15	-	1
ETS 503	Crystallography[1]	15	30	2
ETS 504	Geochemistry of the Elements & Geochemistry and Geophysics in Mineral Exploration	30	D	2
ETS 505	Introductory Structural Geology[2]	15	F	1
ETS 506	Exploration and Mining Methods	15	-	1
ETS 507	Environmental Engineering	15	-	1
ETS 508	Data Analysis in Geology*	15	-	1
ETS 509	Photogeology, Remote Sensing and Geographical Information Systems*	15	30	2
	Semester II			
	Special Courses for M.Sc. Programme in Gemmology			
ETS 510	Fundamentals of Gemmology	30	-	2
ETS 511	Descriptive Gemmology I	15		1
ETS 512	Descriptive Gemmology II	15	-	1
ETS 513	Management of Gem Industries and National and International Gem Trade	15	-	1
ETS 514	Colour Enhancement and Value Addition	15	-	1
ETS 515	Fashioning and Evaluation of Gemstones	15		1
ETS 516	Advanced Gemmology	15	-	1
ETS 517	Gems and Gem Resources of Sri Lanka	15	F	1
ETS 518	Optical Mineralogy	15	30	2
ETS 519	Gems in museums and personal collections	15	-	1
ETS 520	Special Topics in Gemmology	30	D	2
	Special Courses for M.Sc. Programme in Industrial Minerals			
ETS 524	Industrial Minerals and Constructional Materials	15	-	1
ETS 525	Mineral-based Industries of Sri Lanka (1 credit)	15	-	1
ETS 526	Industrial Minerals Field Course		F	1
ETS 527	Instrumental Analysis	30	-	2
ETS 528	Valuation of Mineral Deposits and Economics of Mining	15	-	1
ETS 529	Minerals and Bulk Materials Handling in Industry	15	-	1
ETS 530	Minerals Processing & Process Technology	30	F	2
ETS 531	Problems relevant to Processing and Use of Industrial Minerals	15		1
ETS 532	Computer applications in mineral processing	15	D	1
ETS 533	Metallurgy	30	-	2
ETS 534	Thermodynamics of Mineral Formation and Mineral Processing*	15	-	1
ETS 535	Surface-chemical processing*	15	-	1
ETS 536	Solid/Liquid separation and fine particle processing*	15	-	1
Common Courses for M.Sc. Programme in Gemmology/Industrial Minerals				
ETS 597	Seminar	-	-	1
ETS 598	Field and Industrial Training	-	F	1
ETS 599	Independent Study	500 notional hrs.		5
ETS 699	Research Project **	3000 notional hrs. (one year)		30

Optional courses* * Compulsory for M.Sc. (Research)*

F - Field excursion, D - Demonstration

[1] *Compulsory for Gemmology and Optional for Industrial Minerals.*

[2] *Compulsory for Industrial Minerals and Optional for Gemmology.*

6. PROGRAMME CONTENTS FOR ETS 599 AND ETS 699

Course code	ETS 599
Course title	Independent Study
Credits	05
Compulsory/optional	Compulsory
Prerequisites	--
Time allocation	500 notional hrs.
Aims	Aims: The overall aim is to familiarize the student with concepts and methods involved in scientific research **Specific aims:** 1. To explain the scientific process in the conduct of research. 2. To develop skills to write a review paper and a scientific research proposal. 3. To develop skills to make a presentation. 4. To master the application of statistical methods on quantitative scientific data.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to, 1. Explain the scientific method. 2. Conduct an independent review of literature on a selected topic in the area of Gemmology/Industrial Minerals. 3. Write a formal scientific report conforming to the guidelines provided. 4. Transfer the knowledge gained through (2) and (3) above in the form of a presentation. 5. Complete a research proposal conforming to the guidelines provided. 6. Perform statistical analysis of quantitative data.
Time allocation	300 h of self study
Content	*Review paper*: Review of literature; Development of the review paper in concise and professional manner and logical presentation of results that have been reported, writing the abstract, compilation of the list of references. *Proposal writing*: Interpretation and critical evaluation of results of published research; Formulation of a research problem: Concise literature review, justification, time frame, identification of resources, budgeting, etc. *Project*: Collection and statistical analysis of data on a topic associated with the review paper. *Seminar*: Presentation of literature and data collected on a given topic; Preparation of an abstract, preparation of slides.

Assessment criteria: Continuous Assessment

Component	% marks
Review paper	20
Proposal writing	10
Project	40
Seminar	30

Recommended Texts:

1. Backwell, J., Martin, J. (2011) A Scientific Approach to Scientific Writing, Springer.
2. Postgraduate Institute of Science (2016) Guidelines for Writing M.Sc. Project Report/M.Phil. Thesis/Ph.D. Thesis
3. Priyantha, N (2015) Measurements and Errors in Chemical Analysis, Science Education Unit, University of Peradeniya.

Course code	ETS 699
Course title	Research Project
Credits	30
Compulsory/optional	Compulsory
Prerequisites	CH 599; GPA of 3.00 at SLQF Exit Level 9
Time allocation	3000 notional hrs. (one year)
Aims	Aims: The overall aim is to prepare the student to conduct a research independently. **Specific aims:** 1. To train students to apply scientific method in scientific research. 2. To train students to generate researchable hypotheses. 3. To train students to plan, design and conduct scientific research. 4. To gather reliable scientific data, analyse, and interpret. 5. To develop skills in scientific writing.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to, 1. Apply the scientific method. 2. Design a research project. 3. Complete a research project. 4. Describe ethical issues in scientific research 5. Explain the patenting process in research 6. Make presentations at national/international conferences. 7. Produce a thesis conforming to the requirements of the PGIS. 8. Write manuscripts for publication in refereed journals.
Content	The students will conduct sufficient amount of laboratory/field work on a chosen research topic under the guidance provided by an assigned supervisor/s, make a presentation of research findings at a national/international conference, and produce a thesis.

Assessment criteria

Continuous assessment	End-semester examination
30%	Oral examination (20%) Thesis (40%) Conference presentation (10%)

Recommended Texts:

1. Backwell, J., Martin, J. (2011) A Scientific Approach to Scientific Writing, Springer.
2. Postgraduate Institute of Science (2016) Guidelines for Writing M.Sc. Project Report/M.Phil. Thesis/Ph.D. Thesis
3. Priyantha, N (2015) Measurements and Errors in Chemical Analysis, Science Education Unit, University of Peradeniya.

Contents of other courses

Common Courses in Geology

ETS 501: Basic Geology and Geology of Sri Lanka (3 credits)

Introduction to Geology. The earth. Structure of the Earth. Processes shaping the earth; the agents (rivers, oceans, glaciers and wind), their actions (weathering, soil formation, erosion, transportation, mass movements and deposition) and the landforms. Study of Earth's internal processes: earthquakes, volcanism, plutonism, deformation, orogenesis and metamorphism. Plate Tectonics. Geological Time Scale.

Earth Materials: the formation, characteristics and classification of minerals and rocks. The physical and chemical properties of minerals, and the important rock-forming and economic mineral groups. Igneous, sedimentary and metamorphic rocks and their relationship to mineral deposits. Maps; topographical and geological maps and aerial photographs. Introduction to the geology of Sri Lanka. Laboratory exercises focus on the field identification of minerals and rocks.

ETS 502: Mineral and Crystal Chemistry and Elementary Crystallography (1 credit)

Fundamentals of crystal chemistry and factors controlling the chemistry of minerals. Physical and chemical impurities in minerals. Calculations of structural formulae and end-member compositions from chemical analyses, estimates of ferric-ferrous iron ratios, distribution coefficients. Solid solution and exsolution in minerals, mineral chemistry of common gem and industrial minerals. Structure of minerals, their symmetry and elementary crystallography

ETS 503: Crystallography (2 credits)

Crystals, crystal forms, habits and Miller Indices, crystal symmetry, Crystal systems and symmetry classes, space lattices, space groups. Twin crystals

ETS 504: Geochemistry of the Elements and Geochemistry and Geophysics in Mineral Exploration (2 credits)

Chemical elements, their stable and radioactive isotopes. Their abundance and processes which govern their distribution in geological materials. Geochemistry of chemical elements in gems and industrial minerals. Geochemical exploration techniques. Lithogeochemical, paedo-geochemical and hydro-geochemical techniques: volatile and airborne surveys, surveys in contaminated terrains, isotope methods. An introduction to the use of geophysics to find gem-bearing sediments and deep-seated ore deposits emphasizing gravitational, magnetic, electromagnetic, seismic, induced potential, and other relevant methods.

ETS 505: Introductory Structural Geology (1 credit)

Geological structures in rocks: folds, faults, joints, foliations, lineations etc their identification and classification. Structural geological maps and cross-sections and their construction. Geological structures and field distribution of ore bodies. Some case studies of examples of (a) structural geologically controlled mineralizations. (b) Structural geological problems of mining.

ETS 506: Exploration and Mining Methods (1 credit)

General overview of mining methods, Legal aspects of mining. Preliminary, exploratory drilling and providing up of ore bodies types. Selection of mining techniques to suit ore-body size, shape and rock strength. Mining equipment and factors affecting choice of methods. Surface mining methods, alluvial and bedded deposits, vein deposits and massive deposits. Underground mining methods and equipment. Mining methods practiced in Sri Lanka.

ETS 507: Environmental Engineering (1 credit)

Environmental Impacts of Mining Operations: mine wastes and their potential impacts on the surrounding environment; waste rock and refuse dumps, the monitoring of mine wastes; rehabilitation and reclamation of mined out and waste dump areas.
Environmental Impacts of Mineral Processing Operations: pollution aspects of mineral and metal extraction, including the effects on biological systems, noise and dust; heavy metals and other toxic pollutants in liquid effluents and tailings from minerals operations; methods for the disposal of tailings and the rehabilitation of tailings impoundments.

ETS 508: Data Analysis in Geology (1 credit)
Planning of data collection for an experiment, geoscientific methods, sampling, the nature of data (precision, accuracy, distribution etc.), data analysis, statistical tests, geological modelling with computers and computer simulation.

ETS 509: Photogeology, Remote Sensing and Geographical Information Systems (2 credits)
Aerial photogrammetry, topographic measurements, orographic measurements, geological measurements, remote sensing with satellite images and other remotely collected terrain data, Terrain analysis. Introduction to fundamentals of spatial data management and GIS technology as applied to the mapping, display, and analysis of mining data, Computer usage and applications.

Special Courses in Gemmology

ETS 510: Fundamentals of Gemmology (2 credits)

Gems; basic properties, hardness scale, Nature of light, laws of reflection and refraction, refractive indices, refractometers. Polarised light, uses of polariscope. Pleochroism, Dichroscope, Electrical, magnetic and thermal properties of minerals. Specific gravity and methods of determinations.
Colour and causes of colour in gemstones. Gemmological instrument, hand lens, microscope, gemmological microscope, polarising microscope, special optical properties, chatoyancy, asterism, luminescence play of colours, labradorescence. Inclusions and study of inclusions. Emission and absorption spectroscopy and spectroscopes.

ETS 511: Descriptive Gemmology I (1 credit)

Classification of gemstones, systematic description of crystallography, physical properties, optical properties, absorption spectra, chemical properties, special gemmological features, diagostic features and occurrences of common and less common gemstones.

ETS 512: Descriptive Gemmology II (1 credit)

Synthetic gemstones, history of synthesis, methods of manufacture, methods of differentiation between natural and synthetic stones. Imitation gemstones, glass and plastic imitations; organic materials. Pearls, corals, ivory and shells and amber and others

ETS 513: Management of Gem Industries and National and International Gem Trade (1 credit)
Basic management principles, management of gem industries, practice, procedures and legal aspects of local, national and international gem trade.

ETS 514: Colour Enhancement and Value Addition (1 credit)

Treatable gems and their identifications. Outline of gem enhancement methods; development of doublets, triplets and foil backs and their detections; dyeing and irradiation; heat treatment - principles and practice, types of furnaces; diffusion and other types of enhancement: recent advances in enhancement and value addition.

ETS 515: Fashioning and Evaluation of Gemstones (1 credit)

Outline of methods used for gem cutting, styles of gem cutting and polishing, units of measurement. Principles, philosophy and economics of evaluation. Principles involved in grading of diamonds, colour grading of gemstones

ETS 516: Advanced Gemmology (1 credit)

Introduction to quantative and qualitative analytical techniques; chemical methods, atomic absorption spectroscopy. X-ray Florescence, Florescence Emission Spectroscopy, Electron Microscopy, Mossbauer Spectroscopy, Electron Probe Micro Analysis. Current research in gemmology and new instruments and techniques.

ETS 517: Gems and Gem Resources of Sri Lanka (1 credit)

Historical background; gems of Sri Lanka, mode of occurrence, distributions and origin of gems, gem industries and socio-economic aspects of gem industries in Sri Lanka.

ETS 518: Optical Mineralogy (2 credits)

Principles of optical mineralogy and systematic study of optical properties of important minerals and their identification using polarising microscopes. Study of interference figures.

ETS 519: Gems in Museums and Personal Collections (1 credit)

Gem Bureau, Ratanapura, Nilani Gems, Ratnapura, Bhadra Marapone's Museum, Ratnapura, Gem and Jewelary Authority Collection. British Crown Jewels Collection (Tower of London). Smithsonian Institution Collection

ETS 520: Special Topics (2 credits)

New techniques in gem identification. Recent technological advances in fashioning. New Treatment Methods, Modern Synthetic Stones, e-Marketing of gems on Internet.

ETS 597: Seminar (1 credit)

Students have to give seminar/s on various aspects of gemmology based on a literature survey

ETS 598: Field and Industrial Training (1 credit)

Field experiences in gem deposit location, mining, panning and identification of gems. Familiarization of heat treatment techniques. Duration of this course is two to four weeks and at the end of the course each student have to submit a report for evaluation.

ETS 599: Research Project (6 credits)

Candidates proceeding to the M.Sc. Programme will undertake a research project on a topic agreed upon by the programme coordinator. The candidates will be given the option of selecting a research problem in a preferred area that falls within the disciplines of courses undertaken. The project will be carried out under the guidance of a supervisor/s. The project will be undertaken on a full time basis with a minimum period of four months. The project could be conducted at the Department of Geology, or Chemistry or at his/her working place, if facilities are available. However, in the latter case the work has to be supervised by an external supervisor at the work place, in addition to the supervisor attached to the University of Peradeniya. At the end of the research project the candidates are required to present their results in the form of a dissertation and a seminar. A candidate should obtain a pass on the research project for the award of M.Sc degree.

Special Courses in Industrial Minerals

ETS 524: Industrial Minerals and Constructional Materials (1 credit)

The geology, origin, occurrence, and classification of the chief categories and deposits of commercial, non-metallic minerals and rocks. The requirements of industry as regards the physical and chemical properties of industrial minerals and rocks, and their uses; Geologic and physicochemical factors affecting the stability of industrial minerals and construction materials under conditions of natural weathering and exposure to salts and other pollutants. Economics of industrial rocks and minerals; some mineral processing techniques and potential uses of mineral processing by products.

ETS 525: Mineral-based Industries of Sri Lanka (1 credit)

Industrial minerals and constructional materials of Sri Lanka. Existing industries: Cement, ceramic, lime and tiles inustries. Potential industries: Production of fertilizer from apatite, production of lime, magnesium oxide, processing of mineral sands.

ETS 526: Industrial Minerals Field Course (1 credit)

Excursion/s to or a field camp/s in open-pit and underground mines of Sri Lanka in order to: (a) examine different bodies of mineralisation, their modes of occurrence and relationship to the host rocks, and geological controls of mineralisation, (b) identify the different methods of mining, and problems associated with mining operations and how to overcome the problmes or suggest improvements. The objective of the Field course is to improve the quality of geological observations and the use of field data in geological interpretation and planing mining methodology and operations.

ETS 527: Instrumental Analysis (2 credits)

Introductory Analytical Chemistry. General principles of Analytical Chemistry; Errors and handling small data sets; Sensitivity and detection limits; Sample Preparation Techniques.
Analytical Methods. Titrations; Electrochemical Methods; Chromatographic Methods; X-Ray Analytical Methods: X-Ray powder Diffraction (XRD) and X-Ray Fluorescence (XRF); Absorption Spectroscopy Methods: Atomic Absorption Spectroscopy; UV-Visible absorption spectroscopy of molecules; and Infra-Red absorption spectroscopy
Practicals: Experiments involving instrumental methods will includes Atomic Absorption Spectrophotometry (AAS); UV and Visible Spectrophotometry; Infra-Red spectrophotometry; Electrochemical techniques including pH, ion-selective electrodes, and Electrogravimetry; Fire assaying**.**

ETS 528: Valuation of Mineral Deposits and Economics of Mining (1 credit)

Mineral reserve calculation methods; supply and demand factors and their projection; capitalization, discounting and amortization of mineral deposits; marketing including cartels, taxation, legislation and national interest. The feasibility study and prediction of project costs. Evaluation of capital costs for mine and processing plant. Evaluation of operating costs for mining and processing plant. Overall valuation of project worth by various criteria, such as present value, discounted cash flow, internal rate of return, break even point. Sensitivity analysis. Sources of finance.

ETS 529: Minerals and Bulk Materials Handling in Industry (1 credit)

Bulk material handling: various types of conveyors, feeders including reclamation equipment, storage equipment and design for coarse and fine materials/ores (dry or wet); slurry transport (by pumps, gravity etc.) and storage.
Production of some industrial mineral based products e.g. lime, cement and clays.

ETS 530: Mineral Processing Process Technology (2 credits)

The necessity for minerals beneficiation; mineralogical assessment; comminution - fracture, liberation, size-criteria, energy-size relationships; crushing, grinding and attrition; screening and classification, cyclones; concentration processes - density, electrical, magnetic and other physical methods. Interfacial phenomena, surfactants, flotation; liquid-solid separation - flocculation, thickening, agglomeration, filtration; cyanidation, amalgamation, leaching; drying. This topic is complemented by practical demonstrations of equipment design and operation at a Minerals Engineering Pilot Plant.

Material Balances in process flows: Component and total mass balances of reactive and non reactive systems including recycling. Batch and steady state flows.
Fluid Mechanics: Basic fluid properties, Hydrostatics, stability of floating bodies, viscosity, shear stresses and friction in fluid flow, friction factor and pressure drop relationships in pipe and open channel flows. Velocity and shear stress distributions in laminar and turbulent flow.

ETS 531: Problems relevant to Processing and Use of Industrial Minerals (1 credit)
The course will focus on current problems (a) in mineral processing, (b) hindering better industrial utilization of minerals, and (c) on technological improvements envisaged for potential industrial minerals.

ETS 532: Computer Applications in Mineral Processing (1 credit)

Review of the basic concepts of computer hardware and software used in mineral industry, and their functions. A short course on Expert Systems in the Mineral Industry will be given covering topics such as Artificial Intelligence; Knowledge-based Systems; The Nature of Expert Systems; Expert System Tools; Examples of Expert Systems; and the Applications of Expert Systems in the Mineral Industry.

ETS 533: Metallurgy (1 credit)
Hydrometallurgical processes relating to the production of metals and compounds. Leaching processes and methods. Solution concentration and purification: Practicals to cover leaching methods and kinetic models, solvent extraction, use of ion exchangers and activated carbon for solution concentration and purification.
Metal recovery processes: Cementation, gaseous reduction, compound precipitation, electrowinning. Hydrometallurgical refining of metals. Application of these processes to Cu, Au, Ag, Ni, Al and U. Industrial extraction of metals (with flowsheets) including the extraction of Cu, Au, Ag and Ni and Al from their ores. Operations in extractive metallurgy utilising heat as the prime mover to accomplish chemical and structural changes, as in drying, calcination, roasting, sintering, smelting and converting, oxidation-reduction; Practices and equipment (furnace types) and their advantages and disadvantages.
Introductory pyrometallurgy related to extraction and refining processes used for recovery of gold, silver, copper and nickel. Fire refining: principles of fire refining of metals. Practicals may cover gold, silver and copper smelting and refining.

ETS 534: Thermodynamics of Mineral Formation and Mineral Processing (1 credit)
Thermodynamics of minerals and mineral reactions. Equilibrium and Eh-pH diagrams for minerals. Thermochemistry and thermodynamics review: enthalpy, combustion and heat balances; free energy and predominance diagrams for oxidation, reduction, sulphation (chlorination) processes at high temperatures. Thermodynamics of roasting reactions of sulphides, sulphates and oxides. Predominance diagram representation and kinetics of roasting. Physics and chemistry of melts and slags. Phase diagrams: simple, complex and their use in prediction of slag characteristics. Reactions between phases and detailed calculations of melts and slag composition e.g. for Ok Tedi concentrate. Solution chemistry: liquid-liquid and solid-liquid interactions, speciation; activity-concentration relationship;

ETS 535: Surface-Chemical Processing (1 credit)

Concentration of Minerals by Flotation. Surface chemical properties of minerals; Fundamentals of flotation; Flotation reagents, chemistry of flotation; Flotation Machines (including flotation columns); Flotation circuit design and industrial practice; Research Techniques Applied to Flotation; Industrial Practice and Flotation Process Control.Flotation of sulphide and non-sulphide metalliferous minerals; Coal flotation;
Coagulation, Flocculation and Dispersion. Principles of Coagulation, Flocculation and Dispersion; Colloids, Colloid Chemistry, and the Stability of Colloidal Dispersions; Industrial Applications of Coagulation and Flocculation.
Selective Flocculation in Mineral Extraction*:* The Surface Chemistry of Minerals; Properties of fine mineral particles; Colloids and their properties; Surface Phenomena in Coagulation and Flocculation; Inorganic coagulants; Polymeric Flocculants; Separation of minerals by Selective Flocculation processes.

ETS 536: Solid/Liquid Separation and Fine Particle Processing (1 credit)

Dewatering in mineral processing: principles, techniques and equipment covering screening, thickening, filtering and drying. Agglomeration - balling; briquetting and sintering. Small scale beneficiation techniques e.g. for gold and heavy mineral sands.

ETS 597: Seminar (1 credit)

Students will have to give seminar/s on various aspects of exploration, mining, processing, and utilisation of industrial minerals based on literature survey.

ETS 598: Field and Industrial Training (1 credit)

Industrial Training at a mineral processing plant in all aspects of mining and mineral processing, equipment, products, supervision and management of plant operation and process control. Waste disposal and managing the environment.

ETS 599: Research Project (6 credits)

Students are to take research projects in Mineral Processing or extractive metallurgy. The projects enable students to experience research procedure, handle data and draw together relevant information from various parts of their course work.
Students select topics, normally relevant to PNG and carry out the work under staff supervisors who guide them throughout the duration of the projects.

7. PROGRAMME EVALUATION

Evaluation of Course work

Based on the scheme given below, the overall performance of a student in a given course shall be evaluated by the respective instructor(s) and a grade shall be assigned.

Evaluation Scheme

- For all courses a minimum of 80% attendance is expected.
- The evaluation of each course (except independent study and research project) shall be based on within course and end of course examinations, and assignments. The weightage of marks given below can generally be used as a guideline in the computation of the final grade, except for Independent Study and Research Project.

End of course examination	50 - 60%
Continuous assessments (mid-semester examination, assignments, etc.)	40 - 50%

- Courses with laboratory and/or fieldwork shall be evaluated, where applicable, on a continuous assessment basis.
- The minimum grade a student should achieve to pass a course is C.
- Students will be informed of the evaluation scheme by the instructor at the beginning of a given course.

Grade Points and Grade Point Average (GPA)

The Grade Point Average (GPA) will be computed using the grades earned for core courses and optional courses, taken for credit. Preliminary courses, industrial training, research project and seminar will be evaluated on a pass/fail basis.

On completion of the end of course examination, the instructor(s) is/are required to hand over the grades of a given course to the programme coordinator who will assign the Grade Points using the following table:

Grade	Grade Point
A+	4.0
A	4.0

A^-	3.7
B^+	3.3
B	3.0
B^-	2.7
C^+	2.3
C	2.0
F	0.0

The Grade Point Average (GPA) will be computed using the formula:

$$GPA = \frac{\Sigma c_i g_i}{\Sigma c_i},$$

where c_i = number of credit units for the i^{th} course, and
g_i = grade point for the i^{th} course

Make-up Examinations
'Make-up' examinations may be given only to students who fail to sit a particular examination due to medical or other valid reasons acceptable to the PGIS.

Repeat Courses
If a student fails a course or wishes to improve his/her previous grade in a course, he/she shall repeat the course and course examinations at the next available opportunity. However, he/she may be exempted from repeating the course, and repeat only the course examinations if recommended by the teacher-in-charge or M.Sc. Programme Coordinator. The student may repeat the same course or a substituted (new) optional course in place of the original course. A student is allowed to repeat five credits of coursework free-of-charge. The maximum number of credits a candidate is allowed to repeat is fifteen. The maximum grade, a candidate could obtain at a repeat attempt is a B and he/she is allowed to repeat a given course only on two subsequent occasions.

Evaluation of Research Project
Research project will be evaluated on the basis of a written report (M.Sc. project report) and oral presentation (see Section 6.0 of the PGIS Handbook for the format of the project report).

8. PANEL OF TEACHERS

	Category	Name, qualifications and affiliation and expertise
1.	Lecturer	Prof. P.G.R. Dharmaratne, PhD, FGA, D GemG, MGA Department of Earth Resources Engineering , University of Moratuwa *Field of Specialization: Gemmology*
2.	Lecturer/Outside Expert	Mr Senerath Basnayake , MSc, FGA, MGA, Gemologist, 5 & 6, 2nd Floor, Nabeesha Shopping Complex, 135, Kotugodella Vidiya, Kandy. *Field of Specialization: Gemmology*
3.	Lecturer /Outside Expert	Mr Gamini Zoyza , MSc, PGDiploma, FGA, D GemG, MGA Gemologist, No.04, Gothami Mawatha, Mount Lavinia. (Tel: 011-2726796). *Field of Specialization: Gemmology*
4.	Lecturer/Outside Expert	Mr Ajith Siriwardana, MSc, FGA,IGI,MGA Dip Marketing Gemologist/Appraiser, 92 B 1, Thempola, Raddolugama *Field of Specialization: Gemmology*
5.	Lecturer/Outside Expert	Mr P R K Fernando, MSc, PGDiploma, A I Chem C, MGA Gemologist, No:21/46 A, Singha Road, Kerangapokuna, Wattala *Field of Specialization: Gemmology*
6.	Lecturer/Outside Expert	Mr S M S Abeyweera, MSc, MGA Gemologist, No 14 A Club Road, Kegalle. *Field of Specialization: Gemmology*

7.	Outside Expert	Mr. Dayananda Dillimuni, D Gem G, FGA, MGA Consultant Gemologist, ADSL 46B2, Dias Building, Galle Road, Colombo 03. (Tel: 0774720193) *Field of Specialization: Gemmology*
8.	Lecturer	Prof. R.L.R. Chandrajith, PhD Dept of Geology, University of Peradeniya *Field of Specialization: Geology/Geochemistry*
9.	Lecturer	Dr. C.S. Kalpage, PhD Department of Chemical and Process Engineering, University of Peradeniya. *Field of Specialization: Environmental Engineering*
10.	Lecturer	Prof. C.B. Dissanayake, D.Sc Director, Institute of Fundamental Studies, Kandy *Field of Specialization: Geology*
11.	Lecturer	Dr. H.A. Dharmagunawardhane, PhD Department of Geology, University of Peradenya *Field of Specialization: Geology*
12.	Lecturer	Dr. M.A.S.P.K. Malaviarachchi, PhD Department of Geology, University of Peradeniya *Field of Specialization: Geology*
13.	Lecturer	Mr. U. Amarasinghe, MSc, Department of Geology, University of Peradeniya *Field of Specialization: Geology*
14.	Lecturer	Prof. K. Dahanayake, PhD, Dept of Geology, University of Peradeniya. *Field of Specialization: Geology*
15.	Lecturer	Dr. N.D. Subasinghe, PhD, Institute of Fundamental Studies, Kandy. *Field of Specialization: Geology/Geophysics*
16.	Lecturer	Dr. N.W.B. Balasooriya, PhD Faculty of Applied Sciences, South Eastern University, Samanthurai. *Field of Specialization: Geology*
17.	Lecturer	Mr. A.Wickremasooriya, M.Phil, Department of Geography, University of Peradeniya *Field of Specialization: Geology*
18.	Lecturer	Dr. T. Hewawasam, PhD, Department of Geography, University of Peradeniya *Field of Specialization: Geology*
19.	Lecturer	Dr. R. Fernando, PhD Department of Physics, Open University of Sri Lanka, Nugegoda *Field of Specialization: Geology*
20.	Lecturer	Dr. A.A.J.K. Gunatilake, PhD, Dept of Geology, University of Peradeniya *Field of Specialization: Geology*
21.	Lecturer	Dr. S.W. Nawaratne, PhD, Department of Geology, University of Peradeniya *Field of Specialization: Geology/Gemmology*
22.	Lecturer	Mr. L.R.K. Perera, M.Phil Department of Geology, University of Peradeniya *Field of Specialization: Geology*
23.	Lecturer	Dr. H.M.T.G.A. Pitawala, PhD Department of Geology, University of Peradeniya *Field of Specialization: Geology*
24.	Lecturer	Dr. L.V. Ranaweera, PhD Dept. of Natural Resources, Faculty of App. Sc, Sabaragamuwa Univ., Belihuloya. *Field of Specialization: Geology*

25.	Lecturer	Dr. S. Jinadasa, PhD Department of Civil Engineering, Faculty of Engineering, University of Peradeniya. *Field of Specialization: Environmental Engineering*
26.	Outside Expert	Mr G. Wijesuriya, FGA (Fellowship of Gemmological Association, UK) MSc (PGIS), No.10/1, Aithaliyadda Rd, Kumbiyangoda, Matale. *Field of Specialization: Gemmology*
27.	Outside Expert	Mr K.L.D. Dayasagara, FGA (Fellowship of Gemmological Association, UK), MSc (PGIS), Gemologist/Appraiser, No. 43/27, 9th lane, Pepiliyana Mawatha, Kohuwala, Nugegoda. *Field of Specialization: Gemmology*
28.	Lecturer	Prof. B.S.B. Karunaratne, PhD, Dept of Physics, University of Peradeniya *Field of Specialization: Physics*
29.	Lecturer	Mr. K.A.W. Kodituwakku, B.Sc (Former DGM-Water Resources Board), No. 132/94, Araliya Uyana, Mawathagama. *Field of Specialization: Geology/Geophysics*

* ***Outside Experts:*** *Experts having experience in a particular discipline with no postgraduate qualifications.*

9. PROGRAMME COORDINATOR

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