# PROPOSED CURRICULA

**for**

## A Joint Diploma / Bachelor of Science in Engineering Program in

# GEOLOGICAL ENGINEERING

## and a Master of Applied Science Program in

# ENVIRONMENTAL MANAGEMENT

## at the University of Guyana

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**(GENCAPD)**

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**What can I do with my degree in Geological Engineering?**

*"Degree graduates can work in the areas of environmental protection, geo-technical engineering and geo-technics, geological hazards, GIS, and energy and minerals. The 21st century will be a time of conflict between the use of earth resources and the need for environmental protection—geological engineers will be uniquely positioned to address the problems associated with this conflict.*

*Most geological engineers work for environmental or geo-technical consulting firms, or for government agencies such as the EPA or state departments of natural resources. Job duties range from field investigations of geological and hydrological conditions to design of innovative waste storage or remediation schemes. Monitoring and sampling associated with environmental protection are also areas where geological engineers play an important role.*

*Many geological engineers work on problems associated with hazards such as landslide stabilization, seismic risk, and other geologic hazards. For example, a geological engineer might investigate the risk of a dam failing due to a large earthquake and might recommend geo-technical designs to reduce that risk."*

(Taken from University of Missouri-Rolla)

**ACKNOWLEDGEMENTS**

I would like to express my sincere thanks to Mr. Ayalew Legesse Gebru of GENCAPD who has helped me so much in getting to meet all the stakeholders in such a short time and to understand the diverse issues involved in mining in Guyana. His professionalism and his unselfish support have made my stay in Guyana very pleasant and my work much simpler. I am also very grateful for his guidance and wise council throughout the project.

My grateful thanks go out to Mr. Robeson Benn (Mines Commissioner) and members of his staff, Mr. William Woolford (Deputy Commissioner), Mr. Kampta Persaud (Manager, Geological Services), Mr. Newell Dennison (Manager, Petroleum Division) and Ms. Sandrene Abrams (Senior Chemist). I was on GGMC's premises for the greater part of my stay in Guyana and thank Mr. Benn and all the staff for their kind hospitality.

My appreciation and thanks are extended to Dr. James G. Rose (Vice Chancellor) of the University of Guyana for his warm welcome and for our little chat about the good old days in Canje, Berbice where we both served as "Pupil Teachers". Also to his faculty Dr. William Wilson (Dean), Dr. Phillip DaSilva (Dean), Mr. Evan Persaud (Senior Lecturer), Mr. Sherwood Lowe (Asst. Dean) and Dr. Mark Bynoe (Director) my thanks for their kindness. What about a "Food Research Centre?" I think that you can run with this. "Earn while you learn" or is it the other way around?

Many thanks also to Mr. Doorga Persaud (Exec. Director- EPA) and Ms. Eliza Florendo (Director-EPA). I would like to continue our chat on economic development- "real world" issues. Perhaps we will have the opportunity to do so in the future.

To Roshan Habibullah (Director- IAST) my thanks for his support of the proposed new curriculum and for sharing his vision of Science and Technology and the role of the IAST in the future development of Guyana.

My sincerest thanks go as well to the "people on the front lines". To Mr. Edward Shields (Exec. Secretary) and Mr. Patrick Harding of the Guyana Gold and Diamond Miners Association and to Mr. Hilbert Shields (CEO – Guiana Shield Resources Inc.) for sharing their views on the future of mining in Guyana, their quest in search of exploration dollars, their requirement for skilled workers and as importantly their role in protecting the environment. Our discussions have been very informative and I was very impressed by their depth of understanding of the issues facing the mining industry. I was very impressed by their confidence and hope for the future.

## EXECUTIVE SUMMARY

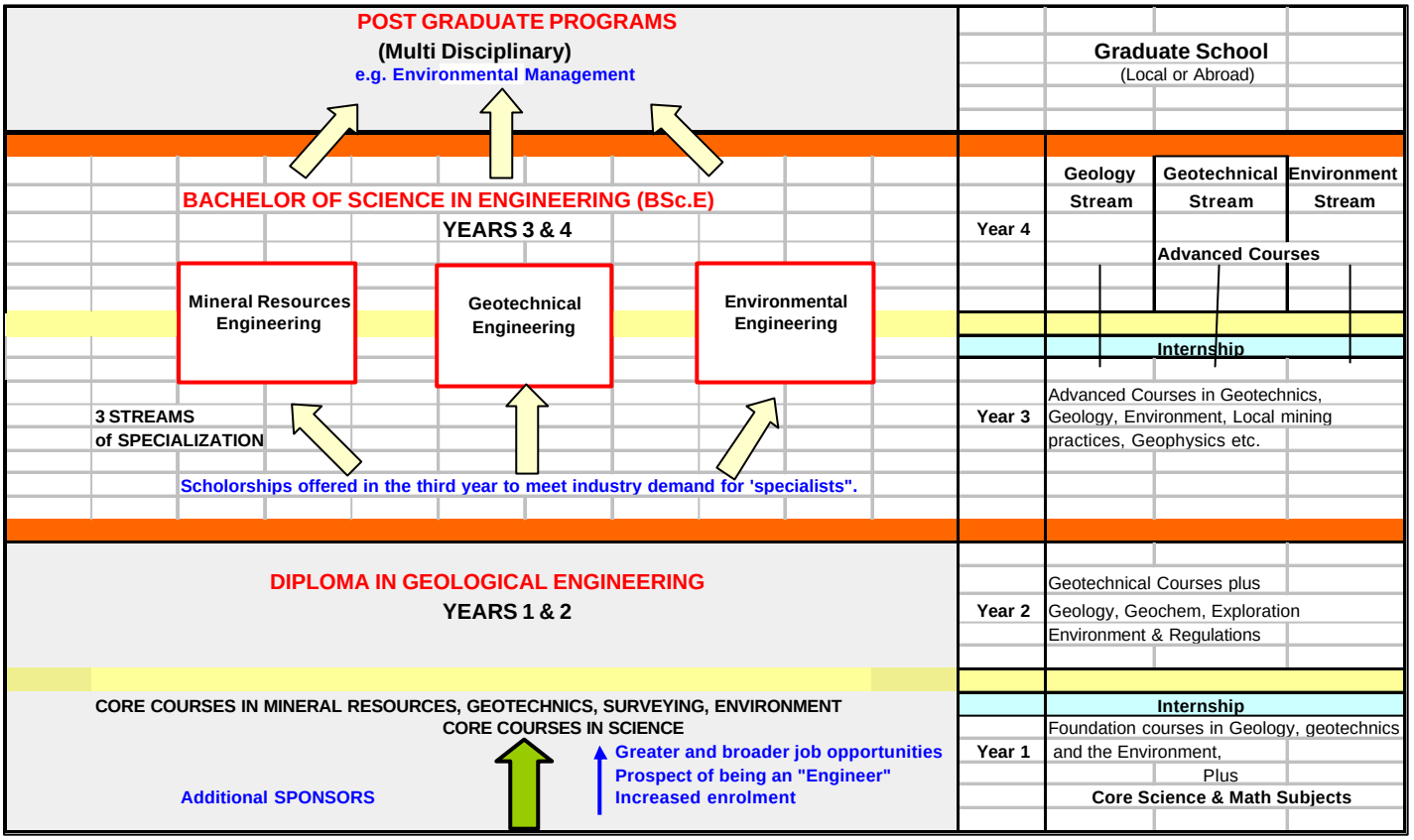
Foresight Business Services of Fredericton, New Brunswick, Canada was contracted by the Guyana Environmental Capacity Development Project for Mining (GENCAPD) to transform the current Diploma in Geology at the University of Guyana (UG) into a full-fledged four-year degree program through curriculum restructuring so that the Geology Degree Program would reflect courses that would provide good background in mapping, mineral prospecting, environmental research and environmental mining. Another requirement was for the consultant to develop a post-graduate curriculum that would address environmental issues in mining. This latter program was to be organized in such a way that students from UG could participate from different science and engineering backgrounds. GENCAPD's support of this project was aimed at enhancing Guyana's capacity in environmental management of its mining industry.

On examination of the issues negatively impacting enrolment of students in the Geology and Mining Engineering Division of the University, the consultant came to the conclusion that transformation of the Diploma Program into a Degree Program and the introduction of new environmental courses would not achieve a major objective of the University and the program Sponsors and that is to see increased student participation. In the past two years, the Geology and Mining programs of UG saw zero enrolment. The Consultant advised the Stakeholders that the restructuring of the curriculum must firstly address the "attractiveness" of the program to potential students. That is, the transformed program must be seen by students as offering better job opportunities not only in a mining industry which they see as "uncertain" with the closure of the Linden bauxite mine and the potential closure of Guyana's larger gold mines, but in other industries as well. Their "job expectation" must be such that students could see that their chances of finding gainful employment at home are improved and that their degree would provide an "advantage" for the future. A "good program" for the students would result in increased enrolment which in turn would make the restructured program "self sufficient". Self sufficiency of a Program in any university is a major boon for the university and for sponsors alike.

The Consultant recommended a change in strategy which would not only provide "greater expectations" for the student but would also meet the need of the university for "program sustainability" in the absence of sponsorship. It would also satisfy the requirement of the sole Program sponsor, the Guyana Gold and Mining Commission (GGMC), for future graduates in mineral resources and environmental management. A very important consideration of the new strategy was to minimize the cost of teaching by utilizing the resources presently available at UG. This has been accomplished by building both the Geological Engineering and the Environmental Applied Science and Management (EAS&M) Programs around the courses presently offered at the university. The new proposed programs would make it easier to attract other sponsors as well, as graduates would also find job opportunities in other sectors including agriculture, coastal defence, public works (road and bridge building) and forestry.

The new proposed Curriculum in Geological Engineering is shown in Figure A (next page).

**FIGURE A**




- Students will go through"**Engineering**" rather than a "Science" oriented Program.
- Graduates from the first two years will receive a Diploma in Geological Engineering and will qualify to work as **Certified Engineering Technicians** .
- Graduates from the 4-year Program will receive a Bachelor of Science in Engine ering degree and will qualify to work as **Professional Engineers** in Geological Engineering.
- These Engineers will receive "majors" in Mineral Resources, Geotechnical or Environmental Engineering.

A Post Graduate Curriculum in Environmental Applied Science and Management (EAS&M) is also recommended for implementation at the University of Guyana. Graduates from the Geological Engineering Program will qualify to enter into the EAS&M program. As well, graduates from other science and engineering programs presently offered at UG will also have the opportunity to enter this post graduate program. However, as this post graduate program has an "applied sciences" component, some students will be required to complete a few "applied" courses before graduating. Students presently enrolled in the "pure sciences" at UG and who would like to enter the EAS&M post graduate program will have the opportunity to take these "applied" courses in their current studies as well.

The success of these Programs at UG in the coming year will depend on how well these Programs are brought to the attention of new students entering from high school. It is therefore recommended

that the University of Guyana immediately develop and implement a “marketing strategy” to attract new students by taking the message directly to high schools and community colleges in Guyana.

**NOTE:** *The introduction of two new Programs in the same year at the University of Guyana will provide some serious challenges which will require careful thought and planning. It is recommended that faculty at UG carefully weigh the “pros and cons” of trying to introduce these two new programs simultaneously. It may be preferable to introduce the GE program in the coming year and delay the post-graduate program for introduction in year two.*

**Introduction:**

In the period of January 5-13, 2004 and February 21- March 1, 2004, the Consultant, Mr. James Chandra of Foresight Business Services, Fredericton, New Brunswick, Canada, visited the University of Guyana (UG), the Guyana Geology and Mines Commission (GGMC) and other stakeholders including the Institute of Applied Science and Technology (IAST), the Environmental Protection Agency (EPA) and the Guyana Gold and Diamond Miners Association (GGDMA) with the intent of advising the University, the GGMC and the other stakeholders on the *"Development of a Curriculum for Undergraduate and Graduate Studies in the Department of Mining, Geology and Environmental Unit at the University of Guyana"*. The Project is sponsored by the Guyana Environmental Capacity Development Project for Mining (GENCAPD-Mining) Project led by Natural Resources Canada with financial support from the Canadian International Development Agency (CIDA).

The goal of the Project is to strengthen capacities for environmental management in the minerals sector of Guyana. The purpose of the Project is to strengthen the capacities of key mining sector institutions in Guyana in the area of environmental management such as the GGMC, EPA, GGDMA, IAST and the University of Guyana. The Project operates with input from key Guyanese stakeholders such as are identified above. Training initiatives such as the development of the above Curriculum are based on those of stakeholders self identified training needs within the scope of the GENCAPD Project Implementation Plan.

It was recognized in the GENCAPD Project Plan that, the development of an in-country Program for undergraduate, graduate degrees and professional diplomas in concert with these stakeholders or partners would be one way of ensuring sustainability in programming and training. This approach would ensure building capacity in environmentally sound mining within tertiary levels of education, address issues of staff turnover, the need fir training at the various levels as well as providing opportunities for part-time training once individuals are employed on a full time basis (continued education). It would bring in faculty from the various disciplines to address a range of issues: Mining, Environmental Studies and the Natural Sciences, Amerindian Studies, the Social Sciences and Law allowing for the prevalence of sustainable knowledge in environmental management in the mining sector.

The *Expected Output* of this exercise would be a coordinated effort at UG for addressing environmentally sound mining and environmental management education in Guyana. *The Expected Outcome* would be increased programming for environmentally sound mining and environmental management and sustainability.

**2. Expectations of Stakeholders:**

It has been suggested, that the task of developing a curriculum that will address the needs of environmental education at UG falls into two categories: the first phase is making an internal needs assessment and the second one is the work of the Consultant.

The University of Guyana Environmental Studies Unit, and the Mining & Geology departments have reviewed the current curriculum being offered in these departments, along with the allied Science subjects, and have made recommendations as follows:

The Department of Geology & Mining wants to introduce among others, at least two environmental courses, Environmental Geology and Mining and the Environment. On the other hand, the Environmental Unit of Natural Sciences wants to strengthen the current BSc programmes and introduce postgraduate courses in Environmental Management.

The Mining & Geology Department of the Technology Faculty is also in need of upgrading the current diploma programme in Geology to a degree level. The department's new curriculum in Geology at the degree level should have a comparable standard to those of Canadian Universities. GGMC will be the main beneficiary of this upgraded curriculum in Geology, and has a plan to improve its staff by sponsoring them at UG. The GGMC has also obtained a mandate from the EPA for protecting the environment in small scale-mining related activities for which an EIA is not needed. GGMC's aim for this responsibility is an integrated approach with an *all rounded personnel* to solve Guyana's mining related environmental problems. *Expertise in a varied discipline, which is key to environmental studies, is lacking in Guyana, thus there is need for versatile personnel capable of responding to the current needs of the commission. This in turn demands the framing of a curriculum that reflects Guyana's needs.*

## 3. Approaching the problem:

Prior to going into Guyana, several days were spent in accessing documentation relevant to the proposed task in Guyana. Several articles in the Guyana press, in UG press releases and in other documents on the Web concerning mining in Guyana were reviewed. Also examined were labor and economic activities in Guyana which would have a bearing on Mining and most importantly, would explain the reasons for the lack of enrolment in the past two years in the Geology Program presently offered at UG. Several parties in Guyana and Canada (Guyanese) were also polled to gain some perspective on the mining problems in Guyana.

Answers were sought on the following:

- What factors influence the student's decision to enter the Earth Science program at UG? (What are their Expectations?).
- How is the Job market in the mining sector in Guyana and the Caribbean?
- The placement of past graduates of UG in the Earth Sciences (where are they?)
- Where do the mining companies in Guyana find skilled and qualified earth scientists?
- What types of skilled professionals do the potential employers really require?
- To what extent are UG Earth Science graduates involved as "Developers" in mining in Guyana? (Junior Mining).
- What factors contributed to the decline and final curtailment in enrolment in the Earth Sciences at UG?
- Would a revamped program in Geology with an emphasis on environmental applications at UG provide the benefits expected by the Sponsor?
- Why is there only one Sponsor?
- Where do the local Mining Association and Association of Engineers come in? (What role would they play?)
- What happens when the "kick start" fund promised by GGMC to UG runs out?

- Would there be any long term gain for UG? (Sustainability of the new Program)
- What benefits would accrue to the Faculty?
- What are the overall benefits to Guyana?

And most importantly,

- Would the revamped Geology/Environment curriculum draw students? (New or from other scientific disciplines in UG).

Answers to these questions and discussions with the stakeholders, on the first visit to Guyana, confirmed the fact that the "proposed" development of the Curriculum asked for by the GGMC, UG and GENCAPD would not achieve a key objective and that is to see improved enrolment of students in the Earth Science Program at UG. Simply put *no students in, no graduates out*. Also, such a curriculum would not meet the University's long term objective of self sufficiency. It would also not have the broad appeal to many industry sectors (potential sponsors and future employers) nor be seen as meeting the greater need in Guyana's economic development aspirations.

## 4. A Revised approach:

A new approach was proposed to the GGMC, UG and the other stakeholders mentioned above. It attempts to address the main question of how to get students excited about entering into such a Program at UG by trying to meet their expectations. The prospective student would now be attracted to the new program and be assured of a higher probability of finding gainful employment locally. The new proposal would also satisfy GGMC's and GENCAPD's requirements as sponsors, bring in new sponsors to support the program and meet the growing need for professionals in other industry sectors in the country. The impact would be broader thus providing greater returns to the people and government of Guyana.

## 5. Recognizing the Broader educational needs of Guyana:

Guyana, like many other under-developed countries in the southern hemisphere have economies that are based on the exploitation of natural resources of the *sea*, *forests* and *minerals* and to a great extent to *agricultural* development which are providing goods for export and now more importantly for "*import replacement*". Looking at where Guyana needs to go or areas on which to focus to advance economic development, it is clear that transportation, coastal defence, public works, agriculture and mining are "key target areas" for development. While it is evident that the rest of the world (developed and developing countries) is focusing on Information and Advanced Manufacturing Technologies, Guyana has but few choices. Guyana is challenged to improve its transportation infrastructure (roads in particular), its coastal defence, its agricultural base and its mining capabilities. These must become areas of focus in the near or immediate term to allow it to leap ahead as the status quo will result in economic stagnation causing Guyana to "implode" on itself. In order to tackle these problems it would require a very skilled work force capable of undertaking assignments (technical and managerial) associated with these industrial sectors. It must be pointed out that a key impediment to trade is that of "certification" of goods that demonstrate they have been exploited, made/manufactured and packaged using sustainable practices. In other words, countries must demonstrate that they have acquired or made these products by not harming the environment. This requirement for "certification" (Green Product) is presently viewed as a "barrier to trade" by many under-developed and/or developing countries. The requirement for such "certification" is here to stay as consumers are more sophisticated and have

become increasingly aware of the negative impact caused by bad manufacturing practices which contribute to global warming, the destruction of our ecosystems and the loss of many species of both flora and fauna.

Guyana must therefore adopt sustainable strategies or have it "forced" upon its struggling economy by its trading partners and by its "bankers". The industrial sectors of focus mentioned above all have an "*environment*" component which must be dealt with to show its people, its trading partners and just as importantly its "money lenders" that development has not affected the environment to cause irreparable harm to workers' health and to the local ecosystem.

## 6. Proposal for a Diploma / Bachelor of Science in Engineering in *"Geological Engineering":*

A common element runs through all four economic sectors outlined above. This element, while it differs slightly across the sectors show the need for a particular "skill set" or type of professional which is required both to undertake technical work and also to "manage" expenditures and technological change, to minimize cost and to build better systems so that maximum economic benefits will arise. The new skills required are those of "Geological Engineers" who are qualified and suited to build roads and structural foundations, drainage systems, open pits, coastal defenses, agricultural drainage systems, quarries, tailings ponds, waste disposal sites and land fills. While it is recognized that other engineering professionals (.e.g. Civil) will be involved, these "geological engineers" will bring strong technical competence to design, development and construction activities, remediation efforts associated with spills and accidents, waste management, develop better preventive measures and better environmental impact assessments (EIA) etc all in the name of "*economic progress with respect for the environment*".

It would be wrong of government, its related departments (Transportation, Agriculture and others) and the University of Guyana to disregard or minimize the importance of the economic challenges outlined above and the urgent need for a Degree/Diploma program at UG in Geological Engineering and to prepare Guyanese youths to build a better Guyana for themselves and not to seek greener pastures across the seas.

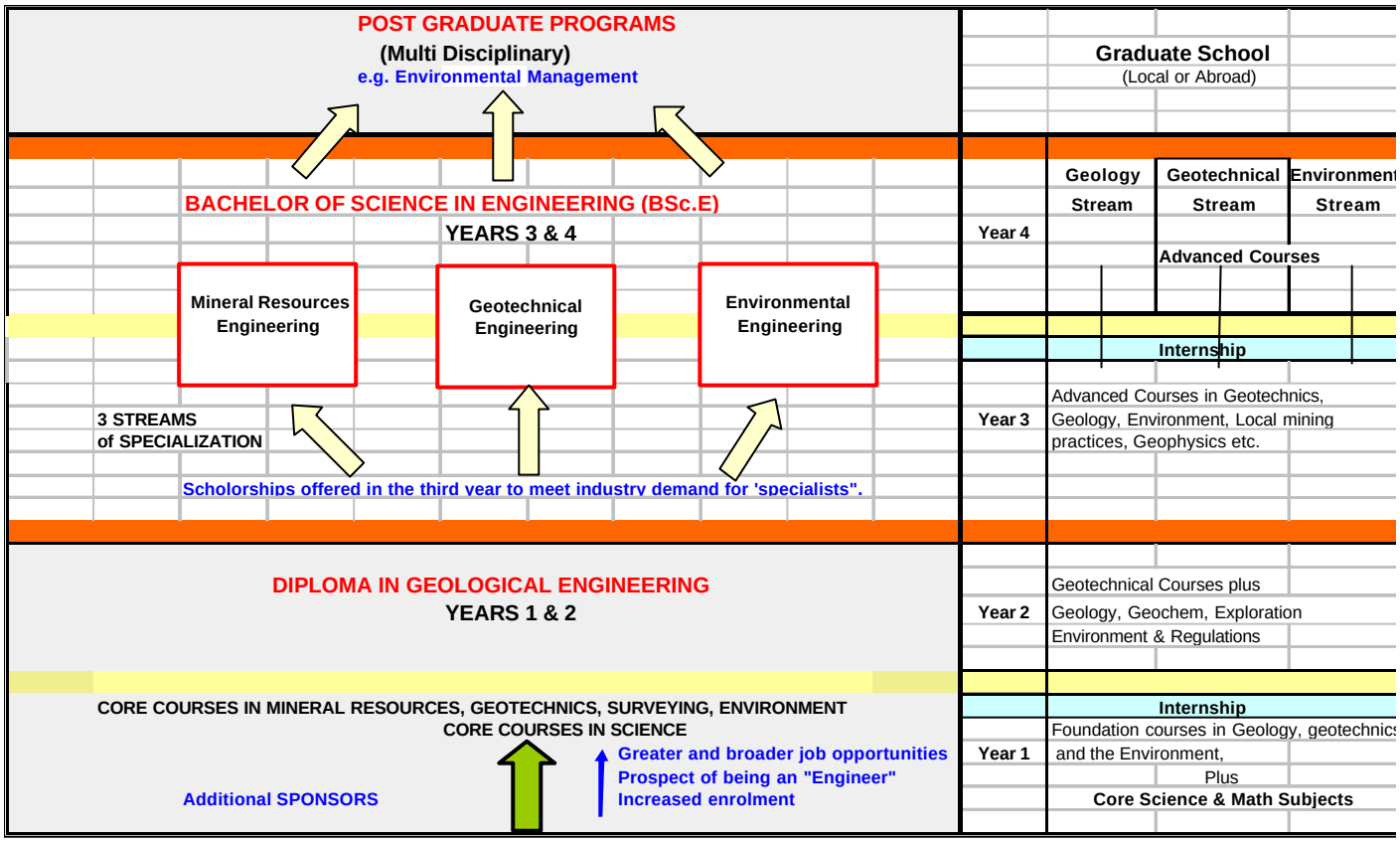
## 7. The New Curriculum:

The move to a new Curriculum in Geological Engineering has been discussed with all stakeholders consulted in Guyana. These stakeholders include the UG (Vice Chancellor and Deans), GGMC (and the Prime Minister), EPA, IAST, the Gold Mining Association, the local Association of Professional Engineers (Dr. William Wilson of UG) and several key individuals in the exploration and mining sector. Unanimous agreement in principle has been reached and all parties concur that a program for the training of graduates in Geological Engineering would bring significantly more employment opportunities for these professionals (students) in Guyana, meet the needs of their respective organizations and bring greater benefits to Guyana's economic development aspirations.

The Curriculum in Geological Engineering would be developed around the model shown in FIGURE 1.

**FIGURE 1**

**Curriculum in Geological Engineering developed around the model in figure below:**




**Geological Engineering** is a relatively recent branch of engineering that has grown out of the interaction of the Geotechnical areas of Civil Engineering and the Science of Geology. The profession is related to the exploration, management and utilization of materials of the earth's crust. Geological Engineering is often related to the early development of project foundations, mineral quantities and qualities, and environmental impact assessment. This means the Geological Engineer needs the people and communication skills common to most engineering disciplines; however they may not appear at the forefront of public involvement as much as their Civil Engineering co-workers.

**Geological engineers** work to satisfy societal needs in the exploration, conservation, utilization and management of earth materials and the resources of the earth's crust. Geological engineers apply the principles of earth sciences and engineering to find and extract earth-bound energy such as oil, natural gas, and coal sources and mineral wealth and metal resources. Geological engineers also aid other engineering disciplines in designing foundations of major structures for various types of loads and in designing waste repository systems to protect the earth and its inhabitants from environmental pollution.

**Geological engineers** frequently work with geologists and civil engineers and play important roles in the study of the interaction between the earth and engineered facilities.

They are involved in planning, design, construction, operation and maintenance of public works and industrial projects. Examples of engineering works with significant Geological Engineering components include: bridges, highways, airports, landfill sites, hydro-electric dams, water and sewage facilities, port facilities and buildings.

**Geological Engineering** may be viewed as a specialization of Civil Engineering or in some cases an Applied Science aspect of Geology. The program at the University of New Brunswick and several other teaching institutions includes three possible options:

Geo-environmental

- design of waste facilities
- protection of the environment from spills or leaks
- provision and protection of quality groundwater

Geotechnical

- structural foundations
- earth structures: dams, road or bridge embankments
- rock mechanics: tunnels or slopes

Mineral Resources

- mine development
- mineral exploration
- mine operation

A large component of Geological Sciences within the **Geological Engineering** curriculum tends to limit the flexibility in designing a program to meet the engineering degree requirements. The program includes approximately 30 percent Civil Engineering, 40 percent Geology, and the remainder a mixture of other engineering, sciences, mathematics and humanities. The three options are made up of small packages of upper level electives taken during the last two years of the program.

## 8. Program Basics in Geological Engineering:

A Proposed Curriculum for a Program in *Geological Engineering* in the Earth Sciences Faculty of the University of Guyana:

The Program will lead to the following:

1. A (2-year) Diploma in Geological Engineering (Dip. Geol. Eng.).
   Designation to be granted by the local Association of Professional Engineers will be – "Certified Geological Engineering Technician".

2. A (4-year or 9-Term) Bachelor of Science in Engineering (BSc.E) in Geological Engineering.

Designation – "Professional Engineer" ((P.Eng. (Geol.))".

The Degree Program students in three Disciplines as follows:

- Geological Engineer (Mineral Resources Engineering Major)
- Geological Engineer (Geotechnical Engineering Major)
- Geological Engineer (Environmental Engineer Major)

3. Both the Diploma and Degree Programs will require "Internship". Time and Duration have to be negotiated between UG and the Guyana Association of Professional Engineers (GAPE). The granting of Professional Status is very important for Student recognition.

**NOTE**: *Professional "Designation" is granted at the Discretion of the Professional Organization and NOT the University. Hence, it is important that the Guyana Association of Professional Engineers (GAPE) is consulted in the development of this new Curriculum so that it can Grant "Accreditation" in keeping with its "Constitution".*

## 9. Benefits of the New Program to Stakeholders:

It is important that the benefits of this new program are stated for its present Sponsors (GGMC and GENCAPD), its Stakeholders and students.

Benefits to Students:

- Upon graduation, Degree recipients will carry the title of a "Professional Geological Engineer" (PGE) while the Diploma graduates will carry the title of "Certified Geological Engineering Technician" (CGET) which will bring greater job esteem.
- Students will receive a Diploma or Degree that is "globally recognized" hence making them more competitive in the job market.
- Students would likely enroll voluntarily and will not see "Scholarships" as the main inducement into the Program.
- Students will see greater job opportunities in several sectors in industry and in Government.
- Scholarships may be accessible (or granted) in years three and/or four of their training so as to meet industry and government need for a particular skill set (Geologist, Geotechnical and/or Environmental Engineer)

Benefits to the University:

- UG will have increased enrolment in the Earth Sciences allowing it to see long term benefits in self sufficiency of the program.
- Enrolment in the Earth Sciences will be steady and will draw both new students and students from other science disciplines at UG where classes are large and job expectations are not as lucrative.
- UG can make the case to attract other Sponsors from Agriculture, Transportation, etc.
- Professional Staff is already in place to undertake teaching, particularly from Civil Engineering and the Environmental Studies unit.

- This new program will fit well in the university's planned amalgamation strategy and for the formulation of the Earth Sciences Faculty.

- With the exception of Geology, most of the equipment is already in place to teach these disciplines. A strategy must be developed by UG to try to acquire scientific equipment particularly for the Geophysics and exploration courses.

  Benefits to Industry:

  - Industry will now have access to trained graduates required in several industrial sectors.
  - The Guyana association of engineers will see increased membership.
  - Local engineering firms will have additional expertise to help bid on Engineering Contract Services in the Caribbean market. In fact Guyanese engineering firms may have the jump on this "niche" market if the program is launched immediately.

  Benefits to Government:

  - Government will see greater efficiencies in the development of its strategic economic sectors.
  - Renewed infrastructure will be better built at lower long term capital and environmental costs.
  - Products destined for home consumption and for export markets will be closer to reaching "Green Product accreditation" because of a better trained labor force.
  - Guyana will attain greater health benefits from better environmental practices in all industrial sectors.

Benefits to GGMC & GENCAPD:

- The principal sponsors of the Project, GGMC and GENCAPD, will achieve their goal of developing better and broader "Environmental Management Practices" not only in the Mining sector, but in several related industrial sectors of Guyana's economy.
- GGMC will have professionals who are better suited to administering the "Regulation" aspects of the mining industry, yet as capable in exploration and mapping.
- For GENCAPD, the "sustainability" of the environmental management Program would be better assured.

## 10. Development of the Curriculum for the Diploma / Degree in Geological Engineering:

In developing the Draft Curriculum for the Diploma / Degree Program in Geological Engineering for use by the University of Guyana, the contractor has tried to incorporate as much of the available Course Material (Curriculum information) developed by and presently being used at the University of Guyana. This is being done to incorporate as many Courses already in place in UG so that a transition to this new Program can be achieved at the lowest possible cost and with a minimum of disruption to teaching practices already in place at UG. The List of Scientific Equipment at UG, GGMC and other stakeholders available for teaching at UG was requested and promised but not as yet received. The Contractor was thus unable to advise UG on missing or necessary pieces of equipment required for the Program.

The Contractor and the University of Guyana are obliged to recognize and adhere to the Intellectual Property (IP) Laws of Canada and the United States. The use by the University of Guyana of Curriculum

information gathered by the consultant or other bodies may impinge or violate the IP Laws in respect of "ownership" by lecturers and/or their universities. The Contractor has tried to avoid any IP infringement and advises both the University of Guyana and GENCAPD of this consideration.

**NOTE:**

*In respect of Intellectual Property rights of professors and universities, the Contractor has met with both the President of the University of New Brunswick and the Chairman of its Geological Engineering department to explore the possibility of their assisting the University of Guyana in the development and implementation of its new Geological Engineering Program. The Contractor has also advised the Commissioner of the GGMC and the Vice Chancellor of UG of the interest on the part of the University of New Brunswick in developing good relations with the University of Guyana. The limited time frame in which this Project has to be completed, did not allow the contractor to advance a Memorandum of Understanding (MOU) between the universities as was discussed with both UNB and UG. Such a MOU is desirable and could be very rewarding to both institutions. It could make the implementation of this new program at UG much easier as the Program is modeled after that of UNB but does not violate its IP rights. The contractor is prepared to assist both universities in advancing this relationship.*

In preparing the Draft Curriculum, the contractor has researched the Program Models and Course outlines used by several Canadian and American colleges and universities. Among the several universities and colleges researched, the notable ones are as follows:

1. University of New Brunswick
2. Millsaps College
3. Colorado School of Mines
4. Queen's University
5. University of New Orleans
6. Ryerson University
7. University of Toronto

In general, many of the universities and colleges researched, including the list above, structure their "Environmental Management/Geology/Engineering" and "Geological Engineering" programs along similar lines. Each specific Curriculum is developed from a list of "Core Courses" which may contain as many as fifty courses which cross several scientific and engineering disciplines. This Core list comprises "foundation courses" at the first and second year levels which predominantly come from disciplines such as Mathematics, Physics, Chemistry, Computer Science, Biology, the "Major area" and to a lesser extent Arts (English requirements). Next from this Core list comes the "compulsory courses" which take the student into his/her area of focus or "major". The rest of the courses in the list are the "Options or Electives" which are selected by the student in consultation with his/her academic advisor.

In the Geological Engineering Program of several universities/colleges, the Core List of Courses follow the pattern as is used by the University of New Brunswick as shown below in **TABLE 1** with Descriptions in **APPENDIX A** (Non IP sensitive). The Contractor has elected to use the UNB model because of its success in meeting the needs of New Brunswick which like Guyana, has similar resource development aspirations and similar fiscal constraints in its economic development objectives.

# TABLE 1
# LIST OF CORE COURSES IN THE GEOLOGICAL ENGINEERING PROGRAM (UNB)

## FOUNDATION & ELECTIVE COURSES

| | | | | Ch | | | |
|---|---|---|---|---|---|---|---|
| CE | 1013 | 1 | Applied Mechanics (Statics) | 4 | 3C | 1T | |
| CHEM | 1882 | 1 | General Chemistry | 5 | 3C | 3L | |
| CS | 1003 | 1 | Intro to computer prog in Fortran | 4 | 3C | 1T | 2L |
| ECON | 1073 | 1 | Economics for Engineers | 3 | | | |
| EE | 1713 | 1 | Electricity & Magnetism | 4 | 3C | 1T | 3L* |
| ENGL | 1103 | 1 | Fundamentals of Clear writing | 3 | 3 | | W |
| GE | 1026 | 1 | Geology Lab for Geological Engineers | 2 | 3L | | |
| GEOL | 1001 | 1 | The Earth: its origin, evolution and age | 3 | 3C | | |
| GGE | 1001 | 1 | Intro to Geodesy & geomatics | 5 | 3C | 3l | |
| GGE | 1803 | 1 | Practicum for Civil Engineers (2 weeks0 | 2 | | | |
| MATH | 1003 | 1 | Intro to Calculus | 3 | 4C | | |
| MATH | 1013 | 1 | Intro Calculus II | 3 | 4C | | |
| ME | 1003 | 1 | Engineering Graphics | 4 | 2C | 3L | |
| ME | 1113 | 1 | Applied Mechanics II : Dynamics | 4 | 3C | 1T | |
| PHYS | 1913 | 1 | Fund of Physics (For Engineers) | 3 | 3C | 1T | |
| PHYS | 1918 | 1 | Physics Lab for Engineers | 2 | 3L | | |
| CE | 2023 | 2 | Mechanics of Materials | 5 | 3c | 3L | |
| CE | 2703 | 2 | Intro. To Fluid Mechanics | 4 | 3C | 1T | |
| GE | 2022 | 2 | Engineering Geology | 4 | 3C | 3L | |
| GEOL | 2131 | 2 | Crystallography & Mineralogy | 5 | 2C | 3L | W |
| GEOL | 2142 | 2 | Chemistry & Physics of Minerals | 5 | 3C | 3L | |
| GEOL | 2212 | 2 | Sedimentology I | 5 | 2C | 3L | |
| GEOL | 2321 | 2 | Structural Geology I | 5 | 2C | 3L | |
| GEOL | 2602 | 2 | Principles of Geochemistry | 5 | 3C | 3L | W |
| GEOL | 2703 | 2 | Field School (14 Days) | 6 | | | W |
| MATH | 2503 | 2 | Calculus and Linear Algebra for Engineers | 3 | 3C | 1T | |
| MATH | 2513 | 2 | Calculus and Linear Algebra for Engineers | 3 | 3C | 1T | |
| STAT | 2953 | 2 | Probability and Statistics for Engineers | 3 | 3C | | |
| CE | 3113 | 3 | Soil Mechanics | 4 | 3C | 3L | |
| CE | 3713 | 3 | Hydraulics and Hydrology | 5 | 3C | 3L | |
| CE | 3933 | 3 | Numerical Methods for Civil Engineers | 3 | 3C | | |
| CE | 3963 | 3 | Engineering Economy | 3 | 3C | | |
| CE | 3973 | 3 | Technical Communications | 4 | 2C | 3L | W |
| GEOL | 3131 | 3 | Igneous & Metamorphic Petrology | 5 | 2C | 3L | W |
| GEOL | 3411 | 3 | Rock Mechanics | 5 | 3C | 2L | W |
| GGE | 3342 | 3 | Imaging and Mapping I | 5 | 3C | 3L | |
| CE | 4003 | 4 | The Engineering Profession (or equivalent) | 2 | 2C | | |
| CE | 4613 | 4 | Construction Engineering | 3 | 3C | | |
| GE | 4983 | 4 | Senior Report I | 8 | | | W |
| GE | 4993 | 4 | Independent Studies in Geology | 3 | | | |
| GEOL | 4512 | 4 | Exploration Geophysics II | 5 | 3C | 2L | |
| GGE | 4403 | 4 | Geographic Information Systems | 4 | 2C | 3L | |
| LAW | 5002 | 5 | Common Law for Engineers | | | | |

**COURSE CODES**

| | |
|---|---|
| A | Alternate Years |
| ch | Credit Hours |
| C | Class Lecture |
| L | Laboratory |
| LE | Limited Enrolment |
| O | Ocassionally Given |
| R | Reading Course |
| S | Seminar |
| T | Tutorial |
| W | English Writing Component |
| WS | Work Shop |
| * | Alternate Weeks |

## COMPULSORY COURSES

### Environmental Engineering (OPTION 1)

| | | | | Ch | | | |
|---|---|---|---|---|---|---|---|
| BIO | 2113 | 1 | Ecology | 3 | 3C | | |
| CE | 3403 | 1 | Intro to Environmental Engineering | 4 | 3C | 3L | |
| CE | 5753 | 1 | Engineering Hydrogeology | 4 | 3C | 3L | |
| GEOL | 3442 | 1 | Environmental Geology | 3 | 2C | 1S | W |
| GEOL | 3631 | 1 | Geochem of Natural Waters | 5 | 2C | 3L | |
| GEOL | 3713 | 1 | Field School (2 Weeks) | 7 | | | |
| | | | All of | 26 | | | |
| | | | 2 complementary Studies Electives (6 ch) | 6 | | | |
| CE | 5113 | 2 | Soil Mechanics II | 4 | 3C | 2L | |
| CE | 5141 | 2 | Embankments I | 3 | 3C | | |
| CE | 5201 | 2 | Road Materials and Structures | 4 | 3C | 2L | |
| CE | 5153 | 2 | Waste Geotechnics | 4 | 3C | 3L | |
| CE | 5432 | 2 | Water and Wastewater Treatment | 4 | 3C | 2L | |
| GEOL | 4501 | 2 | Exploration Geophysics II | 5 | 3C | 2L | |
| GEOL | 4452 | 2 | Environmental Impact Assessment | 5 | 3c | 3l | |
| | | | 11 of | 29 | | | |
| | | | 163 Credit Hours from Electives | 163 | | | |
| | | | TOTAL Credit Hours | 206 | | | |

### Geotechnical Engineering (OPTION 2)

| | | | | | | |
|---|---|---|---|---|---|---|
| CE | 3123 | 1 | Foudation Engineering I | 4 | 3C | 1T |
| GE | 4412 | 1 | Applied Rock Mechanics | 5 | 3c | 2l |
| GE | 5753 | 1 | Engineering Hydrogeology | 4 | 3C | 3L |
| GEOL | 3322 | 1 | Structural Geology II | 5 | 2C | 3L |
| GEOL | 3703 | 1 | Field School (2 Weeks) | 7 | | |
| | | | All of | 25 | | |
| | | | 2 complementary Studies Electives (6 ch) | 6 | | |
| CE | 5113 | 2 | * Soil Mechanics II | 4 | 3C | 2L |
| CE | 5132 | 2 | * Foundation Engineering II | 3 | 3C | |
| CE | 5141 | 2 | * Embankments I | 3 | 3C | |
| GE | 5153 | 2 | * Waste Geotechnics | 4 | 3C | 3L |
| CE | 5201 | 2 | Road materials and structures | 4 | 3C | 2L |
| CE | 5212 | 2 | Pavement Design | 4 | 3C | 3L |
| CE | 5603 | 2 | Construction Equipment and Methods | 4 | 3C | 1T |
| CE | 5623 | 2 | Project Management | 4 | 3C | 1T |
| GE | 4432 | 2 | Rock Mechanics Design | 5 | 2C | 3L |
| GEOL | 4501 | 2 | Exploration Geophysics | 5 | 3C | 2L |
| | | | 11 of | 40 | | |
| | | | 163 Credit Hours from Electives | 164 | | |
| | | | TOTAL Credit Hours | 206 | | |

### Mineral Resources Engineering (OPTION 3)

| | | | | | | |
|---|---|---|---|---|---|---|
| GE | 4442 | 1 | Mineral Resources Utilization | 5 | 3c | 2l |
| GEOL | 3322 | 1 | Structural Gepology II | 5 | 2C | 3L |
| GEOL | 3703 | 1 | Field School (2 Weeks) | 7 | | |
| GEOL | 4461 | 1 | Economic Geology | 5 | 2C | 3L |
| GEOL | 4472 | 1 | Economic Geology II | 5 | 2C | 3L |
| GEOL | 4501 | 1 | Exploration Geophysics I | 5 | 3C | 2L |
| | | | All of | 32 | | |
| | | | 2 complementary Studies Electives (6 ch) | 6 | | |
| CE | 5132 | 2 | * Foundation Engineering II | 3 | 3C | |
| CE | 5141 | 2 | * Embankments I | 3 | 3C | |
| CE | 5201 | 2 | * Road materials and structures | 4 | 3C | 2L |
| CE | 5212 | 2 | * Pavement Design | 4 | 3C | 3L |
| CE | 5603 | 2 | * Construction Equipment and Methods | 4 | 3C | 1T |
| CE | 5623 | 2 | Project Management | 4 | 3C | 1T |
| CE | 5153 | 2 | Waste Geotechnics | 4 | 3C | 3L |
| | | | | 26 | | |
| | | | 4 Credit Hours from | 4 | | |
| | | | 163 Credit Hours from Electives | 160 | | |
| | | | TOTAL Credit Hours | 206 | | |

* One of these courses must be taken to meet the degree requirements.

**(PLEASE OPEN SHEET IN EXCEL FOR DETAILS)**

## 11. Process of arriving at a Curriculum in Geological Engineering at UG.

The University of Guyana's Faculty of Technology Undergraduate Programs guide provided by GENCAPD was reviewed in its entirety to select present courses given at UG which would ideally "match" and better yet be "equivalent" to the Courses in Geological Engineering used at UNB and in other universities in Canada and the United States.

The result of this exercise of "match making" demonstrates that UG already has in place, lecturers, equipment, room and syllabuses which are ideally suited for the general Curriculum in Geological Engineering. However, in several instances some necessary changes in content or more importantly an elaboration or "more emphasis" in particular aspects of the course(s) will be required to meet the requirements of the geological engineering student. This "adjustment to the course" will more likely occur automatically and may not require serious or time consuming efforts of the lecturer. The courses in the Civil Engineering department are the most likely to require this attention. In this regard, it is highly recommended that lecturers in the Civil Engineering department are ***brought in very early as partners*** in the development of this new Curriculum as that department will be the most impacted in the university. *It must be emphasized at this point, that the development of the Curriculum for Geological Engineering at UG is not a static one. Lecturers involved in the delivery of the Program will discover that it will take several years, at a minimum three, before "a comfort level" is reached by faculty and students.* It would very unrealistic to expect that the Consultant would provide the university with the ideal working curriculum. Local considerations such as input from the Gold and Diamond Miners Association and the Guyana Association of Professional Engineers will be challenging but necessary as "industry considerations" will be found to be the most crucial element in the realization and success of this Program.

## 12. Course correlations and "matching" (UNB vs. UG):

The lists of typical Geological Engineering courses offered at Canadian and US universities/colleges researched (such as shown in TABLE 1 and APPENDIX A) were entered into an Excel Workbook with several sheets made up of course outlines from the various teaching institutions. These lists were correlated so that "common courses" were identified. Once these courses were identified, they were placed against the list used at UNB. It was found that the UNB model and course selections were characteristic of, with a few exceptions, the courses and outlines described by others. The result is that the Consultant is able with some degree of confidence to recommend that the University of Guyana and the local stakeholders follow the UNB model in the development of their Curriculum. Of course, the Curriculum would be adapted to meet Guyana's unique needs while at the same time assuring the continued academic integrity and independence of the University of Guyana in setting its own teaching standards. By constructing its new Curriculum around the UNB model, UG will use a proven method which takes into consideration the issues of "accreditation" and recognition by other bodies such as the Guyana Association of Professional Engineers (GAPE).

The next step followed in the development of the DRAFT Proposed Curriculum was the tedious task of correlating and "matching" the present courses offered by the University of Guyana's Faculty of Technology with those of the University of New Brunswick's Geological Engineering Program (APPENDIX B). The "matches" do not indicate a direct correlation, but show that the UNB Course description is reflected to a great extent in the UG Course outlines. Where there is little correlation between the UNB and UG course descriptions, the "missing" UNB course has been identified so that

UG faculty and lecturers can be prepared to develop such courses if deemed necessary. One example of this is that UG does not provide a course (UNB CE 4003 "The Engineering Profession) which deals with *Code of Ethics* and "by-laws of the Guyana Association of Professional Engineers" as required in all Canadian provinces.

The resulting Draft Proposed Curriculum is shown in TABLE 2 where the UNB and UG courses are "matched" side by side. Courses that are not offered at UG are also indicated.

Should UG and its stakeholders wish to pursue this additional program, the Curriculum for the Environmental Management Program presently offered at Ryerson University (Canada) is shown in APPENDIX C.

## 13. Proposed Draft Curriculum in Geological Engineering:

The DRAFT Proposed Curriculum in Geological Engineering at the University of Guyana would be based on the model at the University of New Brunswick and would follow the courses as shown in TABLE 2. This Table shows those courses presently offered at the University of Guyana which corresponds to Courses in the Geological Engineering department of UNB. The correlation is only intended to show that material taught at UG falls within the identified course at UNB. It is there to suggest that UG can make the necessary changes to some of its present courses so that it can readily deliver a Program in Geological Engineering by September 2004. *TABLE 2 (Parts A & B) would represent the PROPOSED B.Sc.E CURRICULUM in Geological Engineering at the University of Guyana. TABLE 3 shows the DRAFT Curriculum for the Diploma Program.* It is recommended that the University of Guyana and stakeholders review the Proposed Curriculum and make the necessary changes to ensure that the needs of the stakeholders and the country are met. The cooperation of the Guyana Association of Professional Engineers (GAPE) would be highly desirable in this review.

# TABLE 2: Course correlations (UG versus UNB) Part A
# (PROPOSED B.Sc. E. CURRICULUM)

**COMPULSORY COURSES**

| UNB | | | | | | | | | UNIVERSITY OF GUYANA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Environmental Engineering (OPTION 1)** | | | | Ch | | | | | **Environmental Engineering (OPTION 1)** | | |
| BIO | 2113 | 1 | Ecology | 3 | 3C | | | | BIO | 223 | Fundamentals of Ecology |
| CE | 3403 | 1 | Intro to Environmental Engineering | 4 | 3C | 3L | | | CIV | 413 | Environmental Engineering I |
| CE | 5753 | 1 | Engineering Hydrogeology | 4 | 3C | 3L | | | CIV | 426 | Engineering Hydrogeology (Resructured Course) |
| GEOL | 3442 | 1 | Environmental Geology | 3 | 2C | 1S | W | | CIV | 423 | Environmental Geology |
| GEOL | 3631 | 1 | Geochem of Natural Waters | 5 | 2C | 3L | | | GEM | 311 | Environmental Chemistry I |
| | | | | | | | | | CIV | 426 | Coastal Engineering |
| GEOL | 3713 | 1 | Field School (2 Weeks) | 7 | | | | | GEM | 300 | Field School (2 Weeks) |
| | | | All of | 26 | | | | | | | |
| | | | 2 complementary Studies Electives (6 ch) | 6 | | | | | | | |
| CE | 5113 | 2 | Soil Mechanics II | 4 | 3C | 2L | | | CIV | ? | Geotechnics I & II Courses (Restructure to "Soil Mechanics II") |
| | | | | | | | | | CIV | 424 | Water Resource Planning and Development |
| CE | 5141 | 2 | Embankments I | 3 | 3C | | | | CIV | 415 | Highway Engineering (Restructure to "Embankments I") |
| CE | 5201 | 2 | Road Materials and Structures | 4 | 3C | 2L | | | CIV | 415 | Highway Engineering (Restructure to "Road Materials and Structures") |
| CE | 5153 | 2 | Waste Geotechnics | 4 | 3C | 3L | | | CIV | 413 | Environmental Engineering I (Rename?" Waste Geotechnics)" |
| CE | 5432 | 2 | Water and Wastewater Treatment | 4 | 3C | 2L | | | CIV | 322 | Water & Waste Water Engineering (Restructure to "W & W Treatment") |
| CE | 5421 | 2 | Water and Wastewater Analysis (Core) | | | | | | CIV | 322 | Water & Waste Water Engineering (Restructure to "W & W Analysis") |
| GEOL | 4501 | 2 | Exploration Geophysics II | 5 | 3C | 2L | | | GEM | 428 | Applied Geophysics I (Magnetic, Radiometric & Gravity Methods) |
| GEOL | 4452 | 2 | Environmental Impact Assessment | 5 | 3c | 3l | | | ENV | 411 | Environmental Impact Assessment & Ecology |
| | | | | | | | | | SSC | 411 | Soil and Water Management |
| | | | 11 of | 29 | | | | | | | |
| | | | 163 Credit Hours from Electives | 163 | | | | | | | |
| | | | TOTAL Credit Hours | 206 | | | | | | | |
| **Geotechnical Engineering (OPTION 2)** | | | | | | | | | **Geotechnical Engineering (OPTION 2)** | | |
| CE | 3123 | 1 | Foundation Engineering I | 4 | 3C | 1T | | | CIV | 310 | Geotechnics I (Foundation Engineering I) |
| GE | 4412 | 1 | Applied Rock Mechanics | 5 | 3c | 2l | | | MEC | ? | New Course to be developed by restructuring Mechanics I (Statics) |
| GE | 5753 | 1 | Engineering Hydrogeology | 4 | 3C | 3L | | | CIV | 426 | Engineering Hydrogeology (Resructured Course) |
| | | | | | | | | | CIV | 427 | Geotechnics II (Foundation Engineering II) |
| GEOL | 3322 | 1 | Structural Geology II | 5 | 2C | 3L | | | GEM | 324 | Structural Geology II |
| | | | | | | | | | CIV | 426 | Coastal Engineering |
| GEOL | 3703 | 1 | Field School (2 Weeks) | 7 | | | | | GEM | 300 | FIELD SCHOOL |
| | | | All of | 25 | | | | | | | |
| | | | 2 complementary Studies Electives (6 ch) | 6 | | | | | | | |
| GE | 5153 | 2 | * Waste Geotechnics | 4 | 3C | 3L | | | CIV | 413 | Environmental Engineering I (Rename?" Waste Geotechnics)" |
| CE | 5113 | 2 | * Soil Mechanics II | 4 | 3C | 2L | | | CIV | ? | Soil Mechanics II (CIV 222 Upgraded) |
| CE | 5132 | 2 | * Foundation Engineering II | 3 | 3C | | | | CIV | 427 | Geotechnics II (Foundation Engineering II) |
| CE | 5141 | 2 | * Embankments I | 3 | 3C | | | | CIV | 415 | Highway Engineering (Restructure "Embankments I") |
| CE | 5201 | 2 | Road materials and structures | 4 | 3C | 2L | | | CIV | 415 | Highway Engineering (Restructure to "Road Materials and Structures") |
| CE | 5212 | 2 | Pavement Design | 4 | 3C | 3L | | | CIV | 415/211 | Highway Eng./ Eng. Materials (Restructure to "Pavement Design") |
| CE | 5603 | 2 | Construction Equipment and Methods | 4 | 3C | 1T | | | CIV | 420 | Civil Engineering, Construction & Maintenance |
| CE | 5623 | 2 | Project Management | 4 | 3C | 1T | | | EMN | 221 | Supervisory Management (With increased emphasis on "Project Management") |
| GE | 4432 | 2 | Rock Mechanics Design | 5 | 2C | 3L | | | MEC | ? | Rock Mechanics Design . (Restructured from "Mechanics" & "Strength of Materials"). |
| GEOL | 4501 | 2 | Exploration Geophysics II | 5 | 3C | 2L | | | GEM | 428 | Applied Geophysics II (Electrical and Seismic Methods) |
| | | | 11 of | 40 | | | | | | | |
| | | | 163 Credit Hours from Electives | 164 | | | | | | | |
| | | | TOTAL Credit Hours | 206 | | | | | | | |
| **Mineral Resources Engineering (OPTION 3)** | | | | | | | | | **Mineral Resources Engineering (OPTION 3)** | | |
| GE | 4442 | 1 | Mineral Resources Utilization | 5 | 3c | 2l | | | MIN | 425 | Mineral Resources & the Environment |
| GEOL | 3322 | 1 | Structural Gepology II | 5 | 2C | 3L | | | GEM | 324 | Structural Geology II |
| GEOL | 4461 | 1 | Economic Geology I | 5 | 2C | 3L | | | GEM | 225 | Economic Geology I (Mineral Deposits I) |
| GEOL | 4472 | 1 | Economic Geology II | 5 | 2C | 3L | | | GEM | 325 | Economic Geology II (Mineral Deposits II) |
| GEOL | 4501 | 1 | Exploration Geophysics II | 5 | 3C | 2L | | | GEM | 428 | Applied Geophysics II (Electrical and Seismic methods) |
| | | | | | | | | | GEM | 326 | Applied Geochemistry |
| | | | | | | | | | GEM | 412 | Petroleum Geology |
| GEOL | 3703 | 1 | Field School (2 Weeks) | 7 | | | | | GEM | 300 | Field School (2 Weeks) |
| | | | All of | 25 | | | | | | | |
| | | | 2 complementary Studies Electives (6 ch) | 6 | | | | | | | |
| CE | 5132 | 2 | * Foundation Engineering II | 3 | 3C | | | | CIV | 427 | Foundation Engineering II. (Restructured from Geotechnics II) |
| | | | | | | | | | CIV | 426 | Engineering Hydrogeology (Resructured Course) |
| CE | 5141 | 2 | * Embankments I | 3 | 3C | | | | CIV | 415 | Highway Engineering (Restructure "Embankments I") |
| CE | 5201 | 2 | * Road materials and structures | 4 | 3C | 2L | | | CIV | 415 | Highway Engineering (Restructure to "Road Materials and Structures") |
| CE | 5212 | 2 | * Pavement Design | 4 | 3C | 3L | | | CIV | 415/211 | Highway Eng./ Eng. Materials (Restructure to "Pavement Design") |
| CE | 5603 | 2 | * Construction Equipment and Methods | 4 | 3C | 1T | | | EMN | 420 | Civil Engineering, Construction & Maintenance |
| CE | 5623 | 2 | Project Management | 4 | 3C | 1T | | | EMN | 221 | Supervisory Management (To include PM) |
| CE | 5153 | 2 | Waste Geotechnics | 4 | 3C | 3L | | | CIV | 413 | Environmental Engineering I (Rename?" Waste Geotechnics)" |
| | | | | | | | | | ENV | 411 | Environmental Impact Assessment & Ecology |
| | | | 4 of | 26 | | | | | | | |
| | | | 164 Credit Hours from Electives | 164 | | | | | | | |
| | | | TOTAL Credit Hours | 206 | | | | | | | |

* One of these courses must be taken to meet the degree requirements.

# TABLE 2: Course correlations (UG versus UNB) Part B
# (PROPOSED B.Sc. E. CURRICULUM )

| FOUNDATION & CORE COURSES | | | | | | | | | FOUNDATION & CORE COURSES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| UNB | | | | Ch | | | | | | | |
| CHEM | 1882 | 1 | General Chemistry | 4 | 3C | 3L | | | CHM | 111 | General Chemistry |
| CE | 2023 | 2 | Mechanics of Materials | 2 | 3c | 3L | | | CIV | 210 | Building Structure I |
| CE | 1013 | 1 | Applied Mechanics (Statics) | | 3C | 1T | | | MEC | 113 | Mechanics I |
| GE | 2022 | 2 | Engineering Geology | 4 | 3C | 3L | | | GEM | 217 | Engineering Geology |
| CE | 3113 | 3 | Soil Mechanics | 3 | 3C | 3L | | | CIV | 222 | Soil Mechanics |
| CE | 2703 | 2 | Intro. To Fluid Mechanics | 5 | 3C | 1T | | | CIV | 213/223 | Fluid Mechanics I &II (Merged) |
| CE | 4613 | 4 | Construction Engineering | 2 | 3C | | | | CIV | 310 / 410 | Geotech./Civil Enging. Construction & Maint. (Restructure and rename) |
| CE | 3713 | 3 | Hydraulics and Hydrology | 4 | 3C | 3L | | | CIV | 311/321 | Hydrology and Hydraulic Engineering (Restructure to separate courses) |
| EE | 1713 | 1 | Electricity & Magnetism | 3 | 3C | 1T | 3L* | | ELE | 111/121 | Electrical Fundamentals I & II |
| MATH | 1013 | 1 | Intro Calculus I | 3 | 4C | | | | EMT | ? | Calculus I (New course) |
| MATH | 2503 | 2 | Calculus and Linear Algebra for Engineers I | 6 | 3C | 1T | | | EMT | 211 | Engineering Maths III |
| CS | 1003 | 1 | Intro to computer programing in Fortran | 5 | 3C | 1T | 2L | | EMT | 122 | Introduction to Computers and Computing |
| MATH | 1003 | 1 | Intro to Calculus II | 2 | 4C | | | | EMT | 311 | Calculus II (New Course needed by restructuring old courses) |
| MATH | 2513 | 2 | Calculus and Linear Algebra for Engineers II | 3 | 3C | 1T | | | EMT | 211 | New Course needed (Math restructured and renamed) |
| CE | 3973 | 3 | Technical Communications | 3 | 2C | 3L | W | | ENG | 123 | Technical Communications and Clear Writing |
| GE | 1026 | 1 | Geology Lab for Geological Engineers | 3 | 3L | | | | GEM | 111 | General Geology |
| GEOL | 1001 | 1 | The Earth: its origin, evolution and age | 2 | 3C | | | | GEM | 111 | General Geology |
| GEOL | 2142 | 2 | Chemistry & Physics of Minerals | 5 | 3C | 3L | | | GEM | 122 | Mineralogy I (Crystallography & Descriptive Mineralogy) |
| GEOL | 2131 | 2 | Crystallography & Mineralogy | 4 | 2C | 3L | W | | GEM | 212 | Mineralogy II (Optical Mineralogy) |
| GEOL | 2321 | 2 | Structural Geology I | 5 | 2C | 3L | | | GEM | 214 | Structural Geology I |
| GEOL | 4512 | 4 | Exploration Geophysics I | 3 | 3C | 2L | | | GEM | 328 | Applied Geophysics I (Magnetic, Radiometric & Gravity Methods) |
| GEOL | 2212 | 2 | Sedimentology I | 5 | 2C | 3L | | | GEM | 311 | Sedimentology |
| GEOL | 2602 | 2 | Principles of Geochemistry | 5 | 3C | 3L | W | | GEM | 316 | Principles of Geochemistry |
| GEOL | 3131 | 3 | Igneous & Metamorphic Petrology | 4 | 2C | 3L | W | | GEM | 313/323 | Igneous Petrology/Metamorphic Petrology (Combined to match) |
| ME | 1113 | 1 | Applied Mechanics II : Dynamics | 4 | 3C | 1T | | | MEC | 123 | Mechanics II |
| ME | 1003 | 1 | Engineering Graphics | 3 | 2C | 3L | | | MEC | 111 | Engineering Drawing I |
| GEOL | 3411 | 3 | Rock Mechanics | 5 | 3C | 2L | W | | MEC | 123/224 | Restructured from "Mechanics/Strength of Materials" |
| STAT | 2953 | 2 | Probability and Statistics for Engineers | 3 | 3C | | | | MIN | 422 | Probability and Statistics for engineers |
| PHYS | 1913 | 1 | Fundamentals of Physics (For Engineers) | 4 | 3C | 1T | | | PHY | 110 | Physics for Engineers |
| PHYS | 1918 | 1 | Physics Lab for Engineers | 3 | 3L | | | | PHY | 110 | Physics for Engineers. |
| GGE | 1803 | 1 | Practicum for Civil Engineers (2 weeks) | 5 | | | | | SRV | 111 | Engineering Surveying I & II Merged (2 weeks field training on Campus) |
| ECON | 1073 | 1 | Economics for Engineers | 4 | | | | | | | Economics Course to be given consideration by UG |
| ENGL | 1103 | 1 | Fundamentals of Clear writing | 4 | 3 | | W | | ENG | 123 | Merged with ENG 123 |
| GGE | 1001 | 1 | Intro to Geodesy & geomatics | 3 | 3C3l | | | | SRV | III/IV | Surveying III & IV merged |
| GEOL | 2703 | 2 | Field School (14 Days) | 5 | | | W | | | | Field School |
| CE | 3933 | 3 | Numerical Methods for Civil Engineers | 5 | 3C | | | | EMT | 321 | Numerical Analysis and Computing. |
| CE | 3963 | 3 | Engineering Economy | 3 | 3C | | | | EMN | 311(?) | Engineering Economy and Management |
| GGE | 3342 | 3 | Imaging and Mapping I | 5 | 3C | 3L | | | GEM | 317 | Remote Sensing |
| CE | 4003 | 4 | The Engineering Profession (or equivalent) | 5 | 2C | | | | | | Exists in other Engineering Courses (Consider separate course) |
| GE | 4983 | 4 | Senior Report I | 3 | | | W | | | | Project I |
| GE | 4993 | 4 | Independent Studies in Geology | 8 | | | | | | | Independent Study |
| GGE | 4403 | 4 | Geographic Information Systems | 5 | 2C | 3L | | | GEO | 314 | Geographic Information Sysyems |
| LAW | 5002 | 5 | Common Law for Engineers | 4 | | | | | | | Exists in other Engineering Courses (Consider separate course) |
| | | | | | | | | | ENV | 222 | Nature Conservation and Management |
| (69 Courses) | | | | | | | | | ENV | 311 | Environmental Chemistry I |
| | | | | | | | | | ENV | 411 | Environmental Impact Assessment & Ecology |
| | | | | | | | | | GEM | 228 | Environmental Geology/Techniques |
| | | | | | | | | | MIN | 112 | Surface Mining I |
| | | | | | | | | | MIN | 215 | Mineral Processing I |
| | | | | | | | | | GEM | 226 | Introduction to Mineral Exploration |
| | | | | | | | | | CIV | 111 | Materials Technology |
| | | | | | | | | | EMN | 221 | Supervisory Management |
| | | | | | | | | | GEM | 223 | Petrology |
| | | | | | | | | | EMT | 111 | Engineering Math I (Algebra and Geometry) |
| | | | | | | | | | EMT | 121 | Engineering Math II (Trigonometry & Advanced Algebra) |
| | | | | | | | | | EMT | 311 | Calculus II (New Course needed by restructuring old courses) |
| | | | | | | | | | AST | 111 | Indigenous People of Guyana |

| COURSE CODES | |
|---|---|
| Alternate Years | A |
| Credit Hours | ch |
| Class Lecture | C |
| Laboratory | L |
| Limited Enrolment | LE |
| Ocassionally Given | O |
| Reading Course | R |
| Seminar | S |
| Tutorial | T |
| English Writing Component | W |
| Work Shop | WS |
| Alternate Weeks | * |

**TABLE 3: Course correlations (UG versus UNB) Part B**
**(PROPOSED DIPLOMA in GEOLOGICAL ENGINEERING CURRICULUM)**

| YEAR ONE Semester One | | | YEAR ONE Semester Two | | |
|---|---|---|---|---|---|
| CHM | 111 | General Chemistry | ELE | 121 | Electrical Fundamentals II (Elec. & Mag.) |
| CIV | 111 | Materials Technology | EMT | 121 | Engineering Mathematics II |
| ELE | 111 | Electrical Fundamentals I (Electricity) | EMT | 122 | Computers and Computing |
| EMT | 111 | Engineering Mathematics I | ENG | 123 | Technical Communication |
| GEM | 111 | General Geology (Focus on Guyana) | GEM | 122 | Crystallography & Descriptive Mineralogy |
| MEC | 111 | Engineering Drawing | MIN | 121 | Surface Mining |
| MEC | 113 | Mechanics I | MEC | 123 | Mechanics II (Dynamics) |
| PHY | 110 | Physics for Engineers | CHM | ? | Chemistry (Additional course selected by UG) |
| | | | | ? | Economics for Engineers (To be Considered) |
| **YEAR TWO Semester One** | | | **YEAR TWO Semester Two** | | |
| CIV | 211 | Engineering Materials II | BIO | 223 | Fundamentals of Ecology |
| CIV | 213 | Fluid Mechanics I | CIV | 222 | Soil Mechanics |
| GEM | 212 | Optical Mineralogy | EMN | 221 | Supervisory Management |
| GEM | 214 | Structural Geology I (Focus on Guyana) | ENV | 222 | Nature Conservation & Management |
| GEM | 217 | Engineering Geology (FoG) | GEM | 223 | Petrology (Focus on Guyana) |
| AST | 111 | Indigineous Peoples of Guyana | GEM | 225 | Economic Geology I (Focus on Guyana) |
| MIN | 215 | Mineral Processing | GEM | 226 | Introduction to Mineral Exploration(FoG) |
| SRV | 111 | Surveying I | GEM | 228 | Environmental Geology |
| GEM | 200 | Field School | | | |

**FoG (TO MAKE COURSE RELEVANT TO GUYANA'S NEEDS)**

## 14. The Case for a post graduate Program in Environmental Management.

The Contractor's Terms of Reference calls for recommendations on the development of a Curriculum for a Postgraduate Diploma / Certificate in Environmental Management Program at the University of Guyana. In this regard, the Contractor would like to suggest that this need will be met under the umbrella of the Proposed Geological Engineering (GE) Program at the University of Guyana. The mention of such a Program and the course descriptions in the Contractor's Terms of Reference (TOR) were the first "clues" that led to the Contractor's suggestion to the stakeholders in Guyana that a Program in Geological Engineering would be preferable over a revamped Geology (Degree) Program as was proposed. All of the courses proposed in the TOR (Section B Item (b) are courses that could be offered in the Geological Engineering Program. These courses could be jointly given by the Geological Engineering staff and the Environmental Sciences Group of UG as they are expected to do under the proposed Geological Engineering Program. The "Environmental Management (EM)" courses could be offered in the *Environmental Option* shown in Figure 1. Further, the "post graduate Program in Environmental Management" was proposed earlier because the initial intent was to have a renewed or revamped Program in Geology where the need for an Environmental Management Program would indeed have been essential. However, in four years time this need will be met by the GE Program when GE graduates would be entering post-graduate school. Careful examination of the proposed courses would show that they "fit perfectly" in the GE Program.

Another point that requires consideration is the fact that attraction of students will become an even greater challenge. In the Consultant's opinion the development of *another environmental oriented Program* at this time may be superfluous and negatively impact cost and resources, not to mention require a well planned promotion and/or marketing strategy which will be needed to attract students into two "competing" programs. The Contractor would like to suggest that the "Business Case" for the Post Graduate Program in Environmental Management needs to be clearly articulated so that the "in-coming" student will have a clear choice as to which option would be preferable based on their expectations. In recommending the proposed Geological Engineering program, the Consultant was examining the greater need of Guyana and the best option for students based on the benefits outlined in Section 9 above. In examining the Business Case for the post graduate program in Environmental Management, faculty should carefully examine the benefits accrued to all parties as previously outlined. The claim made by the Consultant that the GE Program would see present students in Biology, Chemistry and Physics make a switch to that Program (i.e. GE) may be less effective with the introduction of a post-graduate program in EM at this time.

In order to have an appreciation of the challenges involved in introducing two somewhat complementary educational Programs in the same year at the University of Guyana, it is imperative that faculty consult potential students and employers (and sponsors) so that the benefits (pros and cons) of each new program are clearly understood. This consultation process would be imperative as both Programs would impact some of the same members of faculty who would be required to teach the GE Program. In this regard, the Consultant would like to state that in his interviews of stakeholders on his two trips to Guyana it was clearly evident that their (stakeholders') need was for "technically competent" people who would be required to work in the field on a variety of technical problems related to their sector and at the same time ensure that their work is in compliance with environmental regulations. While the EPA, IAST and the GGMC acknowledged the need for greater and better "Environmental Management", it was not evident that the greater "need" was for managers in the public sector (i.e. government) as it was for the private sector where violation (or lack of understanding) of environmental regulations were the major concern. The argument was made time and time again that industry has to "regulate" itself rather than having regulations enforced by government. This would imply, that the greater need in industry and in the public sector was not for "managers" but for technical people cognizant of best environmental practices as would be provided by the GE Program.

However, in the event that UG wishes to pursue the Post-Graduate Program in Environmental Management, the Consultant would like to recommend the following strategy. Further, it may be prudent to delay the post graduate program for the following year so as to allow faculty to focus on one initiative at a time.

## 15. Proposed Curriculum for Post Graduate studies in Environmental Applied Science and Management.

The proposed Curriculum for Post Graduate studies in Environmental Applied Science and Management (EAS&M) follows the model of Ryerson University in Toronto (Appendix C). Pre-requisite for entrance is a Degree in Science or Engineering.

**Master of Applied Science (12 CREDITS):**

Course work (See Appendix C for Course Outlines):

1. EAS&M: Chemical and Biological Pathways (Focus on Guyana) (1 Credit)
2. EAS&M: Environmental Law and Policy (Focus on Guyana) (1 Credit).
3. EAS&M: Seminar in Environmental Applied Science and Management (Focus on Guyana) (1 Credit).

**AND** one of the following two Options:

1. **PROFESSIONAL PROJECT Option (2 Credits)**

**EAS&M Project**: Topic of Project selected by student and approved by EAS&M Program Advisor.

AND seven elective credits, with a minimum of two from Group A and two from Group B (See Appendix C for Course Outlines) (7 Credits):

2. **THESIS Option. (Original Research) (5 Credits)**

**EAS&M Thesis:** Topic and Research area selected by student and approved by EAS&M Program Advisor.

AND four elective credits, with a minimum of one from Group A and one from Group B (See Appendix C for Course Outlines) (4 Credits).

**NOTE:** *Faculty of the EAS&M Program may elect to use the List of Geological Engineering Courses as outlined in TABLES 1 to fulfill the Applied Science requirements of the post graduate program (equivalent to GROUP A of Ryerson)*.

**TABLE 4 Part A**
**Master of Science in Environmental Applied Science and Management**

| **PROJECT OPTION** | | | Credits |
|---|---|---|---|
| **Compulsory** | | | |
| *ES8901 | EAS&M | Chemical and Biological Pathways | 1 |
| ES8921 | EAS&M | Environmental Law and Policy | 1 |
| ES8930 | EAS&M | Seminar in Env. Appl. Science & Mgt. | 1 |
| | | | **3** |
| ES8080 | EAS&M | **PROJECT** | **2** |
| GROUP A Applied Science | EAS&M | (Minimum Two Courses) | 3.5 |
| GROUP B Management | EAS&M | (Minimum Two Courses) | 3.5 |
| | | | **7** |
| | | **TOTAL** | **12** |

| **THESIS OPTION** | | | |
|---|---|---|---|
| **Compulsory** | | | |
| *ES8901 | EAS&M | Chemical and Biological Pathways | 1 |
| ES8921 | EAS&M | Environmental Law and Policy | 1 |
| ES8930 | EAS&M | Seminar in Env. Appl. Science & Mgt. | 1 |
| | | | **3** |
| ES8080 | EAS&M | **THESIS** | **5** |
| GROUP A Applied Science | EAS&M | (Minimum Two Courses) | 2 |
| GROUP B Management | EAS&M | (Minimum Two Courses) | 2 |
| | | | **4** |
| | | **TOTAL** | **12** |

**TABLE 4 Part B**

| | | | Credit | | | |
|---|---|---|---|---|---|---|
| *ES8901 | EAS&M | Chemical and Biological Pathways | 1 | | | |
| ES8921 | EAS&M | Environmental Law and Policy | 1 | | | |
| ES8930 | EAS&M | Seminar in Env. Appl. Science & Mgt. | 1 | | | |
| | | | **3** | | | |
| **ELECTIVES** | | | | | | |
| **Group A: Environmental Applied Science** | | | **Credits** | | | |
| *ES8902 | EAS&M | Water Pollution Control Processes | 1 | **CIV** | **322** | |
| *ES8903 | EAS&M | Pollution Prevention | 1 | | | New |
| *ES8904 | EAS&M | Waste Management | 1 | **CIV** | **413** | |
| ES8905 | EAS&M | Air Pollution Science and Engineering | 1 | | | New |
| ES8906 | EAS&M | Water Pollution Transport | 1 | **CIV** | **322** | |
| ES8907 | EAS&M | Wastewater Engineering | 1 | **CIV** | **424** | |
| ES8908 | EAS&M | Soil Remediation | 1 | **CIV** | **222** | Upgraded |
| ES8909 | EAS&M | Environmental Biotechnology | 1 | **BIO** | **223** | |
| *ES8910 | EAS&M | Energy and the Environment | 1 | | | |
| **Group B: Environmental Management** | | | | | | |
| ES8922 | EAS&M | GIS for Environmental Management | 1 | **GEO** | **314** | |
| ES8923 | EAS&M | Environmental Assessment | 1 | **ENV** | **411** | |
| ES8924 | EAS&M | Environmental Management Systems | 1 | **ENV** | **411** | |
| ES8925 | EAS&M | Decision Making/Strategic Plan. In Mgt. | 1 | **EMN** | **221** | |
| ES8926 | EAS&M | Environmental Economics | 1 | | | New |
| ES8927 | EAS&M | Risk Assessment in Environmental Mgt. | 1 | | | New |

**NOTE**:
*The subject matter of most of the EAS&M courses above are covered in the present Geological Engineering courses to be provided at UG in the coming year. The Science Faculty of UG who are planning to introduce the post graduate program in Environmental Management should therefore work very closely with GE Program staff so that the GE courses developed could also be used to meet the Group A credits required in the post graduate Environmental Management program. This will make the transition easier for both programs to be implemented at UG.*

## 16. Certification of staff of Stakeholders in recognition of Training done under GENCAPD.

In recognition of the training of stakeholders' staff under the GENCAPD program, Certificates were presented to the trainees by GENCAPD and by the consulting company, Jacques Whitford & Associates Ltd. (JWAL) of Fredericton, New Brunswick, Canada. Trainees who are desirous of receiving accreditation from the University of Guyana for the GENCAPD training will be offered the opportunity of writing a comprehensive examination at the University in 2004. The examination will be based on the

Curriculum developed and used by JWAL for the GENCAPD training program. Copies of the Curriculum are available from the GENCAPD Office at the Guyana Gold and Mining Commission (GGMC) on Brickdam Street, Georgetown. The examination will take place at the University of Guyana at a time to be advertised.

# APPENDIX A

This Appendix contains the List of Core Courses which is used in teaching the Geological Engineering Program at the University of New Brunswick (UNB).

NOTE:

1. UNB Course Descriptions are shown in Black

2. Course Headings shown in ***Green*** or ***Italic*** (UG Courses) denote that a match was found with UG Courses in the Lists provided to the Consultant. It is recommended that the UG Courses be restructured and in some cases be Renamed in order to have a recognized GE Curriculum at UG.

# APPENDIX A
## University of New Brunswick
## GEOLOGICAL ENGINEERING COURSES

**BIOL 2113 Ecology 3 ch (3C)**
***BIO 223***
Introduces concepts of ecology common to terrestrial, fresh water and marine ecosystems. Provides a basis for further ecological or environmental studies.

**CE 1013 Applied Mechanics I: Statics 4 ch (3C 1T)**
***MEC 113***
This course is designed to introduce first year engineering students to the fundamental concepts of two- and three-dimensional force systems. Related concepts such as centroids and moments of inertia are also introduced. Practical applications include frames, machines, trusses and beams.

**CE 2023 Mechanics of Materials 5 ch (3C 3L)**
***CIV 210***
Elastic and plastic stress, strain; behaviour of beams and columns; torsion; material strength. Prerequisite: CE 1013. Co-requisite: MATH 1013.

**CE 2703 Introduction to Fluid Mechanics 3 ch (3C)**
**CIV 213/223**
Physical properties of liquids and gases, fluid statics, kinematics of fluid flow, energy considerations in steady flow, momentum and dynamic forces in fluid flow, fluid measurements, introduction to forces on immersed bodies. Prerequisites: CE 1013, MATH 1013.

**CE 3113 Soil Mechanics I 4 ch (3C 3L)**
***CIV 222***
Consolidation, shear strength, stresses under loaded areas, effects of water on soil behaviour. Prerequisite: GEOL 1001, GEOL 1026, CE 2023. Co-requisite: CE 2703 or CHE 2703.

**CE 3713 Hydraulics and Hydrology 5 ch (3C 3L)**
***CIV 311/321***
Water flow in pipes; computer-based analysis of pipe networks; characteristics of pumps; open channel flow; similitude and dimensional analysis. The hydrological cycle; precipitation, runoff and hydrograph analysis; the rational method; flood and drought frequency analysis; groundwater flow. Prerequisites: CE 2703 or CHE 2703.

**CE 3933 Numerical Methods for Civil Engineers 3 c (3C)**
***EMT 321***
Numerical methods appropriate to the solution of deterministic problems in civil engineering. Considers root finding, interpolation, integration, solution of systems of algebraic equations, ordinary and partial differential equations. Prerequisites: CS 1003 or equivalent, MATH 2503.

**CE 3963 Engineering Economy 3 ch (3C)**
***EMN 311***
Basic methods of engineering economy including time value of money, compound interest models, interest and discount rates, and depreciation; critical path methods. Emphasis is placed on commonly used computational procedures. Restricted to students with at least 60 ch completed. Prerequisites: CS 1003 or equivalent.

**CE 3973 Technical Communications 4 ch (2C 3L) {W}**
***ENG 123***
Written, oral and visual communications are covered. Written communication skills are enhanced through the preparation of engineering documents. Oral communications topics include public speaking and rules of order for conducting a meeting. Visual communications include the uses of videotape equipment, preparation of transparencies and slides for projection, and preparation and projection of computer generated images. Students are responsible for organizing a technical conference. Restricted to students

with at least 90 ch completed. Prerequisites: CE 1003, ENGL 1103.

**CE 4003 The Engineering Profession 2 ch (2 C) {W}**

***Exists in other UG CIV Courses. UG to consider a similar course with the help of GAPE.***

Institutional structures of engineering in Canada, the code of ethics for engineering, by-laws of the provincial association of professional engineers, personal responsibility and personal liability of the employee-engineer are considered. Presentations are made by practicing professional engineers and other invited lecturers to assist the students with integrating the social, legal, economic, aesthetic and other non-technical aspects into engineering. Restricted to students with at least 135 ch completed in the Engineering degree programme. CE 4003, CHE 4003, EE 4003, GGE 4003 and ME 4003 are equivalent.

**CE 4613 Construction Engineering II 3 ch (3C)**

***CIV 310/410 (To be restructured and renamed)***

Construction of temporary works and construction methods. Includes excavations, trenches, stabilization, sheet piling, cofferdams, formwork, falsework, scaffolding, failure and accident statistics, costs and liability. Emphasis on application of the NB Occupational Health and Safety Commission Act and Regulations to construction. Restricted to students with at least 110 ch completed. Prerequisites: CE 2603.

**CE 3403 Introduction to Environmental Engineering 3 ch (3C)**

***CIV 413***

Introduces the problems and principles of control or modification of the environment. Considers an environmental dimension to all planning, design and analysis functions carried out by engineers. Restricted to students with at least 60 ch completed.

**CE 5753 Engineering Hydrogeology 4 ch (3C 3L)**

***CIV 426***

Covers important topics in quantitative hydrogeology, including: principles of saturated and unsaturated groundwater flow, solutions to groundwater flow problems, well hydraulics and pumping tests, introductory groundwater geochemistry, and contaminant migration and attenuation processes in groundwater. Prerequisites: CE 2703 or CHE 2703, GEOL 1001, GEOL 1026.

**CE 5113 Soil Mechanics II 4 ch (3C 2L)**

***CIV 222 (To be upgraded)***

Soil mechanics principles, elastic and plastic stress conditions, arching, compression and consolidation, bearing capacity, stability, drainage. Prerequisites: CE 3123.

| CE 5141 | Embankments I | 3 ch (3C) |
|---|---|---|

***CIV 415***

Engineering for earthfill structures such as dams, dykes, causeways and other embankment structures employed in civil engineering projects. Prerequisites: CE 3113.

| CE 5201 | Road Materials and Structures | 4 ch (3C 2L) |
|---|---|---|

***CIV 415***

Soil classification, compaction, and stabilization for optimum use in road construction. Structural and hydraulic aspects of small scale drainage systems for roads. Prerequisites: CE 3113, CE 3713.

| CE 5153 | Waste Geotechnics | 4 ch (3C 3L*) |
|---|---|---|

***CIV 413***

Design of sanitary landfills, with emphasis on clay liners and composite liners. Properties of geosynthetics. Geotechnical properties of municipal solid waste. Landfilling procedures. Hydrological evaluation of sanitary landfills. Site selection. Prerequisites: CE 3123.

| CE 5432 | Wastewater Treatment and Pollution Control | 4 ch (3C, 2L) |
|---|---|---|

***CIV 322***

Applied wastewater microbiology, wastewater analysis (physical, chemical, and biological), wastewater treatment processes, industrial and municipal wastewater treatment and management, wastewater treatment systems and plant design. The course content will focus on treatment and management issues of wastewater from industrial, municipal, and domestic sources. Pollution control strategies and protocols are also examined. Prerequisites: CHEM 1882 (or equivalent) and CE 3403 or CHE 2004, or permission of course instructor.

| CE 3123 | Foundation Engineering I | 4 ch (3C 1T) |
|---|---|---|

***CIV 310***

Lateral earth pressures, shallow and deep foundations, stability of cuts and slopes. Prerequisites: CE 3113.

| CE 5132 | Foundation Engineering II | 3 ch (3C) |
|---|---|---|

***CIV 427***

A continuation of earlier soils engineering courses dealing with shallow foundations (including design of reinforced concrete footings), deep foundations, excavations, cofferdams and factors relating to foundation design. Prerequisites: CE 3123.

| CE 5212 | Pavement Design I | 4 ch (3C 3L) |
|---|---|---|

***CIV 415/211 (To be restructured and renamed)***

A study of the design and construction of highway pavements. Production and testing of bituminous materials, design of bituminous mixtures, thickness design for flexible pavements, design of rigid pavements, and construction methods. Prerequisites: CE 3113.

| CE 5603 | Construction Equipment and Methods<br><br>***CIV 420*** | 4 ch (3C 1T) |
|---|---|---|

The use and application of equipment in the construction industry; engineering fundamentals applicable to construction engineering and management practice. Lifting, excavating, transporting, compacting and tunneling equipment; equipment finances, costs and economics are covered. Application of computers in construction equipment and methods. Restricted to students with at least 110 ch completed. Prerequisites: CE 2603.

| CE 5623 | Project Management | 4 ch (3C 1T) |
|---|---|---|

***EMN 221***

Application of management methods for construction projects. Emphasis on supervisory management, contracts, and management methods. Application of critical path methodology for work organization and management control, including planning and scheduling, resource management, optimization techniques and cost control methods. Restricted to students with at least 110 ch completed. Prerequisites: CE 2603.

| CHEM 1882 | General Chemistry-Physical and Inorganic Chemistry | 5 ch (3C 3L) |
|---|---|---|

***CHM 111***

Intended primarily for non-Science students who require an introduction to physical and inorganic chemistry. Covers chemical equilibria, electrochemistry, thermodynamics and chemical kinetics. WHMIS certification required (see beginning of Chemistry Courses section for details). Prerequisite: CHEM 1801 ("D" grade not acceptable) or 70% in Grade 12 Chemistry.

| CS 1003 | Introduction to Computer Programming | 4 ch (3C 1T 2L) |
|---|---|---|

***EMT 122***

Intended for Science, Applied Science and Engineering students. Introduces the use of digital computers. Includes: problem analysis, algorithm design, and program structure. Use of procedures, loops, and arrays. Debugging and verification of programs. Note: This course may not be taken for credit by CS students. Prerequisite: High School Mathematics.

| | | |
|---|---|---|
| **ECON 1073** | **Economics for Engineers** | **3 ch** |

***Topic covered in other UG CIV Courses.***

***UG to consider separate Course.***

An introductory course designed for students in engineering and computer science programs. Topics covered include price, production and cost theory; aggregate supply, aggregate demand; money and banking; public finance; and international economics. Open only to engineering and computer science students.

| | | |
|---|---|---|
| **EE 1713** | **Electricity and Magnetism** | **4 ch (3C 1T 3*L)** |

***ELE 111/121***

An introductory course in basic circuit analysis techniques for all engineering students. Electric charge, electric energy sources, current, voltage, power and energy. Resistors, resistance and the application of Ohm's law, Kirchoff's voltage and current law, D.C. circuit analysis using equivalent resistor techniques, voltage and current division, loop analysis, mesh analysis, nodal analysis, superposition, and the application of Thevenin's and Norton's Theorems. Capacitors, capacitance and analysis of RC networks. Magnetic circuits, magnetic forces in current carrying conductors. Faraday's and Lenz's Laws. Inductors, inductance and analysis of RL networks. Introduction to A. C. circuits.

| | | |
|---|---|---|
| **ENGL 1103** | **Fundamentals of Clear Writing** | **3 ch (3C) [W]** |

***ENG 123***

A study of the basic principles of clear prose writing, focusing on essay structure and organization, paragraph structure, sentence structure, grammar, punctuation, and word choice, as well as revising and proofreading. Students will submit numerous written assignments.

| | | |
|---|---|---|
| **GE 1026** | **Geology Laboratory for Geological Engineers** | **2 ch (3L)** |

***GEM 111***

An introductory study of: minerals and rocks; physics, chemistry and structure of the earth; geological age determination and summary of historical geology; surface processes, subsurface processes; economic geology of Canada.

| | | |
|---|---|---|
| **GE 2022** | **Engineering Geology** | **4 ch (3C 3L)** |

***GEM 217***

A study of geological materials and hazards; site investigations; environmental geology; geothermal resources and exploitation; and case histories of geological problems in engineering projects. Equivalent to GEOL 2022. Prerequisite: GEOL 1001 and GE 1026 or equivalent.

| | | |
|---|---|---|
| **GE 4983** | **Senior Report I** | **4 ch (2C 4L) [W]** |

***PROJECT 1***

Presents some of the approaches used to formulate a proposal for an engineering study. Each student will: present a proposal which will serve as the basis for the Senior Report, commence work on the project with the guidance of an approved supervisor, and submit a substantial written progress report of the work completed. Restricted to students with at least 110 ch completed. Prerequisite: CE 3973.

| | | |
|---|---|---|
| **GE 4993** | **Senior Report II** | **4 ch (1C 6L) [W]** |

***Independent Study***

A written document based on the proposal in Senior Report I. The subject is investigated using all means available to the student with the guidance of an approved supervisor. The student is required to present the subject of the report orally and attend similar presentations by colleagues. Prerequisite: GE 4983.

| GE 4412 | Applied Rock Mechanics | 5 ch (3C 2L) |
|---|---|---|

***MEC ? (Restructured from Mechanics I (Statics)***

Acquisition and use of geological data in the construction of engineering structures sited in rocks. Design of slopes in rock considered both the two and the three dimensional case of sliding failure. Analysis of failed slopes to determine cohesion along the sliding surface. Improvement of rock slopes including the design of rock anchors. Prerequisites: GEOL 1041/1042/1045 or equivalent. Equivalent to GEOL 4411.

| GE 5753 | Engineering Hydrogeology | 4 ch (3C 3L) |
|---|---|---|

***CIV 426***

Covers important topics in quantitative hydrogeology, including: principles of saturated and unsaturated groundwater flow, solutions to groundwater flow problems, well hydraulics and pumping tests, introductory groundwater geochemistry, and contaminant migration and attenuation processes in groundwater. Prerequisites: CE 2703, GEOL 1001, GEOL 1026 or CHE 2703.

| GE 5153 | Waste Geotechnics | 4 ch (3C 3L) |
|---|---|---|

***CIV 413***

Geotechnical testing and investigations; behaviour and analysis of existing and new waste fills (refuse landfills, wood wastes, sludges, tailings and slimes, dumped fills, and others); location of new sites; evaluation of leachate drainage and control; proper placing of fill material and the global fill; closure of refuse fills. Prerequisite: CE 3123.

| GE 4432 | Rock Mechanics Design | 5 ch (2C 3L) |
|---|---|---|

***MEC 123/224 (Restructured from Mechanics and Strength of Materials)***

Classification, description and testing of the rock mass and the measurement of in-situ stress. Stability of underground openings and design of tunnel supports. Prerequisite: GE 4411. Equivalent to GEOL 4432.

| GE 4442 | Mineral Resource Utilization | 5 ch (3C 2L) |
|---|---|---|

***MIN 425***

Mineral exploration, evaluation, exploitation, processing, marketing and conservation.

| GEOL 1001 | The Earth: Its Origin, Evolution and Age | 3 ch (3C) |
|---|---|---|

***GEM 111***

Novas and Supernovas; The Solar Nebula Theory, Castastrophism and Uniformitarianism. Earth as a heat engine. Origin, growth and main features of the Earth's crust. Origin and evolution of oceans, continents and the atmosphere. The rock cycle, seafloor spreading, plate tectonics, mountain building and deformation of the Earth's crust. Earthquakes, igneous and metamorphic processes and their products, including mineral resources. Credit can be obtained for only one of CEOL 1001 or GEOL 1063.

| GEOL 2131 | Mineral Sciences | 5 ch (2C 3L) [W] |
|---|---|---|

***GEM 112***

Introduction to crystallography and x-ray diffraction techniques. Appraisal of the material properties of minerals and selected ceramics. Fundamentals of silicate chemistry and the behaviour of the major rock-forming minerals at varying pressures and temperatures. Laboratories focus on describing the physical properties of the more common minerals and on their identification in hand specimen. Prerequisites: GEOL 1001/1012/1006 or 1017 or equivalent.

| GEOL 2142 | Chemistry and Physics of Minerals | 5 ch (3C 3L) |
|---|---|---|

***GEM 212***

The study of the compositional variability of minerals and the relationship between mineral composition and mineral assemblage, temperature, pressure, volatile fugacity, cooling rates, etc. The major silicate and oxide mineral groups are emphasized. Laboratories emphasize a variety of methods (polarizing microscope, electron microprobe, x-ray diffraction, IR, UV-

VIS and Raman spectroscopy, etc.) for determining the identity, composition and structural state of minerals and crystalline solids. Prerequisite: GEOL 2131.

| | | |
|---|---|---|
| **GEOL 2212** | **Sedimentology I** | **5 ch (2C 3L)** |

***GEM 311***

Weathering and diagenetic processes. Origin, properties and classification of sedimentary rocks. Physical and biogenic sedimentary structures. Sediment transport mechanisms, particularly sediment gravity flows. Stratigraphic principles. Prerequisites: GEOL 1001/1012/1006 or 1017 or equivalent.

| | | |
|---|---|---|
| **GEOL 2321** | **Structural Geology I** | **5 ch (2C 3L)** |

***GEM 214***

Emphasis on description and classification of folds, faults, foliations, lineations and joints, and the use of primary structures. Labs include geological maps and cross sections, and stereographic projection. Prerequisites: GEOL 1001/1012/1006 or 107 or equivalent.

| | | |
|---|---|---|
| **GEOL 2602** | **Principles of Geochemistry** | **5 ch (3C 3L) [W]** |

***GEM 316***

Origin of elements. Theories of the origin and chemical evolution of the earth, atmosphere, and oceans. Laws governing the distribution of elements in the earth. Application of phase diagrams to petrologic problems of the crust and mantle. Chemical weathering. Use of stable and radioactive isotopes in geology. Geobarometry and geothermometry. Hydrothermal process and base-metal ore deposits. Prerequisites: CHEM 1012, 1017 (or equivalent), MATH 1013, GEOL 2131.

| | | |
|---|---|---|
| **GEOL 2703** | **Field School (14 days)** | **6 ch [W]** |

***Field School***

Principles of stratigraphy and geological mapping. Prerequisites: GEOL 1001/1012/1006 or 1017 (or equivalent); GEOL 2131, 2212, and 2321 are recommended. Accommodation expenses are paid by the student.

| | | |
|---|---|---|
| **GEOL 3131** | **Igneous and Metamorphic Petrology** | **5 ch (2C 3L) [W]** |

***GEM 313/323 Combined***

Petrogenesis of igneous and metamorphic rocks with emphasis on their macroscopic textures, mineral associations, classification and field relations. Laboratories concentrate on the identification of the common igneous and metamorphic rocks using hand specimens and thin sections. Prerequisites: GEOL 2142.

| | | |
|---|---|---|
| **GEOL 3411** | **Rock Mechanics** | **5 ch (3C 2L [W]** |

***MEC 123/224 (Restructured)***

An introduction to the deformation and fracture of rocks when subjected to a natural or man-imposed stress field. The concepts of stress, strain, stress-strain relations; creep and strength are applied to geological materials. The mechanisms involved in the failure of continuous, discontinuous and layered rocks are discussed. Prerequisites: GEOL 1001/1012/1006 or 1017 or approved equivalent.

| | | |
|---|---|---|
| **GEOL 4512** | **Exploration Geophysics II** | **5 ch (3C 2L)** |

***GEM 328***

Introduction to principles, survey procedures and interpretation techniques of the electrical and seismic methods of geophysical exploration. The application of these methods is illustrated by examples from exploration of mineral deposits or engineering geology.

| | | |
|---|---|---|
| **GEOL 3442** | **Environmental Geology** | **3 ch (2C 1S) [W]** |

***CIV 423***

The role of geology in the management of our environment. Largely seminar-based with guest lecturers. Prerequisites: GEOL 1001/1012/1006 or 1017 or approved equivalent.

| GEOL 3631 | Geochemistry of Natural Waters | 5 ch (3C, 3L) [W] |
|---|---|---|

***GEM 311***

The principals of chemical equilibria, reaction kinetics and transport applied to natural water systems. Chemical weathering and diagenesis. Chemistry of surface waters, ground water and the oceans. Geochemical cycles. Applications to environmental problems. Labs include chemical analysis of water, carbonate equilibria and geochemical modeling. Prerequisites: GEOL 2602 or GEOL 1001/1012/1006 or 1017, CHEM 2201, CHEM 2111.

| GEOL 3713 | Environment Geology Field School (two weeks) | 6 ch |
|---|---|---|

***GEM 300***

Principles of surficial geology and field sampling of water and recent sediments. Prerequisites: GEOL 2703, GEOL 3441, GEOL 3631.

| GEOL 4452 | Environment Impact Assessment | 5 ch (3C 3L) |
|---|---|---|

***ENV 411***

Baseline assessment studies and site evaluation. Risk/benefit analysis. Overview of relevant environment legislation. Selected case studies. Prerequisites: GEOL 3442.

| GEOL 3322 | Structural Geology II | 5 ch (2C 3L) |
|---|---|---|

***GEM 324***

Stress and strain, introduction to deformational behaviour of rocks. Origin of folds, foliations, lineations, joints and faults. Geometrical analysis. Labs will include simple experiments and advanced map problems. Prerequisites: GEOL 2321, GEOL 3131.

| GEOL 3703 | Field School (two weeks) | 7 ch |
|---|---|---|

***GEM 300***

Principles of structural geology and geological mapping. Provides two weeks supervised training in field work and preparation of an independent structural map and report of a selected area. At least the cost of accommodation expenses are paid by the student. Prerequisites: GEOL 2703, 2321, 3322.

| GEOL 4501 | Exploration Geophysics I | 5 ch (3C 2L) |
|---|---|---|

***GEM 428***

Introduction to the principles, survey procedures and interpretation techniques of the gravity and magnetic methods of geophysical exploration. Examples of regional, geological and structural problems are used.

| GEOL 4461 | Economic Geology I | 5 ch (2C 3L) |
|---|---|---|

***GEM 225***

General features of mineral deposits, their origin, localization and classification, with emphasis on exploration, evaluation and development. Prerequisite: GEOL 3131 or approval of instructor.

| GEOL 4472 | Economic Geology II | 5 ch (2C 3L) |
|---|---|---|

***GEM 325***

Advanced features of mineral deposits, their origin, localization and classification, with emphasis on exploration, evaluation and development. Prerequisite: GEOL 3131 or approval of instructor.

| | | |
|---|---|---|
| **GGE 1001** | **Introduction to Geodesy and Geomatics** | **5 ch (3C 3L)** |

***SRV III/IV Merged***

Introductory geodesy and geomatics. Measuring geometry (surveying, hydrography, satellite positioning, navigation, photogrammetry). Understanding measurements (introductory uncertainty & estimation theory). Managing geographic information. Applications of geomatics techniques, including creation of topographic plans from electronic total stations.

| | | |
|---|---|---|
| **GGE 1803** | **Practicum for Civil Engineers** | **2 ch** |

***SRV 111***

Two weeks of practical exercises following spring examinations. Involves optical distance measurement; trigonometric heighting; taping; balancing angles, height differences, traverses; horizontal circular curves; vertical curves; area & volume computations; stream gauging; elementary photogrammetry. Prerequisite: GGE 1001 or equivalent.

| | | |
|---|---|---|
| **GGE 3342** | **Imaging and Mapping I** | **5 ch (3C 3L)** |

***GEM 317***

Overview and physical basis of remote sensing. Space- and air-borne sensor systems, active and passive sensors. Fundamental geometry of photogrammetry. Image statistics. Rectification of digital imagery. Image enhancement, spectral and spatial filtering. Multi-spectral transformations. Thematic information extraction, classification and accuracy assessment, change detection. Credit will be given for only one of GGE 3342 or GGE 5342. Prerequisite: GGE 2413 or permission of instructor.

| | | |
|---|---|---|
| **GGE 4403** | **Geographic Information Systems** | **4 ch (2C 3L)** |

***GEO 314***

Applications of hardware and software components of geographical information systems (GIS). GIS functions and architecture. Characteristics of GIS data structures and database management systems. Introduction to spatial modeling and analysis. GIS data integration and standards. Prerequisites: CS 1013 or CS 1083, GGE 2413 or permission of instructor.

| | | |
|---|---|---|
| **LAW 5002** | | |

***Topic covered in UG courses***
***Separate course for Engineers required at UG***

| | | |
|---|---|---|
| **MATH 1003** | **Introduction to Calculus I** | **3 ch (4C)** |

***EMT 311***

Functions and graphs, limits, derivatives of polynomial, log, exponential and trigonometric functions. Curve sketching and extrema of functions. NOTE: Credit will not be given for both MATH 1003 and 1823. Prerequisite: A minimum grade of 60% in New Brunswick Advanced Mathematics 120 or equivalent, and a passing score on the Department of Mathematics & Statistics placement test.

| | | |
|---|---|---|
| **MATH 1013** | **Introduction to Calculus II** | **3 ch (4C)** |

***EMT 311 (To be restructured)***

Definition of the integral, fundamental theorem of Calculus, techniques of integration. Improper integrals. First order O.D.E.'s. Taylor polynomials. Complex numbers. Conic sections. Prerequisite: A grade of C or higher in MATH 1003.

| | | |
|---|---|---|
| **MATH 2503** | **Calculus and Linear Algebra for Engineers I** | **3 ch (3C 1T)** |

***EMT 211***

Ordinary differential equations, infinite series, linear algebra. See notes following MATH 2003 and MATH 1833. Prerequisite: A grade of C or higher in MATH 1013.

| | | |
|---|---|---|
| **MATH 2513** | **Calculus and Linear Algebra for** | **3 ch (3C 1T)** |

| | | |
|---|---|---|
| | **Engineers II** | |

***EMT 211 (Restructured)***

Vectors, functions of several variables, polar coordinates and parametric curves, multiple integrals. See note following MATH 2003. Prerequisite: A grade of C or higher in MATH 1013.

| | | |
|---|---|---|
| **ME 1003** | **Engineering Graphics** | **4 ch (2C 3L)** |

***MEC 111***

Engineering drafting is introduced through technical sketching, instrument drawing, and computer aided methods. Fundamentals of manual drafting: use of instruments, scales, lettering, and line styles. Standard drawing types, multi-views, isometrics, pictorials, assembly drawings, cross-sections. Graphics symbols for fasteners, welding, tolerancing and surface finish specification; dimensioning. Use of a commercial CAD software package. The link between manual methods and computer methods is developed. Descriptive geometry and spatial analysis to establish relationships between three-dimensional objects, lines, points or planes, are examined in detail. Drafting is emphasized as a communications medium to convey highly technical information and images in a concise and universally recognized format. Upon successful completion of the course the student will be capable of productive work in a drafting environment.

| | | |
|---|---|---|
| **ME 1113** | **Applied Mechanics II: Dynamics** | **4 ch (3C 1T)** |

***MEC 123***

Vector analysis is introduced and applied to the kinematics and dynamics of particle motion along straight and curved paths. Newton's second and third laws, work, energy and momentum of particles are reviewed. Moments of area and inertia. Rotation of a rigid body around a fixed axis. Motion of a rigid body in a plane. Energy, momentum and angular momentum of a rigid body in plane motion. Simple harmonic motion. Prerequisites: CE 1013, MATH 1917 or equivalent. Co-requisite: MATH 1013.

| | | |
|---|---|---|
| **PHYS 1913** | **Fundamentals of Physics (for Engineers)** | **3 ch (3C 1T)** |

***PHY 110***

Vectors, kinematics. Momentum, force, KE and PE. Simple Harmonic Motion. Standing waves. Kinetic theory of gases. Circular orbits. Gravitation. Electrostatics. Charge, electric field and potential. Atomic structure. Prerequisites: At least 70% in two years of high school Physics plus Grade 12 Mathematics. Students with less than 70% in two years of high school Physics plus Grade 12 Mathematics must take PHYS 1940 instead. Students with less than 80% in two years of high school Physics and Grade 12 Mathematics should take PHYS 1913 in second term.

| | | |
|---|---|---|
| **PHYS 1918** | **Physics Laboratory (for Engineers)** | **2 ch (3L) [W]** |

***PHY 110***

Weekly exercises in practical physics, covering topics in mechanics, electrostatics and atomic physics. Corequisite: PHYS 1913.

| | | |
|---|---|---|
| **STAT 2953** | **Probability and Statistics for Engineers** | **3 ch (3C)** |

***MIN 422***

Probability: Elementary Notions, Discrete and Continuous Distributions, Characteristics of Distribution. Statistics: Sampling, Estimation and Hypothesis Testing, Curve Fitting, Quality Control. Prerequisite: MATH 1013. Note: Credit can be obtained in only one of STAT 1213, 2043, 2253, 2263, 2264, 2593.

# APPENDIX B

This Appendix contains a list of courses taken mostly from the Faculty of Technology department of the University of Guyana **(Black text)**. Courses (Numbers and Descriptions) from the UNB Geological Engineering Program which "match" or "fit well" with these UG courses, have been inserted under the UG Course numbers and above the UG Course description. The UNB Course Numbers and description are shown in ***italic*** or in **red text.**

NOTE:

The List has been developed so that UG Faculty and Lecturers can see the comparison between their present courses and the requirement of the Geological Engineering Program. They could also make the appropriate "tweaks" or changes in their respective course material to suit the Proposed Curriculum in Geological Engineering. It will also help teachers of the courses in determining if their present Course should be updated or changed to meet the new demand.

# APPENDIX B
## UG FACULTY OF TECHNOLOGY

**AST 111 Indigenous People of Guyana (Arts Faculty)**
**Taken from the Arts department of UG.**

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**BIO 223 Fundamentals of Ecology**

***BIOL 2113 Ecology 3 ch (3C)***
*Introduces concepts of ecology common to terrestrial, fresh water and marine ecosystems. Provides a basis for further ecological or environmental studies.*

Basic ecological principles and concepts. The ecosystem concept and biogeochemical cycles, limiting factors, energy in ecosystems, population and community ecology. An introduction to basic ecological methods and analysis. Applications of basic ecological principles in human activities are addressed

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**CHM 111 General Chemistry**

| | | |
|---|---|---|
| ***CHEM 1882*** | ***General Chemistry - Physical and Inorganic Chemistry*** | ***5 ch (3C 3L)*** |

*Intended primarily for non-Science students who require an introduction to physical and inorganic chemistry. Covers chemical equilibria, electrochemistry, thermodynamics and chemical kinetics. WHMIS certification required (see beginning of Chemistry Courses section for details). Prerequisite: CHEM 1801 ("D" grade not acceptable) or 70% in Grade 12 Chemistry.*

Introduction to science and measurement; Elementary theory of the structure of the atom; the Periodic Table; Specification, Quantification and Reactions of matter; Structure & Bonding; Kinetic Theory of matter and Gas Laws. The liquid and Solid states; the reason (energetics), the aim (equilibria) and the rate (Kinetics) of chemical change; classification, combination and separation of matter.

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**CHM 122 – General Chemistry IA**
**(Additional course requested by UG)**

Thermochemistry and elementary chemical thermodynamics; Chemical kinetics; Chemical equilibrium (general concepts); solubility equilibrium; acid-base equilibrium; redox equilibrium and electrochemistry; phase equilibrium.

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**CIV 111 – Materials Technology I**

- Composition and manufacture of Portland Cement
- Hydration, setting and hardening of cement
- Types of cement and their properties; Admixtures of Portland cement
- Classification of aggregates; Sources and production processes
- Properties and characteristics of aggregates; factors affecting properties
- Grading of aggregates
- Properties of concrete in the plastic state: consistency; workability, uniformity; segregation and bleeding; Factors affecting properties
- Curing of concrete
- Properties in the hardened state: strength; creep permeability; durability
- Shrinkage; chemical resistance; abrasion and impact resistance; thermal movement; moisture movement; fire resistance; Factors affecting properties
- Clay bricks and blocks; Materials and Manufacturing processes. Classification types and sizes.
- Properties of Clay Bricks – Appearance, strength, water absorption, soluble salt content, durability, thermal and sound insulation
- Mortars for jointing; types uses; plasticizers; batching; mixing; pointing; Selections of mortar mixes.

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**CIV 121 – Engineering Materials I**

| | | |
|---|---|---|
| ***CE 5201*** | ***Road Materials and Structures*** | ***4 ch (3C 2L)*** |

*Soil classification, compaction, and stabilization for optimum use in road construction. Structural and hydraulic aspects of small scale drainage systems for roads. Prerequisites: CE 3113, CE 3713.*

The nature of timber; Types of wood cells and their functions, Botanical definition of hardwoods and softwood.

- Anatomical structure of hardwoods and hardwoods; Growth characteristics; Nomenclature.
- Moisture in timber; Equilibrium Moisture Content (EMC), Fibre Saturation Point (FSP).
- Conversion and Seasoning.
- Defects; Decay and Preservation.
- Physical properties – Density, specific gravity, porosity; Moisture movement; Strength properties; Factors influencing strength.
- Impact resistance; abrasion resistance; chemical resistance, thermal insulation; behavior in fire.
- *Types of bitumen; manufacture and composition.*
- *Properties of bitumen; uses and applications of various bituminous products.*
- *Bitumen or cutback bitumen as a binding agent in road construction; Surface dressing, grouting, bitumen macadam and wet mix bitumen macadam.*
- *Specific gravity, penetration, softening point, solubility, penetration index, ash content.*
- Thermoplastics and thermosetting plastics; Forming methods.
- Engineering properties and uses of plastics.

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**CIV 210 – Building Structure I**

| | | |
|---|---|---|
| ***CE 2023*** | ***Mechanics of Materials*** | ***5 ch (3C 3L)*** |

*Elastic and plastic stress, strain; behaviour of beams and columns; torsion; material strength. Prerequisite: CE 1013. Co-requisite: MATH 1013.*

- To allow students to analyze simple components of the building system.
- To develop in student an understanding of analytical techniques with emphasis on graphical and handbook designs.
- To give students an appreciation of structures and its relevance to Architecture.

**Fundamental Concepts**

Structure in Architecture. Development of structural science. The structural engineer and the architect. Structural requirements of a building. The structural elements. Introduction to structural behaviour of buildings. The behaviour of materials under load. Structural properties of materials.

Types of structure: framed and mass structures. Elements of a structure: rod, beam and slab. Structural forms: plane and space. Types of joints: stiff and pinned. Types of support: encastre, hinge and roller. Equilibrium equations: forces and moments in the x, y and z plane. Conditions of determinacy: determinate and indeterminate structures.

Classification of loads: dead, live, wind, point and uniformly distributed. Factors of safety. Units of measurement.

**Statics and Introduction to structures**

Forces and systems: tensile, compressive, concurrent and non concurrent systems. Resolution of forces: rectangular components. Determination of resultant forces: graphical (triangle of forces, parallelogram of forces and force diagram) and calculation (trigonometry and formulae).

Moments: clockwise and anticlockwise. Resultant moments. Beam support reactions.

Nature of Stress/Strain: uniform, tensile, compressive and shear. Working stress. Stress/strain relationship: Hooke's law. Young's modulus, compound bar analysis. Two-dimensional stress system.

Centre of gravity: location, eg., of composite bodies and figures. Moment of area and inertia. Radius of gyration.

Section modulus. Bending moments and shear force of beams. Theory of bending.

Construction of bending moment and shear force diagrams – emphasis on graphical methods.

Relationship between bending moment and shear force. Deflection of beams – graphical methods.

Deflection of beams – graphical methods. Frame analysis – stress diagram and method of joints.

Frame analysis – stress diagram and method of joints.
Defection: Clark Maxwell method and Williot-Mohr diagram
Defection: Clark Maxwell method and Williot-Mohr diagram.

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**CIV 211 – Engineering Materials II**
***(CONCRETE)***
***CIV 415/211 (To be restructured and renamed)***

| | | |
|---|---|---|
| ***CE 5212*** | ***Pavement Design I*** | ***4 ch (3C 3L)*** |

*A study of the design and construction of highway pavements. Production and testing of bituminous materials, design of bituminous mixtures, thickness design for flexible pavements, design of rigid pavements, and construction methods. Prerequisites: CE 3113.*

Week 1
Properties of fresh and hardened concrete: consistency, workability, permeability, shrinkage, durability – chemical resistance, carbonation, etc.
Laboratory practicals.

Week 2
Strength; Curing of concrete; Influence of curing on ultimate strength.
Laboratory practicals.

Week 3
Characteristics; reheological properties.
Laboratory practicals.

Week 4
Concrete mix design; purpose of mix design; methods of mix design – DOE, Cement and Concrete Association and ACI methods; Factors affecting mix design. Normal and lightweight concrete.

Week 5
Concrete construction practices: batching, mixing, transporting, placing, compacting, finishing and curing.
Laboratory practicals.
Week 6
Construction and expansion joints. Formwork design, handling and striking. Mortars for jointing; types uses; plasticizers; batching; mixing; pointing; selections of mortar mixes.
Laboratory practicals.

Week 7
Quality control and economy in concrete production and construction

Week 8 MID-SEMESTER EXAMS

Week 9
Materials for road construction: Types of pavement materials. Characteristics of road construction materials.
Laboratory practicals.

Week 10
Bituminous material and mixtures. Types of bituminous materials, characteristics and uses of bituminous materials.
Laboratory practicals.

Week 11
Properties and grading of road making aggregates. Design of bituminous mixes.
Laboratory practicals.

Week 12
Bitumen and cutback bitumen as a binding agent in road construction; bitumen macadam and wet mix bitumen macadam.
Laboratory testing.

Week 13
Properties of bitumen: specific gravity, penetration index, softening point, solubility, ash content.
Laboratory testing.

Week 15 **Final Exams.**

Assessment:

| | |
|---|---|
| Course work | 40% |
| Assignments | 10% |
| Tests | 15% |
| Labs | 10% |
| Tutorials/Quizzes | 5% |
| Exams | 60% |

Reading List:

1. Neville, A.M. Properties of Materials (3rd ed.), Longman Scientific and Technical, London.
2. Neville, A.M. and Concrete Technology, Longman, London.

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**CIV 213 – Fluid Mechanics I**

***CE 2703 Introduction to Fluid Mechanics 3 ch (3C)***

*Physical properties of liquids and gases, fluid statics, kinematics of fluid flow, energy considerations in steady flow, momentum and dynamic forces in fluid flow, fluid measurements, introduction to forces on immersed bodies. Prerequisites: CE 1013, MATH 1013.*

Properties of fluids: mass density, specific weight, specific gravity specific volume, viscosity surface tension, compressibility, vapour pressure.
Pressure intensity, pressure head, hydraulic jack, pressure gauges, barometer.
Fluid pressure measurement: piezometer, U-tube, Measurement of pressure differences.
Hydrostatic pressure: total and resultant pressure on vertical and inclined plane surface; pressure diagrams; Inclined circular lamina; Sluice gates; Vertical chain; Dock gates; Lock gates; Curved surfaces; Cylindrical gates; Parabolic surface.
Buoyancy: Archimedes principles for thrust on immersed body.
Stability and metacentre. Metacentric height and stability of floating vessels.
Dimensional analysis
Hydraulic similitude; geometric similitude
Froude number; Reynolds number
Hydraulic models
Translation and rotation of liquid masses: horizontal motion; Vertical motion.
Rotation of open vessels
Rotation of closed vessels

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**CIV 223 – Fluid Mechanics II**

***CE 2703 Introduction to Fluid Mechanics 3 ch (3C)***

*Physical properties of liquids and gases, fluid statics, kinematics of fluid flow, energy considerations in steady flow, momentum and dynamic forces in fluid flow, fluid measurements, introduction to forces on immersed bodies. Prerequisites: CE 1013, MATH 1013.*

Fundamentals of fluid flow: fluid flow concepts; Steady and unsteady flow.

- One-dimensional, two-dimensional and three-dimensional flows.
- Uniform flow, laminar flow; streamlines, streamtubes.
- Non-uniform flow; turbulent flows; boundary layers; Radial pressure gradient.
- Dynamics of fluids in steady motion: concept of control volume; continuity equation; momentum equation.
- Bernoulli equation; computation of total head using Bernoulli's equation.
- Steady flow energy equation. Energy grade line; Flow nets.
- Application of continuity equation to physical situations, e.g., forces on nozzles, pipe bends and forces due to the impingement of jets on surfaces.
- Application of momentum equation to physical situations, e.g., forces on nozzles, pipe bends and forces due to the impingement of jets on surfaces.
- Application of Bernoulli's equation to physical situations, e.g., forces on nozzles, pipe bends and forces due to the impingement of jets on surfaces.
- Flow measurement and instrumentation: Pitot tube, Orifices, Venturi Meter.
- Flow meters, floats, stream gauges, etc. Laboratory practical.
- Weirs, Sluices.

**CIV 222 – Soil Mechanics**
***CIV 222 (To be upgraded)***

| | | |
|---|---|---|
| ***CE 3113*** | ***Soil Mechanics I*** | ***4 ch (3C 3L)*** |

*Consolidation, shear strength, stresses under loaded areas, effects of water on soil behaviour. Prerequisite: GEOL 1001, GEOL 1026, CE 2023. Co-requisite: CE 2703 or CHE 2703.*

| | | |
|---|---|---|
| ***CE 5113*** | ***Soil Mechanics II*** | ***4 ch (3C 2L)*** |

*Soil mechanics principles, elastic and plastic stress conditions, arching, compression and consolidation, bearing capacity, stability, drainage. Prerequisites: CE 3123.*

- Soils – Air – Water relationship. The nature of soil: properties and characteristics of soils, specific gravity, unit weight, bulk density, saturated density, porosity, void ratio, forces between clay particles.
- Engineering description and classification of soil/rock. Field and laboratory identification; particle size analysis.
- Plasticity of soils; Atterberg Limits; Unified and AASGTO foil classification systems.
- Stresses in soils: stress at a point; total, effective and normal stresses.
- Shear strength of soils: Mohr's stress circle; stress-strain relationship; Mohr-Coulomb failure criterion.
- Shear strength of compact, loose and saturated soils, shear strength tests.
- Compressibility and consolidation: immediate and time-related settlement; principle of one-dimensional consolidation; normally consolidated soils; in-situ stresses and K. conditions; e-log p curves.
- Over-consolidated soils; determination of reconsolidation pressure, e-log p curves. Laboratory and field methods of compaction; compaction equipment; compaction tests.
- Moisture content and seepage: water cycle, permeability, field and laboratory determination.
- Shrinkage and swelling; capillary phenomenon.
- Theory of flow nets, construction techniques of flow nets and phreatic liens, piping and its control, design of filters.
- Site investigation: purpose of subsurface exploration; Methods of sampling; preparation of data sheets and writing the report.

**CIV 310 – Geotechnics I**
**CIV 310/410 Geotechnics I & II**
**(*CIV 310/410 (To be restructured and renamed)*)**
**Restructure to "Foundation Engineering" and "Soil Mechanics II")**

| | | |
|---|---|---|
| ***CE 4613*** | ***Construction Engineering II*** | ***3 ch (3C)*** |

*Construction of temporary works and construction methods. Includes excavations, trenches, stabilization, sheet piling, cofferdams, formwork, falsework, scaffolding, failure and accident statistics, costs and liability. Emphasis on application of the NB Occupational Health and Safety Commission Act and Regulations to construction. Restricted to students with at least 110 ch completed. Prerequisites: CE 2603.*

| | | |
|---|---|---|
| ***CE 3123*** | ***Foundation Engineering I*** | ***4 ch (3C 1T)*** |

*Lateral earth pressures, shallow and deep foundations, stability of cuts and slopes. Prerequisites: CE 3113.*

To provide the student with a working knowledge of geotechnical engineering.

- Site investigation: visual inspection, surface methods, drilling techniques, in-situ testing methods, seismic and resistivity surveys.
- Stress in soils: Effective and total stress concepts, Mohr-coulomb failure envelope and Coulomb equation, stress-strain relationships.

- Stress distribution under circular and rectangular foundations. Boussinesq's theory, Newmark and Westergaard influence charts, bulbs of pressure and slope methods.
- Consolidated and over-consolidated clays and their e-log p curves. Settlement calculations for normally consolidated and over-consolidated clays.
- Immediate settlement of cohesionless soils, use of influence factor in settlement computations.
- Bearing capacity theory and Terzaghi's bearing capacity equations.
- General bearing capacity equation, effect of water table on bearing capacity. Eccentrically loaded foundations.
- Eccentrically loaded foundations cont'd bearing capacity of foundations on layered soils.
- Lateral earth pressure: active passive and at rest earth pressure, Rankine earth pressure theory.
- Coulomb earth pressure theory. Types of retaining structures, application of earth pressure theories to the design of retaining structures.
- Design of retaining structures cont'd. Analysis of retaining structures – slip circle failure.
- Types of instability mechanisms, methods of stability analysis. Slip circle methods.
- Taylor's stability numbers and stability charts, infinite slope analysis.

**Laboratory exercises**

Field sampling methods for laboratory testing.
Shear strength of cohesionless material
Unconfined compression test
Triaxial test – Unconsolidated undrained
Permeability of fine grained soil
Permeability of coarse grained soil
Consolidation test
Flow nets demonstration
Flow of water through dams demonstration
Atterberg limits
Hydrometer analysis

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**CIV 410 – Geotechnics II**
***CIV 310/410 (To be restructured and renamed)***

***CE 4613 Construction Engineering II 3 ch (3C)***

*Construction of temporary works and construction methods. Includes excavations, trenches, stabilization, sheet piling, cofferdams, formwork, falsework, scaffolding, failure and accident statistics, costs and liability. Emphasis on application of the NB Occupational Health and Safety Commission Act and Regulations to construction. Restricted to students with at least 110 ch completed. Prerequisites: CE 2603.*

The objectives of this course are to provide the student with the knowledge required for the analysis and design of foundations, and the application of the principles of engineering materials and the principles of soil mechanics in foundation engineering. On successful completion of this course, the student will be capable of designing both shallow and deep foundations under the guidance of an experienced practising engineer.

- Subsurface investigation: planning and conducting the investigation. Methods and equipment. Reporting and Data presentation.
- Sheet pile walls and other retaining structures. Construction methods for sheet pile walls.
- Cantilever sheet pile walls – clay and sandy soil.
- Anchored sheet pile wall – clay and sandy soil. Reinforced earth structures – Geotextiles and metallic strip reinforcement.
- Braced cuts, Lateral earth pressure in braced cuts.
- Tschebotarioff's pressure envelopes. Stability of braced cuts.
- Pile foundations. Types of piles and their structural characteristics. Estimation of pile length.
- Installation of piles, load transfer mechanism, equations for estimating pile capacity.
- Point bearing capacity of piles, Settlement of piles, pull out resistance of piles.
- Pile driving, formulae (ENR and Modified ENR formulae), Janbu's

formula, Pile load tests. Group piles – efficiency, consolidation, settle.

- Elastic settlement of pile groups, Uplift capacity of pile groups, negative skin friction.

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**CIV 322 – Water and Waste Water Engineering I**

**(Treatment)**

| | | |
|---|---|---|
| ***CE 5432*** | ***Wastewater Treatment and Pollution Control*** | ***4 ch (3C, 2L)*** |

*Applied wastewater microbiology, wastewater analysis (physical, chemical, and biological), wastewater treatment processes, industrial and municipal wastewater treatment and management, wastewater treatment systems and plant design. The course content will focus on treatment and management issues of wastewater from industrial, municipal, and domestic sources. Pollution control strategies and protocols are also examined. Prerequisites: CHEM 1882 (or equivalent) and CE 3403 or CHE 2004, or permission of course instructor.*

To instill in the student a thorough understanding of:

i. The scientific principles involved in maintenance of a just balance in the Eco-system.

ii. The current principles and methodology used in Water Supply and Waste water Engineering with emphasis on local systems.

- Water sources, resources and conservation. The planning of water supply system.
- Surface- and ground- water sources; demand; System design for the collection and distribution of surface water supplied, including the impoundment and intake of surface water.
- System design for the collection and distribution of ground- water; Abstraction, the removal of ground water, storage and distribution.
- Network analysis.
- Water quality standards for domestic and other purposes. Water quality analysis: theory and application of instrumentation used in water quality analysis.
- Water treatment: the application of physical, chemical and biological processes to the treatment of water, Scientific basis and design of unit processes in water treatment.
- Management in water supply Engineering.
- Municipal sewerage systems.
- Engineering design for collection, treatment and disposal.
- Wastewater quality and quantity; objectives of water and wastewater treatment: microbiology of wastewater treatment, solid-liquid separation method.
- Physical, chemical and biological tests: phenomena.
- On-site wastewater disposal: individual and small community disposal systems.
- Environmental considerations in wastewater disposal.
- Water supply practice in Guyana.

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**CIV 424 – Water Resources Planning and Development**

The course is aimed at providing the students basic skill in carrying out projects in water resources and allied field. Upon successful completion of this course, the students should acquire competence in executing planning and development projects in water resources engineering with a high degree of confidence.

- Overview of Water Resources Engineering in Guyana
- State of the art Water Resources Engineering in Guyana
- Engineering and Economic Planning concepts
- Applications of Engineering and Economic Planning concepts in water resources engineering
- Identification and Preliminary evaluation of Projects
- Project Formulation and Appraisal
- Economic Analyses

- Financial Analyses
- Applications of Planning in water supply
- Development of Water Supply systems: Surface water and Ground water systems
- Estimation of Population and Water Needs
- Application of Planning in Drainage and Irrigation Engineering
- Development of Drainage and Irrigation projects
- Application of Planning in Coastal Engineering
- Development of coastal defence systems
- Regional Planning in Water Resources Engineering
- Case Study

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**CIV 413 – Environmental Engineering I**
**(See APPENDIX D)**

| | | |
|---|---|---|
| ***CE 3403*** | ***Introduction to Environmental Engineering*** | ***3 ch (3C)*** |

*Introduces the problems and principles of control or modification of the environment. Considers an environmental dimension to all planning, design and analysis functions carried out by engineers. Restricted to students with at least 60 ch completed.*

| | | |
|---|---|---|
| ***CE 5153*** | ***Waste Geotechnics*** | ***4 ch (3C 3L*)*** |

*Design of sanitary landfills, with emphasis on clay liners and composite liners. Properties of geosynthetics. Geotechnical properties of municipal solid waste. Landfilling procedures. Hydrological evaluation of sanitary landfills. Site selection. Prerequisites: CE 3123.*

To introduce the student to the theory and practice of environmental engineering and environmental impact assessment.

- Design and construction of sanitary and storm sewer systems including pumping stations.
- Solid waste disposal: types and quantities of domestic and industrial wastes.
- Collection. Processing and final disposal, including incineration, composting.
- Sanitary landfill: the recovery of useful materials and the disposal of wastes or residues on land.
- Land reclamation.
- Environment impacts of land use change.
- Pollutants pathways, clime change.
- Air borne wastes and control of atmospheric pollution: sources, types and effects of atmospheric pollutants.
- Inter-relationships between the disposal of solid, liquid and gaseous wastes and the pollution of air, land and water.
- Environment management principles. Pollution and waste management.
- Vehicle emissions, indoor air quality.
- Conservation systems and mitigation of forest destruction.
- Environmental impact assessment: introduction to principles.
- Applications of environment impact assessment. Case study.

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**CIV 415 – Highway Engineering**
**(Restructure to "Embankments I)**
***CIV 415/211 (To be restructured and renamed)***

| | | |
|---|---|---|
| ***CE 5141*** | ***Embankments I*** | ***3 ch (3C)*** |

*Engineering for earthfill structures such as dams, dykes, causeways and other embankment structures employed in civil engineering projects. Prerequisites: CE 3113.*

| | | |
|---|---|---|
| ***CE 5201*** | ***Road Materials and Structures*** | ***4 ch (3C 2L)*** |

*Soil classification, compaction, and stabilization for optimum use in road construction. Structural and hydraulic aspects of small scale drainage systems for roads. Prerequisites: CE 3113, CE 3713.*

| CE 5212 | Pavement Design I | 4 ch (3C 3L) |
|---|---|---|

*A study of the design and construction of highway pavements. Production and testing of bituminous materials, design of bituminous mixtures, thickness design for flexible pavements, design of rigid pavements, and construction methods. Prerequisites: CE 3113.*

- Types, properties and manufacture of road-making materials: stone, gravel, sand, laterites, sand clay, clays, clay-bricks, bauxite capping, burnt earth, quarry overburden, siftings. Quarrying and stockpiling.
- Sampling and testing: Gradation, strength, hardness, flakiness index, moisture content and other suitable classifications.
- Bituminous materials: asphalts, tars, emulsions, cut-backs. Manufacture of asphaltic materials. Testing penetration viscosity, flash point, ductility, distillation, durability; cement as a filler in asphaltic mixtures.
- Mechanical soil stabilization processes: Compaction, grading, control. Chemical soil stabilization processes: bituminous, cement, lime; Properties of stabilized soils: strength, durability, permeability, influence as moisture content.
- Embankment design: Subgrade stresses, settlement of embankment; stability of slopes; protection of slopes against erosion. Ground water and seepage problems.
- Pavement design: Pavement types and wheel loads; traffic type and volume; stresses in flexible pavement; stresses in rigid pavement; factors affecting pavement design.
- Pavement, distress, performance, surveys, evaluation, establishing design criteria.
- Design of flexible pavements: AASHO, CBR and other methods of flexible pavement design.
- Design of asphaltic mixtures by Marshall and Hveem stability, Hubbard-Field and other methods.
- Flexibility, permeability and skid resistance of asphaltic mixes, construction and maintenance.
- Design of rigid pavements.
- Pavement evaluation and strengthening.
- Principles of maintenance, rehabilitation and strengthening pavements.
- Use of computer software for highway design.

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**CIV 420 – Civil Engineering Construction & Maintenance**

***CE 5603***

*The use and application of equipment in the construction industry; engineering fundamentals applicable to construction engineering and management practice. Lifting, excavating, transporting, compacting and tunneling equipment; equipment finances, costs and economics are covered. Application of computers in construction equipment and methods. Restricted to students with at least 110 ch completed. Prerequisites: CE 2603.*

To impart to the student the principles, methodology and practices of construction and maintenance engineering with particular emphasis of the applications in the local construction industry.

- Revision of Contracts: General and Particular Conditions, Duties and authority of the Engineer and the Engineer's representative, Obligations of the contractor. Sub-contracts.
- Change Conditions Clauses. Provisional sum and items: variations in price, labour and materials; daywork: new rates. Completion certificates and maintenance period.
- Construction Equipment: Mechanics of operation and factors affecting the selection of equipment used in construction work earth moving and excavation equipment, soil stabilization and compaction equipment trucks; pumping equipment; pile driving equipment.

- Equipment used in concrete technology for batching, mixing, transporting and placing concrete including grouting; crane; hoists.
- Construction Technology and Quality Control: Buildings – concrete, claybrick, wood, steel frames; earth works: cofferdams. Road construction.
- Value Engineering: Introduction to safety engineering. Causes and prevention of accidents in the construction industry. Accident statistics.
- Site organization, access and circulation, layout of plant and materials storage.
- Construction Project Planning: Planning techniques: Job planning and programming.
- Project Management using Computer Software.
- Maintenance engineering: Types of maintenance; planning and execution of maintenance, preventative and corrective maintenance.
- Buildings and Bridge maintenance systems and methods.
- Road maintenance systems, strategies and methods.
- Sea defence maintenance systems and methods.
- Computer applications in maintenance engineering.

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**CIV 423 – Environmental Engineering II**

The course is designed to give the students the basic knowledge of environmental impacts and the preparation of statements on different various engineering projects and operations.

On completion of this course, the students should be equipped with necessary skills to analyze, estimate and predict environmental impacts of different activities on the environment.

The knowledge gained should also enable them to prepare the statements, make recommendations and control the impacts to meet the established environmental standards. Basic skills in giving legal advice to avoid litigation would also be acquired for different settings.

- Revision of Environmental Engineering concepts
- Effect of Green Movement
- Financial Implications of Environmental Compliance
- Environmental Policy Act and its Implementation
- Framework for Environmental Assessment
- Description of the Environmental Setting
- Prediction and Assessment of Impacts on the Water Environment
- Prediction and Assessment of Impacts on the Noise Environment
- Prediction and Assessment of Impacts on the Biological Environment
- Prediction and Assessment of Impacts on Cultural Environment
- Prediction and Assessment of Impacts on Socio-economic Environment
- Methods of Impact Analysis
- Practical Considerations in Writing Impact Statements
- Coastal Zone Management concepts; Applications of Coastal Zone Management

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**CIV 426 – Coastal Engineering**

***CE 5753 Engineering Hydrogeology 4 ch (3C 3L)***

*Covers important topics in quantitative hydrogeology, including: principles of saturated and unsaturated groundwater flow, solutions to groundwater flow problems, well hydraulics and pumping tests, introductory groundwater geochemistry, and contaminant migration and attenuation processes in groundwater. Prerequisites: CE 2703 or CHE 2703, GEOL 1001, GEOL 1026.*

To instill in the students an understanding of the theory and applications of coastal engineering and the dynamics of coastal environments, and to equip them with the capability to analyze and design coastal structures. The emphasis will be systems relevant to the coast land.

- Introduction to the principles of water development.
- Theory of tidal motion and its numerical modeling.

- Classification, mixing and hydraulic behaviour of estuaries.
- Wave fundamentals and the classification: Random wave motion, wave refraction and reflection, wave transformations in shallow water and in the vicinity of structures.
- Introduction to wave and water level prediction: short and long term statistics and the "design" wave, wave induced loading on coastal and offshore structures.
- Coastal structures: Design considerations, types, purpose, applications, design criteria.
- Design of breakwaters.
- Design of Revetments.
- Design of Groynes.
- Littoral transport: Coastal sediment transport and pollutant transport.
- Numerical modeling of coastal water and sediment/pollutant transport.
- Measuring and data collection techniques.
- Design strategies based on measurements and field data.

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**CIV 427 – Foundation Engineering**

**No text given in Faculty of Technology Under Graduate Programs Guide.**

| | | |
|---|---|---|
| ***CE 5132*** | ***Foundation Engineering II*** | ***3 ch (3C)*** |

*A continuation of earlier soils engineering courses dealing with shallow foundations (including design of reinforced concrete footings), deep foundations, excavations, cofferdams and factors relating to foundation design. Prerequisites: CE 3123.*

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**CIV 311/321 Hydrology / Hydraulic Engineering (Res. to Hydraulics and Hydrology)**

**CIV 311 – Hydrology**

| | | |
|---|---|---|
| ***CE 3713*** | ***Hydraulics and Hydrology*** | ***5 ch (3C 3L)*** |

*Water flow in pipes; computer-based analysis of pipe networks; characteristics of pumps; open channel flow; similitude and dimensional analysis. The hydrological cycle; precipitation, runoff and hydrograph analysis; the rational method; flood and drought frequency analysis; groundwater flow. Prerequisites: CE 2703 or CHE 2703.*

To introduce the students to the theory and practice of hydrology and hydrometeorology with special emphasis on hydrological practices in Guyana. On successful completion of this course the student will be equipped to analyze and design basic systems which require a knowledge of the fundamental principles and methodology of Hydrology.

- The hydrologic cycle: introduction to the hydrometeorlogical systems and observations.
- Precipitation, stream flow, evapotranspiration.
- Hydrological forecasting: collection, processing and storage of hydrological and meteorological data.
- The hydrometeorlogical network in Guyana.
- Ground water: occurrence and movement fluctuation; exploration and exploitation of ground water resources: surface and sub-surface investigation for ground water.
- Ground water resources: quantity and quality; artificial recharge; sea water intrusion.
- Management of ground water resources: depletion and sustainability; monitoring systems, pollution and remediation.
- Model studies and analysis of ground water systems.
- Introduction to water well technology.
- Surface water: stream flow gauging, instrumentation and anlysis.
- Hydrograph analysis, estimating and analysis of run-off.
- Floods and flood management, rainfall-runoff modelling.
- The unit hydrograph, rainfall and flood frequency, flood routing.

- Introduction to hydrological modeling: catchment simulation models, parameter identification and model validation, statistical methods in hydrological studies.

**CIV 321 – Hydraulic Engineering**

| | | |
|---|---|---|
| ***CE 3713*** | ***Hydraulics and Hydrology*** | ***5 ch (3C 3L)*** |

*Water flow in pipes; computer-based analysis of pipe networks; characteristics of pumps; open channel flow; similitude and dimensional analysis. The hydrological cycle; precipitation, runoff and hydrograph analysis; the rational method; flood and drought frequency analysis; groundwater flow. Prerequisites: CE 2703 or CHE 2703.*

On successful completion of this course the student will be equipped to analyze and design basic systems which require a knowledge of the fundamental principles and methodology of Hydraulic Engineering.

- Hydraulic Principles: Laminar flow. Critical velocity. Reynold's number and relative roughness.
- Turbulent flow. Shear stress. Velocity distribution. Head loss.
- D'Arcy-Weishbach equation. Friction factor. Pipe systems. Siphons. Hardy Cross method.
- Equivalent pipes, Compound, looping and branching pipes. Forces on bends. Water hammer. Hazen-Williams formula.
- Ground water: energy, momentum and mass balance, steady state flow, aquifers, well hydraulics.
- Open Channel Flow: Steady flow. Uniform flow. Varied flow. Chezy and Manning equations.
- Velocity distribution, Specific energy, Critical depth, Maximum flow, Hydraulic jump, Back water curves, controls, channel delivery. Practical applications.
- Unsteady flow in open channels: waves, surges, flood routing through channels and reservoirs.
- Hydraulic structures: gates, spillways, energy dissipation, intakes.
- Flow measuring devices.
- Introduction to sediment transport: bulk, dispersion and mixing. Forces of moving fluids. Similitude and models.
- Fluid Machinery: Impact of jets on fixed and moving plates. Impulse and reaction turbines.
- Pumps. Efficiency. Specific speed. Cavitation.
- Introduction to Hydropower engineering.

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**CIV 415/211 Highway Eng./Eng. Materials**

**(Restructure to "Pavement Design)**

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**ELE 111/121 Electrical Fundamentals I&II**

**ELE 111 – Electrical Fundamentals I**

| | | |
|---|---|---|
| ***EE 1713*** | ***Electricity and Magnetism*** | ***4 ch (3C 1T 3*L)*** |

*An introductory course in basic circuit analysis techniques for all engineering students. Electric charge, electric energy sources, current, voltage, power and energy. Resistors, resistance and the application of Ohm's law, Kirchoff's voltage and current law, D.C. circuit analysis using equivalent resistor techniques, voltage and current division, loop analysis, mesh analysis, nodal analysis, superposition, and the application of Thevenin's and Norton's Theorems. Capacitors, capacitance and analysis of RC networks. Magnetic circuits, magnetic forces in current carrying conductors. Faraday's and Lenz's Laws. Inductors, inductance and analysis of RL networks. Introduction to A. C. circuits.*

The main objective of this course is to enable the students to develop a thorough understanding of basic concepts of Electricity, D.C. Circuits, Electrical Measurements and Electrostatics.

**The Nature of Electricity**

Atomic structure. Voltage Current. Potential soruces.

Nature of resistance. Resistivity. Wire tables. Temperature effects.

**OHM's Law. Power. Energy**
Ohm's Law. Power Energy. Efficiency.
The series circuit. Voltage sources in series. Kirchhoff's voltage law. Voltage dividers.
The parallel circuit. Kirchhoff's current law. Current sources in parallel. Current divider rule. Short circuits.
Analysis of Series – Parallel circuits. Star/delta transformation.

**Circuit Analysis Techniques**
Generalized Kirchhoff's (Branch current) analysis. Loop analysis. Source conversion.
Superposition theorem.
Thevenin's Theorem.
Norton's theorem. Maximum power transfer theorem.

**D.C. Instruments**
The D' Arsonval movement. Ammeter. Voltmeter. Ohmmeter. Megger. Wheatstone Bridge. Loading effects and tolerance.

**Electrostatics**
Electrostatics Field. Dielectric Materials. Capacitance. Series and parallel capacitors.
Transients in capacitive networks. Energy stored by a capacitor.

**ELE 121 – Electrical Fundamentals II**

| | | |
|---|---|---|
| ***EE 1713*** | ***Electricity and Magnetism*** | ***4 ch (3C 1T 3*L)*** |

*An introductory course in basic circuit analysis techniques for all engineering students. Electric charge, electric energy sources, current, voltage, power and energy. Resistors, resistance and the application of Ohm's law, Kirchoff's voltage and current law, D.C. circuit analysis using equivalent resistor techniques, voltage and current division, loop analysis, mesh analysis, nodal analysis, superposition, and the application of Thevenin's and Norton's Theorems. Capacitors, capacitance and analysis of RC networks. Magnetic circuits, magnetic forces in current carrying conductors. Faraday's and Lenz's Laws. Inductors, inductance and analysis of RL networks. Introduction to A. C. circuits.*

This course is a continuation of ELE 111. The main objective is to enable the student to develop a thorough understanding of basic concepts of Electromagnetism, A.C. circuits and three-phase theory.

**Electromagnetism**
Revision of elementary magnetic concepts.
Electromagnetism. Force on a current carrying conductor in a magnetic field.
Laws of electromagnetic induction (Faraday and Lenz's Laws) Eddy current.
Calculation of mmfs for simple circuits. Hysteresis.
Self and mutual inductance. Energy stored in magnetic fields.

**A.C. theory and circuits**
Generation of alternating voltages. Simple a.c. generator. Sine and cosine wave forms, frequency and speed of rotation of a.c. machine.
Period and frequency of various types of waveforms.
Instantaneous, average and r.m.s. values of alternating current and voltage. Form factor.
Phasor representation of sinusoidal waveforms. Symbolic rotation.
Calculations based on A.C. circuits involving combinations
of R.L. and C.
Power in A.C. circuit, power factor and its significance.

**Resonance**
Series and parallel resonance. Half power points. Q – Factor.

**Three-phase theory**
Generation of three-phase voltages and currents.
Advantages of three-phase systems.
Phase relationship. Star and delta connections.
Relationship between current and voltage phasors for balanced conditions.
Three-phase power and its measurement by two-watt meters method.

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**EMN 221 – Supervisory Management**

| | | |
|---|---|---|
| ***CE 5623*** | ***Project Management*** | ***4 ch (3C 1T)*** |

*Application of management methods for construction projects. Emphasis on supervisory management, contracts, and management methods. Application of critical path*

*methodology for work organization and management control, including planning and scheduling, resource management, optimization techniques and cost control methods. Restricted to students with at least 110 ch completed. Prerequisites: CE 2603.*

- Basic principles of management; Organisational Structures – Public Enterprise versus Private Enterprise; Business – government relations.
- Concepts of Supervisory Management: The role of the supervisor; Basic supervisory skills – Organising and delegating, Conflict resolution.
- Introduction to Behaviour Theory.
- Individual Supervision: Training and monitoring; Motivation and discipline; Appraisal
- Group Supervision: Group behaviour & sociology; Group dynamics; Coordinating & monitoring; Problem solving techniques.
- Introduction to Planning & Control: Planning Tools & Techniques
- Critical Path Method; PERT.
- Supervision and Productivity: improving work methods; Cost Reduction & Control Techniques.
- Quality Control; Feedback Analysis.
- Contract Components: forms of engineering contract; invitation: conditions of contract; specifications; obligations of parties; litigation. Case Study.
- Occupational Health & Safety: Safety and Accidents; Hazards and their identification.
- Health and safety Standards in engineering.
- Industrial Relations: Trade Unions; Labour Relations; Personnel Relations.
- Grievances disputes; negotiations and settlements; arbitration method.

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**EMN 311 Engineering Economy and Management**

***CE 3963***

***Engineering Economy 3 ch (3C)***

*Basic methods of engineering economy including time value of money, compound interest models, interest and discount rates, and depreciation; critical path methods. Emphasis is placed on commonly used computational procedures. Restricted to students with at least 60 ch completed. Prerequisites: CS 1003 or equivalent.*

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**EMN 420 Civil Engineering, Construction & Management**

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**EMT 111 – Introduction to Engineering Mathematics**

**(Algebra and Geometry)**

To give the student an understanding of various topics in Mathematics for analyzing quantitative, and simple engineering and design consideration problems.
At the end of this course the successful student will have established as suitable base for further leaming in design, and structural analysis.
Assessment will be by Coursework and Final Examination. The weighting given for each section (see Description of Course) will be approximately represented in both the Coursework and the Final Examination. Coursework will comprise assignments, tests, quizzes, etc. The Final Examination will be as single three hour paper.

**Algebra**
Indices, surds, logarithms. Algebraic solutions of quadratic equations. Simultaneous equations. The remainder theorem. Arithmetic and Geometric progressions.

Calculus
Limits and Derivatives. Differentiation of Algebraic functions. Application of differentiation to find maxima, inflexion, tangents, normal, rates of change and small increases. Integration of algebraic functions. Application to finding arc length, areas and volume of revolution.

**Analytic Geometry**
Analytic geometry of a straight line, circle, parabola, ellipse and hyperbola. Problems on Loci.
Cartesian and Polar coordinate system.

Trigonometry

Angular measurements. Degrees and radians. Length of arc, area of sector, area of segment, Elevations and depressions, Trigonometric ratios. Addition, Double-angle formula. Solution of triangles.

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**EMT 121 Engineering Math II (Trigonometry & Adv. Algebra)**

**(See Syllabus)**

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**EMT 122 – Introduction to Computers and Computing**

| | | |
|---|---|---|
| ***CS 1003*** | ***Introduction to Computer Programming*** | ***4 ch (3C 1T 2L)*** |

*Intended for Science, Applied Science and Engineering students. Introduces the use of digital computers. Includes: problem analysis, algorithm design, and program structure. Use of procedures, loops, and arrays. Debugging and verification of programs. Note: This course may not be taken for credit by CS students. Prerequisite: High School Mathematics.*

To give the student a fundamental knowledge of computers, applications, and computer programming.
**(This course is not meant to provide detailed knowledge of computer hardware or application software).**
At the end of this course, the student should be able to prepare and attach the peripherals to a computer system, use these peripherals and subsystems, manipulate the operating system, carry out costing and other spreadsheet analyses, and write simple programs for common engineering, architectural and other computation.

**1. Overview of Hardware**
What is as computer. Brief discussion of first and second generation computers, Discussion of third generation computers, Brief discussion of fourth generation or networks.
Central Processing Unit.
Primary data Store – Memory: RAM, ROM, Addressing.
Secondary Store – Hard disk, floppy disks, tapes, compact disks.
Input and Output Devices – Keyboard, monitor, printer, computer ports.

**2. Fundamentals of DOS**
The keyboard layout and special keys.

Booting and rebooting – Loading the system, some things that may happen after loading the system.
Brief introduction to 'config.sys' and 'autoexec.bat' files.
Directory structure and purpose.
The 'default' drive and directory.
Changing drives and directories.
Viewing, creating, removing directories.
Files: Viewing, coping, renaming, deleting, undeleting, printing, etc.
Significance of names.
Commands: Internal DOS, External. Simple commands for batch files.
Simple batch file examples.
File Care and Protection – Attributes and Write Protection.
Hiding: advantages, disadvantages, usefulness.
Viruses: Checksumming. Encryption.
Compression and Archiving.
Peripheral Usage and care.
Disk usage: Formatting process. Bad sectors. Used blocks.
Fragmentation and efficiency. Disk organizers.
Dick checking. Disk copying. Write protection.
Structure of diskettes.
Care of diskettes including brief discussion of surface decay and deposits. How disk drives get dirty.

Cleaning/alignment problems (no student practice required).
Parking and locking a hard drive.
Use and care of printers.
Power and cooling requirements. The internal power. The UPS.
Care of keyboard, monitor, mouse.

**3. Editors and Wordprocessors**
Creating a text file. Fundamentals of SOME editing package.
Exploration of its help and menu systems (if feasible).
Extra power of wordprocessors over plain editors. Overlap of roles.

Wordprocessor for plain text file.
Creating a simple document: Starting and exit.
Use of the help and menu systems.
Boldface, Underline, Sizes, Centering, other enhancements. Saving, retrieving a document.

**4. Spreadsheet Fundamentals**
Creating and editing a spreadsheet:

The menu. Setting columns and rows. Entering labels, numbers and formulae. Copying and moving data and formulae. Changing data and formulae. Inserting rows and columns.
Saving and Printing the spreadsheet. Retrieving a spreadsheet.
Graphing the data.
Project or assignment is required for this section.

**5. Programming**
Properly structured programming in Basic, Fortran, or some other imperative language.
General purpose utility commands.
Numerical variables and arithmetic. Input and output.
Relational expressions and conditional blocks.
Program loops.
Programme development, testing and documentation.
Project or assignment is required for this section.

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**EMT 211 Engineering Math III**
**(See Syllabus)**

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**EMT 311 – Calculus**
**(New course to be restructured from other math courses)**

**Overview**
This course, along with its sister course EMT 321, was developed primarily in the call to semesterisation. The courses EMT 311 and EMT 321 are one-semester courses which cover the subject matter of the year-long predecessor TMT 320.
EMT311 carries a highlighted emphasis on the use of Bessel functions, and the behaviour of orthogonal function sets. It is expected to be run in the first semester, because of the needs of various departments at the third year level. The intention is to address some particular needs as early as possible during the year-cycle.

This course provides some assistance in carrying out the work required in a range of degree-level courses in Mechanical, Electrical and Civil Engineering. It is not a specific prerequisite of any third-year course.

The course of itself can be run in any semester, and is not a prerequisite for EMT 321. Thus the courses EMT 311 and EMT 321 can be fitted anywhere within the third year of a semester-based system.

**Rationale**
The course is born of the need to semesterise. It is part of a splitting of the course EMT 320. Additionally, it includes a greater highlighting of the use of different solution sets in different situations.

The course is also arranged in a way that specifically assesses the prescribed portions of the syllabus.

**Course Aims**
- To guide the student as to the occurrence of differential equations and integral functions in Engineering

- To provide the student with a basic operational understanding of some of the calculus- based methods of solving differential equations.
- To provide substantial practice in the use of these methods.

**Objectives**
By the end of this course, the student should be able to
- Understand the use of path integration in a multi-dimensioned space, as applied to various problems in Mechanical, Electrical and Civil Engineering.
- Apply the methods of separation of variables to solve boundary-value problems in Engineering.
- Assess the appropriateness of using the method for the problem in question.

**Duration**
The course will run for fifteen weeks. There shall be four hours per week. The total of sixty hours over the entire semester will be allocated to lectures and tutorial working sessions in the approximate ratio of 45 hours of lectures and 15 hours of tutorial. Over any two-week period there should be at least one hour of tutorial work.

**Assessment**
Coursework will contribute 40% to the total assessment. A final examination is weighted at 60%.

| Course Work Weightings: | | |
|---|---|---|
| | Topic | Weight |
| Test 1 | Vector Calculus | 16% |
| Test 2 | Partial Differential Equations | 16% |
| Test 3 | Fourier methods in Non Cartesian Systems | 8% |

Assessment: At least two in-class tests (40%)
A final Examination (60%)

**Topics**
**Vector Calculus**
Vector differentiation.
Line and double integration.
Problems and Applications in line and Double Integration. Derivation of Green's Theorem.
Circulation and Stokes' theorem.

Applications and Problems in Stokes' Theorem
Divergence and Gauss' Theorem.
Applications and Problems in Gauss' Divergence Theorem.
Volume integral. Applications of divergence and curl to multi-dimensions.
General Tutorial Work and discussion session on topics covered in hours 1 – 18
Test: Topics covered in hours
Tutorial on Test. General review of topics covered in hours 1 – 20.

**Partial Differential Equation**
Derivation of the Heat Equation.
The method of Separation of Variables.
Separation of Variables applied to Heat Transfer Equations.
Applications and Problems on the Heat transfer equation.
Derivation and solution of the Wave Equation.
Applications and Problems on the Wave equation
Derivation and solution of the Laplace equation
Applications and Limitations on the Method of Separation of Variables. General Tutorial Work and discussion session on topics covered in hours 25 – 38/
Test: Topics covered in hours 25 – 38
Tutorial on test. General review of topics covered in hours 25 – 40.

**Bessel Functions and Orthogonal Sets**
Solution of differential equations in series. Generation of recurrence relations. Automatic generation of sequences from recurrence relations.
Derivation and solution of differential equations in polar and cylindrical co-ordinates (Bessel's functions).
Applications and Problems in Bessel functions.
Introduction to general orthogonal function sets.
General Tutorial Work and discussion session on topics covered in hours.
Test: topics covered in hours 45 – 50
Review: topics covered in hours 45 – 50, Applications and Limitations on Separation of Variables and orthogonal functions. Alternatives.
Revision and tutorial on topics of hours 25 – 40
Revision and tutorial on topics of hours 1 – 20.
**Recommended Texts:**
**Advanced Engineering Mathematics**
by P O'Neal is considered a comprehensive text for both 3rd and 4th years

Advanced Engineering Mathematics
by Kreysig is considered a comprehensive text for both 3rd and 4th years.

'Advanced Calculus'
by Kaplan or another similar book should be helpful (secondary recommendation).

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**EMT 321 Numerical Analysis and Computing**

***CE 3933 Numerical Methods for Civil Engineers 3 c (3C)***

*Numerical methods appropriate to the solution of deterministic problems in civil engineering. Considers root finding, interpolation, integration, solution of systems of algebraic equations, ordinary and partial differential equations. Prerequisites: CS 1003 or equivalent, MATH 2503.*

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**ENG 123 – Technical Communication**
**Technical Communication and Clear Writing**

***CE 3973 Technical Communications 4 ch (2C 3L) {W}***

*Written, oral and visual communications are covered. Written communication skills are enhanced through the preparation of engineering documents. Oral communications topics include public speaking and rules of order for conducting a meeting. Visual*

*communications include the uses of videotape equipment, preparation of transparencies and slides for projection, and preparation and projection of computer generated images. Students are responsible for organizing a technical conference. Restricted to students with at least 90 ch completed. Prerequisites: CE 1003, ENGL 1103.*

| | | |
|---|---|---|
| ***ENGL 1103*** | ***Fundamentals of Clear Writing*** | ***3 ch (3C) [W]*** |

*A study of the basic principles of clear prose writing, focusing on essay structure and organization, paragraph structure, sentence structure, grammar, punctuation, and word choice, as well as revising and proofreading. Students will submit numerous written assignments.*

- Introduction to Communication principles: Written Communication; Oral communication.
- Work choice; Objectivity – passive versus active words Correctness – incorrect words and phrases.
- Simplicity and ambiguity; redundancy, tautology. Vocabulary exercises including Technical Terms.
- Information retrieval; sources of information; library information retrieval; online computer searches; confidential sources.
- Referencing: the Harvard and Numeric systems; Articles versus Papers versus reports; Bibliography, references and footnotes.
- Proposal Writing: object of a proposal; elements and structure of a proposal. Proposal case study/exercise.
- Short reports, memos and letters: Readability; structure; grammar and punctuation; conventions and jargon.
- Types of Technical Reports: Pre-Feasibility, Feasibility.
- Inception, Progress and Final reports.
- Structure of analytical reports: background; literature review; methodology; conclusion; recommendations.
- Report case study
- Speech Making: Impromptu and planned speeches
- Seminar presentations; communicating with audience – use of visual aids.
- Oral presentation

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**ENV 411: Environmental Impact Assessment (4 credits, 3 assignments, 1 test, 1 field trip)**

The objective of this course is to foster understanding of the role of Environmental Impact Assessment in Environmental Management and to provide a working knowledge of current

environmental, social and economic impact assessment methods. In addition, the course aims at preparing students to be sufficiently competent to take responsibility for aspects of

Environmental Impact Assessment. Further, the course examines the potential impact of

development on environmental quality, social well being and regional economies, and considers in detail how these impacts can be quantified and analysed.

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**ENV 321: Environmental Chemistry II (4 credits, 4 Lecture hours per week,**

**14 tutorial hours, one field trip)**

The objective of this course is to provide students with:

? a knowledge of the structure of the atmosphere and the major chemical

reaction types occurring in the atmosphere.

? a knowledge of the problems associated with air pollution, concentrating

specifically on the sources of the tropospheric air pollutants, their effects

on plants, human health and materials and the control of these pollutants.

? an introduction to the geosphere and more specifically soil and to their

importance to man.

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**ENV 411: Environmental Impact Assessment (4 credits, 3 assignments, 1 test, 1 field trip)**

| | | |
|---|---|---|
| ***GEOL 4452*** | ***Environment Impact Assessment*** | ***5 ch (3C 3L)*** |

*Baseline assessment studies and site evaluation. Risk/benefit analysis. Overview of relevant environment legislation. Selected case studies. Prerequisites: GEOL 3442.*

The objective of this course is to foster understanding of the role of Environmental Impact Assessment in Environmental Management and to provide a working knowledge of current

environmental, social and economic impact assessment methods. In addition, the course aims at preparing students to be sufficiently competent to take responsibility for aspects of

Environmental Impact Assessment. Further, the course examines the potential impact of

development on environmental quality, social well being and regional economies, and considers in detail how these impacts can be quantified and analysed.

To foster an understanding of the structures and materials that characterized the earth. Additionally, to introduce students to the geological processes at work in the physical environment.
Geology as a Science and its Role in Society.
The Earth, Inside and Out.
Minerals
Magnas, Igneous Rocks, Volcanoes and Plutons
Sediments and Sedimentary Rocks
Metamorphism and Metamorphic Rocks
Weathing
Mass-Wasting
Streams and Drainage Systems
Deserts and Wind Action
Glaciers and Glaciation
The Ocean Margins
Cycles of the Earth – The Hydrological Cycle (with emphasis on ground water): The Rock Cycle.
Geological Time
Plate Tectonics
The Earth's Resources.

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**GEM 111– General Geology**

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|---|---|---|
| ***GEOL 1001*** | ***The Earth: Its Origin, Evolution and Age*** | ***3 ch (3C)*** |

*Novas and Supernovas; The Solar Nebula Theory, Castastrophism and Uniformitarianism. Earth as a heat engine. Origin, growth and main features of the Earth's crust. Origin and evolution of oceans, continents and the atmosphere. The rock cycle, seafloor spreading, plate tectonics, mountain building and deformation of the Earth's crust. Earthquakes, igneous and metamorphic processes and their products, including mineral resources. Credit*

| | | |
|---|---|---|
| ***GE 1026*** | ***Geology Laboratory for Geological Engineers*** | ***2 ch (3L)*** |

*An introductory study of: minerals and rocks; physics, chemistry and structure of the earth; geological age determination and summary of historical geology; surface processes, subsurface processes; economic geology of Canada.*

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**GEM 112– Mineralogy I (Optical Mineralogy)**

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|---|---|---|
| ***GEOL 2142*** | ***Chemistry and Physics of Minerals*** | ***5 ch (3C 3L)*** |

*The study of the compositional variability of minerals and the relationship between mineral composition and mineral assemblage, temperature, pressure, volatile fugacity, cooling*

*rates, etc. The major silicate and oxide mineral groups are emphasized. Laboratories emphasize a variety of methods (polarizing microscope, electron microprobe, x-ray diffraction, IR, UV-VIS and Raman spectroscopy, etc.) for determining the identity, composition and structural state of minerals and crystalline solids. Prerequisite: GEOL 2131.*

To introduce students to Mineralogy and to the application of the principles used in identifying mineral specimens.

**Crystallography**
Elements of Crystallography; Characteristics of Crystals; Faces, Forms, Measurement of Solid Angles; Zones.
Symmetry Elements
Planes of Symmetry; Axes of Symmetry; Centre of Symmetry; Crystallographic Axes.
Crystal Systems
Cubic System; Orthorhombic System; Tetragonal System; Monoclinic System; Hexagonal System; Triclinic System.
Concepts
Definition of a mineral; Synthetic minerals; Biogenic minerals; Ore minerals; Industrial minerals; Economic minerals; Strategic minerals.
Common Rock-Forming Minerals and their physical properties, uses and mode of occurrences.
Secondary Minerals, their physical properties, uses and modes of occurrence.
Accessory Minerals, their physical properties, uses and modes of occurrence.
Brief Description of the chemical classification of Important Mineral Groups.

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**GEM 122 – Mineralogy II**
**(Crystallography & Descriptive Mineralogy)**

*Introduction to crystallography and x-ray diffraction techniques. Appraisal of the material properties of minerals and selected ceramics. Fundamentals of silicate chemistry and the behaviour of the major rock-forming minerals at varying pressures and temperatures. Laboratories focus on describing the physical properties of the more common minerals and on their identification in hand specimen. Prerequisites: GEOL 1001/1012/1006 or 1017 or equivalent.*

To introduce students to the classification of minerals and the identification of the important ones.

Listing the important minerals in each of the Mineral Classes.

Details of Essential Mineral Groups: Silica Group
Feldspar Group
Amphibole Group
Pyroxene Group
Mica Group
Clay Mineral Group
Feldspathoid Group
Zeolite Group, Pneumatolytic Minerals.
Introduction to Crystal Optics
Mineral Exploration Methods.

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**GEM 124 – Structural Geology I**

To introduce students to the structural analysis of the six (6) basic geological structures: folds, faults, joints, lineation, foliation and cleavage. Students will be taught to recognize these structures, measure their orientation and describe their physical and geometric components.

**Nature of Structural Geology (2 hrs)**
Purpose of Structural Geology; Relation of Structural Geology to other Geological Sciences; Concept of Detailed Structural Analysis.
**Folds (22 hrs)**
Basic definitions (anticlines, synclines, antiforms, synforms, anticlinoria and synclinoria); Geometric analysis of folds (limbs, hinge point, line and zone; axial surfaces and traces, crestal line and surface, trough); Classification of folds (based on common shapes, interlimb angle, dip of axial surface/line, etc.); Plunge of folds; Refolding; Fold Systems; Causes of Folding; Kinematics of Folding.

**Faults (20 hrs)**
Some definitions (faults, fault zones, microfaults, shear zones); Physical and geometric components of faults (hanging and footwalls, faultlines, strike, dip, slip, separation, throw, etc.); Classification of faults; Nature of fault surfaces and zones (slickensides, fault rocks, etc.).

**Joints (4 hrs)**

Definitions; Origins; Classifications; Geological Significance.

**Foliation, Cleavage and Lineation (8 hrs)**
Definitions; Origins; Classifications; Geological Significance.

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**GEM 324 Structural Geology II**
**(Replace GEM 214 – Structural Geology II)**

| | | |
|---|---|---|
| ***GEOL 2321*** | ***Structural Geology I*** | ***5 ch (2C 3L)*** |

*Emphasis on description and classification of folds, faults, foliations, lineations and joints, and the use of primary structures. Labs include geological maps and cross sections, and stereographic projection. Prerequisites: GEOL 1001/1012/1006 or 107 or equivalent.*

| | | |
|---|---|---|
| ***GEOL 3322*** | ***Structural Geology II*** | ***5 ch (2C 3L)*** |

*Stress and strain, introduction to deformational behaviour of rocks. Origin of folds, foliations, lineations, joints and faults. Geometrical analysis. Labs will include simple experiments and advanced map problems. Prerequisites: GEOL 2321, GEOL 3131.*

To further expose students to structures, i.e. geological contacts and primary structures. Additionally, emphasis is placed on the recognition of structures on maps, airphotos and in the field. Use will be made of numerous practical exercises.

**Geological Contacts (8 hrs)**
Depositional Contacts; Uncomformities; Intrusive Contacts; Fault Contacts; Ductile Shear Zones.

**Primary Structures (12 hrs)**
Usefulness of primary structures (guide to strain, way-up criteria, clues to transport direction); Sedimentary structures of depositional origin (bedding, cross-stratification, ripple marks, parting lineation, pebble imbrication, sole marks); Sedimentary structures of deformational origin (primary folds, mud cracks, differential compaction, boundins and pinch-and-swell structures, etc.); Primary volcanic structures (flow structures, late-stage fracturing).

**Field Study and Map Representation of Folds (14 hrs)**
Field Study and Recognition of Faulting (10 hrs)
Causes of Folding and Faulting (4 hrs)
The Role of Structures in Deposit Formtion (4 hrs)
Structural Geology of the Guiana Shield, (with particular reference to Guyana) (4 hrs)

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**GEM 217 Engineering Geology**
**Being drafted at present.**

| | | |
|---|---|---|
| ***GE 2022*** | ***Engineering Geology*** | ***4 ch (3C 3L)*** |

*A study of geological materials and hazards; site investigations; environmental geology; geothermal resources and exploitation; and case histories of geological problems in engineering projects. Equivalent to GEOL 2022. Prerequisite: GEOL 1001 and GE 1026 or equivalent.*

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**GEM 313 Igneous Petrology**
***GEM 313/323 Combined***
**(From GEM 123 – Igneous Petrology and Practicals)**

| | | |
|---|---|---|
| ***GEOL 3131*** | ***Igneous and Metamorphic Petrology*** | ***5 ch (2C 3L) [W]*** |

*Petrogenesis of igneous and metamorphic rocks with emphasis on their macroscopic textures, mineral associations, classification and field relations. Laboratories concentrate on the identification of the common igneous and metamorphic rocks using hand specimens and thin sections. Prerequisites: GEOL 2142.*

This course is intended to familiarize student with the classification of the principal rock-types and their identification in hand specimens.

**Igneous Rocks, Volcanoes and Plutons**
Magma; Composition; Gases Dissolved in Magma; Temperature; Viscosity; Effects of

Temperature on Viscosity; Effects of Silica Content on Viscosity.

**The Origin of Magma**
Geothermal Gradient; The Effects of Pressure on Melting; Partial Melting; Basal, Granitic and Andesitic Magma.

**Solidification of Magmas**
Magmatic differentiation by Fractional Crystallisation; Bowen's Reaction Series; Continuous Reaction Series; Discontinuous Reaction Series.

**Classes of Igneous Rocks**
Intrusives; Extrusives. Texture: Phanerites and Aphanites; Porphyrics, etc. Mineral Assemblages.

**Varieties**
Granite and Granodiorite; Pegmatite; Diorite; Peridotite and Anorthosite; Rhyolite and Dacite; Andesite; Basalt.

**Lava Pyroclasts and Volcanoes**
Obsidian; Pumice; Vesicles and Amygdules. Pyroclasts and Tephra: Pyroclastic Rocks; Conversion of Tephra to Pyroclastic Rock.

**Volcanoes**
Shield Volcanoes; Pyroclastic Cones; Stratovolcanoes; Craters, Calderas and other Volcanic Features; Resurgent Cauldrons; Lava Domes.

**Thermal Spring and Geysers**
Fissure Eruptions on Land; Fissure Eruptions Beneath the Sea; Sheet Flows; Pillow Lava; Ophiolite Complexes.

**Plutons**
Minor Plutons; Dike; Sill; Laccoliths; Volcanic Pipes and Volcanic Necks.
**Major Plutons**
Batholiths; Stocks; Stoping; Xenoliths.

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**GEM 323 – Metamorphic Petrology**
***GEM 313/323 Combined***

| | | |
|---|---|---|
| ***GEOL 3131*** | ***Igneous and Metamorphic Petrology*** | ***5 ch (2C 3L) [W]*** |

*Petrogenesis of igneous and metamorphic rocks with emphasis on their macroscopic textures, mineral associations, classification and field relations. Laboratories concentrate on the identification of the common igneous and metamorphic rocks using hand specimens and thin sections. Prerequisites: GEOL 2142.*

***(Course presently being restructured)***
To familiarize students with the classification of the main rock types and the identification of these in hand-specimens.

**Metamorphism (10 hrs)**
Controlling Factors in Metamorphism; Chemical Reactivity Induced by Fluids.

**Grades of Metamorphism (10 hrs)**
Low Grade; Medium Grade; High Grade; Retrograde; Prograde; Temperature.

**Metamorphic Responses to Changes in Temperature and Pressure (10 hrs)**
Foliation; Slaty Cleavage; Schistosity; Mineral Assemblages.

**Kind of Metamorphic Rocks (10 hrs)**
Slate; Phyllite; Schist; Gneiss; Metamorphism of Basalt; Greenschist; Amphibolite and Granulite; Metamorphism of Limestone and Sandstone.

**Kinds of Metamorphism (10 hrs)**
Cataclastic Metamorphism; Contact or Termal Metamorphism; Metamorphic Aureole; Hornfels.

**Burial Metamorphism (10 hrs)**
Regional Metamorphism; Metamorphic Zones; Isograd.

**Metamorphic Facies (10 hrs)**
Place of Metamorphism; Metamorphic Minerals.

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**GEM 216 – Mineral Deposits I**
**(Economic Geology I)**
**(Change to GEM 225)**

| | | |
|---|---|---|
| ***GEOL 4461*** | ***Economic Geology I*** | ***5 ch (2C 3L)*** |

*General features of mineral deposits, their origin, localization and classification, with emphasis on exploration, evaluation and development. Prerequisite: GEOL 3131 or approval of instructor.*

To introduce the subject of Mineral Deposits.
To recognize definitions and application of terminology as pertained to Mineral Deposits.

**Introduction (12 hrs)**
The Importance of Metals; What makes an Ore Deposit?; Geological and Geochemical Factors; Other Factors; Abundant and Scarce Elements; Some Trends and Implications.

**Distribution of the Elements (7 hrs)**
Introduction: Classification of the Elements; Division of Minerals into Groups.

**Economic Considerations**
Principal Steps in the Establishment and Operation of a Mine; Mineral Exploration; Feasibility Study; Mine Development; Mining; Ore Dressing; Smelting; Refining; Marketing.

**Some Important Factors in the Evaluation of a Potential Orebody (15 hrs)**
Ore Grade; By-Products; Commodity Prices; Mineralogical Form; Grain Size and Shape; Undesirable Substances; Size and Shape of Deposits; Ore Character; Cost of Capital; Location; Environmental Considerations; Taxation; Political Factors.

**Nature and Morphology of the Principal Types of Ore Deposits (14 hrs)**
Syngenetic; Epigenetic; Discordant Orebodies; Regular Shaped Bodies; Irregularly Shaped Bodies; Sedimentary Host Rocks; Igneous Host Rocks; Metamorphic Host Rocks; Residual Deposits; Supergene Enrichment.

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**GEM 226 Mineral Deposits II**
**GEM 325 Economic Geology II**
**(Replace GEM 226 – Mineral Deposits II)**

| | | |
|---|---|---|
| ***GEOL 4472*** | ***Economic Geology II*** | ***5 ch (2C 3L)*** |

*Advanced features of mineral deposits, their origin, localization and classification, with emphasis on exploration, evaluation and development. Prerequisite: GEOL 3131 or approval of instructor.*

This course is designed to acquaint the students with the chemical and physical principles in the formation of mineral deposits.

**Mineral Deposits Formed by Internal Processes (30 hrs)**
Introduction; Igneous Rocks; Magmatic Segregation Deposits; Examples of Magmatic Segregation Deposits; Contact Metasomatic Deposits; Pegmatite Mineral Deposits; Hydrothermal Mineral Deposits; Form of Hydrothermal Numeral Deposits.

**Mineral Deposits Formed by Surface Processes (30 hrs)**
Evaporite Mineral Deposits; Chemical Precipitated; Sedimentary Iron Deposits; Manganese Deposits; Sedimentary Cu – Pb – Zn Deposits; Placer Deposits; Residual Deposits; Residual Deposits of Laterite and Aluminum. Residual Deposits of Nickel; Secondary Enrichment – (supergene Enriched Deposits).

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**GEM 228 Environmental Geology/Techniques**

**GEM 228 – Historical Geology**

To acquaint students with the means by which rocks and their fossil contents can be used to interpret the events, and their sequence, that have occurred throughout earth's history.

**Subject Matter of Historical Geology (2 hrs)**
The relative importance of each rock class in Historical Geological Studies.

Ordering Geological Events (4 hrs)
Law of Uniformitarianism; Law of Original Horizontality; Law of Cross-Cutting Relations; Law of Superposition; Law of Inclusion; Law of Faunal Succession.
The Geological Time Scale (2 hrs)
Lithostratigraphy and Biostratigraphy (6 hrs)
Absolute and Relative Age in Geology (4 hrs)
Correlation of Rock Units (6 hrs)
Depositional environments (6 hrs)
Sedimentary Structures and Other Sedimentary Attributes (4 hrs)
Mapping Techniques in Historical Geology (4 hrs)
Structure and Isopach Contouring; Lithofacies Maps; Stratigraphic Cross Section; Paleocurrent Analysis; Paleographic Maps.

**GEM 311 Environmental Chemistry**

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|---|---|---|
| *GEOL 3631* | *Geochemistry of Natural Waters* | *5 ch (3C, 3L) [W]* |

*The principals of chemical equilibria, reaction kinetics and transport applied to natural water systems. Chemical weathering and diagenesis. Chemistry of surface waters, ground water and the oceans. Geochemical cycles. Applications to environmental problems. Labs include chemical analysis of water, carbonate equilibria and geochemical modeling. Prerequisites: GEOL 2602 or GEOL 1001/1012/1006 or 1017, CHEM 2201, CHEM 2111.*

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**GEM 316/326 Principles of Geochemistry**
(Drafted from GEM 125 – Mineral Exploration I, and GEM 226)
**GEM 326 Applied Geochemistry**
**Presently being drafted.**

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|---|---|---|
| *GEOL 2602* | *Principles of Geochemistry* | *5 ch (3C 3L) [W]* |

*Origin of elements. Theories of the origin and chemical evolution of the earth, atmosphere, and oceans. Laws governing the distribution of elements in the earth. Application of phase diagrams to petrologic problems of the crust and mantle. Chemical weathering. Use of stable and radioactive isotopes in geology. Geobarometry and geothermometry. Hydrothermal process and base-metal ore deposits. Prerequisites: CHEM 1012, 1017 (or equivalent), MATH 1013, GEOL 2131.*

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**GEM 125 – Mineral Exploration I**

To show the range of processes by which mineral deposits might originate; and to describe how these processes can occur in major geological features. Also to introduce mineral exploration techniques.

**Global Setting of Mineral Deposits**
Metallogenic Provinces; Distribution of Mineral Deposits; Mineral Deposits of the Cratons; Mineral Deposits and Plate Margins (Ore Deposits at Constructive Margins, Ore Deposits at destructive margins); Mineral Deposits within Plates.

**Exploration**
Introduction; Preliminaries; In-house preparation, published and unpublished reports; Compilation of base maps; Interpretation of satellite photographs, aerial photographs, remote sensing data, photogeological maps; Geophysical, geological, geochemical maps, information transfer to base map.

**Geophysical Methods**
Airborne Remote Sensing Methods; Magnetic Methods, Electromagnetic Methods; Seismic Methods; Gravity Methods; Ground-based Methods; Geological Prospecting; Electrical Surveys; Summaru.

**Geochemistry: Geochemical Sampling Techniques**
Reconnaissance Geochemical Surveys; Project Design; Stream Sediment Sampling; Heavy Mineral Stream Concentrate; Spring and Well Water Sampling; Rock Sampling; Field Documentation.

**GEM 226 Intro To Mineral Exploration**

**Follow-up and Detailed Geochemical Surveys (15 hrs)**
Project Design (general objective, follow-up surveys, detailed surveys); Detailed Stream Sampling Techniques; Prospecting; Heavy Mineral Stream Concentrate Sampling Techniques; Soil Sampling (choice of Horizon and Field Techniques, Treatment of the Results, Priority Rating); Rock Sampling.

**Sample Preparation (20 hrs)**
Stream Sediment and Soils; Drying (field air drying, oven drying, laboratory air drying of samples for analysis of mercury); Sieving; Rolling; Splitting (Mechanical splitting: Riffle Splitter, Cone and Quartering); Grinding; Packaging and Labelling; Stream Concentrates; Drying; Heavy Liquid Separation; Bulking; Splitting; Grinding; Packaging and Labelling; Rocks.

**Data Presentation (15 hrs)**
Reconnaissance Data; Sample Location Map; Geochemical Result Maps; Anomaly Index Map; Follow-up Data; Detailed Data; Sample Location Map; Geochemical Result Maps; Geology Maps.

**Mining Methods and Economics (15 hrs)**
Introduction: Evaluation of Ore Bodies; Geological Considerations; Exploitation: Mining Methods; Open-Pit Mining; Underground Mining; Mineral Processing; Crushing; Separation and Concentration; Smelting and Refining; Copper Smelting; Copper Refining.

**Social/Environmental Aspects of Mining**
Introduction; Exploration and Evaluation; Exploitation; The Treatment Plant; Smelting – The Sulphur Dioxide Problem; Control of Sulphur Dioxide.

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**GEM 317 Remote Sensing**
**APPENDIX C**

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|---|---|---|
| ***GGE 3342*** | ***Imaging and Mapping I*** | ***5 ch (3C 3L)*** |

*Overview and physical basis of remote sensing. Space- and air-borne sensor systems, active and passive sensors. Fundamental geometry of photogrammetry. Image statistics. Rectification of digital imagery. Image enhancement, spectral and spatial filtering. Multi-spectral transformations. Thematic information extraction, classification and accuracy assessment, change detection. Credit will be given for only one of GGE 3342 or GGE 5342. Prerequisite: GGE 2413 or permission of instructor.*

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**GEM 328 Applied Geophysics I (Mag; Radiometrics & Gravity)**
**APPENDIX C**

| | | |
|---|---|---|
| ***GEOL 4512*** | ***Exploration Geophysics II*** | ***5 ch (3C 2L)*** |

*Introduction to principles, survey procedures and interpretation techniques of the electrical and seismic methods of geophysical exploration. The application of these methods is illustrated by examples from exploration of mineral deposits or engineering geology.*

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**GEM 412 Petroleum Geology**

**(See UG Syllabus)**

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**GEO 314 Geographic Information Systems**
**(From Geography Department of UG)**

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|---|---|---|
| ***GGE 4403*** | ***Geographic Information Systems*** | ***4 ch (2C 3L)*** |

*Applications of hardware and software components of geographical information systems (GIS). GIS functions and architecture. Characteristics of GIS data structures and database management systems. Introduction to spatial modeling and analysis. GIS data integration and standards. Prerequisites: CS 1013 or CS 1083, GGE 2413 or permission of instructor.*

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**MEC 111 – Engineering Drawing I**

| | | |
|---|---|---|
| ***ME 1003*** | ***Engineering Graphics*** | ***4 ch (2C 3L)*** |

*Engineering drafting is introduced through technical sketching, instrument drawing, and computer aided methods. Fundamentals of manual drafting: use of instruments, scales, lettering, and line styles. Standard drawing types, multi-views, isometrics, pictorials, assembly drawings, cross-sections. Graphics symbols for fasteners, welding, tolerancing and surface finish specification; dimensioning. Use of a commercial CAD software package. The link between manual methods and computer methods is developed. Descriptive geometry and spatial analysis to establish relationships between three-dimensional objects, lines, points or planes, are examined in detail. Drafting is emphasized as a communications medium to convey highly technical information and images in a concise and universally recognized format. Upon successful completion of the course the student will be capable of productive work in a drafting environment.*

**Drawing Office Practice**
Lay out of drawing sheet, margins, title block, lettering number.

Abbreviations, Conventional Representation.
Language of Lines.
Scales – Full size, half size, twice full size, etc.

**Projection Drawing**
Orthographic Projections – First and Third angle, multiview representation.
Orthographic Projection – simple Engineering components and dimensioning.
Oblique Projection – Cavalier, cabinet.
Isometric Projection – Circles, Curves.

**Plane Geometry**
Construction – angles, Triangles, Perpendiculars, Quadrilaterals, Construction – Polygons.
Inscribed, escribed, concentric circles.
Construction – Ellipses
Engineering application of Plane Geometry
Enlargement and reduction of Figures according to area. Conversion of area.

**Solid Geometry**
Construction of whole and Truncated cylinders and cones from given data – orthographic views, development, true Shape. Whole and Truncated prisms and pyramids.
Projections and sections of Prisms cones cylinder and pyramids.

**Fasteners**
Bolt and nut constructions, representation.
Rivets screws, pins, other locking devices.

**Assembles and Details**
Prepare assembles from given details (up to 6 components)
Parts List.

**Sketching**
Sketching sold geometic shapes and Engineering components.
N.B. 1 semester of MEC 111 = 3 hours

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**MEC 121 – Engineering Drawing II**
(MEC 111 & 121 Combined)

| | | |
|---|---|---|
| ***ME 1003*** | ***Engineering Graphics*** | ***4 ch (2C 3L)*** |

*Engineering drafting is introduced through technical sketching, instrument drawing, and computer aided methods. Fundamentals of manual drafting: use of instruments, scales, lettering, and line styles. Standard drawing types, multi-views, isometrics, pictorials, assembly drawings, cross-sections. Graphics symbols for fasteners, welding, tolerancing and surface finish specification; dimensioning. Use of a commercial CAD software package. The link between manual methods and computer methods is developed. Descriptive geometry and spatial analysis to establish relationships between three-dimensional objects, lines, points or planes, are examined in detail. Drafting is emphasized as a communications medium to convey highly technical information and images in a concise and universally recognized format. Upon successful completion of the course the student will be capable of productive work in a drafting environment.*

To apply the principles of plane and solid geometry in solving engineering drawing problems. To interpret and produce working drawings in engineering to given specifications. To apply techniques of sketching as a means of rapid communication in engineering.

**Loci**
Cycloid Involutes Archimedian spiral – Their engineering application.

Links and mechanisms, single and double Dar systems.

Parabola and hyperbola and engineering applications.
Lines and space – de – fermining rue lenghts.
Engineering problems solved by application of the above.

**Solid Geometry**
Projection of whole and truncated solids to show plans elevations in first and third angle drawing.
Auxiliary views of truncations and whole, prisms, cylinders and pyramids.
Development of the above solids.
Intersections and interplue, trations of solids and their development.

**Engineering Drawing**
Third angle projections:
Drawing of engineering components in third angle projections.
Assembly of engineering components to make a complete working drawing. Sectioning:
Using cutting planes to show insides of engineering components.
Whole section and part section drawing of details to make up an assembly.
Introduction to limits and fits and dimensioning to show these.

**Engineering Drawing**
Electrical, Symbols and components; their graphic representation; line diagrams and simple circuitry.

**Sketching**
Free band sketching, of various components in isometric oblique, and lined diagram.

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**MEC 113 – Applied Mechanics**

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|---|---|---|
| ***CE 1013*** | ***Applied Mechanics I: Statics*** | ***4 ch (3C 1T)*** |

*This course is designed to introduce first year engineering students to the fundamental concepts of two- and three-dimensional force systems. Related concepts such as centroids and moments of inertia are also introduced. Practical applications include frames, machines, trusses and beams.*

- Addition and subtraction of vectors, vectors notations.
- Displacement, velocity and acceleration.
- Relationship between displacement, velocity, acceleration and time.
- Velocity time graph
- Motion of projectiles. Path of projectile. Range on horizontal and incline planes. Time of flight.
- Absolute and relative velocity
- Relationship between angular displacement, angular velocity and Angular acceleration.
- Relationship between linear and angular velocity. Conversion from angular to linear velocity. Combine linear and angular motion.
- Torque and angular motion (rotation). Moment of inertia of annular rings and disc, radius of gyration. Motion in a circular path; Direction of acceleration. Centripetal and centrifugal acceleration. Conical pendulum.
- Balancing of rotation masses. Mass moment of inertia.
- Stability of vehicle on circular path, banking of roads and race tracks.
- Periodic Motion; Definition and fundamental equation mathematical approach to simple harmonic motion. Motion of mass supported by spring motion of simple pendulum.
- Impulse and Momentum; Conservation
- Of moment collision of elastic bodies and impact of two bodies.
- Direct impact of two spheres. Rate of change of angular momentum.
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**MEC 123 – Mechanic II**
***MEC 123/224 (Restructured***
***MEC 123/224 (Restructured from Mechanics and Strength of Materials)***

| | | |
|---|---|---|
| ***GEOL 3411*** | ***Rock Mechanics*** | ***5 ch (3C 2L [W]*** |

*An introduction to the deformation and fracture of rocks when subjected to a natural or man-imposed stress field. The concepts of stress, strain, stress-strain relations; creep and strength are applied to geological materials. The mechanisms involved in the failure of continuous, discontinuous and layered rocks are discussed. Prerequisites: GEOL 1001/1012/1006 or 1017 or approved equivalent.*

| | | |
|---|---|---|
| ***GE 4432*** | ***Rock Mechanics Design*** | ***5 ch (2C 3L)*** |

*Classification, description and testing of the rock mass and the measurement of in-situ stress. Stability of underground openings and design of tunnel supports. Prerequisite: GE 4411. Equivalent to GEOL 4432.*

| | | |
|---|---|---|
| ***ME 1113*** | ***Applied Mechanics II: Dynamics*** | ***4 ch (3C 1T)*** |

*Vector analysis is introduced and applied to the kinematics and dynamics of particle motion along straight and curved paths. Newton's second and third laws, work, energy and momentum of particles are reviewed. Moments of area and inertia. Rotation of a rigid body around a fixed axis. Motion of a rigid body in a plane. Energy, momentum and angular momentum of a rigid body in plane motion. Simple harmonic motion. Prerequisites: CE 1013, MATH 1917 or equivalent. Co-requisite: MATH 1013.*

**Forces and Frame Work**

General conditions for equilibrium. Translation and rotation. Parallel force systems. Center of gravity and centroid. Bow's notion. Graphical solution. Concurrent, co-planar forces. Frame structure – Assumptions, struts, ties, rigidity and redunancy.
Method of sections. Resolution of forces of joints.

**Friction and Machines**
Limiting value of static friction. The laws of friction. Angle of repose. Friction and the inclined plane, general case efficiency.
Motion down the plane.
The screw-thread.
Mechanical advantage, velocity ratio, efficiency.
The ideal machine. The law of machines.

**Moments of Area**
First and second moment of area. Polar second moment of area.

Important theorems involving second moments of area.
Moment of area. Radius of Gyration. Section modulus.

**Stress and Strain**
Intensity of stress. Types of stress and application.
Tensile and compressive strain and application.
Shear strain and application.
Elasticity, Hooke's Law.

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**MEC 214 – Strength of Materials I**
***(Same as Rock Mechanics)***
***MEC 123/224 (Restructured)***

| | | |
|---|---|---|
| ***GEOL 3411*** | ***Rock Mechanics*** | ***5 ch (3C 2L [W]*** |

*An introduction to the deformation and fracture of rocks when subjected to a natural or man-imposed stress field. The concepts of stress, strain, stress-strain relations; creep and strength are applied to geological materials. The mechanisms involved in the failure of continuous, discontinuous and layered rocks are discussed. Prerequisites: GEOL 1001/1012/1006 or 1017 or approved equivalent.*

This course covers the requirements of students to understand the principles underlying engineering design. It sets out to continue the formulation of the foundation work required to provide a comprehensive explanation of the behaviour of solids under loads to students.

To develop a working knowledge of the relation between the loads applied to non rigid bodies made of given material and the resulting deformation of the body.

To develop an understanding of the relations between the loads applied to the non rigid body and the stresses produced in the body.

**Stress-Strain Relations**
Normal stress and strain. Tensile and Compressive Stress. Tensile and Compressive Strains. Working stresses and Factor of Safety. Stress-Strain diagrams. Elasticity and Plasticity. Linear Elasticity and Plasticity. Linear Elasticity and Hooke's Law. Lateral Strain and Poisson's Ratio. Composite bars in tension and compression. Temperature Stresses. Temperate Stresses in Composit Bars. Strain energy and work done in the Tensile Test. Stress in Thin Cylinders.

**Analysis of Stress and Strain**
Plane Stress. General Two-Dimensional Stress System. Stresses on the Inclined Plane. Principal Stresses and Maximum Shear Stress. Mohr's Circle of Plane Stress. Strain in an Inclined Direction. Mohr's Circle of Strain. Elastic Stress Strain relationships. Relationship between E, G and v. Strain….. Strain Energy for two dimensional stress systems.

**Shearing Force and Bending Moment**
Types of Beams. Shearing Force. Bending Moment. Types of Loads (Concentrated loads, Uniformly distributed loads, Combined loads). Types of support. Relationship between load, shearing force, and bending moment. Shear Force and Bending Moments Diagrams.

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**MEC 224 - Strengths of Materials II**
***(Same as Rock Mechanics)***
***MEC 123/224 (Restructured from Mechanics and Strength of Materials)***

| | | |
|---|---|---|
| ***GE 4432*** | ***Rock Mechanics Design*** | ***5 ch (2C 3L)*** |

*Classification, description and testing of the rock mass and the measurement of in-situ stress.*

*Stability of underground openings and design of tunnel supports. Prerequisite: GE 4411. Equivalent to GEOL 4432.*

This course covers the requirements of students to understand the principles underlying engineering design. It sets out to continue the formulation work required to provide a comprehensive explanation of the behaviour of solids under loads to students.

To develop a working knowledge of the relation between the loads applied to non rigid bodies made of given material and the resulting deformation of the body. To develop a understanding of the relations between the loads applied to the non rigid body and the stresses produced in the body.

**Bending in Beams**
The Bending Relationship. Direct and Bending Stress. Elastic Section Modulus. Composite Beams. Reinforced Concrete Beams. Principal Moment of Inertia.

**Shear Stress in Beams**
Cross Sectional Shapes of Beams. Variation of Shear Stress. Shear Stresses in Rectangular Beams. Shear Stresses in the Web of Beams with Flanges. Shear Stress in Circular Beams.

**Torsion**
Torsion of Circular Bars. Non uniform Torsion. Torsion of Thin-wall cylinders. Torsion of Solid Circular Shafts. Relationship between Stress. Strain and Angle of twist. Relationship between Torque and Shear stress. Torsion of Hollow Circular Shafts. Torsion of Tapered Shafts. Torsion of Thin Tube of Non Circular Section. Torsion of Rectangular Strip. Torsion of Solid Rectangular and Square Section. Combined Bending and Twisting.

**Deflection of Beams**
Differential Equation of Deflection. Deflection by the Integration of the Bending Moments Equation. Deflecting irrigation of the Shearing Force and Load Equation. Moments of Area Method.

Assessment will be continuous course work assessment and a final examination at the end of the academic year.

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**MIN 112 – Surface Mining I**

This course is intended to expose the student to the methods utilized for the extraction of minerals from near – the – surface deposits.

**Unit I Introduction**
Minerals, rocks and ore. Definition of mining terms. The mining engineer. Life cycle of a mine: financial considerations. Job description of mines production engineer. Mining and man. Unit operations in mining.

**Unit II Excavating and Loading Euipment: Capabilities and Limitations**
Conventional Machines: the loading shovel; the crawler dragline; the hydraulic shovel/dragline. Mobile Machines: crawler – mounted versus rubber-tyred; the front-end tractor shovel; the bulldozer; the ripper; the tractor-scraper.

**Unit III Single Seam Strip Mining with Walking Dragline(s)**
Dragline Terminology. Walking and Digging procedures for walking dragline. Simple side casting. Cut/range diagrams. Thicker overburden: stripping without rehandle. Advanced benching/chopdown method. Thicker overburden: stripping with rehandle, extended benching method. The pullback method. Overburden bridge/intermediate extended bench method. Terrace mining. Thick mineral/shallow overburden deposits. Opening up the deposit. Sitting of the box-cut. End-cut method. Side-cut method. Rehandle (end-cut) method. Borrow pit method. Cut/range diagrams for box-cuts. Spoiling practice and sequence. Spoil pile stability. Advantages and disadvantages of walking draglines when used in strip mining.

**Unit IV Single seam strip mining with the stripping shovel**
The stripping shovel. Cut/range diagrams. Opening up the deposit. Advantages and disadvantages of stripping shovels when used in strip mining. Stripping shovel versus walking dragline.

**Unit V Single seam strip mining with bucket wheel excavator(s)**
Continuous Excavators: the bucket chain excavator (BCE), the bucket wheel excavator (BWE), Advantages of continuous excavators. Strip mining with BWE's. Advantages and disadvantages of BWE's when used in strip mining.

**Unit VI Single seam strip mining under thick overburden and/or thick mineral conditions**
Transport methods. Factors affecting mine layout. Methods of advance: features of parallel advance operations, features of rotating pit operations, working the field. Opening up the mine.

**Unit VII Case Studies in Strip Mining**
Guymine, Linden. U.S.A. practice

**End of term exam**

Course Assessment: Coursework 40%
Final Exam 60%

**RECOMMENDED TEXT**
1. Sinclair, J. Quarrying, Opencast and Alluvial Mining. Elsevier Publishing Co. Ltd. 169
2. Pfleider, E.P. Surface Mining: The American Institute of Mining, Metallurgical and Petroleum Engineers Inc., NY, 1968.

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**MIN 215 – Mineral Processing I**

This course will introduce students to the basic terms, concepts and the processes used in the winning of values from their ores. The basic steps of (a) liberation, (b) sizing, (c) separation, (d) dewatering will be studied in turn.

**Unit I Comminution**
Crushing, grinding.

**Unit II Sizing**
Industrial screens, classification, particle size analysis.

**Unit III Concentration**
Ore sorting, gravity concentration, heavy medium separation, magnetic and high tension separators, froth flotation.

**End of term examination.**

**Course Assessment**:
Coursework 40%
Final Exam 60%

**RECOMMENDED TEXT**
1. Pryor E.J. Mineral Processing, Elsewer Publishing Co. Ltd. 1965.
2. Wills B.A. Mineral Processing Technology, Pergamon 2nd ed. 1981.

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**MIN 225 – Mineral Processing II**

The course will introduce students to the basic terms, concepts and the processes used in the winning of values fromtheir ores.

**Unit I Solid Liquid Separation**
Sedimentation, filtration, thermal drying.

**Unit II Gravity Concentration**
Particular emphasis will be placed on the techniques used to recover cassiterite, ilmenite, rutile, ziron, monazite, garnet, magnetite and quartz from alluvial deposits.

Unit III The processing of Gold, Diamond and Bauxite Ores
Gold ores: gravity separation plus amalgamation, cyanidation. Diamond ores: heavy medium separation, electronic sorting, grease tabling. Bauxite

Week 15 End of Term Examination

**Course Assessment** Coursework 40%
Final Exam 60%

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**MIN 422 Probability & Stats. for Engineers**
(Taken from **MIN 422 – Mining Engineering II)**

| | | |
|---|---|---|
| ***STAT 2953*** | ***Probability and Statistics for Engineers*** | ***3 ch (3C)*** |

*Probability: Elementary Notions, Discrete and Continuous Distributions, Characteristics of Distribution. Statistics: Sampling, Estimation and Hypothesis Testing, Curve Fitting, Quality Control. Prerequisite: MATH 1013. Note: Credit can be obtained in only one of STAT 1213, 2043, 2253, 2263, 2264, 2593.*

This course prepares the student to be able to interpret new developments in operations research and mine planning.

Further Geostatistics

The characteristics of Regionalised Variables. Variograms and Semi-variograms. Estimation of area.
Kri's relationship. Intrinsic Grading. Volume – Variance relationships.
Regularisation and deregularisation. Extension variance. Estimation of the total amount of ore.
Design of a sampling programme. Krigging. Grade Control. Grade – tonnage curves.

Operations Research Techniques in Mining
Linear, integer and dynamic programming. Design making in operations research. Graphical solutions. Algebral solutions.

Probabilistic Models
Review of probability theory. Decision theory and games. Project scheduling – PERT-CPM. Inventory models.

Mathematical Modelling
Systems simulation
Truck fleet sizing. Truck/rail movement. Shovel/truck.

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**MIN 425 Mineral Resources & the Environment**

| | | |
|---|---|---|
| ***GE 4442*** | ***Mineral Resource Utilization*** | ***5 ch (3C 2L)*** |

*Mineral exploration, evaluation, exploitation, processing, marketing and conservation.*

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**PHY 110 Physics for Engineers**
**(See UG Syllabus)**

| | | |
|---|---|---|
| ***PHYS 1913*** | ***Fundamentals of Physics (for Engineers)*** | ***3 ch (3C 1T)*** |

*Vectors, kinematics. Momentum, force, KE and PE. Simple Harmonic Motion. Standing waves. Kinetic theory of gases. Circular orbits. Gravitation. Electrostatics. Charge, electric field and potential. Atomic structure. Prerequisites: At least 70% in two years of high school Physics plus Grade 12 Mathematics. Students with less than 70% in two years of high school Physics plus Grade 12 Mathematics must take PHYS 1940 instead. Students with less than 80% in two years of high school Physics and Grade 12 Mathematics should take PHYS 1913 in second term.*

| | | |
|---|---|---|
| ***PHYS 1918*** | ***Physics Laboratory (for Engineers)*** | ***2 ch (3L) [W]*** |

*Weekly exercises in practical physics, covering topics in mechanics, electrostatics and atomic physics. Corequisite: PHYS 1913.*

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**SRV 111 – Engineering Surveying I**

| | | |
|---|---|---|
| ***GGE 1803*** | ***Practicum for Civil Engineers*** | ***2 ch*** |

*Two weeks of practical exercises following spring examinations. Involves optical distance measurement; trigonometric heighting; taping; balancing angles, height differences, traverses; horizontal circular curves; vertical curves; area & volume computations; stream gauging; elementary photogrammetry. Prerequisite: GGE 1001 or equivalent.*

- Introduction to plane and geodetic surveying; Basic principles of surveying.
- Chain surveys; types of survey chains; systems and methods of measurements; chaining; chain pins; chaining as quad.
- Techniques of chaining; offsetting, picking up details.
- Field notes: booking and plotting, detailing, errors and mistakes.
- Maps and Plans: scales, grids, drawing office practice.
- Obstacle surveys: types and execution. Simple optics and coordinate geometry; optics of survey instruments.
- Leveling: principles of leveling; types of leveling; heights, elevations and topography.
- Level instruments – design and use. Types of levels; reading and stadia hairs.
- Calibration of Levels: two peg test. Leveling staves, booking and reductions.

- Flying levels, bench marks, heighting, etc.
- Sectioning: principles: longitudinal sections, cross-sections; contours.
- Compass surveying: use of the compass in the field.
- Compass traverses and adjustments.

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**SRV III/IV Surveying I & II (Merged)**

**SRV 121 – Engineering Surveying II**

- Plane table survey: principles and techniques; types of plane tabling; use of plane table in the field.
- Traversing techniques with the plane table.
- The Theodolite; principles, design, tests and use. Techniques of observation with the theodolite; booking of angles; calibration, etc. Testing the theodolite.
- Traversing: principles, use and adjustments.
- Booking and adjustments of traverses. Observing a Quod.
- Areas and Volumes: Computation of areas and volumes of earthworks.
- Mathematical and graphical computation of areas and volumes; use of planimeter and computing scales.
- Setting out principles: sewers, drains and small buildings.
- Setting out – advanced and modern techniques. Settiing works.
- Simple curves: calculations and laying out.
- Setting out of simple curves.

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**SSC 411 Soil and Water Management**

| | | |
|---|---|---|
| ***CE 5432*** | ***Wastewater Treatment and Pollution Control*** | ***4 ch (3C, 2L)*** |

*Applied wastewater microbiology, wastewater analysis (physical, chemical, and biological), wastewater treatment processes, industrial and municipal wastewater treatment and management, wastewater treatment systems and plant design. The course content will focus on treatment and management issues of wastewater from industrial, municipal, and domestic sources. Pollution control strategies and protocols are also examined. Prerequisites: CHEM 1882 (or equivalent) and CE 3403 or CHE 2004, or permission of course instructor.*

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**CIV 220 – Building Structures II**

To develop in students an understanding of analysis techniques with emphasis on graphical and handbook designs. To give students an appreciation of structures and their relevance to Architecture.

**Statically Indeterminate Structures:**
Moment distribution and slope deflection methods of analysis.

Deflection:
Unit load and Macaulay's Method.

**Columns:**
End fixture of columns, effective length, slenderness ratio, behaviour, column strength calculation: formu la. Design of isolated pad foundations.

**Load bearing walls:**
Types of walling materials. Design considerations, effective height, end restraint, thickness, slenderness ratio, safe working loads for solid and cavity walls (with and without openings). Eccentricity of loading.

**Design of strip foundations**

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**CIV 414 – Advanced Concrete Structures & Design**

The aim of the course is to expose the students to more advanced topics in structural analysis. The emphasis is on complex structures and modern analysis techniques with emphasis on computer applications. On successful completion of the course students should be equipped with the essential knowledge and skills to analyze most structures encountered in practice, as well as be adequately prepared for post-graduate studies in field of structures.

- Analysis of beams loaded in combined flexure, shear and torsion at the ultimate limit state.

- Design of beams for combined flexure, shear and torsion.
- Serviceability limit states of deflection and cracking. Creep and Shrinkage in R.C. Structures.
- Design of flat slabs.
- Yield Line Analysis of slabs.
- Applications of Yield Line Analysis in the design of slabs.
- Design of r.C. Columns: slender columns; uniaxial and biaxial bending; combined bending and axial compression.
- Design of rigid frames and multi-storey concrete buildings.
- Design of shear walls; Strut and tie methods; design of joints and corbels.
- Design of reinforced concrete bridges. Structural forms for reinforced concrete bridges. Design considerations, loadings.
- Design of reinforced concrete bridges.
- Design of R.C. liquid retaining structures: Tanks and Reservoirs.
- Design of R.C. water retaining structures: Retaining walls.
- Prestressed concrete: mechanics of the prestressed section; pre and post tensioning. Analysis of a beam section for given moment and prestress.
- Definition of Central and Limit Kerns; derivation and use of magnel diagrams for critical section. Introduction of statically indeterminate beam structures.
- Concept of concordancy for tendon profile; determination of steel envelope throughout beam.
- Derivation of concordant tendon profiles; concept of linear transformation of tendon profile.

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**CIV 425 – Advanced Structural Analysis**

The aim of the course is to expose the students to more advanced topics in structural analysis. The emphasis is on complex structures and modern analysis techniques with computer applications. On successful completion of the course students should be equipped with the essential knowledge and skills to analyze most structures encountered in practice, as well as be adequately prepared for post-graduate studies in field of structures.

- Review of Matrix Structural Analysis
- Stiffness method and formulations
- Derivation of element stiffness matrices
- Assembly of structure Stiffness matrix
- The Direct Stiffness Method
- Computer applications – Programming the stiffness method
- Analysis of horizontal grid frames and grillages
- Analysis of beams on elastic foundations
- Place Theory
- Thin plates in cylindrical bending
- Analysis of thin plates; Navier solution
- Shell theory: analysis of thin shells
- Analysis of thin shells
- Advanced Structural dynamics
- Introduction to the Finite Element Method
- Formulation and applications of FEM

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**CIV 317 – Structural Analysis I**

To expose the students to more advanced and modern methods of structure analysis for determinate and indeterminate structures, and develop their capability to analyze complex structures both manually and by the application of computer methods of analysis.

- Indeterminate structures: Static and kinematic indeterminacy. Concept of compatibility; general methods of analysis of statically indeterminate structures; Behaviour of statically indeterminate structures; Degree of statical indeterminacy of 2-D rigid jointed structures.
- Slope-deflection method: continuous beams and rigid frames without sway.
- Slope-deflection method: rigid frames with sway.
- Moment distribution method: continuous beams.
- Moment distribution method: rigid jointed frames. Special techniques in the moment distribution.
- Work and Energy: Virtual Work and Energy principles: Potential energy; Complementary Energy. Principle of Virtual Work: unit load theorem.
- Unit displacement theorem: Application to the analysis of beams and trusses.

- Application of the Principle of Virtual Work in analysis of frames.
- Elastic instability analysis: Introduction to stability; single degree of freedom system; buckling, bifurcation and snap through; General theory of elastic instability.
- Elastic instability: Euler critical loads for axially loaded and eccentrically loaded columns; Ideal and real column behaviour: axially loaded column with initial deformation; Buckling due to imperfections.
- Lateral torsional buckling: Derivation of beam-column differential equation. Solution for various boundary conditions (pin-ended column, fixed end/clamped column, propped cantilever).
- Buckling of frames. The use of stability functions, application of computer methods.
- Practical design of axially loaded struts: Perry-Robertson formula.
- Applications of Computer methods in structural analysis.

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**CIV 417 – Structural Analysis II**

To expose the students to more advanced and modern methods of structural analysis with emphasis of computer applications.

- Introduction to Matrix Structural Analysis; Stiffness and Flexibility Methods; Levels of Analysis (direct; semi-automatic; automatic). Generalized displacements and forces, degrees of freedom, global and member coordinates/axis.
- The Flexibility Method; Flexibility Matrix, Member Action & Support Actions, and Joint Displacements; application to beams and trusses.
- Flexibility Method: Equivalent Joint Loadings, Member Flexibility Mastrices; System Flexibility Matrix Analysis of framed structures.
- Introduction to Stiffness Method; behaviour of elements; beam, truss, frame elements; element stiffness Matrices, stiffness coefficients.
- Matrix Stiffness Method for Analysis of continuous beams.
- Matrix Stiffness Method for Trusses and Frame.
- Direct stiffness method: Assembling individual element matrices; Computers applications: manipulation of large matrice, node numbering to reduce the computing time.
- Plastic analysis of structures: Elementary principles of plastic theory and design. Plastic moment of resistance and shape factor to various sections.
- Plastic Analysis; Plasticity, Upper and Lower Bond Theorems; Plastic Collapse of Frames.
- Upper and Lower Bond Theorems: Application to design of continuous beams and frames. Discussion of the advantages and disadvantages.
- Plastic Analysis of frames: Combination of Mechanism.
- Dynamics: Elementary structural dynamics; Dynamic Loads, Structural Modeling (degrees of freedom, lumped mass stiffness and flexibility). General cases of disturbing force.
- Dynamics: Free damped vibrations of single degree of freedom, elastic structures, viscous damping differential equation and its solution.
- Flexural vibrations of beams and frames. Wind induced oscillations; Natural frequency, initial conditions; Design for earthquake loads.

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**CIV 318 – Structural Design I**

To expose and familiarize the student with design principles for reinforced concrete, and the use of various design codes for reinforced concrete. Emphasis will be placed on design standards being used in local practice and on the applications in computer design of structures.

- Behaviour of reinforced concrete. Stress-strain characteristics of steel and concrete. Grades of concrete and reinforcing steels. Effects of triaxial stress states, structural forms. Construction methods.
- Design methods: elastic design, load and resistance factor design (LRFD), Limit State design – philosophy and

principles. Design codes and standards. Estimation and distribution of dead and live loads, effects of wind pressure.

- Reinforced concrete beams – ultimate limit state: rectangular stress block, ultimate moment of resistance for singly and doubly reinforced beams.
- Design of rectangular and flanged beams for the ultimate limit state. Shear, bond, anchorage and curtailment.
- Reinforced concrete beams – serviceability limit states: deflection, cracking.
- Design of continuous beams. Design for torsion.
- Column design: axially loaded short columns. Eccentrically loaded short columns, reinforcement rules.
- Design of Slender columns: Effective heights and slenderness.
- Design of columns for uniaxial and biaxial bending.
- Reinforced concrete slabs: types of slabs. Ultimate and serviceability limit states, shear in slabs. Design of one-way spanning slabs.
- Design of two-way spanning slabs.
- Design of shallow foundations: isolated footing, combined footing.
- Design of Strip foundations.
- Design of water retaining structures.
- Design of retaining walls.

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**GEM 229 – Mineral Exploration Case Studies**

This final semester course is tailored to acquaint students with the real-life application of many of the techniques and principles they have encountered in the previous semesters. Emphasis is on local examples and on countries with similar geological environments as ours.
The Exploration and Exploitation of the Omai Gold Deposit.
The Exploration and Proposed Exploitation of the Mahdia Alluvial Gold Deposit.
Exploration Work at the Marudi Mt Gold Deposit.
Petroleum Exploration in Guyana.
Mine-based Exploration for Bauxite at Linen.
Exploration for Gold and Base Metals at Groete Creek.
Winston/Lake Massive Sulphide Discovery (in Canada).
The large-scale Search for Alluvial Diamond Targets in the Mazauni River Basin.
The Search for Primary Diamond Sources in Guyana.
Pork-knocking: An Example of small-scale Exploration and Mining.
The Search for Industrial Materials in Guyana: Dimension Stones, Clay/Kaolin, White Sand and Gemstones.
Multi-element Geochemical Surveys in Guyana.

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**GEM 211 – Sedimentology**

| | | |
|---|---|---|
| ***GEOL 2212*** | ***Sedimentology I*** | ***5 ch (2C 3L)*** |

*Weathering and diagenetic processes. Origin, properties and classification of sedimentary rocks. Physical and biogenic sedimentary structures. Sediment transport mechanisms, particularly sediment gravity flows. Stratigraphic principles. Prerequisites: GEOL 1001/1012/1006 or 1017 or equivalent.*

To familiarize student with the classification of rocks and to identify these in hand-specimens.

**From Sediment to Sedimentary Rock (14 hrs)**
Sediments and Sedimentation; Clastic Sediments; Chemical Sediments.

**Transport and Deposition of Clastic Sediments (14 hrs)**
Transportation; Environmental Clues; Diagenesis and Lithification.

**Textures and Structures of Sedimentary Rocks (14 hrs)**
Sedimentary stratification – (beds, bedding planes and laminations)
Regular Bedding; Graded Bedding; Current Bedding; Slump Bedding; Regular Bedding (folded); Mud-cracks.

**Classification and Formation of Sedimentary Rocks (14 hrs)**
Detrital and Chemical/Organic Detrital; Psammites; Psephites; Pelites.

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**MEC 122 – Workshop & Maintenance Technology & Materials II**

**Welding**

Safety precautions, equipment and care –gas cylinders and torches. Arc welding equipment. Welding rods and fluxes.

Types of weld.

Preparing and adjusting gas welding –equipment. Preparation of material. Simple welding joints – Tee =, lap, butt. Ets cutting with torch. Cleaning up the weld.

Brazing – preparation of materials. Use of flux. Making a bronze weld.

Arc welding – safety precautions, equipment and accessories. Electrodes. Preparation for welding. Making the weld. Resistance welding.

**Machine Work**

Lathe work – safety precautions. Turning, boring. Use of face plate and four jaw chuck.

Screw cutting.

Milling – setting up the machine with specific cutters. Use of dividing head. Milling flat surfaces, squaring, slotting.

Shaping machine – setting up the job. Adjusting the length and position of stroke. Cutting speeds and feed.

Machining horizontal surfaces.

Introduction to the surface grinder. Grinding flat surfaces.

**Lubrication and Wear**

Purpose of lubrication, types of lubricants – oils and grease. Methods of application of lubricants. Lubrication system.

Examination and testing for wear in shafts and bearing. Wear in clutches and transmission systems.

**Repair Processes**

Casting repair, shaft and roller refurbishing – welding, milling and grinding.

# APPENDIX C

**(A possible model for the development of Post Graduate studies in Environmental Management at the University of Guyana)**

**Environmental Applied Science and Management**
**(RYERSON UNIVERSITY, Toronto, Canada)**

**Master of Applied Science**

This Appendix contains the List of Courses which is used in teaching the Master of Science in Environmental Applied Science and Management at Ryerson University in Toronto.

## Master of Applied Science

| | | Credits |
|---|---|---|
| *ES8901 | Env.Ap.Sci. & Mgt.: Chemical and Biological Pathways | 1 |
| ES8921 | Env.Ap.Sci. & Mgt.: Environmental Law and Policy | 1 |
| ES8930 | Env.Ap.Sci. & Mgt.: Seminar in Env. Appl. Science & Mgt. | 1 |

AND one of the following Options:

**PROFESSIONAL PROJECT Option**

| | | |
|---|---|---|
| ES8080 | Env.Ap.Sci. & Mgt.: Project | 2 |

AND seven Elective credits, with a minimum of two from Group A and two from Group B. 7

**THESIS Option**

| | | |
|---|---|---|
| ES 8090 | Env.Ap.Sci. & Mgt.: Thesis | 5 |

AND four Elective credits, with a minimum of one from Group A and one from Group B. 4

Total Credits Required **12**

**ELECTIVES**

**Group A: Environmental Applied Science Credits**

| | | |
|---|---|---|
| *ES8902 | Env.Ap.Sci. & Mgt.: Water Pollution Control Processes | 1 |
| *ES8903 | Env.Ap.Sci. & Mgt.: Pollution Prevention | 1 |
| *ES8904 | Env.Ap.Sci. & Mgt.: Waste Management | 1 |
| ES8905 | Env.Ap.Sci. & Mgt.: Air Pollution Science and Engineering | 1 |
| ES8906 | Env.Ap.Sci. & Mgt.: Water Pollution Transport | 1 |
| ES8907 | Env.Ap.Sci. & Mgt.: Wastewater Engineering | 1 |
| ES8908 | Env.Ap.Sci. & Mgt.: Soil Remediation | 1 |
| ES8909 | Env.Ap.Sci. & Mgt.: Environmental Biotechnology | 1 |
| *ES8910 | Env.Ap.Sci. & Mgt.: Energy and the Environment | 1 |

**Group B: Environmental Management**

| | | |
|---|---|---|
| ES8922 | Env.Ap.Sci. & Mgt.: GIS for Environmental Management | 1 |
| ES8923 | Env.Ap.Sci. & Mgt.: Environmental Assessment | 1 |
| ES8924 | Env.Ap.Sci. & Mgt.: Environmental Management Systems | 1 |
| ES8925 | Env.Ap.Sci. & Mgt.: Decision Making/Strategic Plan. In Mgt. | 1 |
| ES8926 | Env.Ap.Sci. & Mgt.: Environmental Economics | 1 |
| ES8927 | Env.Ap.Sci. & Mgt.: Risk Assessment in Environmental Mgt. | 1 |

**Group C: Environmental Applied Science and Management**

ES8950 Env.Ap.Sci. & Mgt.: Independent Study in Env. Sci. & Mgt. 1

***Platform Courses:** The program offers a set of five platform courses in environmental applied science. They are structured to provide both foundational knowledge and advanced study at the graduate level. These courses enable students from a wide range of academic backgrounds (including geography, Public Health Urban and Regional Planning, and Environmental Studies) to take engineering and applied science subjects.

Students who successfully complete a Platform Course will have the option of enrolling in advanced applied environmental science courses in subsequent semesters.

Course Numbering: the second digit of the four digit course number indicates whether the course is a one-term credit (1-9) or more than a one-term credit (0). For example, CC8900 is a one credit course, CC8020 is a two credit course, and CC8095 is three credits.

**Environmental Applied Science and Management**

**ES 8080: Env.Ap.Sci. & Mgt.: Project**

The research project option is intended for students following a professional career path in environmental applied science and management, and is typically conducted in an applied setting. In the project, students propose and carry out advanced work in an industry or a public sector organization under the direction of a faculty supervisor and a project supervisory committee. The research project is submitted in a written report to the faculty supervisor and is evaluated by a project examining committee. 2 Credits

**ES 8090: Env.Ap.Sci. & Mgt.: Thesis**

In the thesis option, students conduct an advanced examination of a topic in the environmental applied science and management areas. Students propose and carry out the research under the direction of a faculty supervisor and a thesis supervisory committee. On completion, the research is submitted in a thesis format, to the supervisor and defended by the student before a thesis examining committee. 5 Credits

**ES 8901: Env.Ap.Sci. & Mgt.: Chemical and Biological Pathways**

This course is devoted to the examination of fundamental and applied aspects in chemical and bio-geochemical processes in the environment. It will primarily deal with the mechanisms which affect the dispersion of naturally occurring and xenobiotic compounds in soils and water. The use of such information and its incorporation into environmental models will be covered. The effect of environmental impacts on chemical and biological processes will be emphasized. The course will include a combination of lectures, student-led seminars and case studies, and a computer-modeling workshop/laboratory. (Platform Course) 1 Credit

**ES 8902: Env.Ap.Sci. & Mgt.: Water Pollution Control Processes**

This course will examine the sources of water pollution including wastewater, non-point source pollutants and storm water run off. The analytical characterization of contaminants will be covered for the major sources and control processes will be reviewed with a focus on wastewater processes. This will be followed by a review of the most relevant technologies used to treat industrial and municipal effluents. (Platform Course) 1 Credit

**ES 8903: Env.Ap.Sci. & Mgt.: Pollution Prevention**

The course examines a number of industry-environment interactions. It discusses pollution prevention and industrial ecology, and it presents a survey of environmental concerns including material and energy budgets, life-cycle assessment, and industrial process wastes and their minimization. Design for environmental quality is discussed including energy use and design for energy efficiency. The course explores the future of industrial activity with regard to the environment and it reviews studies in selected industrial applications. (Platform Course) 1 Credit

**ES 8904: Env.Ap.Sci. & Mgt.: Waste Management**

This course describes the development of solid waste management in response to legislative requirements for waste transport and disposal. To know when solid waste is a resource or a disposal problem requires its analysis and classification. Processing and handling of solid waste demands the proper application of available technology and basic engineering principles. These will be explained and followed by more advanced principles related to separation (including recycling), processing, and transformation of solid waste. Hazardous waste and hazardous materials, as well as federal and provincial regulatory processes governing hazardous wastes, will also be examined. Waste stabilization and solidification, land disposal of waste, environmental site and subsurface characterization will be discussed. Physical conversion of waste including incineration technologies, chemical and biological conversion technologies as well as successful combinations of the three will be described. The course will conclude with a brief review of the main issues in integrated solid waste management. (Platform Course) 1 Credit

**ES 8905: Env.Ap.Sci. & Mgt.: Air Pollution Science and Engineering**

This course examines the nature and movement of pollutants released into the atmosphere and the theoretical aspects upon which devices and technologies for air pollution engineering are based. The characteristics of airborne contaminants are examined and their dispersion is discussed in relation to atmospheric circulation patterns, wind profiles, turbulent diffusion, topographical effects, local circulation effects, temperature in the atmosphere, atmospheric stability, general plume behavior and the Gaussian model. The characteristics and operation of the relevant devices and technologies are investigated. The design of devices and their integration into overall pollution control systems are covered. The devices considered include: settling chambers, cyclones, particulate scrubbers, electrostatic precipitators, fabric filters, VOC incinerators, adsorption, absorption, and condensation devices**. 1 Credit**

**ES 8906: Env.Ap.Sci. & Mgt.: Water Pollution Transport**

A quantitative analysis of surface and subsurface water pollution pathways is crucial to the development of water pollution prevention and control plans. This course discusses the point and

non-point pollution sources in urbanized areas with emphasis on modeling approaches and analysis techniques. It examines the processes governing contaminant transport and behavior including advection, dispersion, diffusion and adsorption. Topics include: surface hydrology, municipal water use cycle, urban drainage systems, point and non-point pollution sources and pollution control strategies for sanitary, storm, and combined sewer systems. It also examines natural groundwater quality, the geochemical origin of major ions in natural groundwater, causes of hardness, groundwater age determination using isotopes, common causes of groundwater contamination, and the transport and biochemical transformation of contaminants in the unsaturated and saturated groundwater zones. 1 Credit

**ES 8907: Env.Ap.Sci. & Mgt.: Wastewater Engineering**

The course is an advanced description of the unit operations in wastewater engineering. It includes physical, chemical and biological processes. In the first case, filtration, sedimentation and clarification of solids will be discussed. Liquid-liquid and gas-liquid separations will follow. Chemical operations will include neutralization, precipitation, chemical redox and ion exchange. The last part of the course will cover fixed and suspended growth biological processes. 1 Credit

**ES 8908: Env.Ap.Sci. & Mgt.: Soil Remediation**

This course overviews the design and operation of processes for soil remediation. Contaminants of interest include halogenated and non-halogenated volatiles, halogenated and non-halogenated semi-volatiles, fuel hydrocarbons, pesticides and inorganics. Seven groups of technologies will be examined: (1) excavation and off-site disposal, (2) soil venting, (3) bioremediation, (4) thermal technologies, (5) chemical technologies, (6) mechanical flushing and washing, and (7) natural attenuation. Exclusion CV8204. 1 Credit

**ES 8909: Env.Ap.Sci. & Mgt.: Environmental Biotechnology**

This course, as a series of lectures and student-led discussions, covers the application of biologically-based technologies in environmental control and remediation. Particular emphasis is placed on understanding the key metabolic processes involved in biodegradation and biodeterioration. Areas of application covered include control of biodeterioration, biologically-based remediation of air, soil, solid waste, wastewater, energy, and bio-control agents. The relevant technologies are also discussed along with the potential positive and negative impacts which may be associated with the use of biotechnologies in the environment. 1 Credit

**ES 8910: Env.Ap.Sci. & Mgt.: Energy And The Environment**

A review of thermodynamic fundamentals is provided including combustion, electricity generation, co-generation, heating, cooling and incineration. Energy utilizing technologies in the residential, commercial, institutional, industrial and transportation sectors and their impacts on the environment are examined. Methods and technologies for controlling and reducing the environmental impacts of energy technologies are discussed. The course covers the design of energy technologies for environmental management. (Platform Course) 1 Credit

**ES 8921: Env.Ap.Sci. & Mgt.: Environmental Law and Policy**

Major themes in environmental law and policy are the effects of scientific uncertainty, political interest groups, economic principles and environmental ethics on the development of environmental policies and laws. Current concepts such as sustainable development, the precautionary principle and the ecosystem approach are critically examined in relation to their legal manifestations. Traditional and novel legal techniques for motivating change in behavior are compared in terms of their effectiveness: performance and procedural approaches, bench-marking, economic rewards and sanctions, and internal auditing. A comparative approach is taken with environmental laws and policies in other jurisdictions such as the United States and the European Union. A close connection is made between environmental management systems and the need for establishing a due diligence defence for all members of an organization in the event of prosecution. 1 Credit

**ES 8922: Env.Ap.Sci. & Mgt.: GIS for Environmental Management**

Geographic Information Systems (GIS) are used to examine the spatial dimensions of environmental data and provide capabilities for data analysis in managing environmental problems. GIS systems are being increasingly recognized for their environmental modeling capabilities. This course indicates the uses of GIS in support of site evaluations, effects monitoring, policy development and decision making. Environmental management research opportunities are explored through lectures, case studies, seminars and hands-on activities using major GIS software packages. 1 Credit

**ES 8923: Env.Ap.Sci. & Mgt.: Environmental Assessment**

This course provides an integrated, interdisciplinary approach to the application and evaluation of current biophysical, social and economic impact assessment. It examines environmental assessment as an environmental decision making instrument in provincial, federal and international contexts and it reviews methods to predict, evaluate and mitigate impacts in both human and natural environments. The course reviews the technical and scientific concepts that must be addressed in a comprehensive assessment of project impacts on complex, interacting physical and human systems. This is complemented by a critical appraisal of institutional structure and decision making in environmental management. Evaluation methods and practical applications are emphasized. 1 Credit

**ES 8924: Env.Ap.Sci. & Mgt.: Environmental Management Systems**

This course examines the legal, economic and ethical reasons for the development, implementation and monitoring of a comprehensive, location-specific Environmental Management System (EMS). An EMS enables an organization to systematically identify environmental concerns and address them. The elements of a generic EMS are explored: planning and risk assessment phases; establishment of a policy; the outline of organization arrangements; design of the array of programs that address specific sets of environmental concerns such as production methods, energy use and waste disposal; and the development of a program of periodic environmental audits. The requirements of ISO 14000 are explored. Issues relating to the integration of EMS with quality management systems and occupational health and safety systems are discussed. 1 Credit

**ES 8925: Env.Ap.Sci. & Mgt.: Decision Making/Strategic Plan. in Mgt.**

This course presents methods in tackling decision making problems and strategic planning issues in

engineering and management. Topics in quantitative decision theory such as influence diagrams, decision trees, subjective probability assessment, and the role of information in decision making including Bayesian analysis are discussed. Multi-criteria decision making techniques such as multi-attribute utility theory and Analytic Hierarchy Process are covered. Key steps and end results of the strategic planning process are analyzed. Formulating planning assumptions, analyzing opportunities, setting objectives, developing strategies and implementing strategic plans are discussed. Case studies are an integral part of the course. 1 Credit

**ES 8926: Env.Ap.Sci. & Mgt.: Environmental Economics**

Environmental economics considers economic tools and analyses and their application in understanding environmental issues. Key economic concepts such as opportunity cost, marginal benefits and costs, and consumer and producer surplus are applied in examining the relationship between economic activities and the environment. The equimarginal principle, the Coase theorem, and the central concepts in cost-effectiveness and cost-benefit analyses are discussed. Case studies are used to illustrate the role of economics in evaluating environmental policies and regulations. The course also examines how business managers are meeting the environmental challenge. The question of how environmental problems and policies affect different groups within society is a central focus of the course. 1 Credit

**ES 8927: Env.Ap.Sci. & Mgt.: Risk Assessment in Environmental Mgt.**

This course examines the application of risk analysis and assessment in environmental management. It reviews the methods of estimating probabilities and consequences of risks in the environment including new technologies, chemicals, biological agents and risk generating facilities. Risk analysis includes risk identification, risk pathways, exposure models and dose-response relationships. The course also sets out the principles of risk management and the process by which risks are perceived and communicated in making environmental decisions. A critical evaluation of risk assessment in environmental decision making is supported by a review of selected cases. 1 Credit

**ES 8930: Env.Ap.Sci. & Mgt.: Seminar in Env. App. Sci. & Mgt.**
The seminar course introduces students to a range of existing environmental problems and the ways that management concepts, drawn from both environmental science and management, can be applied to them. Seminars will include the participation of academic and professional experts in a number of disciplines who will present research and case reviews in environmental practice. Students are assigned to multi-disciplined teams and are required to apply science and management concepts to environmental applied science and management problems. Students demonstrate in their group work, problem definition and analysis, the design of feasible solutions and multi-disciplinary processes for achieving objectives. Each team is required to produce a report that outlines the analytic and decision resolution of the problem. 1 Credit

**ES 8950: Env.Ap.Sci. & Mgt.: Independent Study in Env. Sci. & Mgt.**

Individual directed study of subject areas in environmental applied science and management not addressed in the current curriculum will be carried out under the supervision of a faculty member. A program of supervised, advanced study related to the student's area of concentration will be negotiated on an individual basis with the supervising faculty member. The independent study course is normally intended for students in the final semesters of study. 1 Credit

# APPENDIX D

This Appendix contains the descriptions for four courses that may be considered for inclusion in the Geological Engineering Program at UG.

They are as follows:

- ENVIRONMENTAL GEOLOGY
- REMOTE SENSING
- GEOPHYSICS I
- GEOPHYSICS II

# ENVIRONMENTAL GEOLOGY

## Course Description

This course is intended to provide a background on concepts and processes that allow students to make meaningful assessments of problems related to human interactions with natural geologic systems.

The following topics are covered with each taking about 20-30 minutes to cover. The Course can be presented in the form of Lectures (1 topic/Lecture period) or Seminars. In the case of seminars, each student can research and present a topic of their particular interest.

1. Resource use concepts.
    - Metallic minerals
    - Industrial minerals
    - Aggregates
    - Decorative building materials
    - Other
2. Soils
3. Natural Hazards
4. Floods
5. Channelization
6. Landslides
    - Slope stability
7. Earthquakes
    - Measurement
    - Prediction and hazard reduction
8. Volcanic activity
9. Coastal hazards
10. Water
    - Hydrologic Cycle
    - Water Table problems
    - Water supplies
    - Dams, Reservoirs and Canals
11. Waste management
12. Hazardous Chemicals
13. EPA Protocols
14. Radiation
    - Uranium
    - Radon
    - Cosmic
15. Nuclear Waste management
16. Environmental Health
17. Trace elements
18. Mineral and Energy Resources
19. Energy reserves
20. Population
21. Global monitoring
22. Land use
23. Acid Rain

RECOMMENDED TEXTS:

1. FOUNDATIONS OF ENVIRONMENTAL GEOLOGY.
   Edward A. Teller (Author) Prentice Hall- 8th Edition. Oct. 27, 1999.
   ISBN: 0130224669
2. LABORATORY EXCERCISES in ENVIRONMENTAL GEOLOGY
   Harvey Blatt (Author) McGraw Hill Science/Engineering/Math. 2nd Edition. (August 1, 1997)
   ISBN: 0697282880

# TUTORIAL
# REMOTE SENSING, IMAGE INTERPRETATION & ANALYSIS

## (As the University of Guyana may not have its own Hardware/Software System to teach this Course, the Contractor recommends this site as it is available on line for educational use.)
## Please use the web address below to access the TUTORIAL)

http://rst.gsfc.nasa.gov/Front/tofc.html

***TABLE OF CONTENTS***

IRS-1, JERS, RESURS, OKEAN, CBERS, and MicroSat (AlSat-1) Series / Hyperspectral Imaging / Radar and Thermal Systems / Meteorological, Oceanographic, and Earth Systems Satellites / The Commercialization of Space / The Systems (Multisource) Approach to Remote Sensing / Military Intelligence Satellites / Medical Applications of Remote Sensing

Concluding Remarks

Section 1: Image Processing and Interpretation - Morro Bay, California

Morro Bay, California in context; TM Band 3 Image of Morro Bay / Ground and Aerial Photographs of Morro Bay area / Thematic Mapper Bands / Analysis of the Morro Bay Scene / Mystery Feature / Band Information Characteristics / False Color View / The Mystery Feature up Close / True Color View / Other Color Combos / Prelude to Computer Processing; Preprocessing / Contrast Stretching and Density Slicing / Spatial Filtering / Principal Components Analysis / Ratioing / Unsupervised Classification / Supervised Classification / Minimum Distance Classification / Maximum Likelihood Classification / FIRST EXAM

Section 2: Geologic Applications I - Stratigraphy & Structure

General Background / Some General Concepts underlying the Science of Geology / Using Landsat for Geological Studies / Geologic Map of Waterpocket Fold / Specialized Images of Waterpocket Fold / Maximum Likelihood Classification of the Waterpocket Fold / Geologic Folds in General / Recognition of Faults & Joints / Lineaments & Fractures / Several Case Studies of Fracture Analysis

Section 3: Vegetation Applications - Agriculture, Forestry, and Ecology

General Principles for Recognizing Vegetatio n / The SPOT Satellite; Kenya & Rift Valley of Africa / South West Kansas, U.S.A. and Morocco / The Vegetation Index: Africa and other Scenes / Forest Applications; Amazon Rain Forests; Deforestation / Ecological Damage: Natural and Manmade

Section 4: Urban and Land Use Applications - From Los Angeles to Beijing

Los Angeles, San Diego, Tucson, Las Vegas, and Honolulu / New York, Miami, Atlanta, New Orleans, Dallas-Fort Worth and St.Louis / The U.S. Capital: Washington D.C.; Baltimore, MD; Philadelphia, PA / Buenos Aires; Paris, France; Munich, Germany; Budapest, Hungary; Florence, Italy; Riyahd, Saudia Arabia; Beijing and Shanghai; China / Dallas-Fort Worth, First MSS Landsat (ERTS) Scene; Archaeological Studies

Section 5: Geologic Applications II - Mineral & Petroleum Exploration

Geological Setting at White Mountain, Utah / Ratio, PCA & Maximum Likelihood Analysis of the Utah Site / The Goldfield, Nevada Study / Finding Oil & Gas in Oklahoma

Section 6: Space Flight Across the U.S - Boston to Denver to San Francisco; Landsat Tours the World

The U.S. Flight: General Background / Boston, MA / Pennsylvania, Appalachians / Chicago, Illinois / The Kansas Great Plains / Denver, Colorado, and Front Range / Four Corners - Colorado, New Mexico, Arizona, and Utah / Nevada: the Basin and Range / San Francisco Bay Area, California; the West Coast / GEOGRAPHY QUIZ GAME /

Canada / Central and South America / Europe (including Rome) / Middle East and Africa / Asia / Australia and New Zealand

Section 7: Regional Studies - Use of Mosaics from Landsat

How Mosaics are Made / Photographic, MSS, and DEM Mosaics of parts of the Western U.S. / MSS Mosaic of the U.S.A., Alaska, Mexico; International Mosaics

Section 8: Radar and Microwave Remote Sensing

Radar Defined / How RADAR works / Harrisburg, Pennsylvania, and Nigeria/Cameroon / Foreshortening and Layover; Effect of Illumination Direction / Harrisburg, Pennsylvania; Polarization; Radar Penetration / Seasat Images / SIR-A, -B, and -C on the Space Shuttle; TOPEX/Poseidon; Radarsat, ERS, ALMAZ, and JERS / Passive Microwave; Lidar

Section 9: The Warm Earth - Thermal Remote Sensing

Planck Blackbody Law / The Wien Displacement Law and Emissivity Effects / Heat Capacity, Thermal Conductivity, Thermal Inertia Defined / Diurnal Heating Effects / Thermal Properties of Water; Thermal Sensors / White Mountain Thermal Features; Lakes Erie/Ontario TM Band 6 / Death Valley TM Data; Mauna Loa, Hawaii, TIMS Data / The Heat Capacity Mission; Weather Satellites / Thermography; Night Vision

Section 10: Aerial Photography as Primary & Ancillary Data Sources

Elements of Aerial Photography / The Photographic Process / Photogrammetry

Section 11: The Earth's Surface in 3D - Stereo Systems and Topographic Mapping

Ways to Characterize the Earth's Surface in Maps / The Display of Contours / Seeing in Stereo / Measuring Heights from Individual and Paired Images / Digital Elevation Models (DEMs) and Viewing Modes / The GPS System / Altimetry / Radar Stereo/Interferometry / Stereo Pairs from Space / Additional Examples of Stereo from Space / The Shuttle Radar Topography Mission

Section 12: The Human Remote Senser in Space - Astronaut Photography
Guest Writer: Dr. Paul D. Lowman Jr.

Mercury and Gemini / Apollo Photography / Skylab and Apollo-Soyuz / Shuttle Photography; Kosmos / A Gallery of Photos from Space

Section 13: Collecting Data at the Surface - Ground Truth; The "Multi" Concept; Hyperspectral Imaging Spectroscopy

Rationale for Surface Observations / Training Sites; Mixed Pixels / Accuracy Assessment / Field Instruments and Measurements; Data Collection Platforms / The "Multi" Concept: Multiplatforms and Multilevels / Multisensors / Multitemporal Coverage; Kuwait Study / The "Multi" Concept: A Case Study of Mt. Etna in Sicily / Hyperspectral Imaging Spectroscopy / Principles of Spectroscopy / Absorption Processes / Factors that Modify or "Confound" Spectral Curves; Data Analysis / AVIRIS and other Imaging Spectrometers / Examples of Imaging Spectrometer Products; Multisensor Analysis

Section 14: The Water Planet - Meteorological, Oceanographic and Hydrologic Applications of Remote Sensing

Hydrologic Cycle; Meteorological Satellites (General) / Meteorology - Weather and Climate: A Primer / Metsat Instrumentation: AVHRR / Atmospheric Sounders; Classes of Metsats / TIROS and Nimbus / ESSA, DMSP, SSM/I, TRMM / NOAA Series / Geostationary Satellites; GOES; Insat, Meteosat; GMS / International Meteorological Satellites / / ERBS, UARS; ADEOS / Hurricane Andrew; 1993 Storm of the Century / Oceanographic Observations; El Niño / Seasat; TOPEX-Poseidon; NSCAT; SeaWinds / CZCS; SeaWiFS / Ice Monitoring / Hydrologic Applications: Drought, Snow Cover; Flooding / Hydrologic Applications: Mapping Floods

Section 15: Geographic Information Systems - The GIS Approach to Decision Making

Maps and Attributes / Data Elements and Models / GIS Defined / A GIS Case Study in Africa / Decision Making; Suitability Determination / Conducting a GIS Analysis / The PP&L Siting Problem / A GIS/Remote Sensing Case Study in Archaeology: Burgundy, France / References

Section 16: Earth Systems Science - Earth Science Enterprise and the EOS Program
Guest Writer: Dr. Mitchell K. Hobish

Overview of ESE and EOS; Global Changes / Possible Degradation of the Earth's Atmosphere / Earth System Science / Earth System Cycles / National and International Programs / Mission to Planet Earth / EOS Platforms/Sensors; Mission Profiles / Data Handling: EOSDIS / Terra is Now Operational; MODIS and MISR / Terra is Now Operational: ASTER, MOPITT, and CERES / Aqua is Now Operational; Envisat / Satellite Formation Flying; NPOESS / Background Readings

Section 17: Use of Remote Sensing in Basic Science Studies I - Mega-Geomorphology

MegaGeomorphology Defined; Geomorphic Maps / "Geomorphology from Space" / Tectonic/Volcanic Landforms / Fluvial/Deltaic/Coastal Landforms / Karst/Lacustrine/Aeolian/Glacial Landforms / Terranes as Terrains: The Klamath, Oregon Study / The Klamaths from Space / Terranes in TM Imagery; Ridges and Elevations / Geomorphic Parameters from Maps / Summary of the Klamath Terrane Project

Section 18: Basic Science II: Impact Cratering

Distribution of Craters / Cratering Mechanics / Crater Morphology / Shock Metamorphism / Remote Sensing of Craters

Section 19: Planetary Remote Sensing - The Exploration of Extraterrestrial Bodies

Remote Sensing Techniques / Planetary Parameters / Pre-Apollo Exploration of the Moon / Early Spacecraft Visits to the Moon / Unmanned Lunar Landers; Lunar Stratigraphy / The Apollo Program - Man on the Moon / Apollo Instrument Experiments / Post-Apollo Lunar Exploration / Mercury and Venus / The Magellan Mission / Mars; The Red Planet / The Martian Atmosphere; Ice at the Poles / Martian Landscapes: Linear Features, Volcanoes, and Impact Craters; Exotic Terrains; Martian Stratigraphy / Life on Mars; Resumption of Martian Exploration; Future Plans for Mars; The Martian Satellites / Overview of the Outer Planets / Jupiter / The Galilean Satellites / Saturn and Its Moons / Uranus, Neptune and Their Satellites / Asteroids and Comets / Comet Shoemaker-Levy

Section 20: Astronomy and Cosmology: The Description, Origin, and Development of the Universe

Preface (including a review of Relativity and Quantum Physics) / Origin and Early Development of the Universe; Big Bang Eras; Expansion of Space / The Hubble Space Telescope; Galaxies / Images of Galaxies and Stars outside the Visible Light Range. / Special Features of Galaxies: Colliding Galaxies; Galactic Gases; Starbursts and Active Galactic Nucleus / Birth, Life, and Death of Stars / Novae and Supernovae; Pulsars, Quasars, and Black Holes; Gamma Ray Bursts; and Colliding Stars / Spectral Analysis of Star Composition; Element Synthesis in Stars / Space-Time and Expansion / Evidence for the Big Bang; the Redshift; Galactic Distances; Age of the Universe; Cosmic Background Radiation; Expansion Models; Dark Matter and Energy / Recent Innovations about the Concept of "Universe": Dark Energy and an Accelerating Universe?; Varieties of Universes (Multiverses); Philosophical Implications / Origin of Planetary Systems/Some Additional (Metaphysical) Comments / Letters by N.M. Short regarding Creationism and Intelligent Design

Section 21: Remote Sensing into the 21st Century
Guest Writer: William E. Stoney

Outlook for the Future; FINAL EXAM / Exam Questions / Exam Answers

Appendix A: Modern History of Space
Guest Writer: J. Rosalanka

The 1970's
Introduction / American Space Policy / American Civilian Space Program (NASA) / American Military Space Program: Initial Military Operations / Russian Space Program / European, Asian, and Commercial Space Programs

The 1980's
Introduction / American Space Policy / American Civilian Space Program (NASA) / American Military Space Program: Initial Military Operations / Russian Space Program / European, Asian, and Commercial Space Programs

The 1990's
Introduction & American Space Policy / American Civilian Space Program (NASA) / American Military Space Program: Initial Military Operations / Russian Space Program / European, Asian, and Commercial Space Programs

Appendix B: Interactive Image Processing
Guest Writer: J. Love

Introduction / The Nature of Satellite Digital Data / Digitization / Image Processing / Introduction to PIT / Installing PIT from the Internet / Installing PIT from the CD-ROM / General Overview of PIT / Displaying Images / Histograms and Scatter Plots / Ratioing and Principal Components / Unsupervised Classifications / Supervised Classifications / Conclusion

Appendix C: Principal Components Analysis
Guest Writer: Dr. Jon W Robinson

Introduction / Linear Combinations / Singular Matrices / Space / Standardizing Sets

Appendix D: Glossary
Guest Writer: J. Weissel

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Direct any questions concerning Tutorial Content to the Primary Author: Nicholas M. Short, Sr.
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Contributor Information

Last Updated: November 1, 2003

The Tutorial is hosted by the EOS-Goddard Program Office (Code 420). Please direct any questions or comments regarding the Website to John Bolton of that office.

OTHER RECOMMENDED TEXTS:

1. REMOTE SENSING AND THE ENVIRONMENT: An Earth Resource Perspective
John R. Jensen (Author). Prentice hall. 2nd Edition. June 3, 2000.

2. ENVIRONMENTAL MODELLING WITH GIS & REMOTE SENSING
Andrew Skidmore, Hendrick Prins (Editors)
Publisher: Taylor & Francis. 2nd Edition. Jan. 15, 2002
ISBN: 0415241707

# GEOPHYSICS I

GEOPHY I is meant to be a course that gives a student an introduction to the basic principles of the Gravity, Magnetic and Radiometric methods of exploration geophysics, some experience in the design of field surveys and data processing and an appreciation of the main applications of each method. It is desirable that a student brings to the course a knowledge of physics, an understanding of basic geology and the ability to use certain mathematical and statistical techniques. Since many of the assignments are based on the use of computers, it is also useful to have experience with computer processing of data.

At the end of the course, each student should have achieved the following objectives:

1. A knowledge of the physical properties of rocks which determine the response of each method.
2. An understanding of the physics of each method.
3. An appreciation of the basic principles of instrumentation and some "hands on" experience with available equipment.
4. The ability to plan, layout and execute a survey.
5. The ability to do data reduction for each method.
6. The ability to plot and present data and make interpretations in terms of simple models.
7. An awareness of the main applications and limitations of each.

**Outline of Course**

**INTRODUCTION**

Development of Geophysics and its relationship to other sciences.
Definition of exploration geophysics.
General methods of measurement and data reduction.

**MAGNETIC METHOD:**

Introduction: Example of a Magnetic Survey
Physical Basis of magnetism.
Magnetic domains, magnetization and magnetic susceptibility.
Magnetic Flux, B and H fields and units.
Magnetic properties of minerals and rocks.
Basic description of geomagnetic field and its variations.
Magnetic pole theory, magnetic potential, Poisson's variations.
Magnetic anomaly of a Sphere.
Review of magnetic anomalies of simple models related to geomagnetic latitude.

Magnetometers: Basic principles of fluxgate magnetometers, proton magnetometers and optical absorption magnetometers.

Survey Design and Procedure:

Airborne Surveys.
Instrumentation, magnetic compensation of aircraft, choice of flight parameters, data reduction, error correction, leveling corrections, IGREF subtraction, gridding, gradient measurements.

Marine Surveys:
Instrumentation, tow configurations, choice of track parameters, data reduction and error correction, gradient measurements.

Ground Surveys:
Survey layout, station spacing, data reduction and error correction, gradient measurements.

Application of Magnetic Surveys:

Mapping of ocean floor, geological mapping, oil exploration, exploration in the mining industry, engineering and environmental studies.

**GRAVITY METHOD:**

Introduction: Examples of gravity surveys.
Newton's law, measurement of gravity, units, field concept and potential.
Density of minerals and rocks.
Gravity effects of simple mass distributions.

Gravity Method:

- Measurements
  - Gravity instruments.
  - Calibration
  - Absolute and relative measurements of gravity.

- Gravity Surveys
  - Field operations
  - Correcting for drift and tidal errors.
  - Plotting and interpretation.
    - Bouguer gravity anomaly.
    - Regionals and Residuals.
    - Derivatives.

- Gravity modeling of subsurface structures
  - 2 D Models
  - Correlation with other geophysical methods.

- Airborne and marine surveys.

**RADIOACTIVITY METHOD:**

- Introduction
  - Principles of radioactivity.
  - Radioactive decay processes and equilibrium.

- Radioactivity of rocks and minerals.
  - Igneous, metamorphic and sedimentary processes.

- Instruments
  - Geiger-Muller counter.
  - Scintillation meter.
  - Gamma-ray spectrometer.
  - Other
  - Calibration of instruments (General)
  - Measurement of Background radiation and correction methods.

- Field methods
  - Hand-held instrument
    - Calibration using test pads.
    - Field procedures.
    - Data reduction.
    - Plotting and interpretation.

  - Vehicle-mounted system
    - Calibration using test pads and ground data.
    - Field procedures
    - Data reduction
    - Plotting and interpretation

  - Airborne Systems.
    - Calibration using test pads, test strip and ground data
    - Field procedures
    - Data reduction
    - Plotting and interpretation

- Correlating between methods
  - Pitfalls and overcoming them.

RECOMMENDED TEXTS:

1. INTRODUCTION TO GEOPHYSICAL PROSPECTING.
   Milton B. Dobrin, Carl Sarit. McGraw Hill College Div. 4th Edition.
   ASIN: 0070171963

2. AN INTRODUCTION TO GEOPHYSICAL EXPLORATION
   Michael Brooks, Ian Hill, Philip Keary.

Blackwell Publishers. 3rd Edition (May 2002)
ISBN: 063249294

3. APPLIED GEOPHYSICS
W.M. Telford, L.P. Geldart, R.E Sheriff (Authors)
Cambridge Press. 2nd Edition (Oct.1990)
ISBN: 0521339383

Instruments required:

1. Gradient Magnetometer
2. Gravity Meter (plus geodetic survey equipment such as Levels and Tripods).
3. Integrating Spectrometer.

# GEOPHYSICS II

GEOPHYSICS II is meant to be a course that gives a student an introduction to the basic principles of the
Seismic and Electrical methods of exploration geophysics, some experience in the design of field surveys and data processing and an appreciation of the main applications of each method. It is desirable that a student brings to the course knowledge of physics, an understanding of basic geology and the ability to use certain mathematical and statistical techniques. Since many of the assignments are based on the use of computers, it is also useful to have experience with computer processing of data.

At the end of the course, each student should have achieved the following objectives:

8. Kknowledge of the electrical and physical properties of rocks which determine the response of each method.
9. An understanding of the physics of each method.
10. An appreciation of the basic principles of instrumentation and some "hands on" experience with available equipment.
11. The ability to plan, la yout and execute a survey.
12. The ability to do data reduction for each method.
13. The ability to plot and present data and make interpretations in terms of simple models.
14. An awareness of the main applications and limitations of each.

## Course Outline

**ELECTRICAL METHODS:**

1. Electrical properties of rocks and minerals. (1 Lecture Period)
   - Electrical properties.
     - Electrical potentials
     - Electrical conductivity (most important)
     - Dielectric constant.

   - Electrical potentials. (1 Lecture Period)
     1. Electro-kinetic potential (streaming)
     2. Diffusion potential (liquid junction) (Electrochemical)
     3. Shale (Nerst) potential (Electrochemical)
     4. Mineralization potential.

   - Electrical Conductivities. (1 Lecture Period)
     1. Electronic or ohmic
     2. Electrolytic
     3. Dielectric

2. Resistivity Method (2 Lectures plus 1 Lab)

- Factors controlling resistivity.
  - Porosity
  - Property of solutions
  - Filling of pore spaces.

- Configuration of Arrays (1 lecture period plus 1 Lab)
  - Wenner
  - Schlumberger
  - Three –electrode (pole-dipole)
  - Dipole-Dipole

3. Induced Polarization (IP)

   - Time and Frequency Domain IP Measurements.

4. Electromagnetic Methods. (3 Lecture Periods)
   - Electromagnetic waves
   - Basis of the Electromagnetic method.
   - Very Low Frequency (VLF) EM.
   - Time and Frequency Domain EM Measurements.
   - Transient EM Method (TEM)
   - Induced Pulse Transient System (INPUT)

**SEISMIC METHODS:**

Introduction: (1 Lecture Period)

- Elastic Constants
- Types of Seismic Waves (Compressional (P), Shear (S) and Rayleigh waves.
- Seismic detectors

1. Refraction Methods.
   - Synthetic models (1 lecture period)
   - General Wave front Method (1 Lecture Period)
   - Reversed Wave front Method (1 lecture period)
   - Critical Distance Method (1 lecture period)
   - The Plus-Minus Method (1 lecture period)
   - The Reciprocal Method (1 lecture period)
   - The Delay Time Method. (1 lecture period)

2. Applications
   - Depth to bedrock
   - Rippability Assessment
   - Foundation conditions
   - Materials surveys

- Blasting Assessment
- Dynamic Elastic constants
- Vibration monitoring
- Ground water exploration
- Mining applications
- Base metals
- Coal
- Uranium
- Other applications

2. Reflection Method. (2 Lecture Periods)
   - Principles
   - Methods
   - Field procedures
   - Data processing
   - Applications

RECOMMENDED TEXTS:

1. INTRODUCTION TO GEOPHYSICAL PROSPECTING.
   Milton B. Dobrin, Carl Sarit. McGraw Hill College Div. 4th Edition.
   ASIN: 0070171963

2. AN INTRODUCTION TO GEOPHYSICAL EXPLORATION
   Michael Brooks, Ian Hill, Philip Keary.
   Blackwell Publishers. 3rd Edition (May 2002)
   ISBN: 063249294

3. APPLIED GEOPHYSICS
   W.M. Telford, L.P. Geldart, R.E Sheriff (Authors)
   Cambridge Press. 2nd Edition (Oct.1990)
   ISBN: 0521339383

Instrument required:

1. Electrical Equipment such as VLF-EM, IP, SP.
2. Seismograph (Minimum 2 Channels – digital)

# APPENDIX E

# COMPANY PROFILE

FORESIGHT BUSINESS SERVICES
Business Development & Engineering Services
74 Baxter Court, Fredericton, New Brunswick, Canada E3B 6M1
Tel: (506) 454-0561 E-Mail: jchandra@nbnet.nb.ca

We focus on your Success!

## COMPANY PROFILE:

Multi-disciplined business development and engineering firm that assists private sector companies, public sector agencies, NGOs and Universities, public sector organizations in the Atlantic Canada region, establish strategic alliances, procurement strategies, supply arrangements, joint ventures, technology transfer, concessions, licensing and public-private partnering.

***Business Services provided:*** Specializing in mentoring of new start-ups, commercialization of new technologies, business development activities such as Business and Market Plans and Export Development strategies. We also cover R&D Tax Credit audits and Intellectual Property protection.

***Engineering Services provided:*** Geophysical, Geological, Geochemical, Mining and Environmental studies covering all rock types and all terrain.

## FORESIGHT BUSINESS SERVICES and its Associates

### Sector Specialties:

Technology Development and Commercialization
Aboriginal Products, Services & Technology
Advanced Manufacturing Technologies
Bio-Industries
Chemicals, Plastic & Advanced Materials
Forest Industries
Industrial Minerals
Base Metal and Oil & Gas Exploration
Resource and Environmental Mapping using GIS and Remote Sensing

***Past & Present Clients:***
Universities
First Nations Bands
Private Sector companies
Government Departments
Community Economic Development Agencies
Non-Profit Organizations

**Publications & Internal Government Documents (SHORT LIST)**

An Aerospace/Defence Industry Development Strategy for NB, January 2002

An R&D/Innovation Strategy for New Brunswick, January 2002.

An Economic Development Strategy around the Refurbishment of the Point LePreau Nuclear Power Plant, December 2001.

A review of the Effectiveness of R&D Tax Credits on SR&ED work in NB relative to Canada. , February 2001.

Potential Economic FLASH POINTS in the Natural Resources Sectors of New Brunswick. A Ten year Forecast Period 2000-2010, July 30, 2000.

Economic Reports on 13 Economic Development Regions of NB, Sample Title The Acadian Peninsula Region, A Regional Sectorial Development Tool, March 15, 2000.

A New Brunswick Metalworking Industry Strategy, 2000-2005, December, 1999.

Industry Sector Profiles 1998. (May, 1999), A sectorial review of New Brunswick's Industries, ED&T. 325 Pages

Industry Sector Profiles 1996. (April, 1997), A sectorial review of New Brunswick's Industries, ED&T. 250 Pages.

New Brunswick INDUSTRY ACHIEVERS, A compilation of profiles of successful or leading companies in NB, (March 1, 1996) ED&T. 42 Pages.

New Brunswick GROWTH INDUSTRIES, A compilation of profiles of the companies with growth potential., ED&T, March 1, 1996. 84 Pages.

Industry Sector Profiles 1994 (June, 1993), A sectorial review of New Brunswick Industry, ED&T. 215 Pages.

An Investor's Guide to the New Brunswick Mining Industry, A guide of Mining Acts and Regulations; Labor and Operating costs. Paper first presented at The Mineral Investment Seminar in Tokyo, Japan in 1994.

The NB Mining Industry - A Review and Investment Opportunities, Mineral Policy Sector. Energy, Mines & Resources. Report on Mineral Workshop, Tokyo, Japan. March 10-11, 1993. J.J Chandra.

Proposed Belledune Zinc Refinery (1985), An economic evaluation, Dept. Of Natural Resources & Energy (152 pages)

Heath Steele Mines (1985), History and feasibility of future operation. Written after closure in early 1985. Dept. Of Natural Resources & Energy (150 pages).

Mt. Pleasant Tungsten Mine (1986), History and feasibility of future operation. Written after closure of mine in 1986. Dept. Of Natural Resources & Energy (168 pages).

NORANDA in New Brunswick (1991), An internal evaluation of Noranda's activities in NB. Dept. Of Commerce & Technology.

Geographic Information Systems, A Review of GIS Activities In Government, 1988 A paper prepared for the development of policies and strategies for the effective use of GIS in support of Government and the development of a viable GIS service sector.

An Atlantic Institute for Geo-Information Technology (A Prospectus), Dept. Of Commerce & Technology, J. Chandra, D. Coleman (This Prospectus was adopted by the Council of Maritime Premiers for implementation of the Champlain Institute).

Government Participation in Mineral Resources Development and the Return on Investment to the People. The NB Potash Industry. A Case Study (53 Pages) 1980

The Law of the Sea & Sea Floor Mining (43 Pages) 1979

Foreign Investment and the Canadian Mining Industry. (38 Pages) 1980

Canadian Offshore Mineral Rights. (Federal-Provincial Disputes re Gas/Oil Developments in the Canadian Off-shore) ( 35 Pages) 1979.

The NB Mining Industry, "Review and Investment Opportunities" Mineral Policy Sector. Energy, Mines & Resources. Report on Mineral Workshop, Tokyo, Japan. March 10-11, 1993. J.J. Chandra

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Technologies and the NB Mining Industry: Into the 21st Century. Paper presented at the CIM Technical Conference - Technological Innovation and Automation. September 10-13,1987. Bathurst, NB. J.J. Chandra

New Brunswick Mineral-based Commodities for the Manufacturing Sector. "Identification of possible manufacturing opportunities" DNRE. 86-3 ISBN 0712-4563, J.J. Chandra.

A report on the New Brunswick Mining Industry. Occupational and Economic Outlook to 1995. Taggart, J.L.C (Employment & Immigration Canada) Chandra, J.J. (NB Dept. Of Forest & Mines) Leger, JV (NB Dept. of Labor) 1986.

Comparison of Linear and Curvilinears Identified from Digital Enhancement of LANDSAT TM Data with Faults Depicted on Geologic maps. Yazdani, R; Derenyi, E (Dept. Of Surveying Engineering, UNB) Chandra, J.J.

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Geophysical Modeling of Salt Masses and Basement Structures in the Moncton and Cumberland Basins, NB J.J. Chandra and T.C. Webb. Paper presented at the A.G.S. Symposium on January 28, 29, 1983

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**Affiliations**

American Society of Geophysicts (Past Member)
Association of Professional Engineers of New Brunswick
Atlantic Geoscience Society (Past Member)
Canadian Geothermal Energy Association (Past Member)
Canadian Institute of Mining & Metallurgy (NB Branch)
The Canadian Geo-Technical Society (Past Member)