NATIONAL TECHNICAL UNIVERSITY OF ATHENS

School of Mining and Metallurgical Engineering

Curriculum Guide 2015-2016

Athens 2015

CONTENTS

I. BRIEF HISTORY OF N.T.U.A.

The National Technical University of Athens (N.T.U.A.) is the oldest technical university in Greece.

In its initial form, it was founded as the "School of Arts", in the Spring of 1837, almost simultaneously with the modern Greek State, after the liberation of Greece from the Turkish yoke. At that time, it was a technical school, operating on Sundays and holidays, to offer instruction to those desiring to master in building construction.

The first reformation took place in 1840 and the "School of Arts" switched over to daily operation along with the Sundays counterpart. Studies reached the three years, were enriched with new disciplines and the administration was taken over by the Committee for the Encouragement of National Industry.

A second major change occurred in 1863 with the introduction of theoretical and applied education for managers and technicians in building construction, metals industry, sculpture, painting, ceramics, tanning, soap manufacturing etc. in 1872 the School was transferred from Pireos Street to the Patission Street Complex.

In 1887, the School was promoted to a higher education establishment for Building Construction Engineers, Architects and Mechanical Engineers and its title became "School of Industrial Arts".

In 1914, the establishment was given the official title of "Ethnicon Metsovion Polytechnion". "Ethnicon" means "National" and "Metsovion" was introduced in the title to honour the establishment's great donors and benefactors Nikolaos Stournaris, Eleni Tositsa, Michail Tositsas and Georgios Averof, all from Metsovo, a small town in the region of Epirus. The same title is still in use in Greece but, abroad, the title "National Technical University of Athens" is used instead in order to avoid possible misconceptions regarding the Institution's academic status. The last radical reformation in the organization and administration of N.T.U.A. took place in 1917, when a special bill gave N.T.U.A. a new structure and established the Schools of Civil, Architecture, Surveying, Mechanical & Electrical and Chemical Engineering.

Today, N.T.U.A.'s Schools educate 13,000 students and are located –except the School of Architecture– on the Zografou Campus, a spacious (910,000m^2) and open green site, 6 km from the centre of Athens. It includes buildings of 260,000m^2 with fully equipped lecture theaters, laboratories, libraries, a Central Library, a Computer Centre and a Medical Centre. Also, on the campus are a Hall of Residence, restaurants, stationery and bookshop, a gymnasium and playing fields.

II. N.T.U.A. STRUCTURE AND ADMINISTRATION

The current legal framework for higher education came into effect in 1982. In accordance with this, N.T.U.A. is divided into nine Schools, as follows:

1. School of Civil Engineering
2. School of Mechanical Engineering
3. School of Electrical and Computer Engineering

4. School of Architecture
5. School of Chemical Engineering
6. School of Rural and Surveying Engineering
7. School of Mining and Metallurgical Engineering
8. School of Naval Architecture and Marine Engineering
9. School of Applied Mathematical and Physical Sciences

As prescribed by law, each School is administrated by a General Assembly consisting of the representatives of Teaching and Research Personnel (TRP: Professors, Associate Professors, Assistant Professors and Lecturers), the representatives of the Scientific and Teaching Personnel (STP: Assistants and Research Associates), the representatives of the Administrative and Technical Personnel (ATP) and representatives of the Students. Certain matters of minor importance are handled by an Executive Board.

A special Electorate elects a professor or an associate professor as Dean of the School and another member of the same rank as Deputy Dean.

Each School is subdivided into Departments covering scientific areas. Departments are also administered by General Assemblies, which are similar to the School's Assembly. The Head of a Department, called Director, is elected amongst the members of the General Assembly.

Finally, there may be further subdivisions, in the shape of laboratories, which deal with specific scientific topics. Each laboratory is headed either by a professor or by an associate professor or even by an assistant professor but administratively it belongs to a Department or directly to the School.

N.T.U.A.'s general administration is effected by the Senate, which consists of the Presidents of the Schools, one TRP member from each School, representatives of STP, representatives of the Special Research Personnel (SRP), representatives of ATP, the administration staff and the representatives of the students. The Senate is headed by the Rector and two Vice-Rectors, who are professors or associate professors elected by a special electorate comprising all N.T.U.A. staff and students.

III. THE SCHOOL OF MINING AND METALLURGICAL ENGINEERING

1. HISTORY AND STRUCTURE

The Department of Mining and Metallurgical Engineering of the National Technical University of Athens (NTUA) was founded by government decree on February 27th, 1946. According to this decree, the School of Chemical Engineering was subdivided into three Departments: (a) the *Department of Chemical Engineering,* (b) the *Department of Mining Engineering,* and (c) the *Department of Metallurgical Engineering*. The operation of the last two departments was thus started during the academic year 1945-46.

Before the foundation of the Departments of Mining Engineering and Metallurgical Engineering, a number of courses belonging to these disciplines were taught in other departments of NTUA. In particular, since 1878 (when NTUA was called "School of

Industrial Arts") the course "Mineralogy and Geology" was taught in the Department of Civil Engineering, while a little later the course "Iron Metallurgy" was first offered in the Department of Mechanical Engineering. These two courses continued to be offered up to the restructuring that took place in 1914, when the current name was given to NTUA (Ethniko Metsovio Polytechneio), while in 1917 the course "Mining Works" was first offered.

In 1943, by the law 935 created the following Chairs: Mining Engineering, Iron Metallurgy, Metallurgy Engineering, and Economic Geology and Applied Geology. However, the actual functioning of the Department starts during the academic year 1945-46, with the 5-year program of studies in the Department of Mining Engineering and the Department of Metallurgical Engineering. In 1948, three years after the foundation of the two Departments, they are joined together in a single Department under the name "Department of Mining & Metallurgical Engineering", which was still part of the School of Chemical Engineering of NTUA. Thus, during the 1950, 1951 and 1952 years, graduating students from NTUA were designated as having a diploma either in Mining Engineering or in Metallurgical Engineering but not both.

During the academic year 1975-76, the Department was separated from the School of Chemical Engineering and formed an independent department under the name "Department of Mining and Metallurgical Engineering". Under the government law 1268/82 "On the Structure and Operation of the Highest Educational Institutions" (Framework Law), the nine existing at the time faculty chairs were split according to the new law into the following three departments:

- ***Department of Mining Engineering***
- ***Department of Metallurgy & Materials Technology***
- ***Department of Geological Sciences***

The educational and research activities of the School have been separated into the following three (3) departments, each with its corresponding laboratories:

1. Department of Mining Engineering

Subject of the Mining Engineering department is teaching of all these courses related to exploitation of ores, mining engineering and the construction of geo-engineering works, as well as conducting research pertaining to these topics.

- ***Laboratory of Laboratory of Excavation Engineering***
- ***Laboratory of Mining Engineering and Environmental Mining***
- ***Laboratory of Applied Geophysics***
- ***Laboratory of Tunneling Engineering***

2. Department of Metallurgy and Materials Technology

Subject of the Metallurgical and Materials Technology department is teaching of all these courses related to processing of ores and industrial minerals, to metallurgical and materials production, to metals and non-metal materials processing, and the environmental

protection from all these activities as well as conducting research pertaining to these topics.

- ***Laboratory of Mineral Processing***
- ***Laboratory of Metallurgy***
- ***Laboratory of Physical Metallurgy***
- ***Laboratory of Environmental Protection Science and Engineering in Metallurgy & Materials Technology***
- ***Laboratory of Computer-Aided Materials Processing – Rheology and Design for Polymers and Composites***

3. Department of Geological Sciences

Subject of the Geological Sciences department is teaching of all these courses related to geological, ore geology, petrological, geochemical, mineralogical, hydrogeological, geotechnical and geoengineering topics, as well as conducting research pertaining to these topics.

- ***Laboratory of Geology***
- ***Laboratory of Engineering Geology and Hydrogeology***
- ***Laboratory of Mineralogy - Petrology – Economic Geology***

2. CURRICULUM PRINCIPLES

The curriculum of the School of Mining and Metallurgical Engineering has been formed having in mind: (i) the scientific and professional activities of the Mining and Metallurgical Engineers, (ii) the production and development activities of Greece in the corresponding fields, (iii) the prevailing trends in the above two scientific and the related areas.

The curriculum objectives are to give the graduating engineer the necessary scientific and technological knowledge that will enable him/her to successfully face the needs and requirements of the various scientific and professional activities. That is, to enable the engineer to work efficiently and productively in exploiting the mineral and energy resources of the country, in mines, in quarries, in geotechnical works, in industries which add value to mineral raw materials, in metallurgical plants, in metal-forming enterprises, in business and activities related to the protection and rehabilitation of the environment. This means that the graduated Mining or Metallurgical Engineers must be in a position (i) to keep abreast of the latest scientific advances and to be able to go deeper in the area of their special engineering activities, (ii) to be able to collaborate with other engineers or scientists of related disciplines, (iii) to have the flexibility to adjust to scientific and technological developments, and finally (iv) to have a certain level of knowledge, which will allow them, if they so wish, to pursue graduate studies in their field or even beyond that.

The curriculum covers 10 semesters (5 years).

In 1999, in an effort of upgrading the undergraduate curriculum, it was decided that the first seven semesters make up the basic curriculum, while from the 8th semester there are introduced five (5) subject streams, which are completed with the fulfilment of a diploma thesis. These five (5) subject streams of the curriculum are:

(a) Environmental Engineering and Geo-Environment.
(b) Mining Engineering.
(c) Geo-Engineering.
(d) Metallurgical Processes.
(e) Materials Science and Engineering.

During the 8th and 9th semesters, students must choose at least six (six to twelve) courses from a subject stream of their choice. In the case of choosing only six courses from their subject stream, the remainder six courses for the completion of the degree requirements may be selected from the courses offered in the other four subject streams or the course pool, with a maximum number of three courses/semester from any one direction or the pool.

Also, during the 8th and 9th semesters, students must register, attend and pass, in each semester, at least three to four courses of the stream they have selected.

Students selecting the streams of (a) Mining Engineering and (b) Geoengineering must include in the six courses they select at least four courses from the common courses of the two subject streams and also another two from the special courses of each subject stream.

The courses are designated as ***Mandatory*** and ***Electives*** (the students must select one or more courses, according to the program of each semester).

As was already mentioned, the completion of the undergraduate studies is achieved by performing work and submitting a diploma thesis (during the 10th semester) in a course of their choice under the supervision of the instructor teaching the course.

3. DIPLOMA THESIS

a. *Diploma Thesis and the Assignment Process.*

- The Diploma Thesis has the content and the minimal duration (one complete academic semester, the 10th) of a high level assignment. With the Diploma Thesis the specialization, provided by the courses in the last semesters of the Studies, is completed.
- The Diploma Thesis is prepared by the final semester students in a Department and cognitive object of their choice, under the supervision of a School member of the chosen Department, who teaches the most relevant course, with the potential restriction of Section iv. The choice of the Department and the Diploma Thesis subject is made after the student applies to the Secretariat of the School, according to the academic calendar of the School. The determination of the Diploma Thesis subject and the Sector is done:
  - i. By selecting from a list of specific Diploma Thesis subjects that each School member announces at the beginning of each academic semester.
  - ii. With direct agreement between the student and the School member.
  - iii. After a proposal by the student, provided that a School member accepts it.
  - iv. By an application of the student to the School.
- Following the definition of the Diploma Thesis subject, the supervisor informs the Head of the Department, who keeps a record of the Diploma theses in the Department, and the

Secretariat of the School, so that the applications are forwarded to the Board of Directors for the final approval and distribution of the Diploma Theses.

- Each School member has the right and obligation of supervising Diploma Theses, in the field of the courses they teach or in relevant scientific fields.
- In order to ensure the effective supervision and the balanced distribution of educational work among the School members, each School can define, according to the Sectors advice, a low and upper limit of Diploma Theses supervised simultaneously by a School member.
- Since one of the main objectives is the enhancement of student initiative, the Diploma Thesis development is done by each student individually. If required by the nature of the thesis subject, and after the appropriate justification, a team of students can realize the Diploma Thesis provided that each student's individual contribution to the work development and to the thesis presentation is distinct. The extent of the Diploma Thesis should be the appropriate, so that its completion is feasible in one academic semester of full time work, even though the real completion time depends on the student's ability to fulfill the thesis requirements and his commitment.

b. *Diploma Thesis development, submission and examination*.

- The Diploma Thesis is developed under the student's responsibility, with the continuous monitoring and help of the supervisor. The Sector is responsible for the unhindered development and presentation of the Diploma Thesis, using the means it allocates and, if it is needed, in collaboration with the Institution's printing facility. Before each examination period, the supervisor fills out the relevant printed form certifying the initial acceptance of the Diploma Thesis that he/she supervises. After the initial acceptance of the Diploma Thesis, the additional expenses of the student until the final presentation are covered by the Departments or the Schools that are eligible for credit with the corresponding sums of functional expenses, supplies, etc. The eligible Departments or Schools are credited from the State's Budget, after their application, at the beginning of the academic year with an upper limit determined by the Senate.
- The final version of the Diploma thesis is submitted according to the academic calendar and in time, i.e. at least ten (10) working days before the defined examination day. The Diploma Thesis is submitted to the Department Administration, initially in three copies that are forwarded immediately to the three members of the examination committee. The finally approved copy remains in the possession of the supervisor, while two more copies are obligatorily submitted to the School library and the Central Library and are available for lending.
- The Diploma Thesis presentation text is composed using a text processor and an approved template by the School General Assembly and it should include the following:
  i. Synopsis (1.200 to 2.000 words) and Summary (300 to 500 words) in Greek and a foreign language (preferably English).
  ii. Table of contents.
  iii. References.
- The presentation is given by the student orally and in public, on dates set in the academic calendar of the School and according to the program defined by the School Secretariat. Each presentation should be minimum forty five (45-60) minutes long.

- The examination and marking of the Diploma Thesis is performed by a three-member School Committee, proposed by the Department General Assembly and approved by the School's General Assembly or the Board of the School, in case it is authorized. The committee consists of the supervisor, a possible common member and a member with relevant specialization. In case a Diploma Thesis is assigned to a student from a different School, the third member of the examining committee should be from the most relevant Sector of that School.
- If a student does not pass the Diploma Thesis oral examinations, he/she can repeat the examination in the next period, after submitting an application. If he fails again, he applies for a new subject in the same or different scientific field, in order to be examined in another period.

c. Evaluation criteria of Diploma Theses.

- The main evaluation criteria are the following:

i. Updating of the existing knowledge level with the corresponding literature research.

ii. Acquisition of special data (data from lab experiments or field data or theoretical results).

iii. Logical process (e.g. process of assembled data, definition of mathematic models, trials in computers, applications in concrete problems, evaluation of results).

iv. Structure and the written presentation of the Diploma thesis, e.g. the continuity of text, the right use of terminology and language, the precise formulation of concepts, the adequate documentation of scientific conclusions, etc.

v. Originality.

vi. Student's eagerness and initiatives.

vii. Thesis oral presentation.

- The weighting factors of the above criteria depend on the nature of the thesis subject, and they are in the judgment of the examining committee. For the thesis final degree synthesis it is recommended to use special printed forms. The Thesis final grade is the mean value of the three examiners grades, rounded to the nearest integer or half integer. The lower grade, for successful examination, is 5.5. (Scale is 0-10).

From the five years Course Programme of the School and the Diploma Thesis of the fifth year, it can clearly be concluded that the Diploma offered to the students by N.T.U.A. is substantially at least equivalent to the Master's Degree of acknowledged Anglo –Saxon universities.

4. COURSES AND DIPLOMA THESIS MARKING SCHEMES

Marking in all courses is done by the 0-10 scale, without using fractions of an integer, and using as a basis for passing the mark 5. Diploma Thesis marking is an exception, since it is allowed to use half a mark (0.5) and the basis for passing is the mark 5.5. The overall mark for the diploma is calculated by summing the following:

a) the arithmetic average of all course marks taken by the student during his studies, with a weighted coefficient of four fifths (4/5), and

b) the thesis mark, with a weighted average of one fifth (1/5).

Excellent	9 to 10
Very Good	7 to 8,99
Good	5,5 to 6,99
Satisfactory	5 to 5,49
Bad	below 5

5. SCHOOL PERSONNEL

1. Department of Mining Engineering

Professors:	Dimitrios Kaliampakos Georgios Panagiotou Alexandros Sofianos Sofia Stamataki
Emeritus Professors:	Konstantinos Panagopoulos
Associate Professors:	Georgios Apostolopoulos Dimitrios Damigos Konstantinos Modis
Assistant Professors :	Aikaterini Adam Andreas Benardos Maria Menegaki Theodoros Michalakopoulos Pavlos Nomikos
Lab Teaching Staff:	Georgios Amolochitis Dr. Maria Basanou Dr. Dimitrios Labrakis Dr. Athanassios Mavrikos Dr. Georgios Papantonopoulos
Special Administrative and Technical Personnel:	Paraskevi Giouta-Mitra Irini Dimitrellou Evangelia Koffa Konstantinos Kotsalis Dimitrios Lefkaditis Despina Triantafyllidou Efstathios Triantis Emmanouel Tsiavos
Temps:	Polyxeni Kerassovitou Stavroula Platoni

2. Department of Metallurgy and Materials Technology

Professors:	Georgios Anastassakis Styliani Agatzini - Leonardou Iliana Halikia Evangelos Hristoforou Evangelos Mitsoulis Ioannis Paspaliaris Konstantinos Tsakalakis Marios Tsezos Georgios Fourlaris
Emeritus Professors:	P. Neou-Syggouna George Papadimitriou Emmanouel Zevgolis Konstantina Tsaimou
Ex-Professors:	Christos Panagopoulos
Associate Professors:	Dimitrios Panias Nymfodora Papasiopi Emmanuela Remoundaki Athena Tsetsekou Anthimos Xenidis
Assistant Professors:	Spyridon Papaefthymiou
Lecturers:	Maria Taxiarhou
Lab Teaching Staff:	Dr. Georgios Bartzas Dr. Artin Chatzikiosegian Dr. Apostolos Kourtis Dr. Pavlina Kousi Dr. Paschalis Oustadakis Dr. Antonios Peppas Aikaterini Thoma Dr. Petros Tsakiridis
Special Administrative and Technical Personnel:	Ioannis Charlampitas Adamantia-M. Charokopou Irini Christodoulou Maria Gregou Nikolaos Kamarinos Irini Kostopoulou Evangelia Mylona Ilianna Ntouni Elias Sammas Eleanna Tsoukatou

	Aikaterini Vaxevanidou
Temps:	Despoina Kolitsa Aikaterini Meliadou

3. Department of Geological Sciences

Professors:	Theodora Rondoyanni-Tsiambaou
Emeritus Professors:	Kalliopi Alexouli-Livaditi Ioannis Koumantakis Euripides Mposkos Theodora Perraki Pantelis Tsoflias Andreas Vgenopoulos Nikolaos Fytrolakis
Associate Professors:	Elias Chatzitheodoridis
Assistant Professors:	Konstantinos Loupasakis Maria Perraki
Lecturers:	Andreas Kallioras Stavros Triantafyllidis
Scientific Collaborators:	Panagiotis Georgiadis
Lab Teaching Staff:	Dr. Ioannis Bousoulas Dr. Evangelia Lykoudi Dr. Konstantinos Markantonis Dr. Paris Tsaggaratos Dr. Eleni Vasileiou
Special Administrative and Technical Personnel:	Eleni Grigorakou Stavroula Dragoumani Dimitrios Tsiakalos Evanthia Vlachou-Vlavianou
Temps:	Evangelos Rokos

SECRETARIAT

Secretary::	Kalliopi Stathi
Members::	Eleni Eleftheriou Ourania Frangou Maria Galani Kalliroi Papakonstantinopoulou Georgia Patakia
Temps:	Klearchoula Kaminardeli Ioanna Vavva
PC-Laboratory:	Nikolaos Apostolakis Lambros Karalis
School Network:	Konstantinos Kotsalis

For any information, please use the following address:

Secretariat
School of Mining and Metallurgical Engineering
NATIONAL TECHNICAL UNIVERSITY OF ATHENS
Zografou 157 80, Athens
GREECE
Tel. (30) 210-772-2067, 210-772-2068, 210-772-2071
Fax. (30) 210-772-2063

Please visit the school web page at: **www.metal.ntua.gr**

6. COURSE PROGRAMME

1st Semester

Code Number	Course	Hours		
		Lectures	Labs	Exercises
A. Mandatory				
7024	1. Mathematics I	4	-	2
7054	2. Physics I	2	2	-
7222	3. Chemistry	2	3	-
7223	4. Mineralogy	2	2	-
7003	5. Geology I	2	-	-
7195	6. Introduction to Computer Programming	2	2	-
		14	9	2

Final Total Hours **25**

Code Number	Course	Hours		
		Lectures	Labs	Exercises
B. Electives (one subject must be selected)				
7224	1. Philosophy and History of Science and Technology	2	-	-
7102	2. Sociology of Science and Technology	2	-	-
7166	3. History of Mining and Metallurgy	2	-	-

Final Total Hours **27**

Code Number	Course	Hours		
		Lectures	Labs	Exercises
B. Electives *Foreign languages (one foreign language must be selected)*				
7036	1. English & Terminology	2	-	-
7037	2. French & Terminology	2	-	-
7039	3. Italian	2	-	-
7038	4. German	2	-	-

Final Total Hours **29**

2nd Semester

Code Number	Course	Hours		
		Lectures	Labs	Exercises
A. Mandatory				
7072	1. Mathematics II	4	-	2
7253	2. Physics II	2	2	-
7231	3. Geology II	2	2	-
7046	4. Petrology	2	2	-
7254	5. Introduction to Computer Science	2	2	-
7120	6. Economics	2	-	-
7226	7. Engineering Drawing, Mechanical Design - CAD	2	2	-
		16	10	2

Final Total Hours **28**

Code Number	Course	Hours		
		Lectures	Labs	Exercises
B. Electives *Foreign languages (one foreign language must be selected)*				
7078	1. English & Terminology	2	-	-
7079	2. French & Terminology	2	-	-
7081	3. Italian	2	-	-
7080	4. German	2	-	-

Final Total Hours **30**

3rd Semester

Code Number	Course	Hours		
		Lectures	Labs	Exercises
A. Mandatory				
7229	1. Mathematics III	4	-	2
7049	2. Technical Mechanics (Statics)	2	-	2
7225	3. Thermodynamics	3	-	1
7196	4. Electric Circuits – Electronics Technology	2	2	-
7266	5. Design and Development of Information Technology Applications	2	1	-
7227	6. Numerical Analysis	2	-	2
		15	3	7

Total Hours **25**

Code Number	Course	Hours		
		Lectures	Labs	Exercises
B. Electives *Foreign languages (one foreign language must be selected)*				
7040	1. English & Terminology	2	-	-
7041	2. French & Terminology	2	-	-
7043	3. Italian	2	-	-
7042	4. German	2	-	-

Final Total Hours **27**

4th Semester

Code Number	Course	Hours		
		Lectures	Labs	Exercises
A. Mandatory				
7088	1. Probability Theory & Statistics	2	2	-
7232	2. Analytical Chemistry and Physical Methods of Analysis	2	3	-
7005	3. Economic Geology	2	2	-
7149	4. Transport Phenomena I	2	1	-
7230	5. Energy Management - Mass and Energy Balances	2	-	1
7104	6. Mineral Exploration	4	1	-
		14	9	-

Total Hours **24**

Code Number	Course	Hours		
		Lectures	Labs	Exercises
B. Electives				
Foreign languages (one foreign language must be selected)				
7082	1. English & Terminology	2	-	-
7083	2. French & Terminology	2	-	-
7085	3. Italian	2	-	-
7084	4. German	2	-	-

Final Total Hours **26**

Note

The Foreign Languages Curriculum lasts 4 semesters. The total course requirement for Foreign Languages corresponds to a mandatory course of the program. The course mark contributes to the final diploma mark (Senate decision of 18-10-96).

5th Semester

Code Number	Course	Hours		
		Lectures	Labs	Exercises
A. Mandatory				
7228	1. Physical Metallurgy I	3	2	-
7012	2. Extractive Metallurgy I	3	-	1
7264	3. Exploitation of Mines I	3	2	-
7210	4. Mechanical Preparation and Processing of Minerals I	4	-	1
7162	5. Transport Phenomena II	2	1	-
7094	6. Technical Mechanics (Strength of Materials)	2	-	2
		17	5	4

Final Total Hours **26**

6th Semester

Code Number	Course	Hours		
		Lectures	Labs	Exercises
A. Mandatory				
7151	1. Physical Metallurgy II	3	2	-
7063	2. Operational Research	2	-	1
7066	3. Extractive Metallurgy II	3	-	1
7233	4. Exploitation of Mines II	2	2	-
7173	5. Mechanical Preparation and Processing of Minerals II	2	2	-
7234	6. Principles of Production Organization and Management – Business Economics	1	1	-
7258	7. Environment I (Introduction to Environmental Science and Engineering)	2	2	-
		15	9	2

Final Total Hours **26**

During the 6th semester takes place a 1-week educational field excursion in industries relevant with subjects in Mining Engineering, Geological Sciences, and Metallurgy & Materials Technology.

7th Semester

Code Number	Course	Hours		
		Lectures	Labs	Exercises
A. Mandatory				
7092	1. Engineering Geology I	2	2	-
7017	2. Rock Excavation I (Rock Blasting)	3	2	-
7235	3. Environment II (Environmental Protection in Mining & Metallurgy)	2	-	2
7035	4. Metallurgy of Iron I	2	2	-
7181	5. Safety – Health – Legislation	2	-	1
7145	6. Reinforced Concrete – Steel structures	2	1	-
7133	7. Elements of Mechanical Engineering	2	-	2
7237	8. Field Training I*	-	-	-
		15	7	5

Final Total Hours **27**

*This Field Training falls under the mandatory courses category of the 7th semester and takes place during the summer months between the 6th and 7th semesters.

8th Semester

Streams

1. Environmental Engineering and Geo-Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7238	1. Environmental Hydrogeology	2	2	-
7239	2. Environmental Geochemistry	2	1	-
7240	3. Environmental Mining and Quarry Engineering (Selected Topics)	2	2	-
7241	4. Soil Remediation Techniques	2	2	-
7219	5. Methods of Air-Waste Treatment	2	-	1
7031	6. Geostatistics	2	1	

2. Mining Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7065	1. Underground Excavations Support	2	2	-
7034	2. Rock Mechanics	2	3	-
7174	3. Rock Excavation II (Mechanical Excavation)	3	1	-
7242	4. Well Technology	3	1	-
7211	5. Loading and Haulage Equipment in Construction and Mining Works	3	1	-
7176	6. Marbles and Industrial Minerals	2	1	-
7031	7. Geostatistics	2	1	

3. Geo-Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7065	1. Underground Excavations Support	2	2	-
7034	2. Rock Mechanics	2	3	-
7174	3. Rock Excavation II (Mechanical Excavation)	3	1	-
7242	4. Well Technology	3	1	-
7171	5. Engineering Geology II	3	1	-
7009	6. Soil Mechanics & Foundation Engineering	2	2	-
7031	7. Geostatistics	2	1	

4. Metallurgical Processes

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7077	1. Metallurgy of Iron II	3	-	1
7052	2. Hydrometallurgy	1	3	-
7192	3. Technology of Cement and Concrete Production	2	-	1
7143	4. Chemical Kinetics	3	-	1
7214	5. Laboratory Training in Basic Metallurgical Unit Operations	-	3	-

5. Materials Science and Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7117	1. Design, Engineering and Testing of Metals Welding	2	2	-
7153	2. Ceramics	3	1	-
7157	3. Polymers and Composites	2	1	-
7160	4. Solidification, Casting and Non-Destructive Testing	2	1	-
7244	5. Electronic Materials	2	2	-
7167	6. Phase Transformations	2	2	-

Pool Courses (select a maximum of 3 courses)

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7159	1. Science and Technology of Geothermal Fields	2	1	-
7177	2. Mineral Economics	2	1	-
7267	3. Environment and Growth	3	-	-
7090	4. Automatic Process Control	3	-	-
7246	5. Geology and Economic Geology of Greece	3	-	-
7155	6. Industrial Minerals and Rocks	2	1	-
7218	7. Elements of Machining	1	2	-
7136	8. Geodesy and Topography of Mines	3	-	-
7150	9. Solid-State Technology	2	-	-

9th Semester

Streams

1. Environmental Engineering and Geo-Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7110	1. Waste Water Treatment Engineering	2	1	-
7259	2. Solid Waste Treatment Materials Recycling	1	1	-
7260	3. Environmental Chemistry and Mechanisms of Pollutants Mobility	2	2	-
7261	4. Environmental Management - Legislation	2	-	-
7255	5. Field Training II*	-	-	-

2. Mining Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7061	1. Applied Geophysics	2	2	-
7112	2. Open Pit Planning and Design	2	1	-
7200	3. Tunneling Engineering	2	2	-
7111	4. Underground Mine Planning and Design	3	1	-
7175	5. Petroleum Engineering	2	1	-
7268	6. Geological Mapping and Tectonic Analysis	2	1	-
7255	7. Field Training II*	-	-	-

During the summer months between the 8th and 9th semesters take place:

a) Field Training in Mining
b) Field Training in Metallurgy
c) Field Training in Economic Geology
d) Field Training in Applied Geology
e) Field Training in Minerals Processing
f) Field Training in Physical Metallurgy

This Field Training falls under the compulsory courses category of the 9th semester. The students who select a given Field Training must have taken the corresponding elective courses in previous semesters.

During the 8th semester takes place a 1-week educational field excursion in industries relevant with subjects in Mining Engineering, Geological Sciences, and Metallurgy & Materials Technology.

3. Geo-Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7061	1. Applied Geophysics	2	2	-
7265	2. Underground Works	1	-	1
7200	3. Tunneling Engineering	2	2	-
7186	4. Applied Hydrogeology	2	1	-
7202	5. Improvement Techniques of the Geotechnical Behaviour of Geologic Formations	2	1	-
7268	6. Geological Mapping and Tectonic Analysis	2	1	-
7255	7. Field Training II*	-	-	-

4. Metallurgical Processes

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7030	1. Metallurgical Reactors Design	2	1	-
7190	2. Plant Design and Economic Evaluation of Metallurgical Plants	2	2	-
7256	3. Design and Construction of Mineral Processing Plants	2	2	-
7189	4. Metallurgy of Non-Ferrous Metals	2	-	1
7048	5. Refractories	2	1	-
7255	6. Field Training II*	-	-	-

5. Materials Science and Engineering

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7204	1. Surface Technology	2	2	-
7168	2. Metal Forming	3	1	-
7220	3. Polymer and Composite Processing	2	1	-
7179	4. Physical Metallurgy of Iron and Steel	2	2	-
7059	5. Industrial Alloys	2	1	-
7048	6. Refractories	2	1	-
7255	7. Field Training II*	-	-	-

Pool Courses (select a maximum of 3 courses)

Code Number	Course	Hours		
		Lectures	Labs	Exercises
Electives				
7262	1. Project Management	2	1	-
7215	2. Geographical Information Systems	2	2	-
7183	3. Simulation of Mining Systems	2	1	-
7203	4. Computer Applications in Geology	1	2	-
7164	5. Statistical Methods in Research & Production	2	1	-
7257	6. Applied Mineralogy	1	2	-
7263	7. Powder Metallurgy	2	1	-
7236	8. Quality Assurance – Certification	2	2	-
7108	9. Economic Evaluation of Investment Projects	2	1	-
7269	10. Innovation and Entrepreneurship	2		-

*Field Training is mandatory for all streams but is not counted in the course requirements for each stream.

7. COURSES CONTENTS

1st Semester

Mathematics I (7024)

Part A, Linear Algebra: Vector Calculus. Linear Spaces. Matrices. Vector Spaces. Determinants. Linear Transformations. Linear Systems.
Part B, Calculus: Numerical Series. Differential Calculus of Functions of One Variable. Taylor Expansion. Integral Calculus (Indefinite, Definite, Improper Integrals, Applications). Ordinary Differential Equations of 1st and 2nd Order with Constant Coefficients.

Physics I (Mechanics) (7054)

Vector Formulation of Physical Laws. Newton's Laws. Forces (gravitational, electric, magnetic). Equation of Motion. Study of Motion in 1 and 3 Dimensions. Reference Systems. Conservation Principles of Energy, Momentum, and Angular Momentum. Solid-Body Motion. Moments. Rotation around a Steady Axis, Rolling Motion. Gravity Field, Laws of Inverse Square. Oscillations, Decaying Oscillations, Forced Oscillations.
The course includes practical exercises in the lab.

Chemistry (7222)

Atomic Structure (Atomic Standards, Periodic Table of Elements). Chemical Bonds (classical and modern theories on covalent, ionic and metallic bonds, intermolecular forces). Chemical Thermodynamics (definitions of basic thermodynamic variables, driving forces of chemical reactions). Chemical Reactions. Chemistry of Aqueous Solutions (Water Chemistry, Theories of Acids and Bases). Reactions in Aqueous Solutions (ionization of weak acids-bases, solubility of gases, hydrolysis of ions, ion complexation). Chemical Equilibrium, Electrochemistry.
Eight (8) laboratory exercises take place on the Chemistry of Aqueous Solutions.

Mineralogy (7223)

Crystallography, crystals as solids (symmetry elements and operations, notation for crystallographic planes), internal structure of crystals (point groups and space groups, crystallographic projection; description of the 32 crystal classes). Crystal chemistry (bonding, coordination, crystal structures and compositional variations of minerals, defects). Mineral classification. Physical methods for chemical and structural analysis of minerals (e.g. X-ray diffraction, X-ray fluorescence, electron microprobe analysis, Raman and IR spectroscopy, mass spectrometry, atomic force microscopy). Optical microscopy (the polarising microscope). Crystallisation and crystal growth, mineral stability and phase diagrams, mineral reactions. Physical properties of minerals (crystal form and habit, luster, colour, streak, hardness, cleavage, specific gravity, etc.). Systematic mineralogy (rock-forming and synthetic

minerals, mineral classification, systematic description of mineral groups, mineral genesis, uses of minerals).

Geology I (7003)

Planet Earth: Structure, Composition, Temperature, Magnetism, Isostasy. Climatic zones. The Earth's Crust. The Changing Face of the Earth. Geological Time.
Elements of Geomorphology: The Relief of the Earth, External Morphogenetic Processes, Weathering and Soils, Wind Action - Deserts, Glaciers. Hydrogeological Cycle, Underground and Surface Waters. River Erosion, Karst, Mapping of Hydrographic Networks. Lakes, Oceans, Coasts.
Earth Movements - Landslides, Human Impact on Geological Environment.
Use of Surveying Maps, Surveying Sections.

Introduction to Computer Programming (7195)

Introduction to Computers. The Operating System MS-DOS. The MS-Windows Environment and its Software. Word Processing. Spread-sheets. Databases. Computer-Aided Design (CAD). Applications.

Philosophy and History of Science and Technology (7224)

History of Scientific and Philosophical Ideas from the Ancient World to the 16th Century. Myth, Philosophy, Science. Presocratics, Plato, Aristotle, Hellenistic period. Physics since Aristotle and the Middle Ages to Galileo and Newton. Unity of Earthly and Heavenly Physics. Astronomy since Eudoxus and Ptolemy to Copernicus and Kepler. Interconnection between Physics and Astronomy.

Sociology of Science and Technology (7102)

Object and Methods of Sociology (what is Sociology, Study of Society, Sociological Consideration and Methods, Social Sciences). Human Ecology. Population and Social Groups. Group Interaction. Social Institutions. Institution of Education and Socialization. Religions. Economic and Political Institutions. Social Structure. Social Stratification. Family and Kinship. Social Change. Actual Problems of Greek Society (Migration, Urban Growth, Social-cultural Change).

History of Mining and Metallurgy (7166)

Man without Metals: The Stone Age. Man and Native Metals: The Bronze Age - The Iron Age. Ancient Mines. Mechanical Preparation of Minerals: Crushing - Grinding. Ore Dressing. Smelting. Gold: Refining Technique. Silver: Production of Silver in Ancient Laurion. Copper-Bronze: Bronze Production in the 9-7th Century B.C. in Greece. Iron-Steel: Metallurgy of Iron and Steel in the 5th Century B.C. by the Greeks. Uses of Metals. Coins.

2nd Semester

Mathematics II (7072)

Part A, Linear Algebra: Vector Spaces with an Inner Product. Characteristic Values and Vectors of a Matrix. Diagonalization. Square Matrices and Applications.
Part B, Calculus: Euclidean Space $\mathbf{R}^n$. Differential Calculus. Limits, Continuity, Differentiation of Multiple-Variable Functions. Implicit Functions. Extrema. Integral Calculus (Double, Triple, Line, Surface Integrals and Applications). Vector Analysis.

Physics II (7253)

Electrostatics. Coulomb's Law. Electric Field and Potential. Gauss' Law. Potential Gradient. Electric Field Energy. Gauss and Stokes Theorems. Laplace Equation. Conductors. Electric Currents. Ohm's Law. Magnetic Field. Fields around Moving Charges. Biot-Savart's Law. Ampere's Law. Electromagnetic Induction. Magnetic Field Energy. Maxwell's Equations. Electric and Magnetic Fields in Materials. The Wave Equation. Normal Waves. Moving and Stationary Waves. Reflection, Propagation. Electromagnetic Waves. Waves in Optical Systems. Optics. Confluence and Diffraction. Polarization. Optical Instruments. Spectroscopy. *The course includes practical exercises in the lab.*

Geology II (7231)

Internal Geologic Processes. Orogenic Cycles. Palaeomagnetism. Palaeontology. Igneous, Sedimentary and Metamorphic rocks. Flysch and Molasse Formations. Recent Geological Formations.
Tectonic structures: Folds, Faults, Joints. Global Tectonics. Plate Tectonics and associated Geodynamic processes. The geotectonic evolution of the Eastern Mediterranean and Greek Territory. Earthquakes: Magnitude, Intensity, Surface Deformation and Consequences. Active Tectonics.
Geological Maps and Geological Cross sections. (Laboratory and Field Work).

Petrology (7046)

Subject of Petrology. Earth's Structure and Composition. Rocks and Rock-forming Minerals. Igneous Petrology: Magma Genesis; Properties, Crystallization and Differentiation of Magma. Textural Features of Igneous Rocks; Classification and Description. Sediments and Sedimentary Rocks: Genesis, Classification and Description. Metamorphism and Metamorphic Rocks: Types of Metamorphism, Metasomatism. Nomenclature and Description of Metamorphic Rocks.

Introduction to Computer Science (7254)

Historical Evolution of Computers and Structure of a Computer System. From Programme Specification to Code. Compilation; Validation; Verification and Software Maintenance. Use

of Logical Diagrams. Basic Data Structures. Control Structures. Assignment. Loops. Input and Output Procedures. Use of Functions and Subroutines. Applications Using FORTRAN.

Economics (7120)

Economics as a Social Science. Use of Course for Engineers. Satisfaction of Needs and the Quality of Life. Factors of Production. The Market, the State, and the Allocation of the Economic Resources. The Scale of Production. Organization and Structure of Production. Price Determination in Competitive and Monopolistic Markets. Economic Development. Technological Progress and Environmental Protection. The Population. Developments in Countries with Mixed Economies and the Socialist Countries. Money. The National Income and its Distribution. Factors Determining the National Income. International Economic Relations. Economic Growth and Development. Main Features of the Greek Economy. Accession to the European Communities.

Engineering Drawing – Mechanical Design - CAD (7226)

Introduction. Geometrical Designs in 2 Dimensions. Views and View Types. Geometrical Designs in 3 Dimensions. Cuts. Graphs. Introduction to Mechanical Design. Principles of Design. Design of Standard Parts. Types of Design. Computer-Aided Design (CAD).

3rd Semester

Mathematics III (7229)

Series and Serial Functions. Weierstrass Criterion. Power Series. Fourier Series (Trigonometric and Generalized). Inequalities Schwartz, Bessel. Equality Parseval.
Differential Equations (Introduction, Proper Problem Setup, Existence and Uniqueness of Solution Theorems). Differential Equations of 1st, 2nd, and Higher Order. Method of Difference Operators. Solution of Ordinary Differential Equations by the Series Method (Legendre and Bessel Functions).
Systems of Differential Equations. Laplace Transforms. Fourier Transforms: Convolution. Heaviside Function. Dirac Mass. Solution of Differential Equations. Stability Problems.

Technical Mechanics (Statics) (7049)

Rigid-body Equilibrium. Basic Principles. Equilibrium Equations. Superposition Law. Composition of Forces. Funicular Polygon. Center of Gravity. Centroids. Friction. Structures. Supports. Statically Determinate and Indeterminate Systems. Trusses: Simple, Complex Trusses. Analytical and Graphical Solution. Plane Beams: Bending Moments, Shearing Forces and Axial Forces. Diagrams of Internal Forces. Simply Supported Beam, Cantilever Beam, Continuous Hinged Beam. Statically Determinate Frames. Three-hinged Arch. Cables.

Principle of Virtual Work. Influence Lines. Lab Demonstrations in Pilot-Plant Constructions.

Thermodynamics (7225)

Basic Principles and Definitions. Types of Energy. Phase Diagram and Volumetric Behaviour of Pure Substances. Equations of State. First and Second Laws of Thermodynamics. Reversible and Irreversible Processes. Entropy. Heating and Cooling Engines. Homogeneous Mixtures. Basic Relationships of Thermodynamic Properties. Equilibrium and Stability. Phase Equilibrium. Equilibrium of Reactive Systems.

Electric Circuits - Electronics Technology (7196)

THEORY: Electric Circuits, Passive and Active Electrical Elements, Basic Laws and Equations, A and B Class Electrical Circuits, Transient and Sinusoidal Response, Electrical Resonance. Permanent Sinusoidal Response, Complex Numbers, Impedence, Mesh and Node Theorems, Network Theorems. Coupled Circuits, Electrical Power, Multiphase Systems. Semiconducting Devices and Materials, Techniques of Manufacturing, Introduction to Analog and Digital Electronics. Fourier Analysis, Laplace Transforms, Quadropole Theory.
LABORATORY EXERCISES: 15 lab exercises in: Electric Circuits, A and B Class Electrical Circuits, Network Theorems, Frequency Response, Ideal Amplifiers and Applications.
PROJECT: Experimental Implementation and Report Writing of an Application.

Numerical Analysis (7227)

Numerical Errors in the Computer. Linear Systems: Gauss Elimination Method. Vector and Matrix Norms. Stability of Linear Systems. General Iterative Method. Jacobi and Gauss-Seidel Iterative Methods. Least Squares Method. Computation of Eigenvalues and Eigenvectors. Power Methods and Method QR. Lagrange Interpolation. Hermite Interpolation. Splines. Numerical Integration: Trapezoidal and Simpson Rules. Non-linear Algebraic Equations and Systems: Bisection, Secant and Newton-Raphson Methods. Ordinary Differential Equations: Euler, Taylor and Runge-Kutta Methods. Predictor-Corrector Methods. Introduction to Shooting Methods for the Solution of Boundary-Value Problems. Partial Differential Equations: Finite Difference and Finite Element Methods.
The course includes practical exercises with software packages.

Design and Applications of Information Technology (7266)

First principles on how to design an application or solve a technical problem in two different environments: a) the Mathcad whiteboard interface and b) an environment of an easy but popular object-oriented and compiled language, that of Visual Basic 6.0. Mathcad topics include: first aspects in using the environment, and a first set of functions and graphing commands aiming to solving complicated engineering problems. Visual Basic includes topics such as: introduction to the environment of Visual Basic; use of the objects provided by the environment and their properties, events and methods; definition of variables and type variable structures; useful commands for writing code; loops, conditions, graphics commands; events; databases and basics of SQL syntax; use of clipboard; linking of Visual Basic

applications with other windows applications, such as Excel, Outlook and Word. Both Mathcad and Visual Basic are demonstrated to the students with applications they write during the course or receive as homework.

4th Semester

Economic Geology (7005)

Introductory senses and definitions. Morphology and nature of ore bodies. Ore structure and texture. Hydrothermal alteration, types of alterations, alteration zoning. Geotectonic environments, genesis – formation of ore deposits. Metallogenic provinces. Ore deposit types (contemporary classification of ore deposits – USGS). Discrimination between magmatic – hydrothermal deposits, deposits related to surface and sedimentary processes, metamorphic and metamorphosed deposits.
Fossil fuels (coal, oil and gas). Formation environments and types of fossil fuels. Environmental behavior of ore deposits, coal and petroleum.

Probability Theory and Statistics (7088)

Probability. Sample Space and Random Events. Random Variables and Vectors. Distribution and Probability Density Functions. Mean Value and Variance of a Random Variable. Point Estimation and Confidence Intervals of Parameters. Testing Hypothesis. Least-square Estimates. Linear Regression Analysis.

Analytical Chemistry and Physical Methods of Analysis (7232)

Introduction: Sample and Sampling. Solubility, Ionic Strength, Activity Coefficients. Gravimetric Analysis Theory. Volumetric Analysis Theory. Complex Formation Methods: Oxidation. Reduction Theory. Mathematics of Errors and Evaluation of Experimental Results. Introduction to Physical Methods of Analysis. Electrogravimetric Analysis. Applications: Analysis of Alloys and Ores.
Introduction: Electrometry (Potentiometry, Conductometric Methods, Polarography, Electrophoresis). Optical Methods (Colorimetry, Spectrophotometry (visible, ultraviolet), Flame Photometry, Infra-Red Spectrophotometry, Atomic Absorption Spectrophotometry, Emission Spectrography). Thermal Analysis. Gas Analysis. Activation Analysis. Applications of the above Methods in Automatic Control of Chemical Processes and in the Environment.

Transport Phenomena I (7149)

Fluid Mechanics. Viscosity and Viscous Flow. Non-Newtonian Fluids. Continuity Equation. Equation of Motion. Ideal Fluid Behavior. Turbulent Flow. Reynolds Number. Equations of Continuity and Motion in Turbulent Flow. Boundary Layer. Drag. Macroscopic Material Balance. Macroscopic Momentum Balance. Macroscopic Energy Balance.

Energy Management – Mass and Energy Balances (7230)

Energy Requirements in Mining and Metallurgical Industries and Materials Processing. Principles of Energy Optimization. Energy and Thermodynamics. Mass and Energy Balances. Use of PC's in Solving Mass and Energy Balance Problems. Elements from the Theory of Combustion. Energy Savings from Combustion and Heat Transfer. Recycling of Excess Energy.

Mineral Exploration (7104)

Nature of Mineral Exploration. Phases and their Risk of Failure. Prospecting and Prospecting Criteria. Ore Reserves Categories and their Industrial Values. Variability. Ore Reserve Estimation by Static Analysis. Sampling.

5th Semester

Physical Metallurgy I (7228)

Fundamental Characteristics and Properties of Metallic Materials. Atomic Bonding and Crystaline Structure. Solidification of Metals. Elements of Metallography. Dislocations in Crystals. Elastic and Plastic Behavior of Metals. Mechanical Testing. Plastic Deformation and Fracture. Introduction to Fractography. Toughness. Elements of Fracture Mechanics. Fatigue. Strengthening Mechanisms. Elements of Metalworking.

Extractive Metallurgy I (7012)

Introduction. Agglomeration Processes. Drying (Mechanisms and Technology). Calcination, Loosting and Smelting (Chemistry and Technology). Slags. Mattes. Converting Distillation. *Exercises*: Thermodynamic and Other Calculations in Metallurgical Processes.

Exploitation of Mines I (7264)

Introduction to excavation engineering. Rock blasting vs. mechanical excavation. Rock mass properties. Fragmentation.

Rock Blasting Technique: principles, mechanisms and technology. Rock Drilling.
Explosives: detonation theory, properties, types, initiation and firing systems, blasthole charging, transportation, storage, safety.
Design of blasting rounds: bench blasting, tunneling, shaft sinking, controlled blasting, underwater blasting.
Environmental effects of blasting: vibrations, air blast, flyrock.

Mechanical Preparation and Processing of Minerals I (7210)

Dimensional Analysis: Principles, theory and applications to mineral processing. Movement of solids in fluids. Scrubbing, power and capacity calculations of drum scrubbers. Size distribution functions, derivation, properties. Comminution: crushing and grinding. Specific-energy/size - reduction relationships. Crushers, tumbling mills: operational principles, capacity and power calculations. Comminution circuits. Classification: Mathematical treatment, industrial screens, hydroclassifiers, air classifiers, cyclones. Operational principles, capacity calculations. Exercises and problems.
Liberation, Separation Flow Sheets, Mathematical Expression of Separation Results – Exercises, Concentration Methods and Equipment: Attrition and Scrubbing, Sorting, Heavy Media, Jigging, Tabling, Spiral Concentration, Air-Separation.

Transport Phenomena II (7162)

Heat Transfer: Mechanisms of Heat Transfer. The General Conduction Equation. Convection Heat Transfer. Natural and Forced Convection Systems. Radiation Heat Transfer. Planck's Law. Stefan-Boltzmann Law.
Mass Transfer: Fick's Law of Diffusion. Diffusion Coefficient. Mass Diffusion Equation in a Stationary Medium. Transient Diffusion.

Technical Mechanics (Strength of Materials) (7094)

Mechanical Properties of Materials. Hooke's Law. Normal and Shear Stresses, Strains, Stress - Strain Relations. Elasticity. Plasticity. Tension and Compression. Ductile and Brittle Materials. Lateral Contraction - Poisson's Ratio. Factors of Safety. Working Stresses. Analysis of Stress. Triaxial Stress. Mohr's Representation of Stress. Pure Shear. Moments of Inertia. Pure Bending. Bending Moment and Shearing Force. Combined Bending and Axial Load. Simple and Double Eccentricity. The Core of a Section. Neutral Zone. Deflections of Straight Beams. Differential Equation of the Deflection Curve. Effect of Shearing Force. Redundant Constraints. Applications in Indeterminate Systems. Torsion. Buckling. Critical Load. Thermal Effects. Composed Beams. Curved Beams. Theories of Failure. Elastic Strain Energy. Castigliano's Theorem. Fatigue Strength. Theory of Elasticity. Test Demonstration in the Structural Mechanics Laboratory: Materials Behavior and Mechanical Properties. Testing Methods, Experiments. Stress - strain Measurements. Experimental Analysis of Tension. Instruments. Measuring Devices.

6th Semester

Physical Metallurgy II (7151)

General Aspects of the Crystalline Structure and Microstructure of Metals. Phase Diagrams. Solidification. Strain Hardening and Recrystallization. Case Studies of the Iron-Carbon System and Other Important Alloys. The Elastic and Plastic Behavior of Metals. Fracture. Toughness. Fatigue. Creep. Oxidation and Corrosion. Friction, Abrasion and Wear. Case Studies of Some Special Alloys Useful in Mining Applications.

Operational Research (7063)

Subject and Methodology: Historical Perspective. Nature and Definition of Operational Research. Basic Characteristics. Methodology. Problem Classes. Similar Scientific Branches. Practice with Operational Research. Allocation Problems - Linear Programming: Introduction, Allocation Problems, Formulation of the Problem Statement, Simplex Method, Binary Theory, Sensitivity Analysis, Transport Problem, Correspondence Problem, Principle of Decomposition. Non-Linear Programming: Introduction, Unconstrained Optimization Algorithms, Constrained Optimization Algorithms. Dynamic Programming: Introduction, One-Dimensional and Multi-Dimensional Search Problems, Dynamic Programming with Uncertainties. Investment Analysis: Introduction, Investment Problem Statement, Cash Flow Reduction, Planning Stages of Investment, Selection Criteria for Investment, Cost - Benefits Assessment. Decision-Making Analysis: Introduction, Decision-Making Structure, Usefulness Theory.

Extractive Metallurgy II (7066)

Introduction to Hydrometallurgy, Elements of Thermodynamics of Aqueous Solutions, Preparation of Raw Materials, Leaching [leaching agents, factors affecting leaching, leaching mechanisms, leaching systems, kinetics of leaching, leaching techniques (in situ, heap leaching, VAT leaching, agitation leaching at atmospheric pressure and under pressure, microorganisms –assisted leaching)], Solids –Liquid Separation (decantation, filtration), Leach Liquor Purification and Metals Separation (crystallization, adsorption, chemical precipitation, ion exchange, solvent extraction, electrolysis).
Exercises: Calculations in Metallurgical Processes.

Exploitation of Mines II (7233)

Ventilation: Ambient and Climate in Mines. Air Circulation in Mines. Ventilation Measurements and Calculations. Mine Ventilators. Lighting: General Principles and Study Elements of Mine Lighting. Underground Mine Water - Pumping: Origin, Significance and Pumping of Mine Water. Measures and Protection against Water Inrush. Economic Elements. Safety: Study of Accidents in the Mining Industry. Major Dangers during Mine Exploitation. Hygiene. Safety Organization.

Mechanical Preparation and Processing of Minerals II (7173)

Magnetic and Electrostatic Concentration, Flotation, Thickening, Filtration, Pelletizing and Briquetting, Feeding and Transportation, Pumping, Sampling, Control, Flow Sheets, Tailing Deposition, Solid Waste Recycling Laboratory Training: Classification, Sampling, Liberation, Jigging, Tabling, Heavy Media Separation, Magnetic Separation, Flotation, Thickening, Filtration.

Principles of Production Organization and Management – Business Economics (7234)

Production Planning and Budgeting. Elementary Cost Accounting. Cost Control. Production Budget. Industrial Organization. Job Descriptions. Motion and Time Study. Production Control. Inventory Management and Control. Principles of Management. Management by Objectives.
Industrial Organization, Competition, and Entrepreneurial Goals. Principles of Accountancy and Cost Analysis. Profitability and Liquidity. Principles of Scheduling and Forecasting Techniques. Budget. Price Policy and Supply Strategy. Analysis and Evaluation of Technical Projects. Investment Criteria. Technological Choices. Analysis of Entrepreneurial Risk Taking. Growth Incentives.

Environment I (Introduction to Environmental Science and Engineering) (7258)

Ecosystems – Nature of Environmental Problems – Mathematical Relations for Population Evolution – Principal Ecosystems of the Earth – Cyclic Life of Elements in Nature - Environmental Pollution. The Role of Microorganisms.

7th Semester

Engineering Geology I (7092)

Distinction of the geological formations. Site Investigation (geological methods, exploration techniques). In situ and Laboratory tests for the determination of the physical and mechanical properties of soils and rocks. Groutings. Engineering geological behaviour of the geological formations in Greek territory. Slope failures (landslides, rockfalls): terminology, classification, factors affecting slope movements and triggering factors, the frame of the site investigation for slope movements, preventive and remedial measures, main case studies in Greek territory. Land Subsidence (main types serious case studies in Greece and other countries). Elements of slope stability analysis. Principles of engineering geology in the civil engineering constructions with emphasis on tunnel geology. Importance of stratigraphy, hydrogeology and tectonic structure in constructions.

Reinforced Concrete - Steel Structures (7145)

Reinforced Concrete: Material Properties of Concrete and Reinforcement, Members with Rectangular Cross Section Subjected to Bending and Axial Force (Beams, Slabs), Bending of T-Sections, Shear, Torsion, Column Buckling.
Steel Structures: Material Properties of Steel and Connecting Media, Resistance of Members to Tension, Compression, Bending, Shear and their Combinations, Resistance of Bolted and Welded Connections, Stability of Members and Frames.

Rock Excavation I (Rock Blasting) (7017)

Introduction to excavation engineering. Rock blasting vs. mechanical excavation. Rock mass properties. Fragmentation.
Rock Blasting Technique: principles, mechanisms and technology. Rock Drilling.
Explosives: detonation theory, properties, types, initiation and firing systems, blasthole charging, transportation, storage, safety.
Design of blasting rounds: bench blasting, tunneling, shaft sinking, controlled blasting, underwater blasting.
Environmental effects of blasting: vibrations, air blast, flyrock.

Environment II (Environmental Protection in Mining and Metallurgy) (7235)

A. Impact of Mining Activities on the Environment

1. Introduction – Mining Activities and the Environment: Historical Perspective, Today's Relation between Mining Activity and the Environment. Global Trends.
2. Environmental Problems in Quarries (Industrial Minerals and Inert Materials). Visual Pollution – Noise Pollution – Dust Pollution. Case Studies.
3. Environmental Problems in Marble Quarries. Rejects of Mining and Quarrying Activities. Case Studies.
4. Environmental Problems in Other Mining Activities (Gold-Mines, etc.). Acid Outflow. Case Studies.
5. Environmental Problems in Lignite Mines. Remediation of Mining Sites. Case Studies.
6. Mining Activities and Future Progress in Greece. Perspectives.

B. Importance of Environmental Protection in Metallurgy and Materials Technology
Flue Gases. Flue-Gas Cleaning. Solid-Particles Removal Technologies. Flue-Gas Removal (SO_2, Fluoro- and Chloro-Chemical Compounds, etc.). Liquid-Waste Treatment. Solids Retention (Thickening, Filtration). Heavy-Metals Retention (Physical, Chemical and Biological Methods). Acid Drainage. Reduction. Reverse Osmosis. Solid Wastes. Deposition of Solid Wastes (Industrial, Urban, Toxic). Metals, Alloys and Materials Recycling. Dilemma: Environmental Protection or Metallurgical Industries. Applications of Environmental Protection in Metallurgy and Materials Technology.

Metallurgy of Iron I (7035)

Raw Materials: Iron Ores, Scrap, Fuel, Coal. Electric Power. Fluxes. Additives. Iron Alloys. Water. Oxygen. The reduction of iron ores. Fuels in Direct Reduction. The Physical Chemistry of Iron- and Steel-Making. The Manufacture of Pig Iron: Outline of the Blast Furnace Process. Construction of the Furnace Proper. Construction of Furnace Auxiliaries. Chemistry of the Blast Furnace Process. Operation of the Furnace. The Blast Furnace Load. Modern Techniques for Increasing Blast Furnace Productivity. Silicon and Manganese Reactions. Phosphorous Reactions. Sulfur Reactions.

Safety - Health - Legislation (7181)

Accidents in Industry, in Mining and in Metallurgy and Materials Technology. Accident Analysis and Safety Measures. The Indirect Cost of Accidents. Accident Metrology. Use of Statistical Data. Safety during Construction, Maintenance and Operation of a Plant. Error Analysis in Accidents. Responsibilities. Fire Extinction. Dangers from Electric Current and Safety Measures. Safety Measures in Industry. First Aid. Hygiene at Work. Legislation. Health and Safety Committee. Health and Safety Regulations in Mining, Metallurgy and Quarrying. Other Legislation.

Elements of Mechanical Engineering (7133)

Linkages (Bolts, Screws, Rivets, Fasteners). Elements of Motion (Shafts, Axles, Rotors, Couplings, Bearings). Motion Transmission (Gears, Pulleys, Cables, Wire Ropes, Chains, Springs). Motion Transformation (Pistons, Connecting Rods, Crankshafts). Gaskets. Pipes. Internal Combustion Engines. Air Compressors. Pumps. Conveyor Belts. Calculation Methods. Device Selection. Industrial automations, robotics, sensors and feedback control systems.

Field Training I (7237)

Field Training I is one of the compulsory courses of the 7th semester and is taking place during the summer months between the 6th and 7th semesters.
During the 6th semester, field trips are organized in various industries relevant to courses taught in Mining, Metallurgy and Materials Technology, and Geological Sciences.

8th Semester

Streams

I. Environmental Engineering and Geo-Environment

Environmental Hydrogeology (7238)

The Hydrological Cycle. The Hydrological Balance. Rock Properties Affecting Groundwater. Groundwater Movement. Intrinsic Permeability, Hydraulic Conductivity, Storage Coefficient. Vertical Distribution of Groundwater. Geological Formations as Aquifers. Types of Aquifers. Water Level Fluctuations as Environmental Parameters. Overpumping and Consequences. Saline Water Intrusion in Aquifers. Vulnerability of Aquifers. Main Sources of Pollution in Aquifers. Pollution Propagation. Protection of Aquifers, Springs, and Wells against Pollution and Exhaustion. Special Hydrogeological Topics for Water-Waste Treatment and Water Protection. Remediation of Aquifers (Qualitative and Quantitative): Pollutants Removal with Pumping, Hydraulic Traps, Laundering, Chemical Methods, etc. Water Suitability for Various Uses. Groundwater and Engineering Constructions.

Environmental Geochemistry (7239)

Introduction. Release of Main Elements and Trace Elements from the Ground (Soil, Rocks, Geological Formations), the Sea, and the Air. Decomposition. Products of Chemical Decomposition. Main Elements - Trace Elements in Biological Systems. Relations between Ground-Plants-Animals-Humans. Environmental Pollution, Pollution Sources. Deposits as Final Receiver of Pollutants. Methods of Incorporation of Trace Elements in Deposits. Geochemical Mapping. Nuclear Radiation in the Environment. Geochemical Cycle of the Elements. Environmental Geochemistry and Man.

Environmental Mining and Quarry Engineering (Selected Topics) (7240)

Impact of Mining Activities on the Environment: Introduction, Impact on the Natural Enviroment, Impact on Man, Socio-economic Impact, Factors Influencing Environmental Problems.
Visual Pollution: Introduction, Theoretical Background, Assessment Methods for Site Visual Quality, Design of Mining Works for Least Visual Impact on Nature.
Ground Shocks and Air-blast: Introduction, Theoretical Background, Monitoring and Measurements of Ground Shocks and Air-blasts. Measures for Reducing Ground Shocks and Air-Blasts, Shocks and Impact on Humans.
Noise Pollution: Introduction, Theoretical Background, Noise Sources in Mining Activities, Monitoring and Measurements, Predictive Models, Measures for Reducing Noise Pollution, Greek and International Limits.
Air Pollution: Introduction, Theoretical Background, Air Pollution Sources in Mining Activities, Monitoring and Measurements, Predictive Models, Measures for Reducing Air Pollution.
Design Methods for Optimal Environmental Protection. BATNEEC in Mining Activities.
Remediation of Mines and Quarry Sites: Introduction, Factors Influencing the Remediation,

New Land Uses, Criteria for Assessment of Alternative Plans. The Problem of Abandoned Mines and Quarries.

Soil Remediation Techniques (7241)

Part I. Introduction: Ground Pollution – Problems, Pollutant Types, Characteristics of Polluted Sites, Risk Assessment.
Part II. Remediation Techniques: Techniques for Isolation of Pollutant Sources. Physicochemical Processes for Soil Remediation. Chemical Processes. Methods of Stabilization – Solidification. Thermal Methods of Soil Treatment. Biological Methods of Soil Treatment. Other Soil Remediation Techniques.
Part III. Environmental Remediation Plan: Development of an Integrated Area Remediation Plan.

Methods for Air-Waste Treatment (7219)

Atmospheric Pollution from Mining and Metallurgical Activities. Types and Origin of Atmospheric (Industrial and Urban) Pollutants. Methods for Treatment of Atmospheric Pollution. Pollutant Retention. Legal, Administrative and Planning Measures. Theory and Technology of Pollutants Removal from Air Waste. SO_2 Retention. H_2SO_4 and S Production. Retention of Fluoro-, Chloro-, and N-Compounds. Volatile CH_4 and CO. Energy Consumption of Antipollution Units. Air-Waste Dispersion in the Atmosphere from Stacks. Stack Calculations. Ground Concentration Calculations. Dispersion Models for Atmospheric Pollutants. Acid Rain. Site Selection for Industrial Activities. Environmental Impact of Air Waste. Importance of Atmospheric Pollution with regard to Water and Ground Pollution. Comparison between Wet and Dry Removal Methods for Air Waste. Selection of Treatment Method for Air Waste. Dust Recycling from Air Waste in Metallurgical Processes. Examples of Air-Waste Treatment from the Mining and Metallurgical Industries, and Industries dealing with Minerals Processing, Cement, Limestone, Refractories, Inerts, etc.

Geostatistics (7031)

Introduction to Geostatistics. Geostatistical Hypotheses. Structural Analysis. Assessment. Variance. Kriging. Generalized Kriging. Variance of Scedacity. Capacity Correlation. Recoverable Deposits. Ore Simulation. Applications of Geostatistics in Mining Research. Case Studies. Applications of Geostatistics in Mine Exploitation. Case Studies. Recent Advances in Geostatistics.

II. Mining Engineering

Underground Excavations Support (7065)

Behavior of the Rock Mass Surrounding an Underground Excavation. Stresses around Underground Openings. Flat Arc Analysis of Stratified Rock. Blocky Rock Separated by Three Sets of Joints. Squeezing Rock - Relaxation of Surrounding Rock Due to Support

Interaction. Crushed Rock. Swelling Rock. Rock Mass Energy Dissipation During Excavation. Underground Excavation Support Methods. Struts. Frames - Lattice Girders. Concrete - Shotcrete - Additives - Reinforcing Steel Bars - Fibers. Rock Bolts. Natural Support. Rock Fill. Support at Great Depth. Economic Issues. Tutorials.

Rock Mechanics (7034)

Rock and its Discontinuities. Geotechnical Classifications of Rock Mass. Elastic Behavior of Rock. Stress - Strain Diagrams. Failure Criteria. Creeping. Rheological Models. Stresses in-situ. Determination of Rock Strength Properties in the Laboratory and in-situ.

Rock Excavation II (Mechanical excavation) (7174)

Rock excavation by mechanical means. Rock breaking tools: drag picks and disc cutters. Rock cutting theories: Merchant, Evans, Roxborough, Nishimatsu, Ozdemir. Specific energy requirements. Rock abrasiveness. The CERCHAR abrasiveness index. Roadheaders and surface miners. Tunnel boring machines. Dozing, ripping, and scraping. Hydraulic hammers. Performance prediction models. Cutterhead design. Case studies and exercises. Laboratory rock cutting tests.

Well Technology (7242)

Historical Perspective of Exploratory Drilling. Diamond Drilling, Hydro-Drilling, Petroleum Drilling. Other Drilling Methods. Mechanical Parts of Diamond Drilling. Mechanism of Diamond Drilling. Casing. Finishing Techniques. Drilling Data Collection. Factors Influencing Diamond Head Wearing and Drilling Speed. Diamond Drilling Economics.

Loading and Haulage Equipment in Construction and Mining Works (7211)

Engineering Fundamentals: Engines, Transmissions, Hydraulic Systems, Propelling and Steering Systems, Auxiliary Systems. Earth-moving.
Underground Mining Equipment: Excavation Machines (Tunnel Boring Machines, Mobile Miners, Raise Borers, Road-headers, Shearers, Continuous Miners). Materials Handling Equipment (Loading and Haulage).
Surface Mining Equipment: Electric and Hydraulic Shovels, Backhoes, Dozers, Scrapers, Front-end Loaders, Draglines. Ripping. Bucket Wheel Excavators, Bucket Chain Excavators. Trucks, Conveyors. Stackers.
Equipment Management: Selection, Application, Maintenance, and Renewal.
Haulage: Haulage Systems, Methods and Equipment. Continuous and Cyclic Haulage Systems.
Mine Hoisting: Systems and Components.
Exercises.

Marbles and Industrial Minerals (7176)

Marble in Greece - Historical Perspective - Types of Marble and Ornamental Stones - Marble Reserves in Greece - Properties and Specifications of Marble - Search for Marble Deposits -

Marble Pit Exploitation (Discovery - Mining Methods and Cutting of Large Pieces) - Marble Processing (Breaking, Cutting, Smoothing) - By-Products Development. Industrial Minerals.

III. Geo-Engineering

Engineering Geology II (7171)

Engineering geological studies: stages and phases, engineering geological maps and sections. Behaviour of intact, weathering and fracturing rocks: engineering geological description, joint properties, micro tectonic analysis, Schmidt net projection, plane, wedge and toppling failures, daylight envelope. Various systems of rock mass classification. Aggregates: geology, properties, laboratory examinations, and production of them. Elements of environmental integration of civil engineering works. Reservoirs (dams and artificial lakes): various types, terminology, distribution of forces, calculation of the factor of safety, and engineering geological and hydrogeological behaviour of the foundation ground. Engineering geology of linear infrastructure works (roads, railways, pipelines): procedure of the engineering geological study. Engineering geological studies in Urban and Rural Planning.

Soil Mechanics and Foundation Engineering (7009)

Soil structure. Physical Properties. Particle Size Distribution. Atterberg Limits. Classification Systems. Principle of Effective Stresses. In-situ State of Stresses. Permeability. Seepage Problems. Distribution of Stresses. Deformability under Undrained and Drained Conditions. Theory of Consolidation. Shear Strength Problems and Laboratory Simulation. Stability of Earth Slopes.

IV. Metallurgical Processes

Metallurgy of Iron II (7077)

Pneumatic Steel Making Processes. Basic Principles and Importance. Exchangers and Mixers. Industrial Structure. LD Method and Variants. Bottom Oxygen Blown Method (OBM) Steel Making Process. Advantages of the Blown Acid Process. Desulphurization, Dephosphorization, Deoxidation, etc. Open-Hearth Steel Making Process. Chemistry of Electric-Furnace Steel Making. Electric-Furnace Steel Making: Direct Arc Air Type Furnaces and Auxiliaries. Power Supply and Controls. Production Methods for FeSi, FeMn, SiMn, FeNi, FeCr. Production of Stainless Steel. Latest Developments in Metallurgy of Iron and Manufacture of Steel. Plasma Technology in Steel Making. Advantages and Disadvantages, Industrial Applications. Nuclear Steel Making.

Hydrometallurgy (7052)

Special Hydrometallurgical Topics (leaching of oxides and silicates, leaching of sulphides, materials selection for hydrometallurgical plants, analysis of industrial hydrometallurgical flowsheets). *Ten (10) Laboratory Exercises:* 1.Ore Weighting and sampling, 2.Ore chemical analysis (fusion, dissolution, dilution, atomic absorption spectroscopy), 3.Mineralogical analysis by X-Ray Diffraction and Electronic Microscopy, 4.Agitation leaching of ground ore at atmospheric pressure. Application: leaching of lateritic ore with dilute sulphuric acid,

5.Column leaching of agglomerated ore -Simulation of heap leaching. Application: leaching of lateritic ore with dilute sulphuric acid, 6.Pressure leaching of ground ore. Application: leaching of lateritic ore with dilute sulphuric acid, 7.Removal of metal impurities from pregnant leach liquor (pls) by chemical precipitation. Application: removal of Fe^{3+} as hydroxide [$Fe(OH)_3$] and as goethite ($Fe_2O_3 \cdot H_2O$), 8.Removal of metal impurities by microorganisms-assisted chemical precipitation (bio-precipitation). Application: precipitation of Fe^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+} as sulphides by using sulphur –reducing bacteria, 9.Metals recovery by solvent extraction (SX). Application: extraction of Co^{2+} by CYANEX 272), 10.Metals recovery from pregnant leach solution by electrowinning (EW). Application: electrodeposition of Ni from purified sulphate solution.

Technology of Cement and Concrete Production (7192)

The Greek Cement Industry. Structure and Mineralogical Composition of Cements. Cement Types, Composition and Uses. Raw Materials and Calculation of Raw Mix Composition. Size Reduction Operations. Pyroprocessing Technology. Hydration of Cements. Metallurgical Processes in Cement Production. Chemical Behavior of Cement in Production and Use of Concrete. Methods of Aggregates production. Test Methods for Aggregates Materials for Proper Concrete (Particle Size Composition, Shape, Mineralogical Characteristics, Strength, etc.). International and Greek Standards for Cement Testing. Environmental Aspects of Production and Use of Cement and Concrete.

Chemical Kinetics (7143)

Basic Concepts of Chemical Kinetics. Mathematical Description of Kinetic Systems. Experimental Techniques for Kinetic Studies. Interpretation of Experimental Data. Catalysis. Kinetics of Solid-Fluid, Solid-Solid, Liquid-Liquid, Liquid-Gas Systems. Applications in Metallurgy.

Laboratory Training in Basic Metallurgical Unit Operations (7214)

Practical Training in the Laboratory of Metallurgy in the following subjects: Melting and Measurements at High Temperatures. Oxidized Smelting. Reduced Smelting. Differential Scanning Calorimetry. Bioextraction. Metal Extraction with an Organic Solvent.
Measurements of ion-exchange in zeolites. Determination of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD).

V. Materials Science and Engineering

Design, Engineering and Testing of Metals Welding (7117)

Welding Background and Applications. Welding Processes and Their Classification. The Welding Arc and Power Sources. Arc Welding with a Consumable Electrode. Thermal Phenomena in Welding. Metallurgy of Welding. Residual Stresses and Deformation during Welding. Gas-Shielded Arc Welding, TIG, MIG, MAG, Plasma-Spray. Submerged Arc Welding and Hard Surfacing. Resistance Welding. Electron Beam and Laser Welding.

Thermochemical Welding. Cutting. Solid Phase Welding. Welding of Carbon, Alloy and Stainless Steel. Welding of Cast Iron. Welding of Aluminum, Copper and Other Non-Ferrous Metals and Alloys. Elements of Inspection and Automatic Control of Welded Materials. Elements of Welding Design. Safety and Health of Welders.

Ceramics (7153)

Ceramic Industry: Raw Materials, Ceramic Processes and Products. Structure of Ceramics. Development of Microstructure. Formation and Structure of Glass. Phase Equilibrium Diagrams, Phase Transformations. Thermal Processes: Recrystallization, Grain Growth, Sintering. Metastable Diagrams. Porcelain and Glass Ceramics. Technological Properties of Ceramics and Glasses. Processing of Ceramics and Glasses, Drying, Sintering. Advanced Ceramics – Properties and Applications. Technological Requirements for Mechanical, Biological, Chemical Applications. Electronic Ceramics.

Polymers and Composites (7157)

Introduction to Polymer Structure. Macromolecular Chemistry. Crystallinity. Mechanical and Thermomechanical Behavior of Polymers. Viscoelasticity. Rheology. Deformation and Fracture. Polymerization, Types of Polymers, Plastics, Elastomers, Fibers, Applications. Composites. Reinforced Composites. Composite Materials with Metallic or Ceramic Matrix. Composites with Carbon Fibers.

Solidification, Casting, and Non-Destructive Testing (7160)

Solidification of Metallic Materials: Homogeneous and Heterogeneous Nucleation. Solidification of Metals and Alloys. Segregation. Directional Solidification. Casting of Metallic Materials: Metallic Materials for Casting, Making the Mold. Classic and Modern Techniques for Casting of Metallic Materials. Centrifugal and Continuous Casting. Defects of Solidified Metallic Materials. Quality Control of Cast Metallic Materials with Non-Destructive Test Methods (Radiography, Sonar, etc.).

Electronic Materials (7244)

THEORY: Effects and Devices Based on Conducting and Super-Conducting, Semi-Conducting, and Magnetic Materials. Development of Electronic Materials. Diffusion, Lithography, and Etching. Thin and Thick Film Development. Electronic Materials and Application within the Greek Manufacturing Sector.
LABORATORY: Twelve (12) Laboratory Exercises on Applications for Semi-Conducting, Conducting and Magnetic Materials Using Simulation Techniques and Electronic Equipment.
PROJECT: Experimental Implementation and Report Writing of an Application.

Phase Transformations (7167)

Thermodynamics and Phase Diagrams. Diffusion in the Solid State. Diffusion Transformations in Solids: Homogeneous and Heterogeneous Nucleation in Solids. Precipitate Growth. Spinoidal Decomposition. Cellular and Massive Transformations. Ordering

Transformations. Martensite Transformations.

Pool Courses

Science and Technology of Geothermal Fields (7159)

A) Definition of Geothermy. Creation of Geothermal Fields. High and Low Enthalpy Fluids. Literature Survey on Geothermy. Development of Geothermy and Environmental Protection in Greece and the World.
B) Definition of Thermometallic Springs. Creation and Characterization Based on their Chemical and Mineral Composition. Salt Precipitation Problems. Development of Thermometallic Springs. Uses of Thermometallic Springs. Thermometallic Springs in Greece and their Development for Health Improvement and Therapeutic Purposes.

Mineral Economics (7177)

The Role of Mineral Industry in the Greek Economy. Mineral Reserves and Resources. Availability and Scarcity of Mineral Resources. Marketing of Mineral Commodities. Market Structures. Pricing of Mineral Commodities. Elementary Pricing Theory. Means Of Price Stabilization. International Mineral Policies. International Commodity Agreements. Facts and Figures on Selected Mineral Commodities.

Automatic Process Control (7090)

Introduction. Basic Principles. Mathematical Methods for Process Control Systems. Dynamic Systems Behavior. Measurements and Instrumentation. Controllers and their Design. Methods of Assessing System Stability. Automatic Control Applications to the Design of Process Control Systems.

Geology and Economic Geology of Greece (7246)

Geological Structure of the Greek Area. Evolution of the Tethys Alpine System. Pre-Alpine and Alpine Greece. The Geotectonic Zones of Greece. Internal and External Zones. Geological Characteristics and Palaeogeographic Evolution.
Ore Deposits of the Internal Zones. Description of Important Chromitic, Magnesitic, Fe-Ni, P.B.G. Ore Deposits. Ore Deposits of the External Zones: Bauxites - Evaporites. Ore Deposits in Post-Alpine Geological Formations.
Metallogenic Areas and Ages in Greece. Prospects of Development and Exploration of the Mineral Wealth of Greece.

Industrial Minerals and Rocks (7155)

Introduction and Overview, Classification, Mineralogy-Genesis-Occurrence (Texture, Structure, Associated Minerals, Mode of Formation), World Deposits, World Production,

Properties and Uses (with emphasis to Cement Industry and Geopolymers) of the Following Industrial Minerals and rocks: Clays, Kaolin, Bentonite, Zeolites, Limestones, Dolomite, Asbestos, Feldspars, Barite, Evaporites, Perlite, Pumice, Corundum, Emery, Fluorspar, Magnesite, Mica, Phospates, Quartz, Marble, Building Materials.

Elements of Machining (7218)

Introduction. Basic elements of theory (waste development, cutting force/power, surface quality, tool damage, cutting liquids). Cutting tools. Conventional mechanical processing (lathe, milling machine, plane, gear cut, burr drill, corrugation machines, cutting press, polishing machines). Non-conventional mechanical processing (electrowear, ultrasonics, water cut, electric arc, electrochemical process, electron beam use, lasers, other methods). Machine tool control systems. Treatment ability of various materials. Production applications (product design / material selection, method selection / machine tool selection, treatment parameter determination). Mechanical measurements.

Geodesy and Topography of Mines (7136)

Introduction to Geodesy. Shape and Size of the Earth. Reference Surfaces. Ellipsoidal Surfaces. Horizontal Reference Surface. Reference Systems in Geodesy and Topography. Orthogonal System. Field Surveying. Surveying Methods. Tachometry. Measuring Devices for Angles and Distances. Polygonometry. Triangularization. Measurements Organization. Instruments. Global Positioning System (GPS). Density Methods of Triangular Points. Front View, Side View. Altimetry. Instruments. Mean Sea Level. Design - Surveying Plan - Area Calculation - Volume Calculation. Cave Surveying - Underground Surveying. Methodology - Instruments. Axis Planning. Straight and Circular Arcs. Maps - Reading and Use of Maps.

Solid-State Technology (7150)

Basic Principles of Crystallography. Amorphous Solids. Zone Theory. Electric, Dielectric, Thermoelectric, Magnetic, Optical and Thermal Properties of Solid Materials. Magnetic Alloys. Semiconducting Structures. Optoelectronic Materials. Diffusion in Solid State. Diffusion in Metallurgical Processes.

Environment and Growth (inter-departmental course) (7267)

Economic Development (Growth) and Environment (legal, social, economic, political and cultural aspects), Sustainable Development and Critical Consideration, Environmental and Economic Development Policies, Management and Technological Tools (Capabilities - Weaknesses), Environmental economy, Analysis of specific areas - Environmental facts-Response to development practices.
Suggested Indicative sub – cases: Landfill Siting & Alternative Management Proposals, Energy Production (Global Climate Change; Destruction of the ozone layer, Air pollution, Lignite, Natural Gas or Renewable Energy Sources), Tourist Development and the Environment, Agricultural Development and the Environment, Intensive Agriculture and Water Resources, Interaction between the Transportation and the Environment, Effects of High Voltage Networks and Mobiles on Human Health.

9th Semester

Streams

I. Environmental Engineering and Geo-Environment

Waste Water Treatment Engineering (7110)

Physical and Biological Methods of Liquid Waste Treatment. Plant Design for Liquid Waste Treatment. Analysis of Biological Reactors.

Solid Waste Treatment – Materials Recycling (7259)

Introduction (social, environmental and political considerations). Sources of solid wastes. Composition, characteristics, and sampling of wastes. Legislation for solid wastes. Collection, transportation, storage, disposal. Selection at the source (methods, tools, etc.). Recycling and reuse of materials. Design principles for waste disposal. Integrated disposal systems. Solid waste processing. Disposal sites. Risk assessment from disposal sites. Solid wastes from mining activities. Solid wastes from metallurgical activities and minerals processing.

Environmental Chemistry and Mechanisms of Pollutants Mobility (7260)

Introduction, Aqueous Chemistry, Mobility of Pollutants in the Aqueous Phase. Biochemical Environmental Processes. Atmospheric Chemistry – Mechanisms of Pollutants Mobility in the Atmosphere. Soil Chemistry – Pollutants Mobility in the Soil. Interactions between Different Phases.

Environmental Management - Legislation (7261)

Environmental Management. Systems of Environmental Management. Assessment of Environmental Impact. Cost Analysis, Profit Analysis. Environmental Economics. Multicriteria Analysis. Risk Assessment and Management. Environmental Policies. Environmental Legislation.

Field Training II (7255)

Field Training II is one of the compulsory courses of the 9th semester and is taking place during the summer months between the 8th and 9th semesters.
Every student must visit in a mine either in Greece or abroad and stay there for a period of at least one (1) month. During this time, the student collects all necessary information for inclusion in a report, called appropriately “Grand Mining/Metallurgical Assignment”. The report describes the mine and also addresses in depth a particular problem and its solution in

the said mine. The assignment is read and marked by the Professor in charge and the mark is given in the course of the 9th semester.

II. Mining Engineering

Applied Geophysics (7061)

Fundamental Principles, Application Fields, Possibilities and Limits of Applied Geophysics. Geophysical Prospecting Methods: Gravimetric, Magnetic, Electrical, Electromagnetic, Seismic, Radioactive. Well Logging. Other Special Methods (Chemical, Thermal). Instruments for Geophysical Measurements. Geophysical Surveying Techniques. Processing, Representation, and Interpretation of Geophysical Data. Computers in Geophysical Exploration. Field Examples. Economic and Statistical Data in Geophysical Exploration.

Open Pit Planning and Design (7112)

Definitions. Characteristics of Open Pit Exploitation. Stripping Ratio. Methods Employed in the Main Production Phases (Excavation, Loading, Hauling, Waste Disposal). Effect of Slope Angle on the Economics of Exploitation. Slope Stability. Pit Limit Analysis. Production Scheduling. Special Cases: Lignite Mining, Alluvial Mining, Marble Quarries.

Tunneling Engineering (7200)

Types of Tunnels, Clearances and Alignment. Geotechnical Investigation, Qualitative Characterization of Rock Mass. Portal Construction. Soft Ground Tunneling - N.A.T.M., Monitoring, Spilling, Grouting, Shield Tunneling. Rock Tunneling with Blasting - N.T.M. Mixed Face Tunneling. Road Header and Full Face Machine Excavation. Final Lining. Caverns. Micro-tunneling. Sunken Tube Tunnels. Structural Analysis of Each Method. Tutorials.

Underground Mine Planning and Design (7111)

Fundamental Principles of Mining. Methods of Mining with Open Stopes: Brest Mining, Method of Benches, Sub-Level Stoping. Filled-Stopes Methods: Shrinkage Stoping, Cut-and-Fill Method and its Variances, Crosscut Method. Caving Methods: Long-Wall Mining, Room-and-Pillar, Sub-Level Caving, Top Slicing, Block Caving.

Petroleum Engineering (7175)

Formation Evaluation. Logging. Properties of Reservoir Fluids. Volumetric and Phase Behavior of Hydrocarbon Systems. Relative Permeability and Multiphase Flow in Porous Media. Well Test. Primary Recovery. Secondary Recovery. Enhanced Oil Recovery. Factors Influencing Production Operations. Production Installations. Concepts in Reservoir Simulation and Application to Development Planning.

Geological Mapping and Tectonic Analysis (7268)

Cartography and Topographic Maps. Geometric Relations between Topographic Relief and Geological Surfaces. Remote Sensing - Interpretation of Aerial Photographs. Identification of Geological Formations and Geological Contacts: principles and Morphotectonic Characteristics. Chronology of the Geological Events. Complex Structures. Isopach Maps.
Tectonic Structures, Folds - Faults: Geometric, Kinematic and Dynamic Characteristics. Tectonic Stresses and Deformations. Stereographic Projections.
Interpretation of Geological maps and construction of Geological Cross Sections.
Maps of Regions with Economic or Engineering Interest. Geological Maps and GIS.

III. Geo-Engineering

Applied Hydrogeology (7186)

The Hydrological Cycle. Rock Properties Affecting Groundwater. Vertical Distribution of Groundwater. Geological Formations as Aquifers. Types of Aquifers. Recharge. Groundwater Movement. Intrinsic Permeability, Hydraulic Conductivity, Storage Coefficient. Groundwater Levels Fluctuations and Environmental Influences. Saline Water Intrusion in Aquifers. Springs. Exploitation of Groundwater. Wells. Groundwater and Engineering Constructions. Pollution of Groundwater and Protection Methods.

Underground Works (7265)

Special Underground Engineering Modern Infrastructures. Environmental Significance of Underground Engineering. Types and Uses of Underground Engineering. Pros and Cons. Future Trends in Underground Engineering. Examples of Underground Engineering. Construction of Underground Works with the Method of Chambers and Piles. Design of Large Underground Chambers. Configuration of Underground Stations. Cost-Assessment of Excavations in Underground Engineering.

Improvement Techniques of the Geotechnical Behaviour of Geologic Formations (7202)

Ground water lowering techniques, Electrochemical Stabilization, Thermal improvement techniques, Compaction and Consolidation, Vibrocompaction, Vibroflotation, Vibroreplacement, Vibrodisplacement, Grouts and Groutings, Geosynthetics (geotextiles, geogrids, geowebs, geocomposities), Soil chemical stabilization, support and protection techniques (gravity walls, gabion walls, structural and flexible retaining walls, mechanically stabilized earth, berlinoise walls, diaphragm walls, piles, anchors, bolts, nails, dowels, gunite, shotcrete, cables, metallic netting, rockfall protection barriers).

IV. Metallurgical Processes

Metallurgical Reactors' Design (7030)

Ideal Batch Reactor. Steady-State Mixed Flow Reactor. Steady-State Plug Flow Reactor. Size Comparison of Single Reactors. Multiple Reactor System. Recycle Reactor. Temperature and Pressure Effects on Fractional Conversion. Optimum Temperature Progression. Fluid-Solid Reactions. Shrinking Core Model. Determination of the Rate-Controlling Step. Application to Fluidized Bed Reactor. Non-Ideal Flow. Residence Time Distribution. Pulse-Step Tracer Input. Models for Non-Ideal Flow.

Plant Design and Economic Evaluation of Metallurgical Plants (7190)

Design Stages: Basic Detailed Engineering. Design Basis. Cost Analysis of Investment Plans. Flowsheeting. Degrees of Freedom Analysis. Design Variables. Material and Energy Balances. Simulators. Design Optimization. Energy Optimization.

Design and Construction of Mineral Processing Plants (7256)

Introduction. Equipment Calculation. Circuit Calculation. Flow Sheets. Production. Examples. Plant Design. Principles. Selection and Purchase of Equipment. Engineering Design. Construction Planning and Construction Startup. Production Process.

Metallurgy of Non-Ferrous Metals (7189)

Primary Alumina and Aluminum Production: Bayer Process, Hall-Heroult Process, Environmental Consequences, Innovations in Alumina and Aluminum Production, Exergy and Energy Analysis of current industrial practice. Extractive Metallurgy of Cu, Zn, Pb from oxidic and sulphidic ores. Extractive Metallurgy of precious metals.

Refractories (7048)

Definition-Classification-Types of Refractories. Properties and Characterization Methods of Refractories. Preformed Refractory Shapes (Introduction, Raw Materials, Production, Properties, Applications). Special and Insulating Refractories. Monolithic Refractories (Introduction, Raw Materials, Production, Properties, Applications). Fibrous Refractories.

V. Materials Science and Engineering

Surface Technology (7204)

Surface Physics and Chemistry of Solids. Modern Analytical Methods for Surface Studies of Various Materials. Friction, Wear, Lubrication and Lubricants. Methods for Surface Treatment. Various Coating Methods. Properties of Coatings.

Metal Forming (7168)

Basic Concepts of the Mathematical Theory of Plasticity. Fundamentals of Metalworking. Methods of Calculation. Dynamic Recovery and Recrystallization. Texture Formation. Forging. Rolling. Extrusion. Drawing. Sheet-Metal Forming. Machining.

Polymers and Composites Processing (7220)

Rheology in Polymer Processing. Rheometry, Rheological Properties of Polymers and their Measurement. Rheological Constitutive Equations. Polymer Processing Operations (Extrusion, Calendering, Wire Coating, Film Blowing, Fiber Spinning, Injection Molding, etc.). Numerical Methods in Polymer and Composite Processing. Analysis and Design in Polymer Processing with the Lubrication Approximation Theory.

Physical Metallurgy of Iron and Steel (7179)

Fe-C Phase Diagram. Equilibrium Phase Transformations. Typical Phase Transformations in Steel and Cast Iron. Metallography - Properties. Non-Equilibrium Phase Diagrams. TTT and CCT Diagrams (Curves). Martensitic Transformation. Tempering. Secondary Hardening. Alloyed Steel - Alloying Elements. Properties and Applications of Steel and Cast Iron. Carburizing - Nitriding. Steel Amenable at High-Temperature Oxidation. Strongly Alloyed Steel. Stainless Steel. Surface Treatment of Steel and Surface Coatings.

Industrial Alloys (7059)

Alloyed Steel. Tool Steel. Progress in the Technology of Industrial Alloys. Stainless Steels. Powder Metallurgy. Copper Alloys. Aluminum Alloys. Titanium Alloys. Cast Iron.

Pool Courses **(maximum choice 3 courses)**

Project Management (7262)

Introduction to project management. Characteristic phases of the project. Time management. Production means management. Time and cost monitoring. Scheduling of linear projects. Project total quality. Exercises by using specific software packages.

Geographical Information Systems (7215)

Introduction to the methods of analysis, referencing, and graphical representation of qualitative and quantitative elements related to planning and design by Geographical Information Systems (GIS). Introduction to the technology and use of the GIS and the relevant geographical data bases. Practice and use of GIS for different types of engineering, and practical applications to theoretical and applied fields.
The course takes place at the GIS Laboratory of the Department of Architecture and consists of 5 hours/week, of which 2 hours are dedicated to theoretical aspects and 3 hours to practice on related subjects.

Simulation of Mining Systems (7183)

Introduction. Hardware. Operating Systems. Programming Languages. General Applications: Word Processing, Spreadsheets, Databases, Graphics, Statistical Analysis, Project Management. Simulation of Mining Systems. Elements of the GPSS/H Simulation Language and Development of Mining System Models. Computer-Aided Open Pit Mine Planning and Design.

Computer Applications in Geology (7203)

Computer Applications in (a) Geology, (b) Hydrogeology, and (c) Engineering Geology.
The software used includes:
Statistical Treatment of Tectonic Information Using the SCHMIDT Net. Filing, Processing and Presentation of Hydrometeorological Data. Parameter Estimation by Setting the Hydrological Balance. Pumping Tests Analysis with Various Methods. Simulation of Aquifers. Filing, Processing and Presentation of Water Chemical Analysis.

Statistical Methods in Research and Production (7164)

Introduction. General Factorial Design of Experiments and Two-Level Factorial Design. Basic Principles. Definitions, Nomenclature and Symbols. Main Effects and Interactions. Calculation Methods for Two-Level Factorial Design. Practical Significance. Two-Level Fractional Factorial Design. Statistical Inference. Statistical Hypotheses - Need for Randomization. Confidence Intervals. Analysis of Variance (ANOVA). Second-Order Factorial Designs. Composite Design. Orthogonal Design. Non-Orthogonal Symmetrical Design of Experiments. Empirical Models. Optimization.

Applied Mineralogy (7257)

Basic Methods for the Investigation of Minerals, Rocks and Ores (Optical Microscopy, X-ray Diffractometry, Electron Microscopy, Electron Microprobe Analysis). Rock-forming Minerals. Igneous, Sedimentary, and Metamorphic Rocks. Industrial Minerals and Rocks: Chemical Composition, Properties, Genesis, Uses, Greek Deposits. Ores: Genetic Classification (Magmatic, Sedimentary, Metamorphic). Mineral Phases and Textural Characteristics of Ores; their Significance in Ore Dressing and Metallurgical Treatment.

Application to the Main Greek Ores (Chromites), Fe-Ni-Laterites, Bauxites, Cu-Ores, Pb-Zn Ores, Au-Ag Ores, Pyrite, Ilmenite-Ti-Magnetite, Iron Ores).

Powder Metallurgy (7263)

Introduction, production methods of powders in metallurgy, properties of powders (particle size distribution, specific surface, additives), thermal treatment of powders. Compression and shaping, thermal coagulation (mono- or multi-component). Powder metallurgy products: iron and steel, copper, nickel and super alloys, hard metals, high-melting-temperature metals, metal composites.

Quality Assurance - Certification (7236)

Introduction to the Principles of Quality Assurance, Standardization, Certification and Calibration. Introduction to the Series of Standards ISO/EN/ELOT 9000, EN 45000 and ISO 14000. Principles of Development and Use of Testing Laboratories and Corresponding Techniques.

Economic Evaluation of Investment Projects (7108)

Importance of Economics in Mining. Ore Reserve Estimation. Time Value of Money. Mine Property Evaluation. Methods of Investment Appraisal. Marketing of Ores and Industrial Minerals. Financing of Mining Investments. Feasibility Studies. Risk Analysis. Introduction to Mining Law.

Innovation and Entrepreneurship (7269)

Main goal of the course is to prepare a business plan that combines technology with entrepreneurship and aims to familiarize students with the whole cycle of the birth of the business idea, the feasibility study as the first phase of implementation ie the development of a business plan. Students are divided into teams and suggest the idea that study, finally forming a business plan and present to an audience in the classroom. The final grade will be formed by 60% from work and 40% from the final exam. Prerequisites are only the basic knowledge to evaluate investment projects. The course includes lectures and interactions between the development teams (students) and their supervisors.

8. ALPHABETICAL COURSE LISTING

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