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"Scope and Plan of the School of Industrial Science," drafts, 1864

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Wright's Scries & Plans of the School
of Industrial Science published in
1864

School of Industrial Science of the Institute of Technology

It is the design of this school to afford to the public at large opportunities of instruction in the leading principles of Science, especially as applied to the Arts, and at the same time to provide ~~for~~ ^{for} systematic studies ~~of many~~ of the applied sciences, the means of a continuous & thorough training in the studies & practice appertaining to these subjects.

In pursuing this object it is intended to give to the teachings such scope & method that while imparting a due measure of knowledge, ~~may~~ ^{and} ~~may~~ ^{and} cultivating the habits of observation & exact thought so conducive to the progress of invention, ^{the development of} and of an enlightened industry, ~~they~~ ^{they} may ~~contribute~~ ^{help} to extend more widely the elevating influences of a generous scientific culture.

Plan of Instruction

In arranging the plan of instruction for the School of Ind: Science & Art-provision is made for two classes of persons - those who may be expected to resort to the lecture rooms & School of Design for such useful knowledge as they can acquire without methodical study & in hours not occupied by business, and those who enter the ~~school~~ ^{institution} with the view of a progressive systematic training in one or more branches of applied science and who have the preliminary knowledge as well as time for the prosecution of its studies.

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To be admitted to this Division of the School
 Students must have attained a certain degree of preparation,
 and after ^{having} entered they will be subject to close supervision &
 direction in their studies as well as to examinations & other
 tests of acquirement in the progress & at the close of their terms.

In the former of these divisions that of the general & more popular instruction the teaching will be conducted by means of lectures alone, except in the drawing school, & ~~in~~ ⁱⁿ ~~mathematical~~ ^{mathematical} subjects requiring more familiar modes of exposition. As it is the purpose ⁱⁿ these courses to open the halls of the Institute as widely as possible to those who desire to profit by such teachings, students will be admitted to the courses in general & applied science & in drawing without a preliminary examination & subject only to ^{such} conditions & restraints ^{as} are usual in public lectures, & as may be found best fitted to make them useful & interesting.

In the second division of the School that of systematic & professional instruction the student while attending lectures on the several branches will have the benefit of laboratory exercises in Manipulation & Analysis, of continued practice in the kind of drawing appropriate to his studies, & of such ^{prolonged & thorough} training in the class-room & by examinations as will give him a ready command over the (~~Scientific~~ ^{practical}) problems with which as a Mechanician, Engineer, Builder practical Chemist - or ~~at~~ Scientific Musei he ^{may} be called upon to deal. see opposite

In order to enter this division ~~the~~ ^{the} student must give proof of suitable preparation. ~~Applicants~~ ^{They} will be subject to ~~examinations~~ ^{examinations} in their studies, as well as ~~to~~ ^{to} ~~examinations~~ ^{examinations} & other tests of acquirement in the progress and at the close of their terms.

(4)

First Department.

General or Popular Course.

This Department of the School is designed to embrace Lectures in Elementary Mathematics, in Physics & Mechanics, in Chemistry, in Geology & Mining & in Botany & Zoology, ~~particular~~ especial regard being had in each case to the facts & scientific principles, which ~~are~~ ^{are} of leading importance in connection with ~~the~~ ^{the} useful Arts.

These Lectures will be grouped into more or less extended courses as may be found expedient, & besides the ordinary methodical teachings will have for their object - to make known new facts & discoveries in the applied sciences as they are brought to light, as well with a view of stimulating invention as of giving to the public the early benefit of important additions to our industrial knowledge.

In the same department will be included a fully equipped drawing school where in addition to systematic exercises in elementary & free-hand drawing, instruction will be given in artistic design and modelling as applied to manufactures Architecture & Decoration. ~~It~~ It is expected that the Drawing School of the Lowell Institute will

be brought into connection with the School of Industrial Science in such manner as to afford to the Students of the latter the free benefit of its instructions, & that the subjects above referred to will mostly if not wholly come within its new & enlarged plan of operations.

These courses of instruction will be given chiefly in the evenings & will be open to both sexes. From the variety of practical subjects embraced in them, & the convenience of the hour, it is expected that they will be ^{largely} attended by persons engaged in Mechanical Manufacturing & Mercantile pursuits, by teachers & Students in the Normal & other schools, as well as by others whose taste & leisure lead them to avail ^{themselves of} ~~themselves of~~ such instruction.

Programme of the General Course.

I. Lectures & other teachings in Mathematics. VI

These will embrace parts of Arithmetic & Algebra,
and of elementary Geometry Trigonometry & Descriptive
Geometry, with Application to business Computations,
Weights & Measures, Mensuration, Gauging,
Leveling, Projection of Maps Construction of Curves
Problems in Surveying, ~~Navigation~~, ^{and} ~~Navigation~~
~~Navigation~~ Nautical Astronomy - Principles
of Perspective -

II. Lectures on Physics & Mechanics.

This course will embrace the general doctrines of Motion & Force, the Mechanics of Solids & Fluids, the Laws of Sound, Light, Heat, Magnetism & Electricity, Among the topics to be

1. Gravity, the Pendulum & its Applications, Elements of Machinery - Laws of friction, Estimation of Work by Dynamometers... &c
2. Molecular Mechanics. Elasticity. Strength of Materials. Principles of packing - Capillarity. Cohesive force.
3. Pressure & Flow of Water air & gases. Canals, Drainage Mill wheels - Turbines. Pumps. Resistance of fluids - Form of Ships, Paddles & Screws.
4. Waves & their propagation, ^{Source,} Music. Musical Inst. Voice, Hearing, Halls for Speakers &c
5. Light - its Reflexion, Refraction, Dispersion, Interference &c. The Eye. Vision. Optical Instruments. Measure of Light ^{from Sun, Candles, &c} by Photometers. The Spectroscope & its uses.
6. Heat. Expansion, Thermometers, Conduction Radiation & Convection, Absorption; Melting, Evaporation, Steam, Steam Engine, Hot-air Engine, Warming & Ventilation, Manufacture of Ice.
7. Magnetic polarity & induction, Variation, Dip & Intensity, Magnetic Charts, Compass on Ship board and its correction.
8. Static Electricity, Machines, Conductors & Connectors, Accumulators ^{etc}, Lightning Rods &c. Dynamic Electricity - Voltaic Piles & their Chemical, Magnetic & other effects. Induced Currents. Induction Coils. Applications in Blasting, Telegraphy, Electric Light &c.

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III. Lectures on Chemistry & its Applications

The subjects of this course will be embraced under the following heads.

1. Preliminary demonstrations relating to a few leading elements & compounds.
2. General doctrine of Chemical forces, & laws of combination.
3. More detailed account of the Elements & Compounds, especially those which are important in the Arts & domestic economy... including Water Air the Mineral Acids, Alkalies; Iron Copper Lead Tin Zinc Silver Gold &c.
4. Chemical History of the principal organic groups, Sugars, Starches, Alcohol Oils & fatty bodies &c.
5. Chief constituents of the vegetable & animal Organisms with the Chemistry of food Respiration and Nutrition.

Especial attention will be given to the Applications of Chemistry in the Manufacture of Metals, Pottery, Glass, Soap, Illuminating Gas, Cements, Alum, Sugar &c. & in ~~the~~ Dyeing, Bleaching & other Chem. Arts. The actual process where practicable will be experimentally shown & the Uses of Materials & products contained in the Museum will be used in aid of the Lectures. As occasion arises examples will be given of such simple methods of Volumetric Analysis or other Chemical testing as can be usefully shown in the Lecture room.

IV Lectures on Geology & Mining

This course will embrace..

1. A general outline of Mineralogy ^{including chiefly} ~~paracrystalline~~ descriptions of the principal constituents of rocks, & the more important ores & other useful Mineral products, with the Mechanical, Chemical & Optical Modes of discrimination.
2. Division of Rocks into Aqueous, Igneous & Metamorphic. ^{Description} ~~Formation~~ of Stratified; Marine, Delta & Fresh Water Deposits, & of Igneous & Metamorphic Masses with an account of the Actions concerned in their production.
3. Illustrations of Geological structure as seen in ^{flexure,} Axes, & faults, Basins, Valleys of elevation & erosion, ^{foliation & cleavage of rocks &} escarpments, ~~xx~~ with the Method of determining the dip of strata & veins & of Making & Mapping Geological & Mining surveys
4. Organic remains & their use in determining the sequence of the strata.
5. Table of Geological formations from the most ancient to the present time with a special account of the North American States, showing by the use of Maps & Sections the geographic position & range of each great formation, marking out the Coal fields, belts of Iron-bearing Gold-bearing & other Metalliferous rocks, & the ranges of the Granites, Slates sandstones, Limestones, Marbles & other Mineral aggregates which may be brought to the profitable use for building or other purposes.

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V. Lectures on Botany & Zoology

This course will include...

- 1... An outline of Botany embracing the growth
Morphology structure & Classification of Plants
- 2... Economic Botany... Plants useful for food
& in the Arts...
- 3... An outline of Zoology including the Structure
Physiology & Classification of Animals...
- 4... Economic Zoology... Animals useful for food
& in the Arts...

In addition to these general lectures, it is proposed to make special provision for the more extended and technical treatment of branches of industrial knowledge not included or but briefly touched on in the general courses. Such would be the Manufacture of Cotton & other textile fabrics, the Arts of Printing & Engraving - the Manufacture of Paper &c. including for each the History & Statistics of the subject and an account of the Machinery & processes employed illustrated by specimens & Models from the Industrial Museum.

All the subjects of this class may perhaps at an early day be embraced as a distinct & extended course under the head of special Technology in which many of the materials & products gathered in the Museum would find their most useful medium of interpretation.

As the ~~lectures~~^{courses of lectures} above described are intended to meet the general demand for instruction in the applications of Science to the Arts as well as to aid students in preparing for a more thorough course of study they will treat only of such subjects as can be readily understood without previous training. At the same time it will be their aim to teach the several branches to which they relate with such logical accuracy & completeness as to give the student a clear understanding of principles & of their application in household & civic economy & the industrial Arts.

Second Department

Special and Professional Instruction.

This Department of the School is intended first for such Students as by a full course of scientific studies & practical exercises seek to qualify themselves for the professions of the Mechanical Engineer, the Civil Engineer, the Builder & Architect, the Practical Chemist and the Engineer of Mines -

and second for those who aim simply to secure a training in some one or more of the Branches of Applied Science, such as ~~Experimental~~ Descriptive Geometry applied to Construction, Perspective &c; Chemical Analysis; Machinery & Motive powers; General Physics & Chemistry with Manufactures; Geology & Mining; Navigation & Nautical Astronomy. Metallurgy of Iron & Copper &c.

The entire series of Instructions arranged in reference ^{to} ~~to~~ the above named professional divisions offers to the student five Courses having more or less in common viz:

1. A Course on Mechanical Construction & Engineering
2. " " " Civil & Topographical Engineering
3. " " " Building & Architecture
4. " " " Practical & Technical Chemistry
5. " " " Practical Geology & Mining.

No. 3. Files.

The studies of each of these divisions are arranged so as to extend over a period of four years including the first or Introductory Course; but as students will be permitted to enter any of the advanced classes for which they are prepared, they will in many cases be able to complete the prescribed Course in three or even less than three years.

For the first two years the studies & exercises will be the same for all the regular students, each thus obtaining such an acquaintance with the whole field of medical science as is needed for a complete & satisfactory study of either of its professional departments.

The Courses of Instruction in the first & second years will be as follows...

first Year
or
Introductory Course.

1. Algebra, Geometry, Plane Trigonometry.
Geometrical Constructions with compass Protractor & scales. Simple Applications to Mensuration. Heights & Distances, Plain Surveying, Levelling &c.
2. Introductory Physics
3. Introductory Chemistry
4. Descriptive Astronomy
5. Drawing... Linear & Geometric
6. See op.

6. Practice in the use of the Chem. Scale, Thermometer, &c. Lectures &c. - where practical done; the course, but chiefly in the laboratory &c.

The student of each of these branches can easily
 see in the course over a course of four years a building
 up of the most interesting branches, but as a student
 will be permitted to enter any of the above
 classes for which they are prepared, they will in many
 cases be able to complete the prescribed course in
 three or four of the three years.

The first two years the student examines
 into the various branches for all the regular students
 and then returning, but as an experiment will take the
 first part of the first year as is needed for a complete
 satisfactory study of either of the professions respectively.
 The course of instruction in the first two years
 will be as follows:

First Year

Instructional Course

1. Logic, Rhetoric, Greek, Latin, English, History, Geography, Natural Philosophy, Mathematics, and the Principles of Agriculture.
2. Natural Philosophy, Chemistry, and the Principles of Agriculture.
3. Mathematics, Natural Philosophy, and the Principles of Agriculture.
4. Mathematics, Natural Philosophy, and the Principles of Agriculture.
5. Mathematics, Natural Philosophy, and the Principles of Agriculture.

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Second Year.

1. Advanced Algebra, Spherical Geometry & Trigonometry.
Navigation Nautic Astronomy
2. Analytical Geometry. First ideas of the Differ. Calc.
Descriptive Geometry
3. Mechanics treated chiefly without the Calculus.
Machinery & Motors. Steam Engines.
4. Physics with Manipulations to exercise the Student
in the use of Apparatus.
5. Chemistry with Manipulations & simple qualitative
testing.
6. Descriptive & General Geology.
7. Elements of ~~Zoology~~ Botany and Zoology.
8. Descriptive Geometry.
9. Drawing, Geometric, Perspective, Light & Shades

Third year.

The studies of this year will be the same for those pursuing the courses of Mechanic & of Civil Engineering & of Building & Architecture.

1. Differentiated & Integral Calculus. Rational Mechanics.
2. ~~Strength~~ Strength & Strain of Materials, used in Construction. Principles of Joinery - Framework Roof. Wooden Bridges &c.
3. ~~Investigation~~ Investigation of Machinery & Motors. Elements of Machinery, Combustion, Effective work. Dynamometers.
4. Chemistry & Geology of the Materials used in Construction.
5. Combustion & Fuel. Warming, & Ventilation & Lighting.
6. Descriptive Geometry - Applied.
7. Drawing of Machinery, Roof Bridges, Buildings, Maps &c.

Third year

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b. Physical & Structural Geology. Constitutes
an important part of the study of the earth, crust,
phenomena & laws of structure, modes of observation.

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Third Year
Course of Practical & Industrial Chemistry

1. Chemical Analysis .. Qualitative & quantitative, chiefly of inorganic substances, including the volumetric methods. Lectures to accompany the laboratory exercises.
2. Descriptive & Determinative Mineralogy .. Use of Blowpipe &c.
3. Lectures on Combustion & Fuel, ^{and on} Warming & Ventilation & Lighting.
4. Lectures & illustrations on Industrial Chemistry, Manufactures of Glass, Pottery, Tiles, Soda Ash, Acids, Salts & Soaps &c.
5. Drawing of Apparatus .. Plans & projects for chemical works, laboratory arrangements &c.

6 See opposite

Third Year
Course of Practical Geology & Mining -

1. Chemical Analysis Qualitative & quantitative as under the preceding head
2. Descriptive & Determinative Mineralogy - use of the Blowpipe.
3. Lectures on Combustion & Fuel, and on Warming, Ventilation & Lighting
4. Historical Geology. Successive Systems, Groups & formations, with their leading fossils.
Detailed Study of the Geology of N. America -
5. Drawing. Topographic & Geological Sections & Maps. Conventional Representation of Rocks, Colouring of Maps & Sections.

~~4. Historical Geology. Consideration of Successive Systems, Groups & formations with characteristic fossils. -
 Study of the Geology of N. America -
 Special Geology of Coal, Iron, Gold, Salt - &c~~

This year

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Fourth Year.

In this year the ~~courses~~ professorial Courses becoming more completely separate from one another will be as follows.

Course of Mechanical Engineering

1. Investigation of Machinery & Motors Continued.
2. Special Study of Steam & Steam Engines, Stationary, Locomotive & Marine, of Air and Gas Engines, of Hydraulic Machines & Motors, of Pumps, &c.
3. Construction & Arrangement of Machinery in Grain Mills for Grinding - for Textile Manufactures, &c.
4. Drawing of Machines - Working Plans & Projects of Machinery - Mills, &c.

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Fourth Year.

Course of Civil & Topographical Engineering

1. ~~Practical~~ Spherical Astronomy, with the use of Instruments.
2. Location & Construction of Roads - Railways & Canals.
3. Supply & Distribution of Water - Water works - Dams - Mills &c. Distribution of Gas. Drainage. Irrigation.
4. Extended treatment of Structures, Mason work, Arches, Bridges of Stone. Structures in Iron, including Girders, Columns, Roofs. Suspension Bridges. Tubular Bridges &c.
5. Drawing, Working drawings of constructions, & plans & profiles of R. Roads & other surveys, Profile & topographic drawings.

For such students as desire to devote themselves especially to Topographical Engineering the above course will be modified so as to include

1. ^{more} extended study of ~~Practical~~ Astronomy, and practice with Astronomic Instruments.
- No. 4. 2. Lectures & exercises in the higher Geodesy including the survey of Harbours, Coasts & extensive regions.

At the same time a larger space will be allotted to Topographical & Map Drawing, and the subjects mentioned under heads 3 & 4 of the preceding programme will be in ~~great~~ part omitted.

For such students
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Fourth Year.
Course of Building & Architecture.

1. Extended treatment of Structures. Mason work, arches & bridges of Stone. Iron girders, columns, roofs &c.
2. Details on Warming, Ventilation, & Lighting, & on the Distribution of Water & Gas.
3. Lectures on Building or practical Architecture - embracing a review of the materials used, their preparation & mechanical treatment, in the erection of Dwellings, ^{school-houses} Halls, Courts of Justice, Prisons, Manufactories &c. illustrated by Models & Drawings.
4. Lectures on ~~the~~ Architecture as a Fine art with a history and illustrations of the great Architectural works of ~~the~~ Classic Period & Modern times.
5. Architectural Drawing - Projects for Dwellings, school-houses - Churches &c.

Fourth Year.

Course of Practical ^{Industrial} ~~General~~ Chemistry.

1. Chemical Analysis continued, embracing ~~the analysis~~ ^{the analysis} and Commercial testing of
 - (a) Ores, Limestones, Clays & other Crude Mineral Materials
 - (b) Cast Iron, Copper, Lead & ~~and~~ Metallic alloys
 - (c) Soda Ash, Bleaching Selt, Common Salt, Salt Petre, Gunpowder, Indigo, Pigments, Drugs, Guano & other Minerals &c.
 - (d) Drinking & Mineral Waters, Brines & Sea-Water.
 - (e) Coal-gas & other Gaseous Mixtures.
2. Exercises in Organic Analysis.
3. Lectures on Industrial Chemistry including the Arts of Dyeing, Colour-printing, Tanning, Brewing, Distillation, & the Manufacture of Illuminating Gas
4. ^{Drawing.} Plans & projects for Dyeing & Print work, for Gas-works &c.

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Fourth Year
Course of Practical Geology & Mining

1. Special Geology ~~of~~ ^{Copper} Coal Iron ~~Lead~~ ^{Silver} Salt, Plaster &c., with particular reference to N. American localities, and an account of important Mines Quarries &c.
2. Lectures on Mining, treating of
 - (a) Prospecting, breaking ground, boring, blasting, tubing, sinking shafts, driving tunnels, ventilating & lighting;
 - (b) Of the different methods of working Mines
 - (c) of Mining Machinery & Motors, Engines, Pumps, Waggon Drums, Ropes, &c. for lowering & raising the Material -
 - (d) Of the Dressing & Concentration of Minerals - Crushers, ^{amalgamators &c.} stamps, Washers, & Machinery used in the Pa. Anthracite region.
 - (e) Of Quarrying & Open Mining
 - (f) Details of Mining in this Country - with History & Statistics of Mining generally.
3. Drawing, ~~Plans~~ ^{Plans} & Sections of Mines, ^{& Quarries} & other Open Workings, Mining Machinery, & implements - Geological & Topographical Maps of Mining Districts, &c.

Fourth Year

Course in Practical Metallurgy

For students who have passed through the third year's course on Practical Geology & Mining & who wish to prepare specially for the ^{superintendent} direction of Furnace-operations & other branches of Metallurgy the following course will be provided for the fourth year...

1. Special Geology of Coal Iron &c. as in the course of Practical Geology & Mining &c.
2. Chemical Analyses, including Charby Assays in the Wet & Dry ways of Ores, Fluxes, Slags, and of the Metals & their alloys.
3. Lectures on Metallurgy - Review of the more important ^{& their uses} Metals, Descriptions of Fuel & Methods of determining heating power & intensity. Metallurgical Implements, Structures & processes. Crucibles - Furnaces - Blowing Machines. Details of the Melting & Manufacture of Iron Copper Lead Zinc Silver Aluminium &c.
4. Drawing. Plans & projects for Coking Ovens, Furnaces, Refineries Wet & Cold blast arrangements &c.

Military Tactics

The regular students of the School will be taught the use of Small Arms & the Implements of Tactics & for this purpose will be organized into one or more Companies to meet on stated days for Military Instruction & Exercise.

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Admission of Students

The leading principles governing the admission of students into this Department will be —

First.. That all persons who are qualified to enter upon any one of the full Courses or of the special studies of the School shall have the best opportunity of doing so; and Second.. That no students shall be admitted to any of the courses of instruction who have not the preliminary knowledge needed for a satisfactory pursuit of the studies proposed.

Students to be admitted to the Introductory or first year's course must have attained the age of 15 years & must give satisfactory evidence by examination or otherwise of such training in elementary mathematics & in the other subjects taught in the Common Schools as shall hereafter be prescribed.

In order to enter the second year's course the student must be at least 16 years of age & must give evidence by examination or otherwise of such knowledge of the first year's studies as would enable a student of the first year to pass into the second, and a like rule will apply to the case of students seeking admission into the classes of the succeeding years.

To make the opportunities of instruction as widely accessible as possible students will be allowed to enter special divisions of either of the courses, after the first year

as for example the classes of Mathematics of
 mechanic construction of chemical analysis, of
 Physics^{or} of mining & metallurgy, on giving satisfactory
 evidence that they are duly prepared to pursue such
 special studies with advantage.

Diplomas & Certificates.

As the Diploma or Certificate is intended not only to be
 a reward to the student for his diligence & attainments, but
 an assurance to the public of his knowledge & skills in the
 particular department of applied science to which it relates
 it will be conferred on such students only as by their
 examinations & other exercises give proof that they possess
 the prescribed qualifications -; but all students who
 fulfil this requirement shall be entitled to the testimonials
 of the Institute without regard to the greater or
 less number of courses they may have attended
 in the Institution.

The degrees or Diplomas corresponding to the leading
 divisions of the School will be as follows.

- 1. The Degree of Mechanical Engineer
- 2. " " " Civil & Top. Engineers
- 3. " " " Builder & Architect
- 5. " " " Industrial Chemist
- 6. " " " Geologist & Mining Engineer.

To suit the case of Students having received a general scientific education, such as may qualify them to become teachers, rather than a professional training in applied science, a schedule of studies will be appointed embracing the whole of the two first years and certain parts of the third & fourth years ~~course~~ ^{studies} so as to form a general scientific course, for proficiency in which the Degree of Bachelor of Science will be conferred.

To be entitled to either of these degrees the student must pass a satisfactory examination on the whole course of studies and exercises prescribed in his department including the elementary & general, no less than the advanced & special subjects. He must moreover prepare a dissertation on some subject in pure or applied science, or submit an original report on some Machine or work of Engineering or some Mine or ~~Survey~~ Mineral Survey, or Chemical investigation which shall be approved by the faculty of instructors or other examining board. He will be required also to have sufficient familiarity with

The French & German Languages to be able to read without difficulty works in these languages relating to the Sciences & Arts.

Besides the Degrees or Diplomas covering the complete Courses of Study above referred to - there will be given Certificates of Attainment in Special Subjects to such Students, as on examination are found to have ~~acquired~~ ^{attained} the required Proficiency in them. Among the Special Subjects for which such Certificates may be awarded are ..

L.p.

- Machine Drawing
- Topograph & Architectural Drawing
- Architectural "
- Descriptive Geometry & its Applications
- Mathematics Applied to Mechanics & Machinery
- " " " " " Construction
- Physics & Chemistry with Manipulations
- Chemical Analysis -

Method and Apparatus of Instruction

The instructions in this Department of the School will be given through the Medium of

1. Lectures and familiar expositions
2. Oral & written examinations
3. Exercises in the solution of problems
4. Practice in Physical & Chemical Manipulations
5. Laboratory Training in chemical Analyses, ~~and~~ Metallurgy & Industrial Chemistry.
6. Drawing & the Construction of special ^{plans &} projects of Machinery and Works of Engineering & Architecture.
7. Practical exercises in Surveying Levelling Geodesy & Nautical Astronomy.
8. Excursions for the Inspection & Study of Machinery Motors processes of Manufacture, buildings, Works of Engineering, Geological sections, quarries & Mines.

Lectures and Expositions.

As a general rule each lecture will be preceded by interrogations on the subject of the preceding lecture in which the teacher will have the opportunity of re-enforcing the instruction already given as well as of testing the progress of individual pupils.

After the first year the student will be expected to take notes of the lectures as they proceed and afterwards to write them out with the accompanying Diagrams or Drawings, so as to form, in connexion with each of his Clases, a text for immediate study as well as future reference.

In addition to these notes of Lectures he will be expected to study or to consult such books or works of reference whenever such are appointed to be used, but in view of the value of the Method of Lectures combined with expositions as a means of commanding the attention & stimulating the zeal of students this method will be used whenever practicable; and in no case will mere text-book recitation be exclusively relied upon. ~~When necessary expositions will be given from lectures, and~~ ~~generally in the presence of the whole class~~ ~~until~~ ~~habituated~~ ~~to~~ ~~the~~ ~~work~~ ~~the~~ ~~student~~ ~~will~~ ~~have~~ ~~the~~ ~~assistance~~ ~~of~~ ~~his~~ ~~teachers~~ ~~in~~ ~~correcting~~ ~~his~~ ~~notes~~ ~~and~~ ~~in~~ ~~reducing~~ ~~them~~ ~~to~~ ~~methodical~~ ~~order.~~

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Where possible expositions rather than formal lectures are given as in many of the Mathematical classes & in the instruction connected with laboratory work the student will be interrogated by his teacher from time to time in the progress of the lesson as well as at its commencement.

Oral & written examinations

As frequent & thorough examinations form the best means of inciting students to diligence as well as of testing their progress in their studies and of discovering those individual needs & difficulties which the teacher should endeavour to obviate they will constitute a leading feature in every department of instruction in which they can be employed.

Besides the daily oral examinations already referred to as preceding & accompanying the lectures oral examinations will be held once every month, separate from the lectures on a day set apart for the purpose at which each entire class or, where ^{too} numerous, parts of the ^{class} taken in succession will be examined & drilled in the subjects lectured upon or appointed for study during the month just elapsed.

At or near the close of each term viz in the months of Feb and June written examinations

will be held, that of Feb^r embracing the subjects studied during the first term, that of June covering the studies of both terms. On these occasions the courses of instruction will cease and a sufficient period will be set apart to allow the classes time for a brief review of studies & full opportunity for the several examinations.

Mode of conducting the written examinations.

These ~~examinations~~ ^{examinations} will be conducted as follows - The students taken by classes and provided with writing & where necessary with drawing implements & material will be placed at separate tables in the examination room bringing with them neither books nor memoranda of any kind to aid them in their work. The instructor having charge of the class will then furnish to each student a copy in printed or written form of the series of questions which he has prepared to test their proficiency and these the students will be required to answer in writing as well as they can without conferring with one another or consulting any other sources of information.

It shall be the duty of the teachers to keep a ~~written~~ ^{written} numerical record according to forms hereafter to be prescribed of the performance of each student in the several classes both at the monthly oral examinations and at the written examinations just described. These records will form the

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basis for determining the standing of the students at the end of each course & for deciding upon those to whom certificates of proficiency are to be awarded.

Graduating examinations

The Examinations for Degrees will be held at the close of the June term & will be partly oral & partly in writing. In the former each Candidate will be interrogated apart from the rest; in the latter the mode of proceeding will be the same as at the term examinations above described. In both the questions will range over the entire series of studies on which the student is required to be prepared.

As part of these examinations the Candidates will be called upon to exhibit the Drawings & Projects prepared by them for the occasion & to perform such laboratory manipulations & exercises as the examining Committee may specify.

At the same time the Theses of the Candidates will be brought forward for examination and where expedient their Authors be called upon to explain or defend them.

As a further test of their qualifications as Teachers of Science the Candidates for the degree of Bachelor of Science, in addition to their examinations will be required to give a brief oral lecture on such topic embraced in their studies as may at the time be designated for this purpose.

Exercises in Problems.

As a means of enforcing the instruction of the lecture room and of enabling the student to acquire facility in the application of principles to special cases problems will from time to time be given out to the Mathematics & other classes where applicable, of which written solutions will be required, and these solutions the students presenting them may be called upon to explain.

Practice in Physical & Chemical Manipulations.

It will be object of these exercises to make the student practically familiar with the adjustments and use of the apparatus and agents employed in the more important experiments & processes in Natural Philosophy & Chemistry. With this view the students under the direction of their teacher will be called, by small classes at a time, to execute with their own hands various experiments in Mechanics, Pneumatics, Sound, ^{Optics} Electricity & other branches of experimental Physics, and to exhibit Chemical reactions to put up Chemical apparatus, to prepare gases & other bodies & demonstrate their properties by suitable experiments, accompanying these Manipulations when required with an explanation of the apparatus used or of the process or experiment performed.

These exercises will be held either in the lecture rooms or in the appropriate laboratories hereafter to be described as at the time may be found most expedient.

Laboratories and Laboratory training.

The Laboratory arrangements of the school are designed when complete to embrace the following departments:—

1. A Laboratory of Physics & Mechanics
2. A Laboratory of General Cheml. Analysis and Manipulation
3. A Laboratory for Metallurgy & Mining
4. A Laboratory for Industrial Chemistry.

While intended primarily for the instruction of the students these Laboratories will be used for the prosecution of experiments and investigations on subjects referred to them by the Committee of the Museum or the several Committees of Arts, including the examination & testing of new Machines & processes and the conducting of original researches in the different departments of applied science; and in these critical studies & experiments the advanced students may when expedient be permitted to assist.

Laboratory of Physics & Mechanics.

In this Laboratory it is proposed to provide implements and apparatus with which the student may be exercised in a variety of Mechanical & Physical processes and experiments. Thus he may learn practically the methods of estimating Motors and Machines by the Dynamometer, of experimenting on the flow of Water ~~and~~ and Air or other gases and of testing the strength of the materials used in construction; he may become familiar with

the adjustments and applications of the Microscope, he practised in observing with the Barometer Thermometer & Hygrometer, and in a room fitted up for Photometry may learn the mode of measuring the light produced by gas & other sources of illumination & the value of different kinds of burners, lamps & their appendages.

Laboratory for general Chemical Analysis

In this Laboratory provision will be made for a complete and comprehensive course of instruction in qualitative and quantitative analysis embracing organic as well as inorganic substances, and blending lectures with the systematic practice of the Laboratory.

Students proposing to take this course will be expected either to have passed through the first two years teaching of the Institute or to be possessed of such knowledge of general chemistry & physics as these preliminary studies are intended to impart.

Besides this general & extended course it is proposed to have certain partial courses in which students having a special object in view may obtain instruction of a specific kind without going through the entire range of laboratory training. Such would be...

1. Exercises in Organic Analyses.
2. Exercises in Blowpipe Testing.
3. Household & Commercial Analyses. including the Testing of Water, Detection of Adulterants in Food &c. Alchemy. Alchemy.
4. Chemical Toxicology. Detection of Arsenic & other Poisons.

Laboratory for Mining & Metallurgy.

Connected with the general laboratory but forming a distinct department will be a laboratory of Mining & Metallurgy - designed for special instruction in whatever relates to practical Mineralogy, the Chemical Valuation of Ores and the operations of melting & other processes for the separation & refining of Metals.

In this department students already trained to some extent in Analytical processes will be exercised in the examination ^{& discrimination} of rocks & minerals by mechanical & chemical tests, including a course of practice with the Blowpipe, and will be taught the several methods of assaying the Ores & alloys of Copper Iron Lead Silver & other useful Metals as well by the Dry as the Wet ~~Wet~~ Method, of analysing the fluxes used in the melting furnace & the Slags resulting from the blast, and of determining the Combustible Value of the Mineral or other fuel

with which furnaces are supplied.

In aid of these instructions the student will have the opportunity of studying the Models of Mines and of Mining & Metallurgical Implements & Machinery & the Collections of Rocks fossils Minerals and Ores with their Manufactured products provided & arranged specially ~~for~~ to facilitate his studies in this department.

Laboratory for Industrial Chemistry

It is further proposed to connect with the general Laboratory a department of Industrial Chemistry where students may have an opportunity of becoming practically familiar with the Materials, implements & processes of the more important Chemical Arts & Manufactures.

In this department will be provided a collection of Dye stuffs Mordants discharges & other substances used in the Operations of Dyeing Color printing & Bleaching, together with such Apparatus as may be necessary on a small scale to exemplify these several processes as in actual use.

Here the student will have access to Suites of specimens embracing the Crude Materials and products of the Glass ^{and Brick & Tile} & Pottery Manufactures, the different Soaps, Soda Ash Bleaching salts, Acids, Saline products, Lattes, Pigments, Inks, Cements, Tanning substances and other Materials

and products of the Chemical Arts, and will be provided with facilities for studying practically the reactions & processes connected with their use & manufacture.

Provision will also be made in this Laboratory for the practical illustration of the Chemical Modes of Engraving & Lithography & for exhibiting the various Methods & processes of Electro-Metallurgy as applied to silvering gilding & the Deposition of Copper & Brass,

Exercises in Drawing & Design -

The facilities in this Department which are to be anticipated from the Small Drawing School when placed in connection with the School of Adv. Science will

it is expected provide amply for instruction in free & general drawing and thus furnish students with a valuable introduction & continued help in the special branches of drawing & design appropriate to the Applied Sciences with which they are occupied.

Instruction & practice in this department will form an essential feature in the daily duties of the School throughout most of the regular course of four years.

During this time the students will be carried through a course of exercises in Geometrical Drawing including the Applications of Descriptive Geometry to to Perspective & Lights & Shadows, to Carpentry & Stone-Cutting & other practical work. They will be taught Custom drawing, the projection of Maps, the construction of Topographical & geological sections, & the Drawing of Engineering constructions, & ~~also~~ of subjects belonging to household ^{public} & ornamental Architecture. They will also be called on to execute drawings & plans, of Models representing the essential & the internal organs of Machines, as - Articulations, Cranks, Combs, Connecting rods, fly wheels, Pistons, Valves, Steam Cylinders, ~~or~~ wheel work ^{of various kinds} of various kinds, and to prepare ~~plans~~ projects & working plans of Roofs, Arches, Bridges, Mills, Furnaces, Chemical works, Heating & ventilating arrangements, ~~Buildings~~ ^{Buildings} Halls & public buildings, and other constructions ^{such as} ~~works~~ the Mechanician, builder, engineer or manufacturer may be called upon to devise or provide.

In these special exercises the students will be aided by the use of ~~mechanical~~ ^{anatomical} ~~models~~ ^{models} of large drawings of the various elements of Machines, ^{by contact} ~~and~~ Machines in their complete state, & of roofs, Bridges, Domes, ^{Buildings} & other works of Mechanic & Constructive engineering & Architecture.

~~Exercises~~
Visits and Excursions for Observation & Practice.

In Aid of their practical studies of the School and as a means of initiating students into the actual details of the profession for which they are preparing, they will be required from time to time in the progress of the Course, assisted by one or more of their teachers to make visits of inspection to Machine-shops, Engine, Mills, Furnaces & Chemical works and to important buildings & engineering constructions which are within convenient reach.

With a like view and under the same direction they will be expected to spend a part of the vacations of the second & third years in excursions for observation & practice, extending sometimes to distant points & so arranged as to afford to each Class the experience & training most likely to be useful to them in their future pursuits.

Thus in consonance with their specific studies they will severally employ themselves in the details of Road Railway & Topographical Surveys Barometric Measurement Triangulation & Geodetic Astronomy, in taking notes & making drawings of such proper Machinery works of engineering and buildings as are ~~not~~ instructive or remarkable, - and in making themselves practically familiar with the working details of ^{Laboratory} Furnaces, Forges, Rolling Mills & Foundries, with the methods of geological exploration, the tracing of veins & beds, the sinking of shafts, the conduct of Open & underground Operations, the mechanical arrangements for raising the product to the surface & preparing it for use, and in general with all the processes & constructions appertaining to the practice of industrial Metallurgy and the working of ~~Quarries & Mines.~~ Quarries & Mines.

Map of the
Slope & Plan
of the
Scholar's and Science

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"Scope and Plan of the School of Industrial Science," drafts, 1864

W. B. ROGERS

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D.B.P. - Papers

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*Scope and Plan
of the*

SCHOOL OF INDUSTRIAL SCIENCE

OF THE

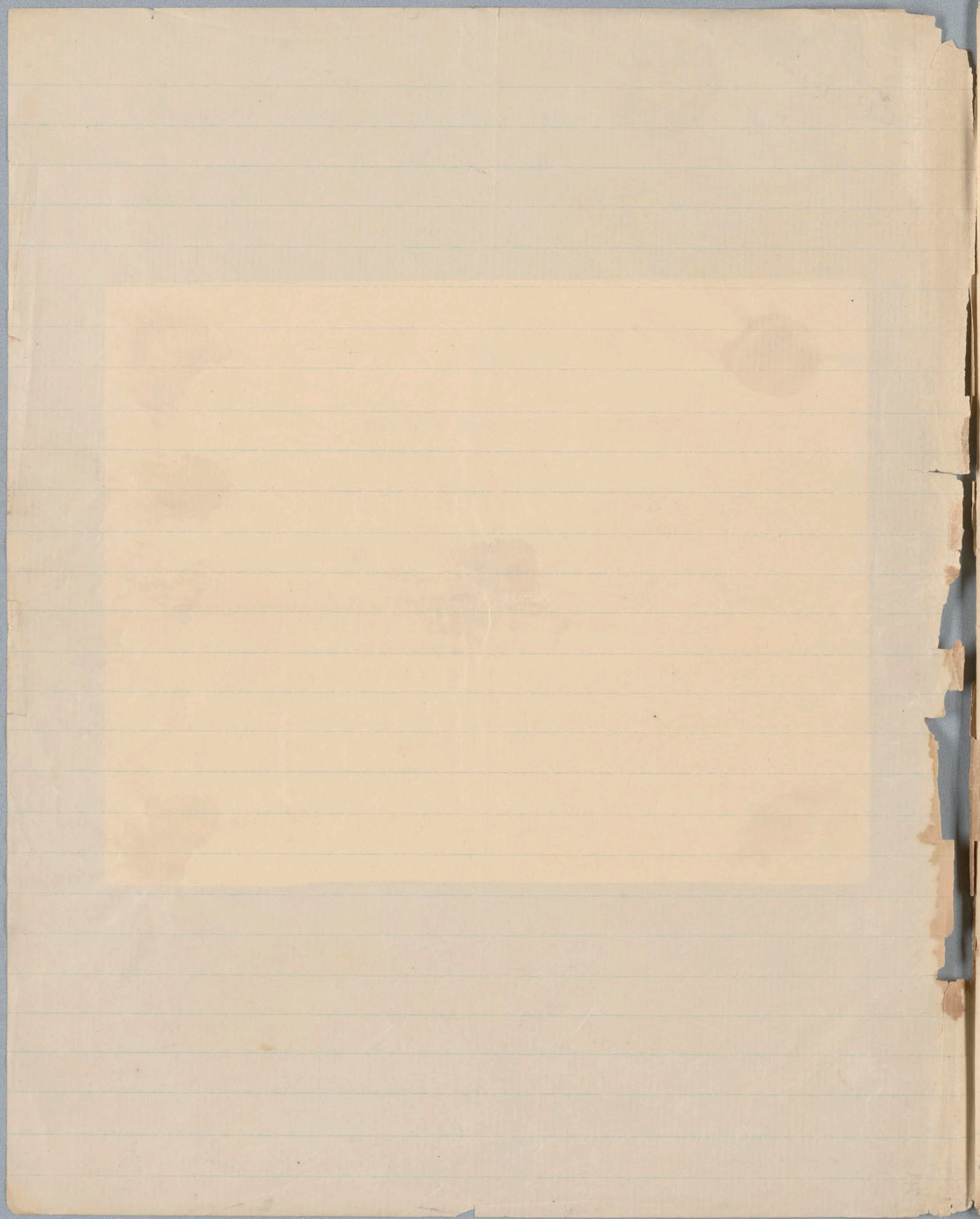
INSTITUTE OF TECHNOLOGY.

Massachusetts

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It is the design of this School to afford to the public at large opportunities of instruction in the leading principles of science, as applied to the arts; and, at the same time, to provide for systematic students of the applied sciences the means of a continuous and thorough training in the studies and practice appertaining to these subjects.

In pursuing this object, it is intended to give to the teachings such scope and method, that while imparting a due measure of knowledge, and cultivating the habits of observation and exact thought,—so conducive to the progress of invention, and the development of an enlightened industry,—they may help to extend more widely the elevating influences of a generous scientific culture.



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PLAN OF INSTRUCTION.

In arranging the plan of instruction for the School of Industrial Science and Art, provision is made for two classes of persons, — those who may be expected to resort to the lecture-rooms and school of design for such useful knowledge as they can acquire without methodical study and in hours not occupied by business; and those who enter the institution with the view of a progressive, systematic training in one or more branches of applied science, and who have the preliminary knowledge as well as time for the prosecution of its studies.

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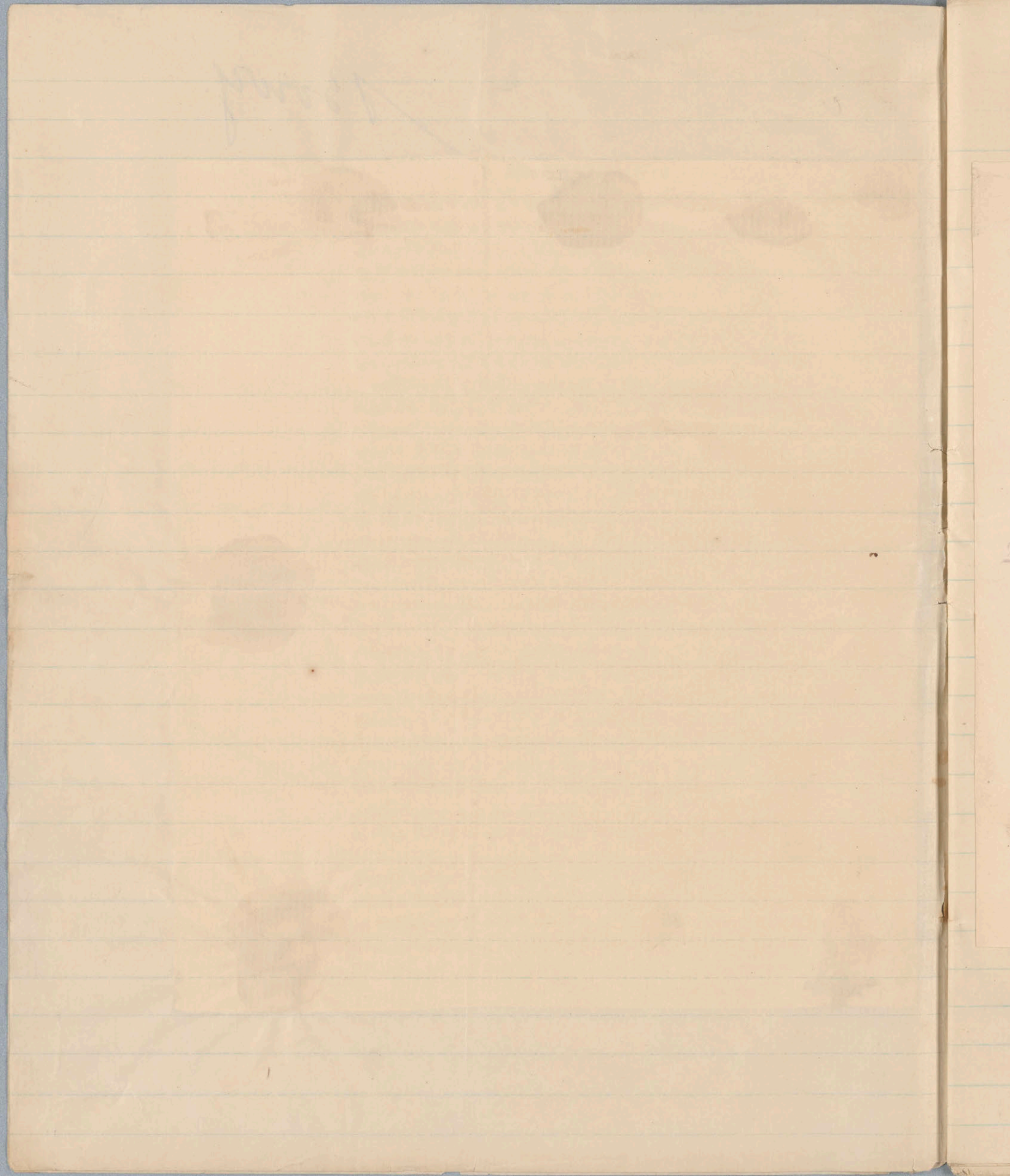
In the former of these divisions, — that of general and more popular instruction, — the teaching will be conducted by means of lectures alone, except in the drawing-school, and in mathematical subjects requiring more familiar modes of exposition. As it is the purpose, in these courses, to open the halls of the Institute as widely as possible to those who desire to profit by such teachings, students will be admitted to the courses on general and applied science, and on drawing, without a preliminary examination, and subject only to such conditions and restraints as are usual in public lectures, or as may be found best fitted to make them useful and interesting.

In the second division of the School, — that of systematic and professional instruction, — the student, while attending lectures on the several branches, will have the benefit of laboratory exercises in manipulation and analysis; of continued practice in the kinds of drawing appropriate to his studies; and of such prolonged and thorough training in the class-room, and by examinations, as will give him a ready command over the problems with which, as a mechanician, engineer, builder, practical chemist, or scientific miner, he may be called upon to deal.

and after exercises

To be admitted to this division of the School, students must have attained a certain degree of preparation, hereafter to be described; and, after having entered, they will be subject to classification and direction in their studies, as well as to examinations and other tests of acquirement, in the progress and at the close of their terms.

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FIRST DEPARTMENT.

GENERAL OR POPULAR COURSE.

This department of the School is designed to embrace lectures in elementary ~~mathematics~~, in ~~physics~~ and ~~mechanics~~, in ~~chemistry~~, in ~~geology~~ and ~~mining~~, and in ~~botany~~ and ~~zoölogy~~; especial regard being had in each case to the facts and scientific principles which are of leading importance in connection with the useful arts.

Caps

These lectures will be grouped into more or less extended courses, as may be found expedient; and, besides, the ordinary methodical teachings will have for their object to make known new facts and discoveries in the applied sciences as they are brought to light, as well with a view of stimulating invention as of giving to the public the early benefit of important additions to our industrial knowledge.

In the same department will be included a fully equipped ~~drawing-school~~, where, in addition to systematic exercises in elementary and free-hand drawing, instruction will be given in artistic design and modelling, as applied to manufactures, architecture, and decoration. It is expected that the drawing-school of the Lowell Institute will be brought into connection with the School of Industrial Science in such manner as to afford to the students of the latter the free benefit of its instructions; and that the subjects above referred to will mostly, if not wholly, come within its new and enlarged plan of operations.

These courses of instruction will be given chiefly in the evening, and will be open to both sexes. From the variety of practical subjects embraced in them, and the convenience of the hour, it is expected that they will be largely attended by persons engaged in mechanical, manufacturing, and mercantile pursuits, by teachers and students in the Normal and other schools, as well as by others whose taste and leisure lead them to avail themselves of such instruction.

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PROGRAMME OF THE GENERAL ~~COURSES~~ LECTURES.

I. — *Lectures and other teachings in Mathematics.*

These will embrace parts of Arithmetic and Algebra, and of Elementary Geometry, Trigonometry, and Descriptive Geometry, with application to business computations, weights and measures, mensuration, gauging, levelling, projection of maps, construction of curves, problems in surveying, navigation and nautical astronomy, principles of perspective.

II. — *Lectures on Physics and Mechanics.*

This course will embrace the general doctrines of Motion and Force; the mechanics of Solids and Fluids; the laws of Sound, Light, Heat, Magnetism and Electricity. Among the topics will be, —

1. Gravity, the Pendulum and its Applications, Elements of Machinery, Laws of Friction, Estimation of Work by Dynamometers.
2. Molecular Mechanics, Elasticity, Strength of Materials, Principles of Framing, Capillarity, Osmotic Force.
3. Pressure and Flow of Water, Air, and Gases; Canals; Drainage; Mill-wheels; Turbines; Pumps.
Resistance of Fluids, Form of Ships, Paddles and Screws.
4. Waves and their Propagation, Sound, Music, Musical Instruments, Voice, Hearing, Halls for Speaking, &c.
5. Light: its reflection, refraction, dispersion, interference, &c.; the Eye; Vision; Optical Instruments; Measure of Light from Gas, Candles, &c., by photometers; the Spectroscope and its uses.
6. Heat; Expansion; Thermometers; Conduction, Radiation, and Connection; Absorption; Melting, Evaporation; Steam; Steam-Engine; Hot-air Engine; Warming and Ventilation; Manufacture of Ice.

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- 7. Magnetic Polarity and Induction ; Variation ; Dip and Intensity ; Magnetic Charts ; Compass on Shipboard, and its Correction.
- 8. Static Electricity, Machines, Conduction and Connection, Accumulation, Lightning-rods, &c.

Dynamic Electricity ; Voltaic Circles, and their Chemical, Magnetic, and other effects ; Induced Currents ; Induction Coils ; Applications in Blasting ; Telegraphy ; Electric Light, &c.

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III. — *Lectures on Chemistry, and its Applications.*

The subjects of this course will be embraced under the following heads: —

1. Preliminary demonstrations relating to a few leading Elements and Compounds.
2. General doctrine of Chemical Forces, and Laws of Combination.
3. More detailed account of the Elements and Compounds, especially those which are important in the arts and domestic economy ; including Water, Air, the Mineral Acids, Alkalies, Iron, Copper, Lead, Tin, Zinc, Silver, Gold, &c.
4. Chemical history of the principal organic Groups, — Sugars, Starches, Alcohol, Oils, Fatty Bodies, &c.
5. Chief constituents of the Vegetable and Animal Organisms, with the Chemistry of Food, Respiration, and Nutrition.

Especial attention will be given to the applications of chemistry in the manufacture of metals, pottery, glass, soap, illuminating gas, cements, alum, sugar, &c., and in dyeing, bleaching, and other chemical arts. The actual process, when practicable, will be experimentally shown ; and the suites of materials and products contained in the museum will be used in aid of the lectures. As occasion arises, examples will be given of such simple methods of volumetric analysis, or other chemical testing, as can be usefully shown in the lecture-room.

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IV. — *Lectures on Geology and Mining.*

This course will embrace, —

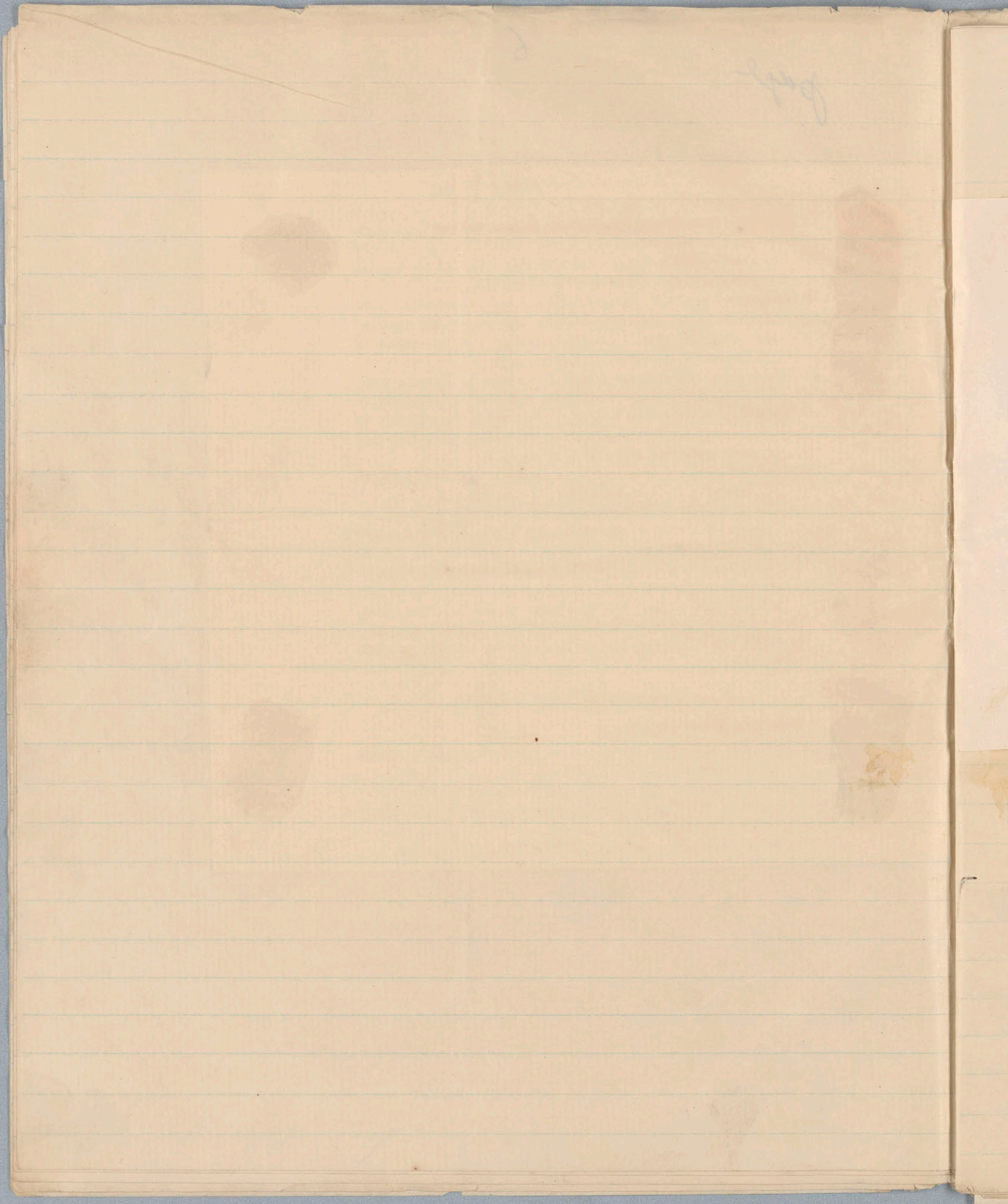
1. ~~An general outline of Mineralogy~~ including, ~~briefly~~ descriptions of the principal constituents of rocks and the more important ores, and other useful mineral products; with the mechanical, chemical, and optical modes of discrimination.
2. Division of rocks into aqueous, igneous, and metamorphic. Description of stratified, marine, delta, and fresh-water deposits; and of igneous and metamorphic masses, with an account of the actions concerned in their production.
3. Illustrations of Geological Structure, as seen in flexures, axes, faults, basins, valleys of elevation and erosion, escarpments, foliation and cleavage of rocks, &c.; with the methods of determining the dip of strata and veins, and of making and mapping geological and mining surveys.
4. Organic Remains, and their use in determining the sequence of the strata.
5. Table of Geological Formations, from the most ancient to the present time, with a special account of the North-American strata; showing, by the use of maps and sections, the geographical position and range of each great formation; marking out the coal-fields, belts of iron-bearing, gold-bearing, and other metalliferous rocks; and the ranges of the granites, slates, sandstones, limestones, marbles, and other mineral aggregates, which may be brought into profitable use for building or other purposes.

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V. — *Lectures on Botany and Zoölogy.*

This course will include, —

1. An Outline of Botany; embracing the growth, morphology, structure, and classification of Plants.
2. Economic Botany, — plants useful for food and in the arts.
3. An outline of Zoölogy; including the structure, physiology, and classification of Animals.
4. Economic Zoölogy, — animals useful for food and in the arts.

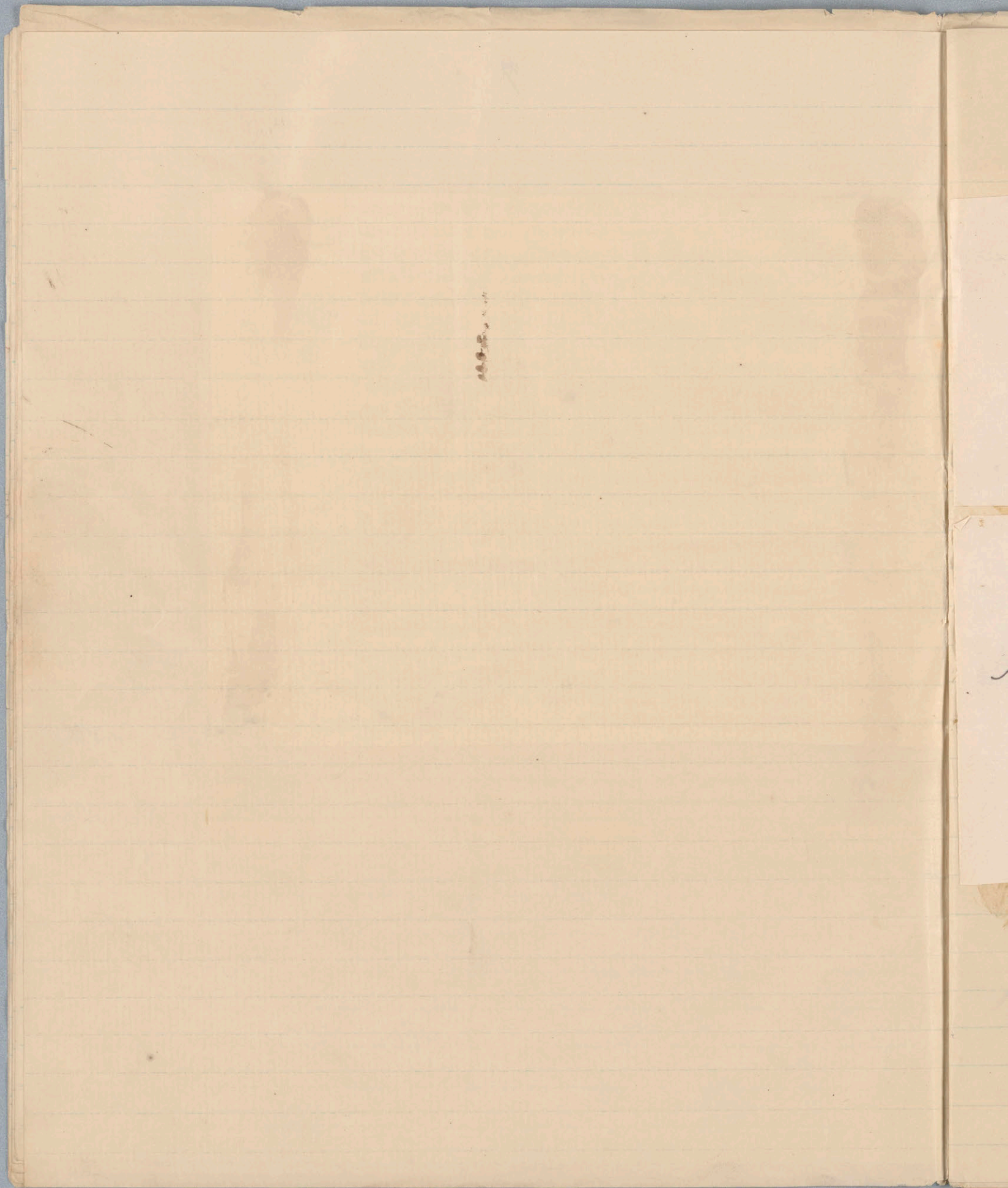


In addition to these general lectures, it is proposed to make special provision for the more extended and technical treatment of branches of industrial knowledge not included, or but briefly touched on, in the general courses. Such would be the manufacture of cotton and other textile fabrics, the arts of printing and engraving, the manufacture of paper, &c.; including for each the history and statistics of the subject, and an account of the machinery and processes employed, illustrated by specimens and models from the Industrial Museum.

All the subjects of this class may perhaps, at an early day, be embraced as a distinct and extended course, under the head of Special Technology; in which many of the materials and products gathered in the Museum would find their most useful medium of interpretation.

As the courses of lectures above described are intended to meet the general demand for instruction in the applications of science to the arts, as well as to aid students in preparing for a more thorough course of study, they will treat only of such subjects as can be readily understood without previous training. At the same time, it will be their aim to teach the several branches to which they relate with such logical accuracy and completeness as to give the student a clear understanding of principles, and of their application in household and civic economy and the industrial arts.

The studies of each of these divisions are arranged so as to extend over a period of four years, including the first or introductory course; but, as students will be permitted to enter any of the advanced classes for which they are prepared, they will, in many cases, be able to complete the prescribed course in three or even less than three years.



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SECOND DEPARTMENT.

SPECIAL AND PROFESSIONAL INSTRUCTION.

Brown

This department of the school is intended, —

First, For such students, as, by a full course of scientific studies and practical exercises, seek to qualify themselves for the professions of the mechanical engineer, the civil engineer, the builder and architect, the practical chemist, and the engineer of mines. And, —

Second, For those who aim simply to secure a training in some one or more of the branches of applied science, — such as descriptive geometry applied to constructive perspective, &c. ; chemical analysis ; machinery and motive powers ; general physics and chemistry, with manipulations ; geology and

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mining ; navigation and nautical astronomy ; metallurgy of iron, copper, &c.

The entire series of instructions, arranged in reference to the above-named professional divisions, offers to the student five courses having more or less in common ; viz., —

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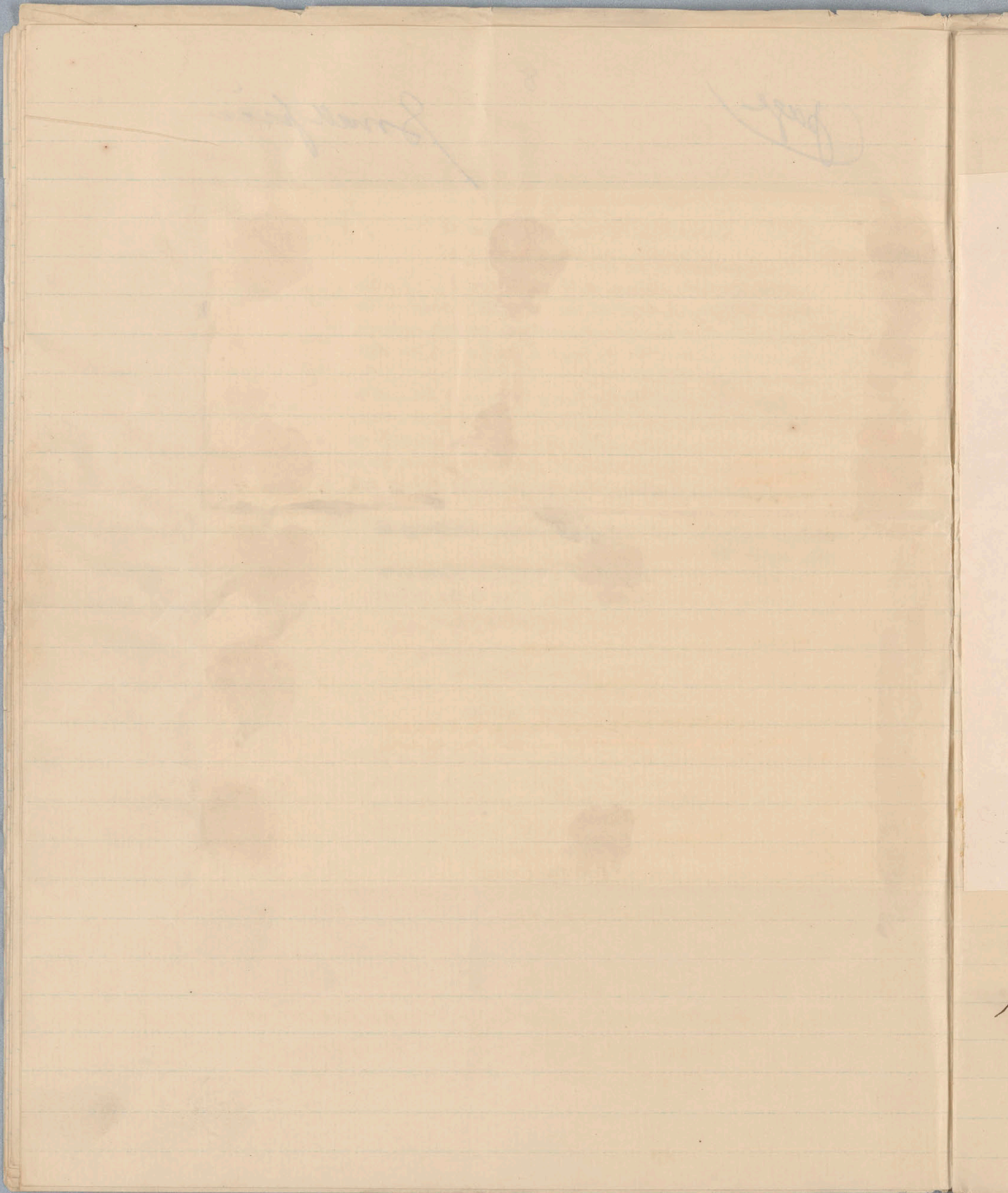
1. A course on Mechanical Construction and Engineering.
2. " " Civil and Topographical Engineering.
3. " " Building and Architecture.
4. " " Practical and Technical Chemistry.
5. " " Practical Geology and Mining.

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on the
descriptive
lectures.

The studies of each of these divisions are arranged so as to extend over a period of four years, including the first or introductory course ; but, as students will be permitted to enter any of the advanced classes for which they are prepared, they will, in many cases, be able to complete the prescribed course in three or even less than three years.

The General Inquiry

Physical & Structural Geology, & Constitution of the Earth's Crust, & the Laws of Strata, & Modes of Observation



For the first two years, the studies and exercises will be the same for all the regular students; each thus obtaining such an acquaintance with the whole field of practical science as is needed for a complete and satisfactory study of either of its professional departments.

The courses of instruction in the first and second years will be as follows:—

FIRST YEAR, OR INTRODUCTORY COURSE.

1. Algebra, Geometry, Plane Trigonometry, Geometrical Constructions with Compasses, Protractor and Scales, Simple Applications to Mensuration, Heights and Distances, Plain Surveying, Levelling, &c.
2. ~~Introductory~~ Physics. *Elementary*
3. ~~Introductory~~ Chemistry. *"*
4. ~~Introductory~~ Astronomy. *"* *5. Botany*
6. ~~7.~~ Drawing, Linear and Geometric.
7. ~~8.~~ Practice in the use of the Chain, Level, Theodolite, &c., Sextant, &c., when practicable, during the course; but chiefly in the vacation succeeding.
8. *French Language.*

SECOND YEAR.

1. ~~Advanced Algebra~~, Spherical ~~Geometry~~ and Trigonometry, Navigation and Nautical Astronomy.
2. Analytical Geometry; ~~and~~ *Elements* of the Differential and Integral Calculus.
3. Mechanics, ~~taught chiefly without the Calculus~~; Machinery and Motors; Steam-engine, &c.
- and 4. Physics with Manipulations, to exercise the student in the use of apparatus.
5. Chemistry with Manipulations, and simple qualitative testing.
6. ~~Descriptive and General~~ Geology.
7. Elements of ~~Descriptive~~ Zoölogy.
8. Descriptive Geometry.
9. Drawing: Geometric, Perspective, Lights and Shadows.
10. *The German Language.*

5. Physical & Structural Geology; Constitution and arrangement of the materials of the earth's crust; Phenomena & Laws of structure; Modes of observation.

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2. The Power of Geography

3. Physical & Political Geography; Institutions and Government
of the Republics of the Latin West; Character &
Form of Structure, Order of Government

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THIRD YEAR.

The studies of this year will be the same for those pursuing the

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Engineering

Courses of Mechanical and of Civil Engineering and of Building and Architecture

Italian

1. Differential and Integral Calculus ; Rational Mechanics.
2. Strength and Strain of Materials used in Construction ; Principles of Joinery, — Framework, Roofs, Wooden Bridges, &c.
3. Investigation of Machinery and Motors ; Elements of Machines ; Combinations ; Effective Work ; Dynamometers.
4. Chemistry and Geology of the Materials used in Construction.
5. Combustion and Fuel ; Warming, Ventilation, and Lighting.
6. Descriptive Geometry applied to Carpentry
7. Drawing of Machinery, Roofs, Bridges, Buildings, Maps, &c.
8. Lessons in Photography

Course of Practical and Industrial Chemistry.

1. Chemical Analysis, qualitative and quantitative, chiefly of inorganic substances, including the volumetric methods. Lectures to accompany the laboratory exercises.
2. Descriptive and Determinative Mineralogy ; Use of Blowpipe, &c.
3. Lectures on Combustion and Fuel, and on Warming, Ventilation, and Lighting.
4. Lectures and Illustrations on Industrial Chemistry ; Manufactures of Glass, Pottery, Tiles, Soda-ash, Acids, Salts, Soaps, &c.
5. Drawing of Apparatus, Plans and Projects for Chemical Works, Laboratory Arrangements, &c.

6. Lessons in Photography.

Course of Practical Geology and Mining.

1. Chemical Analysis, qualitative and quantitative ; as under the preceding head.
2. Descriptive and Determinative Mineralogy ; Use of the Blowpipe.
3. Lectures on Combustion and Fuel, and on Warming, Ventilation, and Lighting.
4. Historical Geology, — Successive Systems, Groups, and Formations, with their leading Fossils.
Detailed study of the Geology of North America.

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5. Drawing, Topographical and Geological Sections and Maps, Conventional Representation of Rocks, Coloring of Maps and Sections

6 *Lectures on Phytosociology.*

FOURTH YEAR.

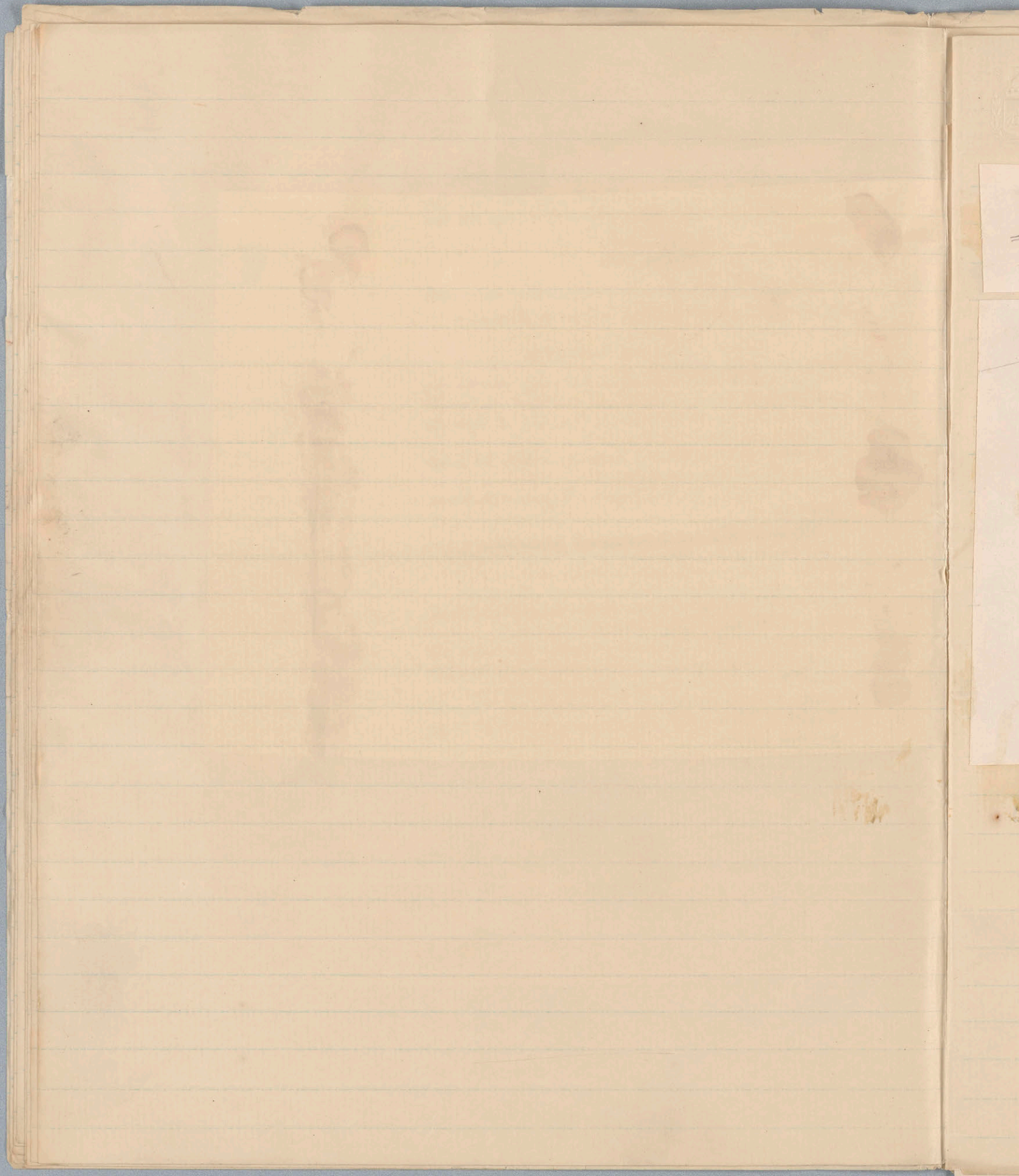
In this year, the professional courses, becoming more completely separate from one another, will be as follows:—

Course of Mechanical Engineering.

1. *Extensions of the Calculus*
2. Investigation of Machinery and Motors continued, *including*
3. Special Study of Steam and Steam-engines, Stationary, Locomotive, and Marine; of Air and Gas Engines; of Hydraulic Machines and Motors; of Pumps, &c.
4. Construction and Arrangement of Machinery in Mills for Grinding, for Textile Manufactures, &c.
5. Drawing of Machines, Working Plans and Projects of Machinery, Mills, &c.

Course of Civil and Topographical Engineering.

1. *Extensions of the Calculus*
2. Spherical Astronomy, with the use of Instruments.
3. Location and Construction of Roads, Railways, and Canals.
4. Supply and Distribution of Water; Water-works; Dams, Ponds, &c.; Distribution of Gas; Drainage; Irrigation.
4. Extended treatment of Structures,—Mason-work, Arches and Bridges of Stone; Structures in Iron, including Girders, Columns, Roofs, Suspension-bridges, Tubular-bridges, &c.
5. Drawing: Working Drawings of Constructions, and Plans and Projects of Railroad and other Surveys; Profile and Topographical Drawing.



For such students as desire to devote themselves especially to Topographical Engineering, the above course will be modified so as to include,—

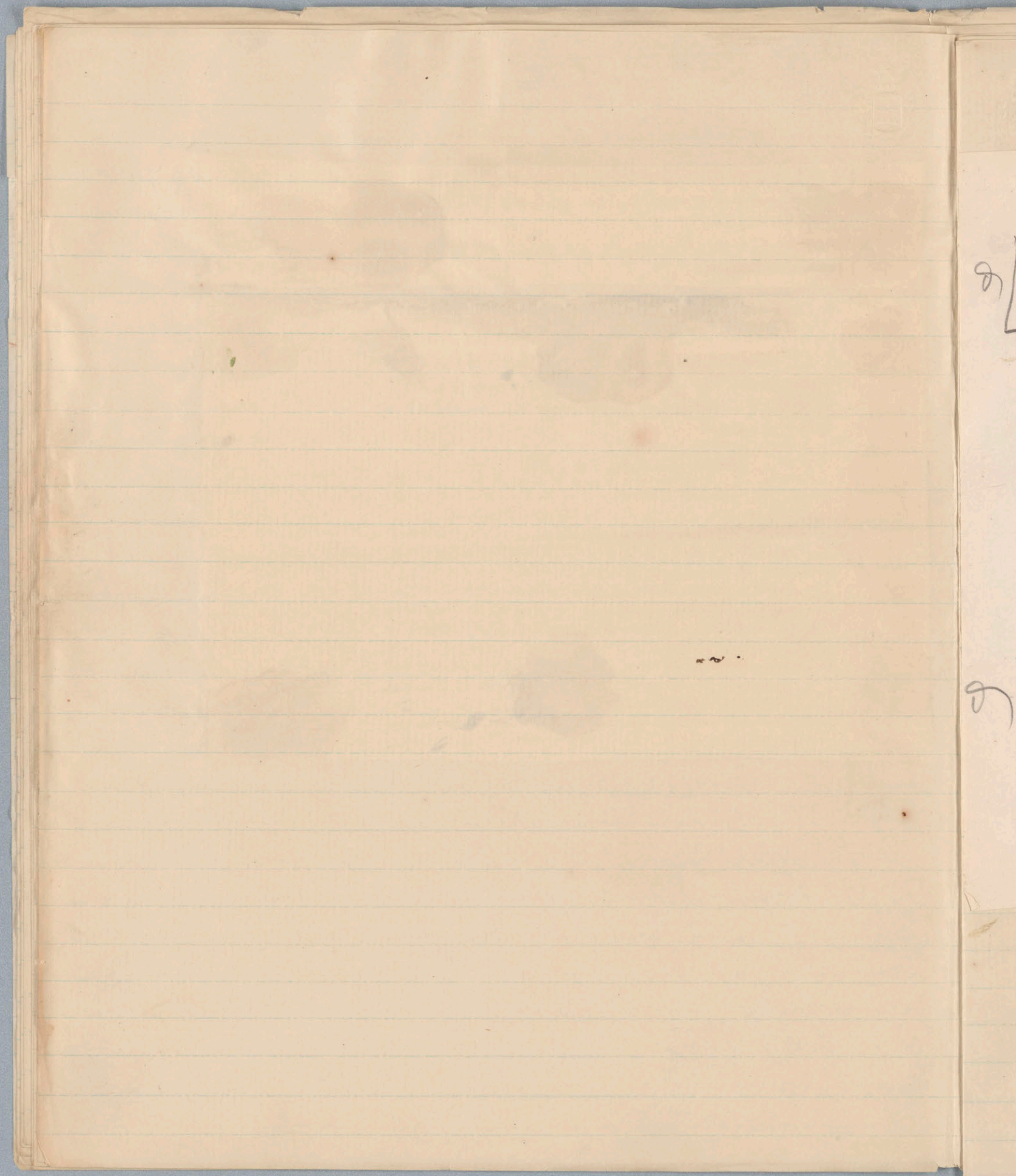
1. A more extended study of Astronomy, and practice with Astronomical Instruments.

2. Lectures and exercises in the higher Geodesy, including the survey of Harbors, Coasts, and extensive regions.

At the same time, a larger space will be allotted to Topographical and Map Drawing; and the subjects mentioned under heads three and four of the preceding programme will be in part omitted.

Course of Building and Architecture.

1. Extended treatment of Structures, — Mason-work, Arches and Bridges of Stone; Iron Girders, Columns, Roofs, &c.
2. Details on Warming, Ventilation, and Lighting; and on the distribution of Water and Gas.
3. Lectures on Building or Practical Architecture; embracing a review of the Materials used, their preparation and mechanical combination in the erection of Dwellings, Schoolhouses, Halls, Courts of Justice, Prisons, Manufactories, &c., illustrated by Models and Drawings.
4. Lectures on Architecture as a Fine Art, with a History and Illustrations of the great Architectural Works of Classical, Mediæval, and Modern Times.
5. Architectural Drawing, — Projects for Dwellings, Schoolhouses, Churches, &c.



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Course of Practical and Industrial Chemistry.

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1. Chemical Analysis continued; embracing the analysis and commercial testing of, —
 - [~~a.~~] Ores, Limestone, Clays, and other crude mineral materials.
 - [~~b.~~] Cast Iron, Copper, Lead, &c., and Metallic Alloys.
 - [~~c.~~] Soda-ash, Bleaching Salt, Common Salt, Saltpetre, Gunpowder, Indigo, Paints, Drugs, Guano, and other Manures, &c.
 - [~~d.~~] Drinking and Mineral Waters, and Sea-water.
 - [~~e.~~] Coal-gas, and other Gaseous Mixtures.
 2. Exercises in Organic Analysis.
 3. Lectures on Industrial Chemistry; including the Arts of Dyeing, Color-printing, Tanning, Brewing, Distillation; on the Manufacture of Illuminating Gas, ~~and~~
 - 4 Drawing; Plans and Projects for Dyeing and Print-work, for Gas-works, &c. 5

Course of Practical Geology and Mining.

- 2/
1. Special Geology of Coal, Iron, Copper, Salt, Plaster, &c., with particular reference to North-American localities; and an account of important Mines, Quarries, &c.
 2. Lectures on Mining; treating of, —
 - [~~a.~~] Prospecting, Breaking Ground, Boring, Blasting, Tubing, Sinking Shafts, Driving Tunnels, Ventilating and Lighting.
 - [~~b.~~] Of the different methods of Working Mines.
 - [~~c.~~] Of ~~Mining~~ Machinery and Motors — Engines, Horses, Pumps, Wagons, Drums, Ropes, &c. — for conveying and raising the material. mining
 - [~~d.~~] Of the Dressing and Concentration of Minerals, Crushers, Stamps, Washers, Amalgamators, &c.; and Machinery used in the Pennsylvania Anthracite Region.
 - [~~e.~~] Of Quarrying and Open Mining.
 - [~~f.~~] Details of Mining in this country; with History and Statistics of Mining generally.
 3. Drawing, — Plans and Sections of Mines and of Quarries, and other Open Workings; Mining Machinery and Implements; Topographical and Geological Maps of Mining Districts, &c.

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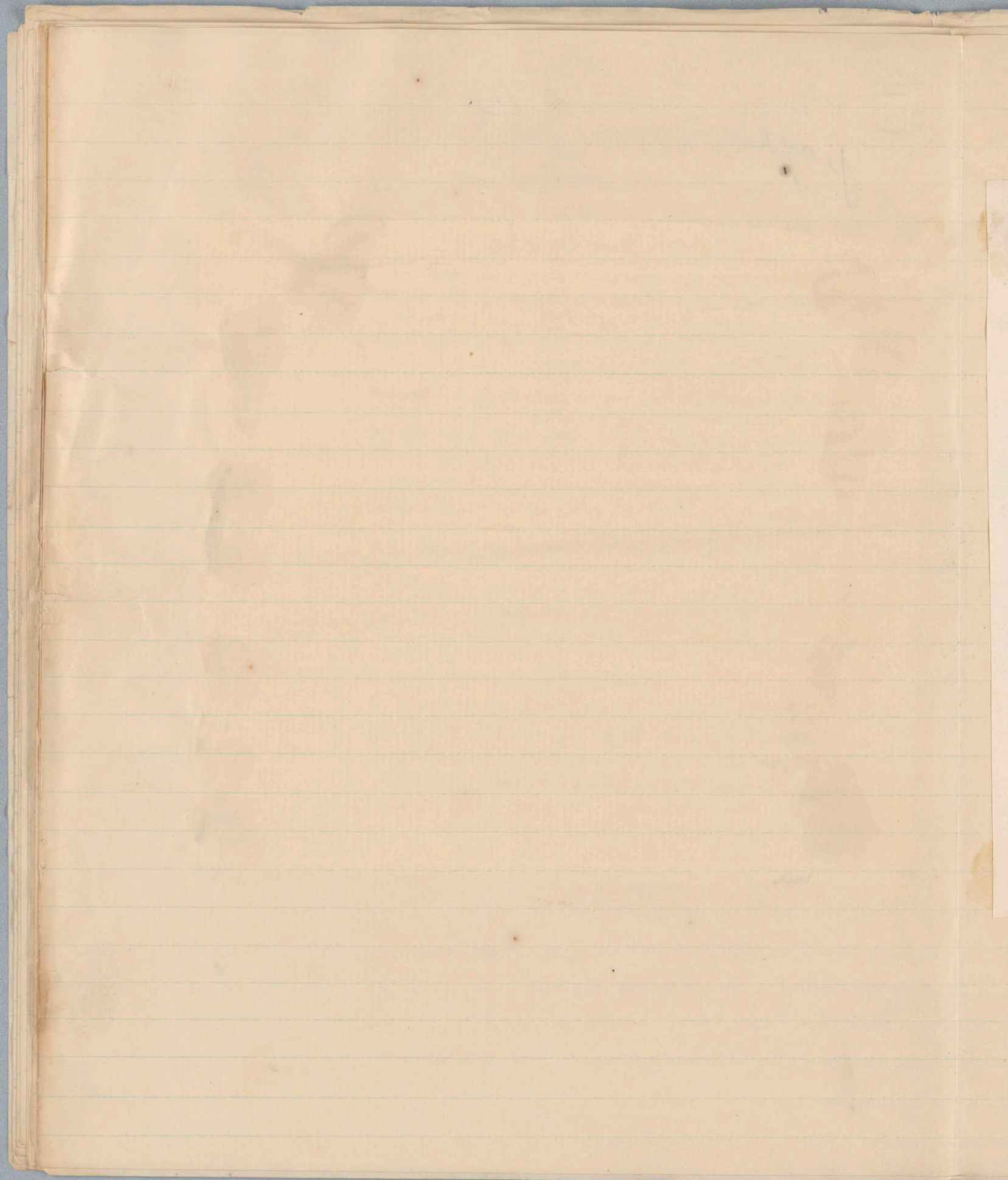
Course of Practical Metallurgy.

For students who have passed through the third year's course on Practical Geology and Mining, and who wish to prepare specially for the superintendence of furnace operations, and other branches of Metallurgy, the following course will be provided for the fourth year: —

1. Special Geology of Coal, Iron, &c.; as in the course of Practical Geology and Mining, &c.
2. Chemical Analysis; including, chiefly, Assays in the Wet and Dry Ways of Ores, Fluxes, Slags, and of the Metals and their Alloys. x
3. Lectures on Metallurgy; Review of the more important Metals and their Ores; Discussion of Fuel, and Methods of determining Heating Power and Intensity.
Metallurgical Implements, Structures, and Processes; Crucibles, Furnaces, Blowing-machines.
Details of the Smelting and Manufacture of Iron, Copper, Lead, Zinc, Silver, Aluminum, &c.
4. Drawing, — Plans and Projects for Cooking-ovens, Furnaces, Refineries, Hot and Cold Blast Arrangements, &c.

MILITARY TACTICS. *Bowz.*

The regular students of the School will be taught the use of small-arms and the simpler parts of tactics; and, for this purpose, will be organized into one or more companies, to meet on stated days for military instruction and exercise.



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Conditions of ADMISSION OF STUDENTS.

The leading principles governing the admission of students into this department will be, —

First, That all persons who are qualified to enter upon any one of the full courses, or of the special studies, of the School, shall have the freest opportunity of doing so; and, —

Second, That no students shall be admitted to any of the courses of instruction who have not the preliminary knowledge needed for a satisfactory pursuit of the studies proposed.

Students to be admitted to the introductory or first year's course must have attained the age of ~~fifteen~~ years; and must give satisfactory evidence, by examination or otherwise, of such training in elementary mathematics, and in the other subjects taught in the common schools, as shall hereafter be prescribed.

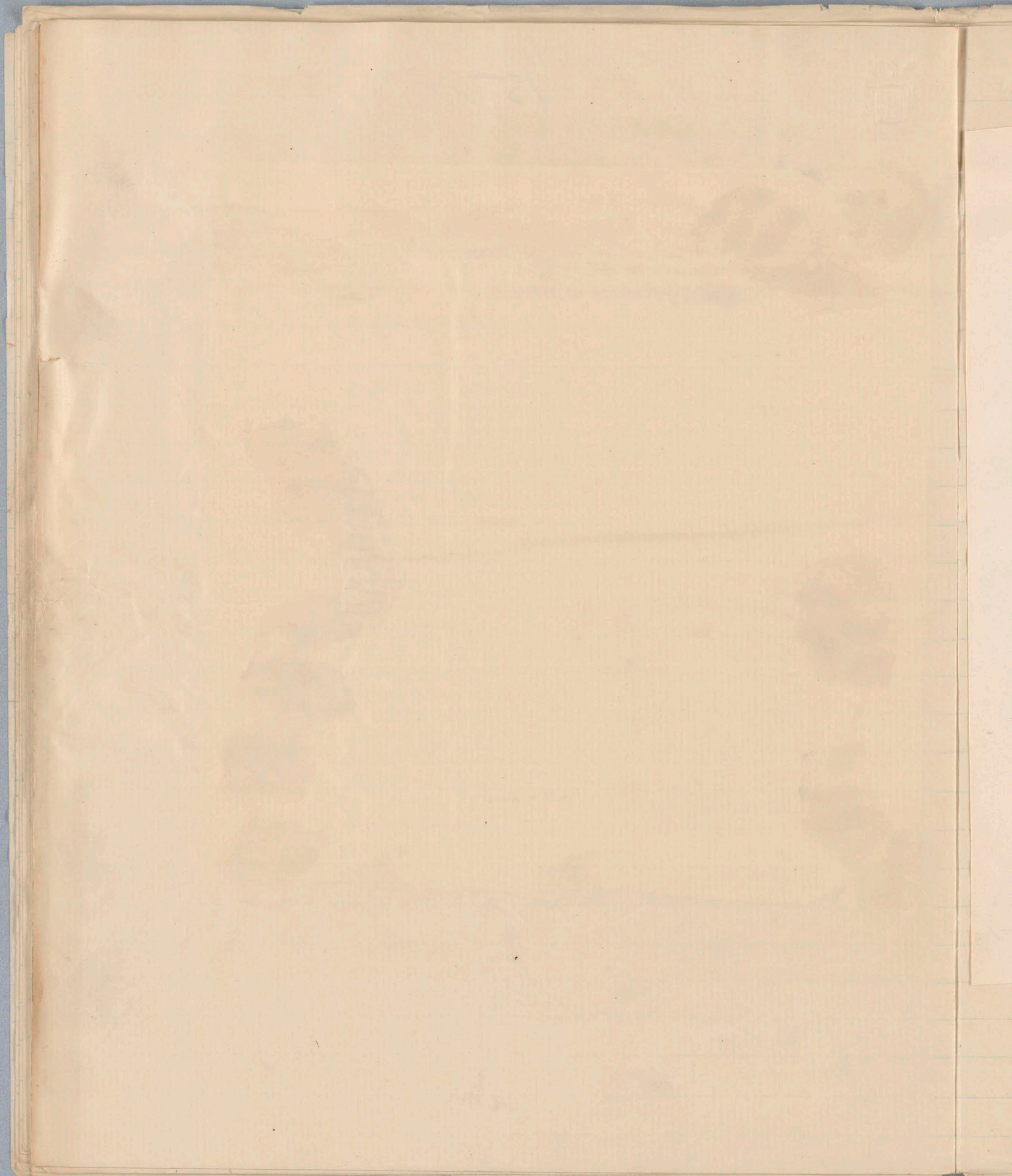
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In order to enter the second year's course, the student must be at least ~~sixteen~~ years of age; and must give evidence, by examination or otherwise, of such knowledge of the first year's studies as would enable a student of the first year to pass into the second; and a like rule will apply to the case of students seeking admission into the classes of the succeeding years.

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To make the opportunities of instruction as widely accessible as possible, students will be allowed to enter special divisions of either of the courses after the first year, — as, for example, the classes of mathematics, of mechanical construction, of chemical analysis, of physics, or of mining and metallurgy, — on giving satisfactory evidence that they are duly prepared to pursue such special studies with advantage.

It will be required that all students have sufficient familiarity with the French and German languages to be able to read without difficulty works in those languages relating to the science and art.



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DIPLOMAS AND CERTIFICATES.

As the diploma or certificate is intended not only to be a reward to the student for his diligence and attainments, but an assurance to the public of his knowledge and skill in the particular department of applied science to which it relates, it will be conferred on such students only as by their examinations and other exercises give proof that they possess the prescribed qualifications; but all students in good standing, who fulfil this requirement, shall be entitled to the testimonials of the Institute, without regard to the greater or less number of courses they may have attended in the Institution.

The degrees or diplomas corresponding to the leading divisions of the School will be as follows:—

1. The Degree of Mechanical Engineer.
2. " " " Civil and Topographical Engineer.
3. " " " Builder and Architect.
4. " " " Industrial Chemist.
5. " " " Geologist and Mining Engineer.

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To suit the case of students having in view a general scientific education, such as may qualify them to become teachers, rather than a professional training in applied science, a schedule of studies will be appointed, embracing the whole of the two first years' and certain parts of the third and fourth years' studies, so as to form a general scientific course; for proficiency in which, the degree of Bachelor of Science will be conferred.

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To be entitled to either of these degrees, the student must pass a satisfactory examination on the whole course of studies and exercises prescribed in his department, including the elementary and general no less than the advanced and special subjects. He must, moreover, prepare a dissertation on some subject in pure or applied science, or submit an original report on some machine or work of engineering, or some mine or mineral survey, or chemical investigation, which shall be approved by the Faculty of Instruction or other examining Board. He will be required also to have sufficient familiarity with the French and German languages to be able to read without difficulty works in these languages relating to the sciences and arts.

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Besides the degrees or diplomas covering the complete courses of study above referred to, there will be given certificates of attainment in special subjects to such students as, on examination, are found to have attained the required proficiency in them. Among the special subjects for which such certificates may be awarded are —

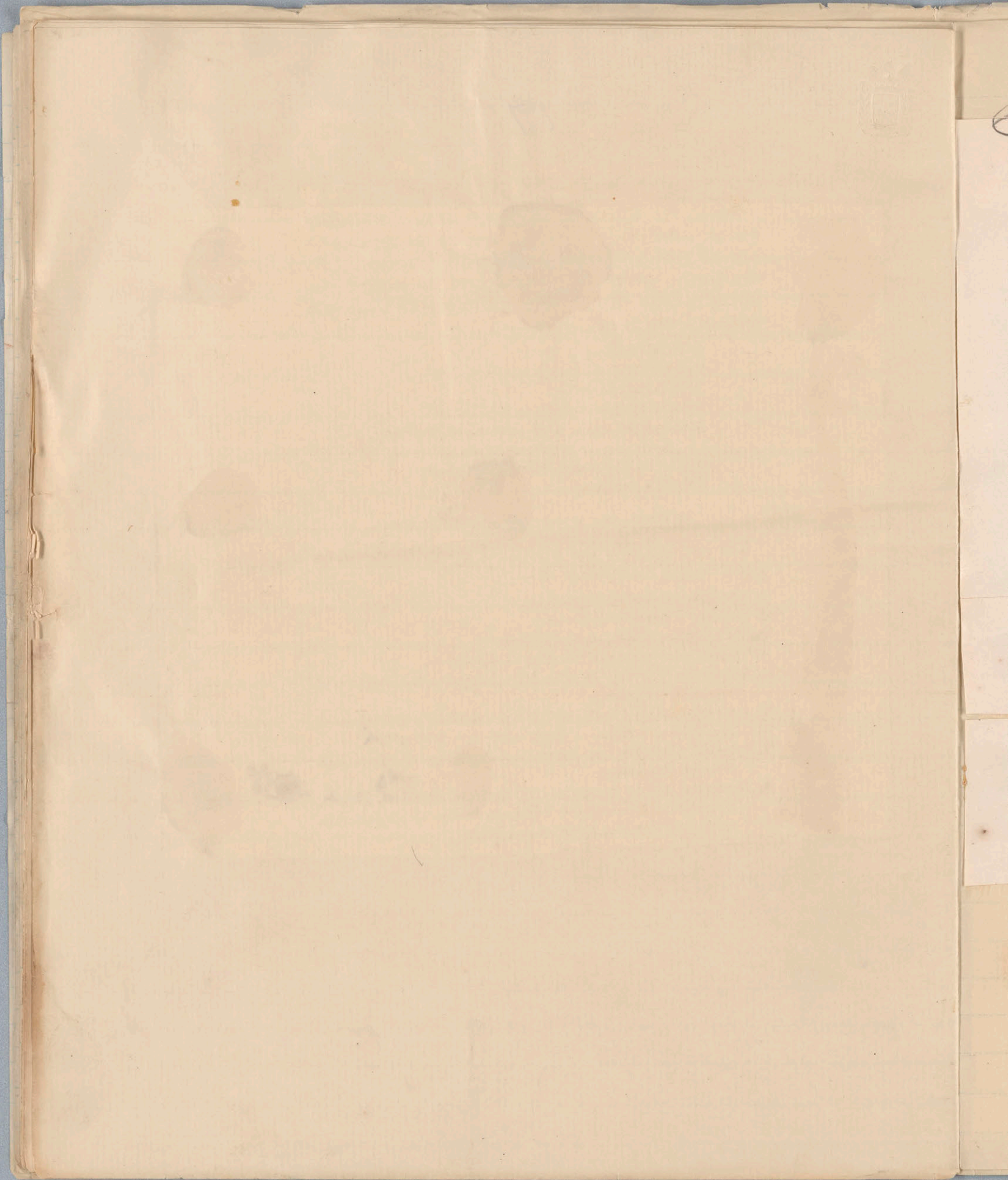
- Machine Drawing.
- Topographical and Constructive Drawing.
- Architectural Drawing.
- Descriptive Geometry and its Applications.
- Mathematics, applied to Mechanics and Machinery.
- “ “ to Construction.
- Physics and Chemistry, with Manipulations.
- Chemical Analysis.

METHODS AND APPARATUS OF INSTRUCTION.

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The instructions in this department of the School will be given through the medium of, —

1. Lectures and familiar Expositions.
2. Oral and Written Examinations.
- ~~3. Exercises in the Solution of Problems.~~
- 3 4. Practice in Physical and Chemical Manipulations.
- 4 5. Laboratory Training in Chemical Analyses, Metallurgy, and Industrial Chemistry.
- 5 6. Drawing and the Construction of Special Plans and Projects of Machines and Works of Engineering and Architecture.
- 6 7. Practical Exercises in Surveying, Levelling, Geodesy, and Nautical Astronomy.
- 7 8. Excursions for the Inspection and Study of Machines, Motors, Processes of Manufacture, Buildings, Works of Engineering, Geological Sections, Quarries and Mines.



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LECTURES AND EXPOSITIONS.

As a general rule, each lecture will be preceded by interrogations on the subject of the ~~preceding~~ lecture, in which the teacher will have the opportunity of re-enforcing the instruction already given, as well as of testing the progress of individual pupils.

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After the first year, the student will be expected to take notes of the lectures as they proceed, and afterwards to write them out with the accompanying diagrams or drawings, so as to form, in connection with each of his classes, a text for immediate study as well as future reference.

In addition to these notes of lectures, he will be expected to study or to consult text-books or works of reference, whenever such are appointed to be used. But in view of the value of the method of lectures, combined with examinations, as a means of commanding the attention and stimulating the zeal of students, this method will be used whenever practicable; and in no case will mere text-book recitation be exclusively relied upon. Until habituated to the work, the student will have the assistance of his teachers in correcting his notes, and in reducing them to methodical order.

Where familiar expositions rather than formal lectures are given, as in many of the mathematical classes and in the instruction connected with the laboratory work, the student will be interrogated by his teacher, from time to time, in the progress of the lesson, as well as at its commencement.

As a means of enforcing the instruction of the lecture-room, and of enabling the student to acquire facility in the application of principles to special cases, problems will, from time to time, be given out to the mathematical and other classes, where applicable, of which written solutions will be required; and these solutions the students presenting them may be called upon to explain.

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ORAL AND WRITTEN EXAMINATIONS.

As frequent and thorough examinations form the best means of inciting students to diligence, as well as of testing their progress in their studies, and of discovering those individual needs and difficulties which the teacher should endeavor to obviate, they will constitute a leading feature in every department of instruction in which they can be employed.

Besides the daily oral examinations already referred to as preceding and accompanying the lectures, oral examinations will be held once every month, separate from the lectures, on a day set apart for the purpose, at which each entire class, or, when too numerous for this purpose, parts of the class, taken in succession, will be examined and drilled in the subjects lectured upon or appointed for study during the month just elapsed.

At or near the close of each term, viz. in the months of February and June, *written examinations* will be held; that of February embracing the subjects studied during the first term, that of June covering the studies of both terms. On these occasions, the courses of instruction will cease; and a sufficient period will be set apart to allow the classes time for a brief review of studies, and full opportunity for the several examinations.

half of the
Scholastic year
Scholastic year

Mode of conducting the Written Examinations.

These examinations will be conducted as follows:—

The students taken by classes, and provided with writing, and, where necessary, with drawing implements; and materials will be placed at separate tables in the examination-room, bringing with them neither books nor memoranda of any kind to aid them in their work. The instructor having charge of the class will then furnish to each student a copy, in printed or written form, of the series of questions which he has prepared to test their proficiency; and these the students will be required to answer in writing, as well as they can, without conferring with one another, or consulting any other sources of information.

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It shall be the duty of the teachers to keep a numerical record, according to forms hereafter to be prescribed, of the performance of each student in the several classes, both at the monthly oral examinations and at the written examinations just described. These records will form the basis for determining the standing of the students at the end of each course, and for deciding upon those to whom certificates of proficiency are to be awarded.

Graduating Examinations.

The examinations for degrees will be held at the close of the June term, and will be partly oral and partly in writing. In the former, each candidate will be interrogated apart from the rest; in the latter, the mode of proceeding will be the same as at the term examinations above described. In both, the questions will range over the entire series of studies on which the student is required to be prepared.

As part of these examinations, the candidates will be called upon to exhibit the drawings and projects prepared by them for the occasion, and to perform such laboratory manipulations and exercises as the Examining Committee may assign.

At the same time, the theses of the candidates will be brought forward for examination; and, where expedient, their authors be called upon to explain or defend them.

As a further test of their qualifications as teachers of Science, the candidates for the degree of Bachelor of Science, in addition to their examinations, will be required to give a brief oral lecture on such topic embraced in their studies as may at the time be designated for this purpose.

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PRACTICE IN PHYSICAL AND CHEMICAL MANIPULATION.

It will be the object of these exercises to make the student practically familiar with the adjustments and use of the apparatus and agents employed in the more important experiments and processes in natural philosophy and chemistry. With this view, the students, under the direction of their teacher, will be called, by small classes at a time, to execute with their own hands various experiments in mechanics, pneumatics, sound, optics, electricity, and other branches of experimental physics, and to exhibit chemical re-actions, to fit up chemical apparatus, to prepare gases and other products, and demonstrate their properties by suitable experiments, accompanying these manipulations, when required, with an explanation of the apparatus used or of the process or experiment performed.

These exercises will be held either in the lecture-rooms or in the appropriate laboratories hereafter to be described, as at the time may be found most expedient.

LABORATORIES AND LABORATORY TRAINING.

The laboratory arrangements of the school are designed, when complete, to embrace the following departments:—

1. A Laboratory of Physics and Mechanics.
2. A Laboratory of General Chemical Analysis and Manipulation.
3. A Laboratory for Metallurgy and Mining.
4. A Laboratory for Industrial Chemistry.

While intended primarily for the instruction of the students, these laboratories will be used for the prosecution of experiments and investigations on subjects referred to them by the Committee of the Museum or the several Committees of Arts, including the examination and testing of new machines and

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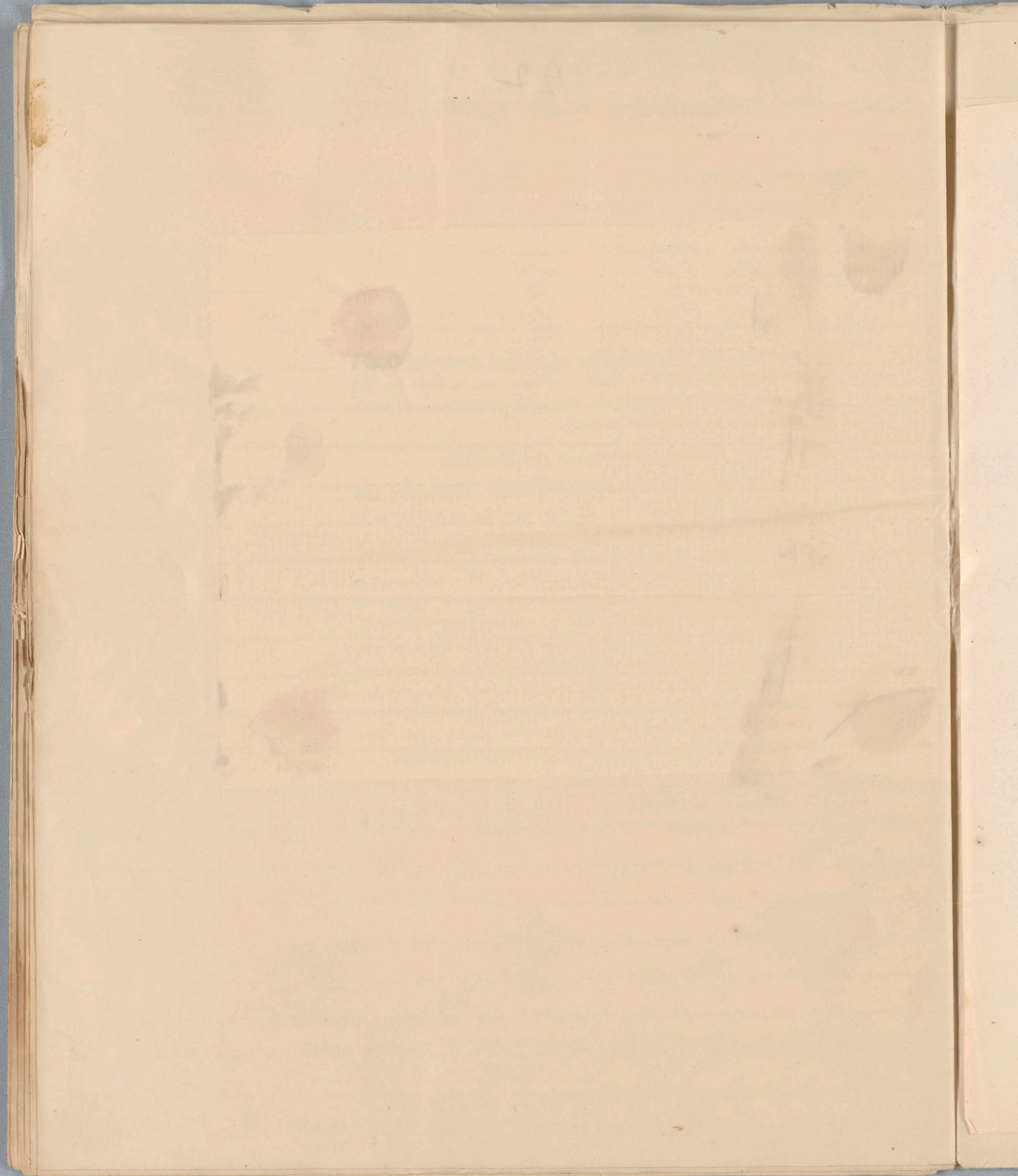
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processes, and the conducting of original researches in the different departments of applied science; and in these critical studies and experiments the advanced students may, when expedient, be permitted to assist.

Laboratory of Physics and Mechanics.

In this laboratory, it is proposed to provide implements and apparatus with which the student may be exercised in a variety of mechanical and physical processes and experiments. Thus he may learn practically the methods of estimating motors and machines by the dynamometer, of experimenting on the flow of water and air or other gases, and of testing the strength of the materials used in construction. He may become familiar with the adjustments and applications of the microscope; be practised in observing with the barometer, thermometer, and hygrometer; and, in a room fitted up for photometry, may learn the mode of measuring the light produced by gas and other sources of illumination, and the value of different kinds of burners, lamps, and their appendages.



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Laboratory for General Chemical Analysis.

In this laboratory, provision will be made for a complete and comprehensive course of instruction in qualitative and quantitative analysis,—embracing organic as well as inorganic substances,—and blending lectures with the systematic practice of the laboratory.

Students proposing to take the course will be expected either to have passed through the first two years' teachings of the Institute, or to be possessed of such knowledge of general chemistry and physics as these preliminary studies are intended to impart.

Besides this general and extended course, it is proposed to have certain partial courses, in which students having a special object in view may obtain instruction of a specific kind, without going through the entire range of laboratory training. Such would be —

1. Exercises in Organic Analysis.
2. Exercises in Blowpipe Testing.
3. Household and Commercial Analyses, including the Testing of Waters, Detection of Adulterations in Food, &c., Alkalimetry, Acidimetry.
4. Chemical Toxicology, Detection of Arsenic and other Poisons.

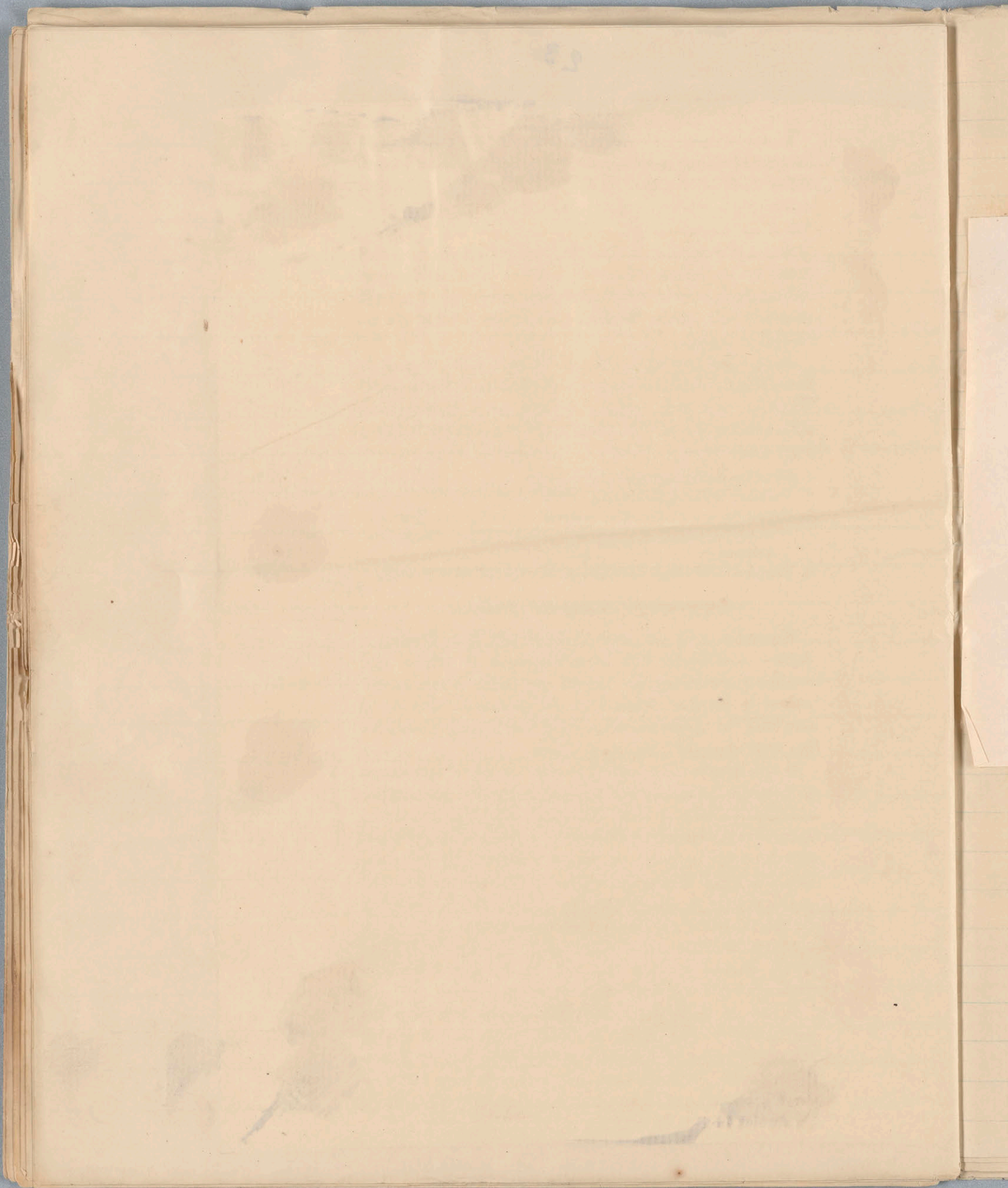
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Laboratory for Mining and Metallurgy.

Connected with the general laboratory, but forming a distinct department, will be a laboratory of mining and metallurgy, designed for special instruction in whatever relates to practical mineralogy, the chemical valuation of ores, and the operations of smelting and other processes for the separation and refining of metals.

In this department, students already trained to some extent in analytical processes will be exercised in the examination and discrimination of rocks and minerals, by mechanical and chemical tests, including a course of practice with the blowpipe; and will be taught the several methods of assaying the ores and alloys of copper, iron, lead, silver, and other useful metals, as well by the dry as the wet method; of analyzing the fluxes used in the smelting furnace, and the slags resulting from the blast; and of determining the combustible value of the mineral or other fuel with which furnaces are supplied.

In aid of these instructions, the student will have the opportunity of studying the models of mines, and of mining and metallurgical implements and machinery, and the collections of rocks, fossils, minerals, and ores, with their manufactured products, provided and arranged specially to facilitate his studies in this department.



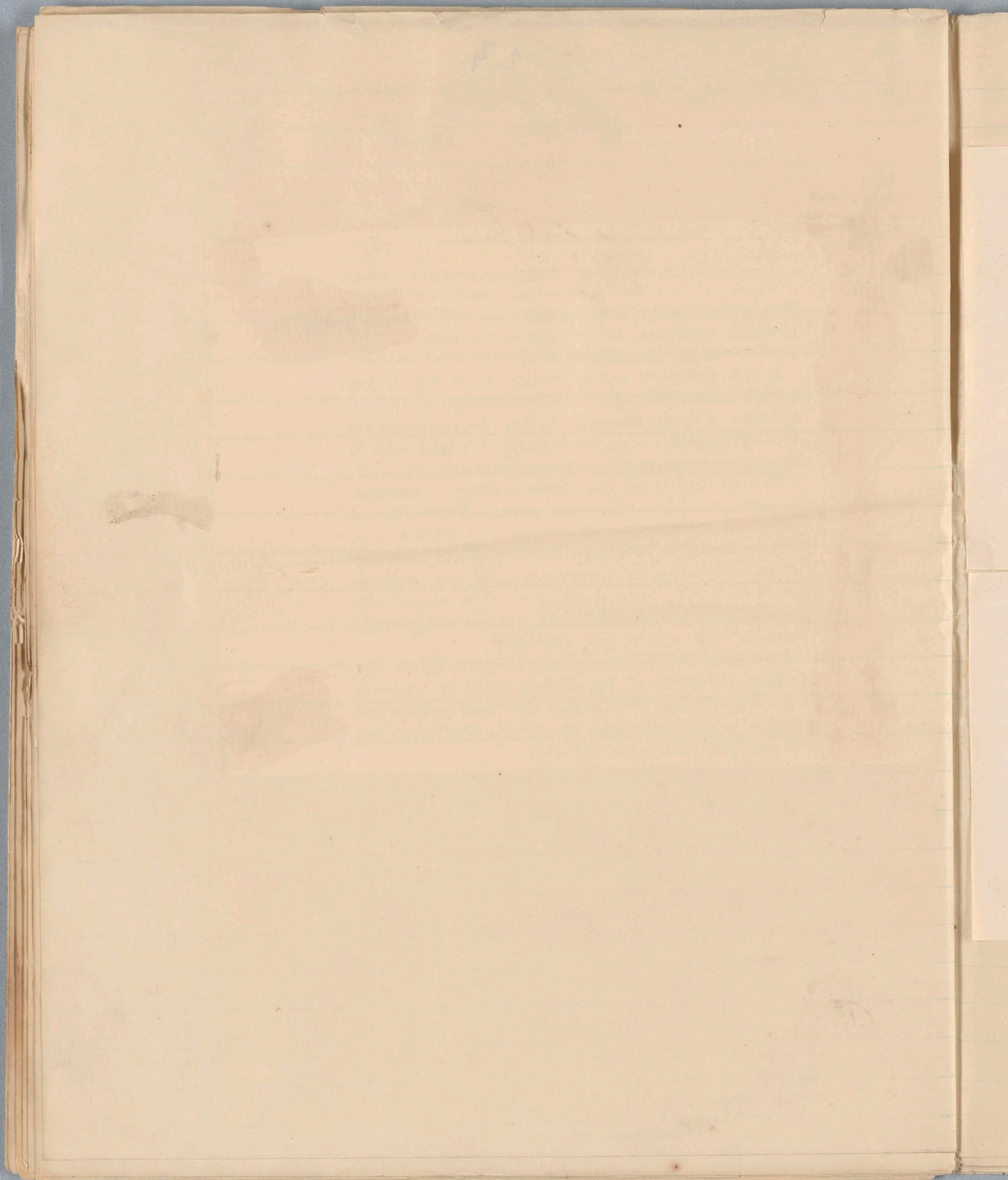
Laboratory for Industrial Chemistry.

It is further proposed to connect with the general laboratory, a department of industrial chemistry, where students may have an opportunity of becoming practically familiar with the materials, implements, and processes of the more important chemical arts and manufactures.

In this department will be provided a collection of dye-stuffs, mordants, discharges, and other substances used in the operations of dyeing, color-printing, and bleaching; together with such apparatus as may be necessary, on a small scale, to exemplify these several processes as in actual use.

Here the student will have access to suites of specimens, embracing the crude materials and products of the glass and pottery, and brick and tile manufactures, the different soaps, soda-ash, bleaching salts, acids, saline products, lakes, pigments, inks, cements, tanning substances, and other materials and products of the chemical arts; and will be provided with facilities for studying practically the re-actions and processes connected with their use and manufacture.

Provision will also be made in this laboratory for the practical illustration of the chemical modes of engraving and lithography, and for exhibiting the various methods and processes of electro-metallurgy as applied to silvering, gilding, and the deposition of copper and brass.



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EXERCISES IN DRAWING AND DESIGN

The facilities in this department, which are to be anticipated from the Lowell Drawing School, when placed in connection with the School of Industrial Science, will, it is expected, provide amply for instruction in free and general drawing, and thus furnish students with a valuable introduction and continual help in the special branches of drawing and design appropriate to the applied sciences with which they are occupied.

Instruction and practice in this department will form an essential feature in the daily duties of the School throughout most of the regular course of four years.

During this time, the students will be carried through a course of exercises in geometrical drawing, including the applications of descriptive geometry to perspective and lights and shadows, to carpentry and stone-cutting, and other practical work. They will be taught ~~cartoon~~-drawing, the projection of maps, the construction of topographical and geological sections, and the drawing of engineering constructions, and of subjects belonging to household, public, naval, and ornamental architecture. They will also be called on to execute drawings and plans of models representing the essential and the internal organs of machines, as articulations, cranks, cams, connecting-rods, fly-wheels, pistons, valves, steam-cylinders, wheel-work, entire machines of various kinds; and to prepare projets and working plans of roofs, arches, bridges, mills, furnaces, chemical works, heating and ventilating arrangements, dwellings, halls and public buildings, and other constructions; such as the mechanician, builder, engineer, or manufacturer may be called upon to devise or provide.

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In these special exercises, the students will be aided by the use of models and large drawings of the various elements of machines, of certain machines in their complete state, and of roofs, bridges, domes, buildings, and other works of mechanical and constructive engineering and architecture.

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VISITS AND EXCURSIONS FOR OBSERVATION AND PRACTICE.

In aid of the practical studies of the School, and as a means of initiating students into the actual details of the professions for which they are preparing, they will be required from time to time, in the progress of the course, assisted by one or more of their teachers, to make visits of inspection to machine-shops, engines, mills, furnaces, and chemical works, and to important buildings and engineering constructions which are within convenient reach.

With a like view, and under the same direction, they will be expected to spend a part of the vacations of the second and third years in excursions for observation and practice, extending sometimes to distant points, and so arranged as to afford to each class the experience and training most likely to be useful to them in their future pursuits.

Thus, in consonance with their special studies, they will severally employ themselves in the details of road, railway, and topographical surveys, barometric measurement, triangulation and geodetic astronomy; in taking notes and making drawings of such processes ~~of~~ machinery, works of engineering, and buildings, as are instructive or remarkable; and in making themselves practically familiar with the working details of laboratories, print-works, furnaces, forges, rolling-mills, and founderies; with the methods of geological exploration, the tracing of veins and beds, the sinking of shafts, the conduct of open and underground operations, the mechanical arrangements for raising the product to the surface and preparing it for use; and, in general, with all the processes and constructions appertaining to the practice of industrial metallurgy and the working of quarries and mines.

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