ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF THE COURSE OF INSTRUCTION.

SEPTEMBER, 1885.

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ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN CIVIL ENGINEERING.

This Course is Voluntary—It is taken up in the Second Class and is continued in the First, and extends over a period of two years. No marks are allowed for the Second Class, the whole being assigned to the First Class.

ALLOTMENT OF MARKS.

For Entire Course. 5,600 — Voluntary.

- Yearly and Intermediate Examinations..... 4,300
- Term Work. { Notes, Drawings and Recitations. } 1,300

Section I—Nature, Production and Use of Materials of Construction.

Marks.....1,900.

Sub-Section A—Materials, descriptive and processes.
Marks.....Examinations..... 400

Sub-Section B—Strength of Materials.
Marks..... { Examinations ..... 300 / Notes and Recitations 200

Sub-Section C—Stresses on Framed Structures.
Marks ..... { Examinations ..... 500 / Notes and Recitations 500

Section II—Design and Execution of Structures.

Marks.....1,900.

Sub-Section A—Field and Office Work relating to Surveys and Construction of Railways and Highways, including Locations, Drafting Culverts, Piers, Trusses, &c.
Marks ..... { Examinations ..... 600 / Notes and Recitations 400

Sub-Section B—Construction routine, Mason Work, Foundations, Line Excavations and Permanent Way Common Roads.
Marks .....Examinations 900

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Section III—*Estimating and Supervision.*

Marks .....400.

Sub-Section A—Estimating, Setting Out and Supervision of Works.

Marks .... Examinations 400

Section IV—*Hydraulic Engineering.*

Marks.....1,100.

Sub-Section A—Storage, Evaporations, flow through orifices and through pipes under pressure.

Marks .....Examinations 500

Sub-Section B—Practical Construction of Water Works.

Marks ..... { Examinations ..... 400 / Drawings and Notes. 200

Section V—*Mechanism and Prime Movers.*

Marks.....300.

Sub-Section A—Steam Engines and Water Engines.

Marks .....Examinations 300

NOTE.—If a Cadet takes *both* the Engineering *and* Architectural Courses, *one-half* only of the marks assigned to Sections I and III (being common to Engineering and Architecture) will be available for *each* subject. If he takes Engineering *only*, then the *full* marks assigned to these sections are available for that subject.

TEXT BOOKS.

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TEXT BOOKS IN CIVIL ENGINEERING.

Principally Lectures.

Rankine's Civil Engineering.
Henck on Railway Curves.
Trautwine's Pocket Book.
Fanning's "Treatise on Water Supply."

BOOKS RECOMMENDED TO BE READ.

Tate's Mechanical Philosophy.
Twisden's Mechanics.
Peck's Mechanics.
Vose on Railway Construction.
Stevenson's "Canals and Harbors."

SUMMARY OF COURSE OF INSTRUCTION IN CIVIL ENGINEERING.

1ST CLASS.

SECTION I.

Nature, production and use of materials of construction.

(Common to Engineering and Architecture.)

SUB-SECTION (A)—MATERIALS, DESCRIPTIVE AND PROCESSES.

Building stones—Their classification, by constituent elements, rather than geologically, calcareous, argillaceous and siliceous, sandstones, limestones, granites, slates, traps.

Durability of stone—Exposure to frost, to heat, to city smoke, hardness, structure, free, granular, shelly, natural or quarry bed.

Making artificial stone—Ransomes process, concrete blocks, breakwater works of North Sea canal, brick clay, mixing, moulding, burning.

Limes—Air limes, water limes, cements, materials, physical characteristics of hydraulic limestones, calcination of limestones, lime kilns, fuel slaking of lime, sprinkling, drowning, immersion, manufacture of artificial hydraulic limes and cements, importance of uniformity of quality, manufacture of Portland cement, Roman mortar, puzzolanas.

Mortar—Sand, manipulation; proportions. Setting and durability of mortars. Theory of the hardening of mortar. Tests of the strength of mortars of lime or cement. Weights per struck bushel. Time required to harden.

Concrete—Of air lime; of cement. Ingredients, definite proportions, manipulations, applications; behavior under frost.

Woods—Age and season for felling, climate, soil, structure; sap wood, heart wood; seasoning in air, water, or steam; girdling.

Decay—Wet rot, dry rot; terredo worms.

Preservation—Ground line; free air current, wet situations; kyanising; creosoting.

SUB.-SECTION (B)—STRENGTH OF MATERIALS.

Stress—Strain, Working load 'tests' set, Factors of safety, Modulus of Elasticity.

Tension—Law; experiments; tables; various woods; irons, steel.

Direct Compression—Law; experiments; tables; various woods, irons, steels.

Compression resulting in cross-breaking or collapsing—Formulas; various woods, irons, steel; solid and hollow cross sections.

Action of transverse load on a beam causing shearing stress towards abutments, causing bending moment towards middle of length of beam.

Resistance of beam to cross-breaking—Formulas, tables; various woods, irons, steel, and influence of cross section area, and form cross sections of equal strength.

Modulus of rupture of cast iron beams.

Allowance for weight of beam.

Limiting length of beam.

Proportion of greatest depth of beam to the span.

Deflection within safe limits of beam.

Expansion and contraction of beams.

Beams fixed at both ends. Beams fixed at one end.

Shearing Stress—Law; experiments; tables; various woods, irons, steels.

SUB-SECTION (C)—DETERMINATION OF STRESSES ON FRAMED STRUCTURES.—(BRIDGES AND ROOFS.)

This course is begun by considering the internal strength of beams and pillars as referred to in the part B of the Syllabus.

Resistance of a beam to crushing or buckling, Gordon's formula.

Practical problems for designing beams to support given loads when acting as pillars.

Formula for the sum of the moments of the fibres of a beam to resist cross-bending.

Formula for the sum of the moments of the fibres of a beam to resist cross-bending with a given factor of safety.

Conditions of equilibrium of any rigid body acted on by a system of forces in space.

Conditions of equilibrium of any rigid body acted on by a system of forces, for a frame.

Rankine's theorem of the equilibrium of all the forces acting on one side of a section.

Expansion of this theorem so as to form a method of sections.

Dead loads, live load, special loads, apex loads.

Effective reactions at the abutments.

Section to cut three bars.

Infinity to right or left for centre of moments.

Positive and negative rotations.

Kinds of stress—red, towards the section; blue, from the section.

Stresses on the chords.

Stresses on the verticals.

Stresses on the diagonals.
Braces—Counter braces.
Definition of the Howe truss.
Separation into systems.
Determination in detail of the stresses on every member of the Howe truss.
Designing of a Howe truss.
Testing of a Howe truss.
Position of the rolling load to produce maximum stress on the main braces.
Position of the rolling load to produce maximum stress on the counters.
Position of the rolling load to produce maximum stress on the chords.
Definition, designing, testing and calculation of the Pratt truss in iron (the Whipple.)
The Phœnixville truss and the Keystone truss.
Separation into systems.
Calculation of stresses on all members of the Phœnixville truss.
Towne's lattice truss and its defects.
Definition, designing and calculating and testing of the Warren girder.
The Fink truss.
The Bollman truss.
Practical specification for bridges of wood and iron.
Drafting various type forms of bridge trusses.
The tubular girder.
Other forms of bridge trusses.
Snow and wind pressure on bridge and roofs. Calculations of the Tay bridge.
Stresses on cranes.

SECTION II.

Design and execution of structures.

SUB-SECTION (A)—PRINCIPLES OF ENGINEERING FIELD WORK AND OF ENGINEERING OFFICE WORK, APPLIED TO SURVEYS AND TO CONSTRUCTION OF RAILWAYS AND COMMON ROADS.

RAILWAY EXPLORATIONS.

Matters influencing the choice of Route.
Organization of Staff—Ranks, duties.
Control and Payments.
Penetrating Country—Moving supplies.

Aneroid explorations—Field observations; check observations; camp observations and weather profile.

Traverses with compass or with transit along roads, rivers, watersheds, or divides. Trial lines with transit and level, or compass and level.

Handling surface—Topography, valleys, ridges, summits, crossings, passes, divides and terraces.

Governing points of a country ruling gradients and local gradients, and adding distance to lessen gradient.

Topographical notes along trial line belt of information, as to streams, roads, slopes, coasts, banks, ice-marks, freshets, river beds, foundation strata.

Approximate estimates off trial line profile—quantities, masonry, excavation, fencing.

PROJECTED LOCATIONS.

Cross sections, summit cuttings, maximum gradients and curvature, level contours, grade contours, alignment distance, and alternative projects.

Compiled profile section—Parliamentary estimates of quanties and cost—Basis for tenders from contractors.

Preparing reports, plans and profiles for Parliament.

ACTUAL LOCATIONS.

Tangents, apexes—intersections.

Reference hubs—centre stakes and pegs.

Circular curves—simple and compound degrees of curvature; calculation of lengths of curves; calculation of points of curvature; long chords and chord offsets problems flowing from curves, avoidance of obstacles closing a curve trace; limit of accuracy desirable.

Reduction of quantities of work by successive improvements of a location; shifting alignment; altering gradients.

Balancing gradients against curvature—formulas used on Canadian Government railways; on Pennsylvania railway; on Canada Pacific railway.

Analysis of mass of trials made by trunk lines advisory committee as to effects of curvature and gradients separate as well as combined upon traction of three types of locomotives.

Rules recommended to be used in future locations for balancing gradients against curvature and for undulating gradients on either curves or straights.

Balancing excavations and embankments—borrowing wasting.

Ballasting—object of ballast, qualities of ballast—tamping; surfacing; shimming; tracklaying; ties.

Rails—principles governing rail section and distance from points of support designing of a rail section, weight per yard.

Rail joints-spliced, fished, chaired or scabbarded, suspended and supported joints. The bridge joint the best. Steel compared with iron rails.

The foregoing course of railway field and office engineering is performed by the cadets in the field by their running of trial and location surveys as if they were in actual service, and the office work is performed in the same manner.

COMMON ROADS AND STREETS.

Uses—Freighting; travel; mails; intercommunication; outlets; commerce; settlement; defence. Colonization is dependent upon and is gauged by the road systems of a country.

Terms—Trunk road; high road; main road; bye road; occupation road; trail.

Routes are decided by reasons topographical, military, agricultural, commercial.

Dimensions—Tables of existing roads and streets; necessities always affecting dimensions; necessities occasionally affecting size of roads.

Surveys—Plans; estimates; reports and staff for constructing common roads are much the same as for railways of the same length.

Gradients of common roads for ascending traffic, and gradients for descending traffic; co-efficients of friction for different road surfaces; co-efficients of draught for a horse at different speeds.

Destructive agents for roads—frost; water; wind; traffic; weights; widths of tires of wheels.

Drainage of water and snow; surface water to run off; sub-water to be sucked away by low drainage; water line to be maintained not less than three feet below road surface in order to have durable road.

Road-bed and road metal.

Cross section—crowning, and footways and side ditches.

Telford's road-bed; Roman road-beds. Macadams road-bed.

Metalling—earth, gravel, broken stone; stone pavement, wood pavement, asphalt pavement, planks, corduroys.

Streets—drainage, dimensions, gradients, alignements, diagonal thoroughfares, rectangular laying off of cities, circular or concentric laying off of cities.

Systems of maintaining the common roads of a country.

Governmental, municipal, corporated individuals.

SUB-SECTION (B), CONSTRUCTION AND DESIGN IN WOOD, STONE, EARTH AND IRON.

Carpentry—Framing of wood work, mortised, scarfed, halved, spliced, fished, dowelled joints.

Beams—Solid, built up, trussed.

Pannelling—Rails, styles, surbases, cheeks and jambs.

Brick-work—English, Flemish and American bond string courses, copings, chimneys, mensuration, estimates.

Mason-work—This comprises a full course of instruction on the specifications for various classes of mason-work used on the Government railways of Canada, and is supplemented by excursions to inspect and explain existing railway structures on Canadian railways.

Process of building for mason-work of bridge piers and abutments, and culverts and cattle guards.

Designing the dimensions at base and top of piers and abutments, and the length of abutments.

Hollow abutments—Cellular; well; and arranging given quantity of masonry to give a shape of greatest strength.

Distinctive principles between "wing wall" abutments and "tower" abutments.

Calculating lengths of wing walls for retaining embankments of earth or rock of given depths, and widths and angles of repose.

Finding lengths of inclined, or of skew culverts on level or on sloping ground by the following methods:—

(1.) Experimentally with rod and level, in a manner analogous to setting out embankment slope stakes.

(2.) By finding, analytically, the point of intersection of two right lines given by their equations.

(3.) By a graphic construction.

(4.) By successively calculated approximations from an assumed length.

Retaining walls for earth and water; earth level with top of wall; earth higher than top of wall.

Dams—Stone; crib; clay; plank.

Principles for economising mason work in culverts by reducing their lengths, by using wing walls, and by raising coping and by selecting of sites.

Principles for economizing mason work in abutments by using cells, and wells and concrete.

Foundations of structures—Explanations of the different kinds of materials which have to be dealt with in founding structures.

Principles governing the permanence of foundations, set-

tlings, scour, frost, springs, piling, platforms, concrete, sand-piles.

Excluding of water from foundation areas, dams, coffer-dams, caissons, divers, pneumatic processes.

Designing and executing rock and earth excavations and embankments, tunnels, slopes, gullets, lifts, falls, chambers.

Drainage of storm and sub-water—Catchwaters; under-drains; road-bed; water tables; crowning; snow sheds.

Fencing—Post and board; block and picket; block and rail; A fence; snow fence.

Protection work—Rip-rap; cribbing and stream diversions.

Designing of iron bridges.

Sections of members of iron bridge frames.

Sections of connections for members of iron bridge frames.

SECTION III.

Estimating, setting out and supervision of Work.

Sub.-Section (A)—Construction and use of Tables of Excavation and Embankment.

The information necessary before estimate of quantities can be made for showing probable cost of a proposed public work.

Calculation of cubic contents of line cuttings and embankments, by the method of mean heights and tables.

Calculation of do do by the method of prismoidal. Formula and tables.

Calculation of do do by the method of mean areas.

Comparison of the advantages and the disadvantages of these methods as regards accuracy in theory, and accuracy in practice and time and labor of the computor.

Construction of Tables, MacNeil's.

do Canadian Pacific Railway.

Methods used on the Intercolonial Railway, the Canadian Pacific Railway, and the Quebec Government Railways for final estimates for contractors.

Setting out of Excavation and Culverts.

Measurement of line excavations, and borrow pits by level, rod and tape in the field, and degree of accuracy required setting in slope stakes, grade pegs, centre cuts and fills, gullets, &c., &c.

Setting out position and lengths of level culverts in the field.

Setting out position and lengths of inclined culverts in the field.

Four methods as shown in the preceding part of this syllabus.

Limit of the safe inclination of a culvert.

Paving to be a few inches below the original level of stream.

Gauging freshet areas, ice marks of floods.

Discharge capacities of various types of culverts.

Precautions with the foundations.

Frost level, springs, scour, wing walls, artificial foundations, &c., &c.

Methods of economizing masonry in culverts by reducing length by means of wing walls, coping, &c., &c.

ESTIMATING QUANTITIES OF MASONRY AND PAVING.

In abutments, piers and culverts off the drawings.

Tabular form for culvert quantities.

Estimates and Contracts general form for Quantities from a Railway profile.

Allowance for shrinkage, balancing, excavation and embankment waste, borrowing.

Details of items.

do prices.

Various methods of letting contracts.

Schedule of prices for limit of work.

Lump sum.

Comparison and history of these methods.

SECTION IV.

Hydraulic Engineering.

SUB-SECTION (A)—WATER SUPPLY; STORAGE EVAPORATIONS FLOW THROUGH ORIFICES AND THROUGH PIPES UNDER PRESSURE.

Introduction :—Necessity of Public Water Supplies; Physiological Office of Water; Sanitary Office of Water Supply.

CONSUMPTION.

Quantity of water required.

Statistics of consumption.

Ancient cities; European cities; American cities.

Increasing consumption.

Relations of supply *per capita* to total population.

Monthly and hourly variations in the draught.

Ratio of Monthly consumption.

Reserve for fire purposes.

RAINFALL.

The liquid and gaseous successions.
General rainfall statistics.
Climatic effects—sections of maximum rainfall.
American western rain system.
American central rain system.
American eastern coast rain system.
Influence of elevation or precipitation.
River basin rains.
Grouped rainfall statistics.
Monthly fluctuations of rainfall.
Secular do do
Local physical influences.
Uniform effect of natural laws.
Great rainfalls.
Maximum ratios of floods to rainfalls.
Volume of water from given rainfalls.
Gauging rainfalls.

FLOW OF STREAM.

Flood volumes inversely as the areas of basins.
Formulas for food volumes.
Tables of do
Seasons of floods.
Influence of absorption and evaporation upon flow.
Flow in seasons of minimum rainfall.
Summaries of monthly flow statistics.
Minimum mean and flood flow of streams.
Mean annual flow of streams.
Tables of flow equivalent to given depths of rain.

STORAGE AND EVAPORATION.

Artificial storage.
Losses incident to storage.
Sub-strata of storage basin.
Percolation from storage basin.
Evaporation loss from a reservoir.
Evaporation from water.
do sand.
do earth.
Ratios of evaporation.
Resultant effect of rain and evaporation.
Practical effect upon storage.

SUPPLYING CAPACITY OF WATER SHED.

Estimate of available annual flow of streams.

Estimate of monthly available storage required.
Utilization of flood flows.
Qualifications of deduced ratios.
Influence of storage upon continuous supply.
Artificial gathering areas.

SPRINGS AND WELLS.

Subterranean waters.
Porosity of earths and rocks.
Causes of percolations
Subterranean reservoirs.
Overflowing wells.
American artesian wells.
Supplying capacity of wells and springs.

IMPURITIES OF WATER.

Composition of water.
Solutions in water.
Mineral impurities.
Organic impurities.
Tables of analysis of potable waters.
Deep well and surface impurities.
Vegetal organic impurities.
Vegetal organisms in water pipes.
Propagation of aquatic organisms.
Purifying office of aquatic life.
Intimate relation between grade of organisms and quality of water.
Agricultural; mineral; manufacturing and sewage impurities.

WELL, SPRING, LAKE AND RIVER SUPPLIES.

Locations for wells; fouling of old wells.
Spring waters; impregnations; mineral springs.
Lake waters; impounding; plant growth.
Preservation of purity; natural clarification.
River waters; pollutions; sanitary discussions.
Spontaneous clarification.
Artificial do
Sugar test of the quality of water.

FLOW OF WATER THROUGH SLUICES, PIPES AND CHANNELS.

Weight, pressure and motion of water.
Atomic Theory—Molecular Theory.
Influence of Caloric—Relative densities and volumes.
Weight of water and its constituents.
Crystalline forms of water.

Formulæ for volumes at different temperatures.
Weight of pond water.
Compressibility and elasticity.
Weights of single molecules.
Pressure of water.
Pressure proportional to depth.
Individual molecular reaction.
Pressure from vertical, inclined and bent volumes of water.
Pressure on unit of surface.
Equivalent forces; weight on measure of pressure.
Line a measure of weight; line a measure of pressure upon a surface.
Diagonal force of combined pressures graphically represented.
Angular resultant of a force represented by sine and cosine of the angle.
Direction of maximum effect.
Pressure upon a curved surface and effect upon its projected plane.
Centre of pressure upon a circular area.
Sustaining pressures upon submerged and floating bodies.
Upward pressure from a submerged lintel.
Syphon—Inverted syphon.
Transmission of pressure to a distance.
Flow of water—Action of gravity upon.
Individual molecules.
Acceleration of motion.
Equation of motion.
Parabolic path of the jet.
Velocity of efflux proportional to the head.
Converting of the force of gravity from pressure into motion.
Resultant effects of pressure and gravity upon the motion of a jet.
Resistance of the air—Theoretical velocities.

Flow of Water through Orifices.

Theoretical volume of efflux.
Converging path of particles.
Classes of orifices.
Form of submerged orifice jet.
Ratio of minimum section of jet.
Volume of efflux—Co-efficient of efflux.
Maximum velocity of the jet.
Factors of the co-efficient of efflux.

Experimental co-efficients, from Michellotti, Bossut, Rennie, Castel, Lespinesse, Ellis.

Co-efficients diagramed.

Effects of varying the head of the proportions of the orifice.

Co-efficients of velocity and of contraction.

Variable value of velocity and contraction.

Jets of various cross-sections.

Flow of water through short tubes.

Adjutage—Vacuum of adjutage, and its effects.

Divergent tube—Inward projecting adjutage.

Experiments with cylindrical and compound tubes.

Range of Eytelwein's Tables.

FLOW OF WATER THROUGH PIPES UNDER PRESSURE.

Definitions of pipe and conduit.

Theoretical volume of discharge.

Mean efflux from pipes.

Sub-division of the head H into h, to generate velocity in pipe; h' to overcome resistance to entry; h'' to overcome resistance of pipe wall.

Resistance of the pipe wall varies directly as the length, and as (approximately) the velocity, and as (approximately) the circumference divided by a function of the area.

Variable values of co-efficient m, and its peculiarities.

Effects of tubercules.

Equation of velocity neutralized by resistance to flow.

Equation of resistance head.

Equation of total head.

Equation of diameter.

Equation of volume.

Relative value of sub-division of total head.

Classified equations for the above.

Mean co-efficients for smooth, rough, and foul pipes.

Bends.

Branches.

How to economize head.

SUB-SECTION (B)—PRACTICAL CONSTRUCTION OF WATER WORKS, RESERVOIR, EMBANKMENTS AND CHAMBERS.

Ultimate economy of skilful construction; embankment foundations; springs under foundations; surface soils; concrete cut-off walls; treacherous strata; embankment core materials; reconnaissance for site; frost covering; slope paving puddle wall; distribution reservoirs; masonry-faced embankment; embankment sluices and pipes; gate chambers; sluice valve areas; gate chamber foundations.

Retaining Walls—Equations of stability; materials; dimensions and cross-sections of retaining walls actually constructed.

Masonry conduits.

Mains and distribution pipes.

Distribution Systems—Hydrants; fire supply.

SECTION V.

Mechanism and Prime Movers.

Sub-Section A.—Steam Engines and Water Engines.

Laboring Forces—Vital, water, steam, wind.

Friction—Laws, co-efficients, tables.

Work—Measure, equality of moments, modulus.

Water Engines—Wheels, pumps, ram.

Steam—Boilers, flue, tubular Cornish.

Steam—Engines, condensing, non-condensing, direct acting, rotative, rotary, compound, the marine engine, the locomotive engine, the compound engine.

Heat—Combustion, radiation, fire grate surface, evaporating surface.

Expansion of Steam and Action of the Valves.

(*a*) Application of the calculus to find analytically the mean pressure of the steam during expansion.

Formula for work performed during expansion.

Work of steam having a mean pressure.

Work of steam considered in relation to the quantity of water evaporated.

Tables of volume of steam derived from one cubic foot of water when evaporated under different pressures.

Modes of Estimating the Power and Performance of Engines and Boilers.

Horse-power.

Duty of engines and boilers.

The indicator.

Dynamometer and gauges.

Proportions of boilers.

Evaporation powers of boilers.

The blast in locomotion.

Steam room and priming.

Strength of boilers.

Boiler explosions.

Steam passages.

Air pump—Condenser and hot and cold water pumps.

Fly-wheel.
Strength of land engines.
Strength of marine engines.

CONSTRUCTION DETAILS OF ENGINES.

Pumping engines.
Various forms of marine engines.
Cylinders, pistons and valves.
Air pump—Condenser.
Pumps, cocks and pipes.
Details of the screw and screw shaft.
Details of the paddles and paddle shaft.
The locomotive engine.

LOSS OF WORK DUE TO FRICTION OF MACHINES.

(*b*) Investigation to find analytically the work absorbed by friction of an axle in a journal.

Practical problems on the friction of an axle.

(*c*) Investigation to find analytically the work absorbed by friction on a flat pivot.

Practical problems relating to the work absorbed by the friction of turbine wheels on their pivots.

(*d*) Investigation to find analitically the work absorbed by the friction between a belt and a pully.

Calculations to find work absorbed by friction of belt on a pully.

(*e*) Investigation to find analytically the work absorbed in compressing an elastic gas, steam or air.

Application of the investigation (*e*) to the calculation of work absorbed (and given out again) by the air compressing engines of the Mont Cenis tunnel.

Application of investigation (*e*) to the calculation of the work done during expansion of a high pressure engine.

Application of investigation (*e*) to the calculation of the work done during expansion of a condensing engine.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN ARCHITECTURE.

This Course is Voluntary—It is taken up in the Second Class and is continued in the First, and extends over a period of two years. No marks are allowed for the Second Class, the whole being assigned to the First Class.

ALLOTMENT OF MARKS.

For Entire Course, 3,200. — Voluntary.

- Yearly and Intermediate Examinations. 1,900
- Term Work. — Notes, Drawings and Recitations. 1,300

Section I—*Nature, Production and Use of Materials of Construction.*

Marks.....1,900.

Sub-Section A—Materials: Description and processes.

Marks—Examinations..... 400

Sub-Section B—Strength of materials.

Marks..... { Examinations. ....300 / Notes and Recitations.....200

Sub-Section C—Stresses on Framed Structures.

Marks. ..... { Examinations..... .....500 / Notes and Recitations.....500

Section II—*History and Principles.*

Marks 200

Sub-Section A—History and Principles.

Marks—Examinations.....200

Section III—*Design and Execution of Structures.*

Marks.....700

Sub-Section A—Buildings, Domestic.
do B— do Public—Civil.
do C— do do —Military.

Marks..... { Examinations..... 300
Notes and Drawings.....400

Section IV—*Estimating and Supervision.*

Marks.....400

Sub-Section A—Measurements, quantities, prices.

Marks. ..... { Examinations..... 200
Notes and Recitations....200

NOTE.—If a Cadet takes up *both* the Architectural *and* the Civil Engineering Courses, one-half only of the marks assigned to Sections I and IV (being common to Engineering and Architecture), will be available for *each* subject. If he takes Architecture *only*, then the *full* marks assigned to Sections I and IV are available for that subject.

As both the Civil Engineering and the Architectural Courses are voluntary it is allowable for any Cadet taking the Architectural Course, to also take up additionally any such subjects or sub-sections of subjects in the Civil Engineering Course as shall carry marks for competition sufficient when added to the 3,200 marks available for Architecture, to raise the total number of marks for competition available for such Cadet to the total number 5,600 marks, available for competition for Cadets taking Civil Engineering only.

TEXT BOOKS.

Principally Lectures.

Mitchell's Elements of Architecture.

BOOKS RECOMMENDED TO BE READ.

Ferguson's "History of Architecture."

SUMMARY OF COURSE OF INSTRUCTION IN ARCHITECTURE.

1ST CLASS.

SECTION I.

Nature, Production and Use of Materials of Construction.

SUB-SECTIONS A, B, & C.

(Common to Engineering and Architecture. For details see Syllabus of Engineering Course.)

SECTION II.

History and Principles.

SUB-SECTION (A)—DESCRIPTIVE AND HISTORICAL.

Early history.
Greek architecture.
Roman do
Byzantine do
Romanesque architecture.
Mediæval pointed do
English mediæval do
Elizabethan do
Renaissance do
Modern do

SECTION III.

Design and Execution of Buildings.

SUB-SECTION (A)—BUILDING CONSTRUCTION.

GENERAL PRINCIPLES.

Foundations, natural and artificial, concrete Béton, hydraulic lime, foundations under water, piles, pile-driving, iron piles.

MASONRY.

Uncoursed rubble, course, ashlar work, through stones, bond beds, joints, tools used.

BRICKWORK.

Bricks, size, thickness of brick walls.

Principles of walling, headers and stretchers. Plans and elevations of walls in English bond. Plans and elevations of walls in Flemish bond. Plans and elevation of walls in lake and herring-bone bond.

Protection against frost, application of wall-plates, tem-

plates, discharging arches, lintels, construction of brick arches, general rule as to brick-work, tools used in brickwork.

Drawing for Bricklayers.

Drawing for bricklayers. Examples of rough arch square-headed windows, extrados, intrados, centreing, square-headed doors, with relieving arch and tie-rod, segment arched windows, Gothic arch in birch wood, with centreing.

Woodwork.

Scantling, modes of lengthening timbers, strapping, bolting, fishing, halving, scarfing, trussed girders, joints in timbers, notching, morticing, fox-tail joint, tennon.

Construction of Roofs.

Gable, hip, mansard, tie beam, rafters principal and common rafters, king-post, strap, queen-posts, arch track, straining beam, struts, purlin, determination of stresses in roofs, wind and snow pressure.

Construction of Floors.

Single floors, trimming, arch and joist, herring-bone truss, sound boards, double floors, binders, ceiling joists, framed floors, floor boards, square-edged, rebated, ploughed, tongued and dowelled.

Partitions.

Principles of construction, fire-proof, must form portion of carcass.

Joinery.

How distinguished from carpentry, mitre-joint, dove-tail joint, staircase, general construction, bracket staircase, dog-legged staircase.

Fire-Proof Construction.

Behavior of various building materials under fire, fire-proof layers.

General Arrangements.

Cellars, drainage, sewerage connections, ventilation, traps, warming, water supply, ready egress in case of fire, doors opening outwards.

Sub-Sections B and C.

Sub-Section A will be continued so as to embrace the designing of domestic buildings and of public buildings, for civil and military purposes.

SECTION IV.

Sub-Section (A)—Methods of Estimating Quantities in Buildings.

Stone work, brick work, wood work, plastering, slating, shingling, painting, glazing.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN ARTILLERY.

ALLOTMENT OF MARKS.

For Entire Course. 4,560	Obligatory		3,000
	Voluntary		1,000
	Drill		400
	Communicating Drill (N. C. Officers only)		160
For 3rd Class.	Obligatory—Yearly and Intermediate Examinations		1,500
	Drill		200
For 2nd Class.	Obligatory—Yearly and Intermediate Examinations		1,500
	Voluntary—Yearly Examinations	A	350
		B	500
		C	150
	Drill		200
For 1st Class.	Communicating Drill (N. C. Officers only)		160

TEXT BOOKS AND BOOKS OF REFERENCE.

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TEXT BOOKS :

Practical and Theoretical Course.

Handbook of Artillery Matériel (*Morgan*).
Manual of Siege and Garrison Artillery Exercises.
Notes on Ordnance, carriages, &c.
Treatise on the Construction of Ordnance (Royal Gun Factory) 1879 (Voluntary).
Treatise on Carriages (Royal Carriage Department) 1879 (Voluntary).
Sladen's Gunnery (Voluntary).
Tracts on Mechanics (Voluntary).

BOOKS OF REFERENCE :

Treatise on Ammunition (R. L.)
Instructions for the Service of the Siege Train.
Field Artillery Exercises (Royal Artillery and R. H. A).
Notes on Manufacture of Gunpowder and Guncotton.
Reports of Experiments with Bashforth's Chronograph.
The Penetration of Iron Armour by Steel Shot (*Noble*).
Owen's Modern Artillery.
Transactions of Royal Artillery Institution.
Reports of the Department of Director General of Artillery.

SUMMARY OF INSTRUCTION IN ARTILLERY.

—o—

Each Cadet fires annually three rounds of Segment Shell, two with percussion and one with time fuze.

Both the practical and theoretical courses are carried on simultaneously during the 2nd and 3rd Terms.

PRACTICAL COURSE.

THIRD CLASS.

(OBLIGATORY.)

Standing gun drill and simple manœuvres of a Field Battery. Disabled ordnance. Drill of Garrison guns on standing carriages and on traversing platforms. Mortars. Drill with Armstrong B. L. R. 6 Pr. and 7-inch guns.

Making up ammunition.

SECOND CLASS.

(OBLIGATORY.)

Material and appliances, knotting and splicing.

Elementary shifts of ordnance, such as slewing, pinching, rowing, raising a gun on skidding, parbuckling and moving a gun on rollers, and on temporary sleighs.

Gyns and sheers.

Special marks for N. C. Officers as Drill Instructors in First Class, 160.

THEORETICAL COURSE.

THIRD CLASS.

(OBLIGATORY.)

Brief History of Artillery to the present day.

Definitions of various terms in Gunnery.

S. B. ORDNANCE.

PRINTED NOTES:

Guns, Howitzers, Mortars and Carronades.—A short description of their natures and uses. The names of the different parts of a gun.

Chambers.—Cylindrical and gomer.

Vents.—The necessity for a vent "bush," "The cone" and "through" vent.

Sighting S. B. Ordnance.

The various lines on a smooth bored gun.

Dispart. Line of metal elevation. Clearance Angle.
Means of giving direction and elevation.
Wooden and brass tangent scales.
Millar's Sights.
Mode of graduating sights.
Examination of S. B. Ordnance.

RIFLED ORDNANCE.

Text Book, Morgan's Treatise.

CHAPTER I—METALS USED IN GUN CONSTRUCTION:

Cast iron, wrought iron, steel, bronze.

CHAPTER II—RIFLED MUZZLE-LOADING BUILT-UP-GUNS:

Construction, process of manufacture, rifling, chambering, sights and fittings, vents, designation, examination, classification.

CHAPTER III—RIFLED MUZZLE-LOADING CONVERTED GUNS—OLD PATTERN R. B. L. GUNS:

R. M. L. converted guns, process of conversion, sights, examination, old pattern R. B. L. guns, construction, breech fittings, rifling, sights, converted 35 cwt. 40 Pr. R. B. L. gun, examination.

CHAPTER IV—NEW TYPE BREECH-LOADING GUNS:

Construction—breech mechanism, systems of obturation, vents, rifling, chambering, manufacturing operations, natures, examination.

December, 250 marks.

AMMUNITION.

CHAPTER V—GUNPOWDER CARTRIDGES, &C.:

Gunpowder, composition, advantages, density; natures of gunpowder; classes; gun-cotton; detonating compositions, cartridges cases and barrels. Precautions to be taken in making up ammunition.

CHAPTER VI—PROJECTILES:

Projectiles for R. M. L. Ordnance, general description.

Armour-piercing projectiles, common and double shell, shrapnel shell, case shot, star shell, studded projectiles for R. M. L. Ordnance, description; service gas check for ditto. Studless projectiles for R. M. L. Ordnance and automatic gas-check, description; altered studded projectiles, studless Palliser shell, projectiles for 16 in. and 12·5 in. new line projectiles for old-pattern Armstrong R. B. L. Guns.

Natures, segment shell, common shell, shrapnel shell and case shot.

Projectiles for Smooth-Bore Ordnance, natures, &c.

Projectiles for new pattern B. L. Guns.

CHAPTER VII—FUZES, TUBES, &C.:

Fuzes for rifled Ordnance, wood time fuzes; description, M. L. wood time fuzes; wood time fuzes with detonators; remarks on wood time fuzes; percussion fuzes for rifled ordnance; Description, Pettman's G. S. fuze, R. L. fuze; large percussion fuze; small percussion fuze; B. L. plain fuze; direct action fuze; delay action fuze; time and concussion fuzes.

Fuzes for S. B. Ordnance. Friction tubes. Vent sealing tubes, Abel's electric fuze; electric fuzes and detonators; safety fuze; quick and slow match; hortfires; wedge wads; tin cups; primers; Hale's war rockets; disabling guns.

March, 250 marks. Repeat course in June, 1,000 marks.

SECOND CLASS.

(OBLIGATORY.)

MILITARY CARRIAGES.

FIELD AND SIEGE CARRIAGES.

TEXT BOOKS:—

Morgan's Treatise and Manual of Siege Artillery Drills.

Printed Notes:—

Principles of construction, pointing out the considerations that govern the height of wheels and the dimensions of the various parts.

The effect of firing on a field or siege carriage.

Considerations by which the various strains on a field gun carriage may be minimized.

Advantages and disadvantages of iron as compared with wood for the construction of a gun carriage.

Construction of wheels and axles, naming the various parts. The *dish* of a wheel and why necessary. The inconveniences arising from the *dish*, and how they are overcome. Definition of *hollow, lead, strut and set.*

Description of the "old pattern" and "new pattern" or "Madras" wheel, pointing out the great advantages of a metal over a wooden nave.

Classification of wheels and axles.

Wooden Carriages.

Description of the carriage for a 40-pr. B. L. R. gun, with traversing saddle.
Points of difference between this and the carriages for S. B. guns.
Limber for above gun carriage.
Description of the mode of shifting shafts for single or double draught and four abreast. Pole *versus* shaft draught.
The question of driving with reins or from horse's back.
The ammunition waggon.
The heavier natures of wooden carriages.
Mortar beds.

Iron Carriages.

The carriage for the 9-pr. R. M. L. gun, Mark II, described in detail, it being the pattern on which all the larger ones are constructed.
The limber for above, its boxes and fittings.
The proposed "Limber System" of carrying ammunition.
The ammunition waggon and its fittings.
Carriage for 12-pr. B. L. gun.
The chief points of difference between the above carriages and those for the 16-pr., 25-pr., 40-pr. and 6·6-in gun.
The overbank attachment and its uses.
The carriages and beds for the howitzers, 40-pr. B. L. converted.
Methods of checking excessive recoil in field and siege carriages, hydraulic buffers and achorages, breaks, &c.

Siege Platform, &c.

The ground platform; Clarke's platform; special platform for the howitzer beds.
Detail of carriages, &c., in a siege unit.
The various other artillery carriages, such as *sling* and *platform waggons, general service waggons, forage waggons, &c.*

Garrison Carriages and Platforms.

General principles of construction.
Wooden carriages and platforms.
The garrison standing carriage, with Allen's break.
The rear chock carriage.
The sliding carriage and wooden compressor, both dwarf and casemate.

Traversing Platforms.

The common, dwarf and casemate platform.

Racers and pivots, real and imaginary.

IRON CARRIAGES AND PLATFORMS.

Wrought iron standing carriage.

Single plate construction of sliding carriages.
The Elswick compressor.
The double plate construction of sliding carriages.
Vavasseur's carriage.
The small port carriage.
The hydraulic buffer.
The elevating screw and quoins.
Worm wheel elevating gear.
The arc and indicator.
Iron traversing platforms, pivots and racers.
Various methods in use for running in and out, traversing and loading guns. Mantlets.
The Moncrieff system, its advantages and disadvantages.
The preservation and care of carriages and their parts.

December, 250 Marks.

ELEMENTARY GUNNERY.

(MANUAL OF ARTILLERY EXERCISES AND PRINTED NOTES)

PART I.—SECTION I.

Definition of Gunnery Terms.

SECTION II.—THE GUN.

1. Material for ordnance.
2. Rifling.
3. Muzzle *versus* breech-loading.
4. Proportion of weight to calibre.

SECTION III.—THE CHARGE.

1. Gunpowder and its action on the bore of a gun.
2. Quality of the ingredients.
3. Porportion of the ingredients.
4. Density.
5. Hardness.
6. Proportion of moisture.
7. Size of grain.
8. Amount of space occupied by charge.
9. Point of ignition of charge.
10. Length of the bore of the gun.
11. Size of the powder chamber.
12. Calibre.

13. Amount of the charge.
14. Weight of the projectile.
15. Windage.
16. Rifling.

Short description of the methods of measuring pressure in the bore and the velocity of the projectile.

THE PROJECTILE.

THE FORCES ACTING ON A PROJECTILE IN THE BORE OF A GUN.

The force of projection of the powder gas.
The rotation imparted by the grooves.

THE FORCES ACTING ON A PROJECTILE DURING FLIGHT.

The force of projection.
The force of gravity.
The resistance of the air.
The rotation due to rifling.
The rotation of the earth.

VARIABLE FORCES ACTING ON A PROJECTILE.

Variability of the charge.
Variability of space occupied by charge in bore.
Difference of level wheels.
Force and direction of wind.

ARTILLERY FIRE.

(MANUAL OF ARTILLERY EXERCISES.)

PART I.—SECTION VI.—FIELD ARTILLERY.

Effect and use of projectiles.

Shrapnel shell.
Common shell.
Firing at moving objects.
Practice with reduced charges.
Use of range tables, times of flight, angles of descent.

PART III., SECTIONS IX AND X.—SIEGE ARTILLERY.

METHOD OF LAYING,—

A. When object is visible.
1. The tangent scale is used.
B. When object is visible from battery, but not from gun.
2. Laying by plumb line.
3. Laying by hanging scales and quadrant.
4. Laying by an auxiliary mark in front.
5. Laying by an auxiliary mark in rear.

6. Laying by Capt. French's scales.
7. Laying on plumb line and mark to rear with service sights.
8. When object is not visible from battery.
8. Obtaining line of fire.
9. Laying the gun.
10. Firing by night.

PROJECTILES USED FROM SIEGE GUNS,—

Their mode of use and effect.
Common shell.
Battering shell.
Shrapnel, case and star shells.
Observations on the effects of fire.
Mode of using rockets.

PART I., SECT. VI.—GARRISON AND COAST ARTILLERY.

Land fronts and sea fronts.
Nature of work to be done.
Principal projectiles—Palliser shot and shell.
When each will be used.
Common shell.
Shrapnel and case.
Notes on penetration of iron plates by chilled projectiles.

DESCRIPTION AND USES OF "RANGE FINDERS," —

PART IV., SECT. IV.,—

And "Siege Train Manual" and "Field Artillery Drill Book."

Nolan's and Watkins range finders.
Principle of Weldon's range finder; the objections to its general use.
The hydroclinometer for elevated batteries.
Arming batteries by night.
Hasty disablement and destruction of ordnance.

March, 250 marks.

MANUAL GARRISON ARTILLERY.—VOL. II

PART V.—

Material and appliances.

PART VI.—

Elementary instruction.

PART VII.—

Machines and transporting carriages.

PART VIII.—

Moving, mounting and dismounting ordnance, carriages and platforms.

PART IX.—

Gun sleighs.

PART X.—

Sheers and derricks.

Repetitionand completion, in June, 1,000 marks.

SECOND CLASS.

SECTION A.—(VOLUNTARY.)

CONSTRUCTION OF CARRIAGES, &c., IN ROYAL ARSENAL

PRINTED NOTES.

Machinery—Steam hammer.
Notes on the various woods, British, and Foreign, used in the construction of carriages, &c.
Form and quality of iron used, tests used.
Nature of bronze used.
Care and preservation of leather, &c.
Sizes of cordage and uses.

MANUFACTURE OF PROJECTILES AND FUZES.

Selection of iron for shells. Preparation of core and mould.
Casting of common shell and shrapnel.
Peculiarities in the manufacture of Palliser projectiles.
Fitting studs and gas checks.
Lacquering inside of shell.
Construction of wooden and metal time fuzes.
Construction of tubes, port fires and rockets.
Various laboratory compositions.

NOTES ON THE MANUFACTURE OF GUNPOWDER.

Manufacture of gun powder.
Manufacture of gun cotton.

SECTION B.—(VOLUNTARY.)

SLADEN'S PRINCIPLES OF GUNNERY.

CHAPTER I.

Definition of terms used in gunnery.

CHAPTER II.

Relation between and problems upon the "angle of spiral" and "twist of rifling." Velocity of Rotation determined

from that translation. Energy due both to translation and rotation, omitting the note to pages 15, 16. Velocity of recoil without noticing the weight of the cartridge and without the considerations in pages 18, 19, which should, however, be read over, the causes of inaccuracy being noticed. Energy of recoil, omitting the cartridge as before. Omit Major Kemmis' table.

CHAPTER III.

Pressure in the bore of a gun.

CHAPTER IV.

Work done by a charge of powder, omitting the table of work and its applications. "Factor of Effect." Velocity in the bore and muzzle velocity, omitting details in pages 31, 32.

CHAPTER V.

Resistance of the air. History up to Bashforth's experiments and conclusions. Calculations leading to $v = \frac{V}{1 + c\,Vs}$ and to the tables of remaining Velocity. Practical use of these tables. Consider the table of K, page 48. Omit table page 54.

CHAPTER VI.

Calculation of Trajectories; vertical height and angle of descent. Omit pages 69 to 84.

CHAPTER VII.

Drift of elongated projectiles. See also manual of Canadian Artillery.

CHAPTER VIII.

Probability of fire.

CHAPTER IX.

Penetration of projectiles. General principles without detail.

APPENDIX.

General acquaintance with the principles of Le Boulengé's Chronograph; Bashforth's Clock and gravity Chronograph; Watkin's Electric Chronograph; Chrusher Gauge and Chronoscope.

Section C.

(Tracts on Mechanics, Part III.)

Application of mathematics to artillery machines, including tackles and purchases; hydraulic and other jacks; elevating screws; triangle gyn, shears, derricks, &c.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN FRENCH.

ALLOTMENT OF MARKS.

For entire Course (Obligatory).....3,000

4th Class.

Marks (Obligatory).....500 { Examinations .....100 / Notes and Recitations...400

3rd Class.

Marks (Obligatory).....600 { Examinations .....150 / Notes and Recitations...450

2nd Class.

Marks (Obligatory).....800 { Examinations ....200 / Notes and Recitations...600

1st Class.

Marks (Obligatory)...1,100 { Examinations .....250 / Notes and Recitations...850

TEXT BOOKS USED.

Contanseau's French Dictionary.
do Grammar.
French Classics, Gustave Masson.
Horace, Corneille.
Cinna do.
Les Écrivains Militaires de la France, Karcher.
Histoire de Charles XII.
Frederick the Great, by Lord Macaulay.
Le Page's "French Master for beginners."
do "Petit lecteur des colleges."
do "Jugevile treasury of French conversation."
Guilgault's Hand Book of French.

SUMMARY OF COURSE OF INSTRUCTION IN FRENCH.

Grammar; reading; dictation; exercises for translation from French into English, and English into French; vocabularies and conversational lessons; comparison of the most usual French and English idioms.

The exercises are graduated in difficulty, according to the ability of cadets.

Special importance is attached to the acquisition at an early stage of the knowledge and correct pronunciation of the sentences, most ordinarily employed in conversation.

A complete course of literature is also given for those who sufficiently understand the French language.

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SYLLABUS OF INSTRUCTION IN PHYSICS.

ALLOTMENT OF MARKS.

For Entire Course.

Obligatory.	Examination	1,200	Total. 2,500
	Recitation	300	
Voluntary.	Examination	1,000	

For Second Class.

Obligatory.	Examinations	400	Total. 700
	Recitation	100	
Voluntary.	Examinations	200	

For First Class.

Obligatory.	Examinations	800	Total. 1,800
	Recitations	200	
Voluntary.	Examinations	800	

NOTE.—In order to quality for *any* Certificate of Graduation or for "Pass" in *Physics*, a Cadet must study *in the Second Class*, the course of *Elementary Inorganic Chemistry* of that Class.

TEXT BOOK.

Ganot's Physics translated by Atkinson (eleventh edition.)

SUMMARY OF INSTRUCTION IN PHYSICS.

CLASS II

EXPERIMENTAL PHYSICS.

(OBLIGATORY.)

Matter: its constitution and physical conditions. Atoms and molecules. General properties of matter. Units of measurement. The metric system.

Energy: its varieties, transmutation and conservation.

Atomic and molecular forces. Chemical affinity, cohesion and adhesion. Elasticity of traction, torsion and flexure. Universal attraction; its laws. Terrestral gravitation, and causes modifying its intensity.

Hydrostatics—

General character of liquids. Equality of pressures. Laws of pressure. Pressure independent of shape of vessel. Hydrostatic paradox. Condition of the equilibrium of liquids. Hydraulic press. Water and spirit level. Artesian wells.

Principle of Archimedes. Equilibrium of floating bodies. Specific gravity. Hydrometers.

Capillarity: its laws and explanation of capillary phenomena. Endosmose, diffusion.

Pneumatics—

General properties of gases. Atmospheric pressure. Toricelli's and Pascal's experiments. Different kinds of barometers. Corrections of barometers for capillarity and temperature. Barometric variations.

Measurement of elastic force of gases. Boyle's law. Manometers. Aneroid barometer.

Archimedes' principle applied to gases. Air balloons. Air-pump, Bianchi's, Sprengel's, Bunsen's and Morren's: Gauge and Babinet stopcock. Uses of air-pump. Condensing pump. Suction and force pumps. Fire engine. Fountain in vacuo. Intermittent fountains. Velocity of efflux. Quantity of efflux. Direction, form and height of jet. Water wheels and turbines.

Sound—

Sound and noise. Cause of sound. Propagation, intensity, velocity, reflection and refraction of sound. Echoes and resonances. Speaking and ear trumpet. Stethescope. Measurement of number of vibrations. Savart's apparatus. Syren. Limit of perceptible sounds.

Musical tones. Pitch, intensity and timbre. Diatonic scale, semitones, chromatic scale. Number of vibrations producing each note. Musical notation.

Wave length. Production and perception of sound. Vibration of strings. Nodes and loops. Wind, mouth, reed and stringed instruments. Chemical harmonicon. Phonograph.

VOLUNTARY.

Motion in a circle. Centrifugal force.

Work; measure of work; unit of work.

The Balance. Conditions to be satisfied in its construction.

Atwood's and Morin's machines for verifying laws of falling bodies. Compound pendulum.

Sound —

Calculation of the velocity of sound in gases. Velocity of sound in various gases. Doppler's principle.

Compound musical tones and harmonics. Helmholtz's analysis of Sounds. Beats. Musical chords.

Verification of laws of transverse vibrations of strings. Nodes and loops of an organ pipe.

Vibrations of rods, plates and membranes. Graphical method of representing vibrations. Phonautograph. Manometric flames.

Text Book.—Ganot's Physics; books 1st and 2nd (selected portion) and books 3rd, 4th and 5th.

CLASS I.

OBLIGATORY.

Heat.—Theories of emission and undulation. General effects of heat. Expansion. Temperature. Thermometers, their manufacture and graduation. Comparison of Fahrenheit, Celsius and Reaumur scales. Corrections on readings of thermometers. Alcohol, differential and metallic thermometers. Maximum and minimum thermometers. Pyrometers.

Linear and cubical expansion; coefficient of expansion. Practical application of principle of expansion. Compensation pendulum and balance.

Expansion of liquids. Force exerted by liquids in expansion. Maximum density of water.

Expansion of gases; its laws. Practical application. Air thermometers. Density of gases.

Fusion; influence of pressure. Latent heat of fusion. Solidification and circumstances retarding it. Change of volume on solidifying. Freezing mixtures.

Vaporization. Elastic force of vapors. Evaporation. Ebullition and circumstances affecting it. Papin's digester.

Latent heat of ebullition. Cold due to evaporation. Carré's refrigerators.

Distillation. Liquefaction of gases. Spheroidal condition. Hygrometric state of atmosphere. Hygrometers.

Conductivity of solids, liquids, and gases. Applications.

Radiation of heat; its laws. Newton's law of cooling. Reflecting, radiating and absorbing powers of substances.

Dynamical theory of heat. Thermal spectrum. Transmutation of obscure rays. Application of properties of absorbing, emitting, and reflecting heat. Radiometer.

Thermal unit. Specific heat. Dulong and Petit's law.

Steam engine. Double and single acting engines. Locomotives. Low and high pressure engines. Hot air and gas engines.

Sources of heat; friction, pressure, percussion, chemical action. Solar and terrestrial heat.

Methods of heating; open fire-places, stoves, steam, hot water. Cold produced by expansion of gases. Absolute zero. Dissipation of energy.

Light.—Definitions. Theories of light. Propagation of light. Shadows. Images produced by small apertures. Velocity of light. Laws of intensity. Photometer.

Reflection; its laws. Formation of images by plane mirrors. Virtual and real images. Multiple images. Diffused light. Concave and convex mirrors; their foci and images. Parabolic mirrors.

Refraction; its laws and effects. Total reflection. Mirage. Prism, and its effect on light.

Lenses; their effect on light, foci, and formation of images. Relative magnitude of image and object. Laryngoscope.

Solar spectrum. Recomposition of white light. Color. Mixed and complementary colors. Spectrum and pigment colors. Homogeneous light. Properties of spectrum. Spectroscope and its application.

Microscope, simple and compound.

Telescope, astronomical and terrestrial.

Camera obscura and lucida. Magic lantern. Solar microscope. Photographic apparatus.

The eye—its parts; path of rays; inversion of images; visual angle. Estimation of distance and size. Distance of distinct vision. Accommodation. Stereoscope. Persistence of impression on retina. Use of eye-glasses. Opthalmoscope.

Magnetism.—Definitions. Theories of magnetism. Magnetic induction. Coercive force.

Directive action of earth on magnets. Terrestrial and magnetic couple. Declination and its variation. Mariner's

compass. Inclination. Astatic needle. Intensity of earth's magnetism. Laws of attraction and repulsion. Magnetic curves.

Methods of magnetising; single, separate and double touch and action of earth. Magnetism of iron ships. Magnetic battery. Circumstances influencing the power of magnets.

Statical Electricity.—Developed by friction, pressure, cleavage, heat. Conductors and insulators. Positive and negative electricity. Theories of Electricity.

Laws of Electrical attraction and repulsion. Distribution of electricity. Loss of charge.

Induction. Limit to its action. Motion of electrified bodies. Electroscopes.

Electrophorus. Plate and cylinder electric machines. Maximum of charge. Holtz's electrical machine. Electric spark. Electric chimes and whorl.

Condensers. Slow discharge and instantaneous. Fulminating plate. Leyden Jar. Residual charge. Electric battery. Condensing electroscope.

Electric discharge; its physiological, luminous, heating, magnetic, mechanical and chemical effects.

Dynamical Electricity.—Galvani's and Volta's experiments. Electricity from chemical action. Voltaic couple. Electromotive series. Electrodes. Voltaic pile. Wollaston's battery, Enfeeblement of current. Daniell's, Grove's, Bunsen's and Leclanche's batteries. Amalgamation of plates. Dry piles.

Detection and measurement of Voltaic currents. Multiplier. Tangent and sine galvanometer. Ohm's law.

Heating, luminous and chemical effects of current.

Electric light; its properties and intensity. Electrolysis. Electroplating.

Action of currents on currents, of magnets on currents and currents on magnets. Ampère's theory of magnetism. Magnetization by currents. Electromagnets.

Telegraphy. Single needle and dial telegraph, and Morse-Sounder. Electric alarum and clocks. Electromotor.

Induction by currents. Lenz's law. Induction by magnets. Extra current. Property and laws of induced currents.

Magneto-electrical machines; commutator. Ruhmkorff's coil, and effects produced by it. Geissler's tubes. Telephone.

Principles of diamagnetism and thermo-electricity.

Meteorology.—Winds; their direction, velocity, cause and rotation.

Fogs and mists, clouds, rain, waterspouts.

Influence of aqueous vapour on climate.

Dew, hoar-frost, snow, sleet, hail, glaciers.

Atmospheric electricity, cloud electricity, lightning, thunder, return shock, lightning conductors, rainbow, aurora borealis. Climate and influences modifying it.

VOLUNTARY.

Heat.—Measurement of coefficient of linear expansion. Measurement of absolute and apparent expansion of mercury, and coefficient of expansion of glass. Correction of barometric and thermometric readings. Determination of the expansion of gases and density of vapours.

Tension of aqueous vapour and of mixed vapour. Laws of mixtures of gases and vapours.

Recent researches in liquefaction of gases.

Measurement of radiant heat. Reflection of heat. Transmission of heat rays. Influence of nature of heat and character of screen on transmission. Diffusion of heat. Relation of gases and vapours to radiant heat, and of absorption to molecular state.

Measurement of specific heat of bodies by fusion, mixture and cooling. Specific heat of gases. Calorimeters. Mechanical equivalent of heat.

Light.—Fizeau's method of determining velocity.

Formulæ for spherical mirorrs. Heliostat.

Measurement of index of refraction in solids, liquids and gases. Spherical aberration. Caustics.

Formulæ relating to lenses. Combination of lenses. Fluorescence and phosphorescence. Achromatism of microscope. Galileo's, Newton's, Gregory's and Herschell's telescopes. Photo-electric microscope. Lighthouse lenses. Stereoscopes.

Undulatory theory of light; its explanation of reflection and refraction. Double refraction.

Interference of light. Diffraction. Newton's rings. Polarization, its effects. Saccharimeter.

Magnetism.—Declination and inclination compass. Methods of determining laws of magnetic attraction and repulsion. Total action of two magnets on each other. Determination of magnetism in absolute measure. Portative force of magnets.

Frictional Electricity.—Electric density. Potential and capacity and their measurement. Potential of a sphere.

Faraday's experiments on induction and theory of induction. Specific inductive capacity.

Armstrong's hydro-electric and Carré's dielectric machine.

Limits to charge of condensers and calculation of condensing force. Charging by cascade. Measurement of charge of a battery. Laws of electric charge Thomson's quadrant

and absolute electrometers. Potential of a Leyden jar. Heating effects of electric discharge. Application in firing mines. Duration of electric spark. Velocity of electricity.

Dynamical Electricity.—Electromotive force. Recent forms of voltaic battery. Gravity batteries. Comparison of power of different batteries. Marine galvanometer. Arrangement of battery for maximum effect.

Laws of heating effects of current. Regulators for electric light. Comparison between tangent galvanometer and voltameter. Polarization. Gas battery.

Laws of angular and sinuous currents. Rotation of currents by currents and by magnets. Directive action of earth on currents.

Writing telegraph. Duplex telegraphy. Earth current. Induction in telegraph cables. Electromagnetic machines.

Inductive action of Leyden discharge, of magnets on bodies in motion, and of earth.

Magneto-electrical machines: Clarke's, Wild's, Ladd's and Gramme's. Siemen's armature.

Microphone. Tasimeter.

Diamagnetism.

Different forms of thermo-electric batteries. Electrical thermometer and pyrometer.

Determination of electric constants.

Meteorograph.

Text Book.

Ganot's Physics. Books 6th to 1

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN CHEMISTRY.

ALLOTMENT OF MARKS.

For Entire Course.

Voluntary.	Examinations	2,200	2,500
	Recitations	300	

For Second Class.

Obligatory.	Examinations	400	500
	Recitations	100	

For First Class.

Voluntary.	Examinations	Inorganic Chemistry	650	2,000
		Organic Chemistry or Chemistry of Metals	550	
		Laboratory	600	
	Recitations		200	

NOTE,—In order to qualify for any Certificate of Graduation, or for "Pass" in *Physics*, a cadet *must* study in the *Second* Class the course of *Elementary Inorganic Chemistry* of the Class

TEXT BOOK.

Bloxam's Chemistry—Inorganic and Organic (fourth edition.)

SUMMARY OF INSTRUCTION IN CHEMISTRY.

CLASS II.

INORGANIC CHEMISTRY.—VOL UNTAR

General principles. Constitution of matter.

Solid, liquid and gaseous condition of matter.

Elements and their classification. Symbols and atomic weights.

Chemical affinity. Chemical combination and mechanical mixture. Solution.

The non-metallic elements: their occurrence in nature, physical and chemical properties, and modes of preparation. Compounds of these elements with each other and with the metals.

Water.—Its decomposition by the galvanic battery, heat, electric spark and chemical action. Constituent elements of water, and their relative weight and volume. Laws of definite proportion—atomic theory.

Hydrogen.—Illustration of its properties, physical and chemical. Diffusion. Theoretical unit of weight and volume. Hydrogen a metal.

Oxygen.—Its history, source and properties. Carbon, phosphorus, sulphur, potassium, iron and zinc burnt in oxygen; differences in the emission of heat and light, and in the character of the products. Oxides, anhydrides, acids, bases and salts. Rôle of oxygen in nature; combustion. Chemical notation and nomenclature. Use of formulæ and equations. Relation of volume of a gas to temperature and pressure.

Analysis and *Synthesis of Water.*—Explosive gaseous mixtures. Oxyhydrogen blow-pipe. Different varieties of water in nature. Tests for its purity and hardness. Presence of organic matter. Action on lead. Petrifying springs; stalactites. Chemical relations of water. Hydrates, efflorescence, deliquescence, crystallization, distillation. Peroxide of hydrogen. Ozone, its production and properties.

Nitrogen.—The air, its constituents and methods of analysis; Eudiometry. Rôle of its several components. Uniformity of composition, how maintained. Proof that air a mechanical mixture.

Carbon.—Natural and artificial varieties. Allotropes. Diamond, its cutting, polishing, valuation and uses; how distinguished from other substances; proof that diamond is pure carbon. Graphite, its uses. Amorphous carbon; different varieties and their applications in the arts. Peculiar value of lampblack as a printing material. Imperfect combustion of

wood in meilers or retorts. Absorption of odors, gases and coloring matters by carbon. Coal, its varieties and their special uses. Products of combustion. Smoke nuisance.

Carbonic Anhydride.—Evolved in respiration, combustion, fermentation, putrefaction, &c. Effect on flame and life; ventilation. Relation of animal and vegetable world to carbonic acid; effervescent drinks. Babcock's extinguisher; liquefaction of carbonic anhydride; carbonates; analysis of carbonic anhydride and of organic substances.

Carbonic Oxide.—Its formation in fires and furnaces; poisonous and other characters. Loss of heat by incomplete combustion; composition by volume and weight of carbonic oxide.

Marsh gas. Explosions in coal mine; safety lamps.

Chemistry of fuel; temperature of ignition and temperature of combustion. Chemistry of the lamp and the candle; structure of flame; conditions necessary to render flames luminous and smokeless; Bunsen burner. Blow-pipe flame. Reduction and oxidation. Hot blast blow-pipe.

Coal Gas.—Its production and purification. Description of gas works. Subsidiary products in distillation of coal.

Silicon.—Silica: varieties in nature, crystallized and amorphous. Dialysis. Silicates: methods of fusion. Varieties of glass and their composition. Annealing, coloring and enamelling of glass. Manufacture of glass utensils.

Boron.—Borax, boracic acid.

General Characteristics of Carbon Group of elements.

Ammonia.—Preparation of the gas and its properties. Extraction of salt from the ammoniacal liquor of gas-works. Liquor ammoniae. Liquefaction of ammonia. Ammonia refrigerator. Ammonium theory. Salts of ammonium. Analysis of ammonia. Atomic weight and volume of nitrogen. Molecular weights and volumes. Atomicity of elements. Molecular types. Determination of nitrogen in organic substances. Production of ammonia and nitrates in nature. Nascent state.

Nitric Acid.—Its manufacture, properties, industrial applications and laboratory uses. Combining weight of nitric acid. Nitrates. Tests for nitric acid. Nitric anhydride.

Nitrous Oxide and Nitric Oxide.—Their preparation and properties. Nitrous anhydride and nitrous acid. Nitrites.

Review of Oxides of Nitrogen.—Anhydrides and acids. Laws of definite, reciprocal and multiple proportions.

Gunpowder.—Preparation of ingredients and manufacture. Properties and products of explosion. Calculation of force of fired gunpowder. Blasting powder.

Guncotton.—Abel's process of manufacture. Effect of tamp-

ing guncotton compared with gunpowder. Theory of explosions.

Bloxam's Inorganic Chemistry, pages 1 to 146; 411 to 438; 511 to 518.

CLASS I.

INORGANIC CHEMISTRY.

Metalloids.—Their occurrence in nature and modes of preparation continued.

Chlorine Group.

Chlorine.—History, occurrence in nature and extraction from common salt. Physical and chemical properties. Attraction of chlorine for hydrogen. Oxidizing, bleaching and disinfecting properties. Applications in industrial arts. Hydrochloric acid—Preparation and properties of the gas and its solution in water. Action of the acid on metals and metallic oxides. Chlorides. Analysis of acid. Molecular weight. Aqua regia. Hypochlorous anhydride and acid. Chloride of lime. Uses of hypochlorites. Chloric acid and chlorates. Preparations and uses of chlorate of potash. Colored fire compositions. Chlorous acid and chlorites. Chloric peroxide. Perchloric acid. Review of oxides of chlorine—Comparison with oxides of nitrogen. Chloride of nitrogen.

Bromine.—Extraction from mineral water and uses. Resemblance to chlorine. Oxides of bromine. Hydrobromic acid. Bromides.

Iodine.—Extraction from sea-weed ashes. Characteristics and uses. Iodic and periodic acids. Hydriodic acid. Iodides. Iodide of nitrogen.

Fluorine.—Its occurrence in nature. Hydrofluoric acid. Etching on glass—(1) dull, (2) clear. Fluorides. Hydrofluosilicic acid.

Review of Chlorine Group.—Group characteristics and individual differences. Gradation in properties. Atomicity and quantivalence of elements and radicles. Types.

Sulphur Group.

Sulphur.—Its occurrence free and combined. Extraction and refining of sulphur. Commercial varieties. Allotropic forms. Electronegative and electropositive sulphur. Received explanation of allotropy and dimorphism. Methods of crys-

tallization: (1), sublimation; (2), fusion; (3), solution. Uses of sulphur. Influence of heat on specific gravity of vapours. Hydrosulphuric acid, its preparation, properties and laboratory uses. Sulphides, their separation into groups. Action of hydrosulphuric acid on paint. Sulphur acids, bases and salts. Action of air on sulphides. Analysis of hydrosulphuric acid. Persulphide of hydrogen. Sulphurous anhydride and acid. Bleaching, deoxidizing and antiseptic properties. Dibasic acids. Acid and normal salts. Sulphites. Tests. Sulphuric anhydride and acid. Old and new methods of manufacture. Theory of the new process. Economic expedients in manufacture. Importance of acid in industrial arts. Physical and chemical properties. Tabular representation of steps in hydration of the anhydride. Impurities and tests. Sulphates. Acid, normal and double sulphates. Determination of composition of sulphuric acid. Polythionic acid series. Structural formulæ of oxides and hydrated oxides of sulphur. Bisulphide of carbon, its preparation and uses. Sulpho-carbonates. Chlorides and iodides of sulphur.

Selenium.—Compounds with hydrogen and oxygen.

Tellurium.—Compounds with hydrogen and oxygen.

Review of sulphur group. General characters. Gradation of properties. Relation to oxygen.

Phosphorus Group.

Phosphorus.—Distribution in nature. Preparation. Varieties. Manufacture of red variety. Physical, physiological and chemical properties of phosphorus. Comparison of red and yellow varieties. Reducing action. Uses. Friction matches, (1) lucifer, (2) silent, (3) safety. Posphorus fuze composition.

Oxides of phosphorus. Table of anhydrides and acids, Structural formulæ.

Phosphoric anhydride and acid. Meta-, pyro-, and ortho-phosphoric acid and salts. Uses and chemical tests for acids and salts.

Phosphorous anhydride and acid. Hypophosphorous acid. Phosphides of hydrogen. Chlorides, iodides and sulphides of phosphorus.

Arsenic.—Occurrences in nature. Extraction from mispickel. Properties and chemical relationship. Arsenious anhydride. Chemical and physiological properties and uses. Arsenites. Scheele's green; Arsenic acid. Arsenates.

Arsenietted hydrogen. Marsh's and Rheinsch's test for arsenic.

Antimony.—Its sources and properties. Alloys. Oxides of antimony. Antimonetted hydrogen. Tests for antimony.

Bismuth.—Extraction, properties and uses. Oxides. Flake white and pearl white.

Review of Phosphorus Group.—Chemical relationship of members of group to each other and to nitrogen. Gradation of properties. Gradual passage from metalloids to metals.

General Review of Metalloids.—Atomicity and quantivalence. Monobasic, dibasic and tribasic acids. Structural formulæ.

Metals and their classification, Alloys, Haloid Salts, Oxysalts and Double Salts. Theory of Types. Principal Metallurgical Operations.

Metals of the Alkalies.

Potassium.—Caustic potash. Carbonate and bicarbonate. Nitre. Chlorate of potash.

Sodium.—Common salt. Manufacture of carbonate of soda. Caustic soda. Borax. Soluble glass. Sulphate and phosphate of soda.

Ammonium.—Its principal salts.

Lithium, Rubidium and Cæsium.—Spectrum analysis. Characteristics of alkali group.

Metals of Alkaline Earths.

Barium, Strontium, Calcium and Magnesium and their chief Salts.—Lime. Gypsum. Mortars. Characteristics of group. Tests. Relation between specific heats and atomic weights.

Metals of the Earths.

Aluminium.—Its preparation and uses. Chief salts. Silicates. Clay. Porcelain. Pottery. Cements. Alum. Ultramarine. Other metals of the earths. Characteristics of group. Tests.

Iron Groups.

Iron.—Ores of Iron. Cast iron, wrought iron and steel. Blast furnace. Chemistry of process of smelting. Hot blast. Grey, mottled and white iron. Chill casting. Refining and puddling. Bessemer process. Different varieties of steel. Catalan process of extracting iron. Oxides and salts of iron.

Manganese.—Oxides and salts.

Cobalt and Nickel and their chief compounds.

Chromium and Uranium.—Bichromate of potash. Characteristics of group. Tests.

Zinc Group.

Zinc.—Methods of extraction from ores. Uses. Galvanized iron.

Cadmium and Indium.—Characteristics and tests.

Copper Group.

Copper.—Smelting of copper ores. Uses of metal. Alloys: brass, bronze, &c.

Lead.—Metallurgy of lead. Extraction of silver from lead ores. Type metal, shot, solder, &c. Salts of lead. Manufacture of white lead.

Thallium.—Discovery by spectroscope. Characteristics and tests of group.

Tin Group.

Tin.—Extraction and purification. Tin plate; alloys. Principal salts.

Titanium, Molybdenum, &c.—General characteristics and tests.

Noble Metals.

Silver.—Extraction from copper by liquation. Standard silver. Electroplating. Principal salts.

Mercury.—Extraction and purification. Uses. Amalgams. Salts.

Gold.—Methods of extracting. Standard gold. Testing and assaying of gold. Gilding. Purple of Cassius.

Platinum.—Sources and preparation. Spongy platinum. Platinum black. Salts.

Iridium, Palladium, &c.—General characteristics and tests.

Bloxam's Inorganic Chemistry: pages 146 to 256, and 411 to 417; selected portions from pages 256 to 410.

Organic Chemistry.

Analysis of Organic Compounds.—Determination of molecular weight. Empirical and rational formulæ. Substitution. Isomerism. Homologous series, saturated and unsaturated compounds.

Classification of Organic Compounds based upon atomicity.

General Characteristics of Groups.—Hydrocarbons. Alcohols. Mercaptans. Ethers. Aldehydes. Ketones. Acids. Anhydrides. Amines. Organo-metallic compounds.

Marsh Gas and Substitution Products.—Halogen substitution products and their general reactions. Chloroform. Hydroxyl substitution products; general re-action of Alcohols. Methyl, Ether and Aldehyde. Formic Acid. Sulphur substitution products. Nitrogen derivatives; Amines, Amides, &c., Nitriles and Nitro compounds. Uses.

Hydrocyanic Acid and Cyanides.—Ferrocyanides and Ferricyanides and similar compounds. Cyanogen, &c. Cyanic Acid. Cyanuric Acid. Fulminates. Polymerism. Compounds of

Methyl with Phosphorus, Arsenic, Antimony and the metals. Compound Ethers.

Ethyl Compounds.—Ethylene and Acetylene and their derivatives. Preparation and properties of Ethyl Alcohol, Ether, Aldehyde. Chloral. Acetic Acid and its Salts. Acetic Anhydride. Oxalic Acid. Glycols. Mercaptan.

Propyl Compounds.—Propylene. Allylene. Acetone. Ketones and their properties. Lactic Acid. Glycerine. Nitroglycerine. Dynamite. Isomeric compounds.

Butyl Compounds.—Butyric, Succinic, Malic and Tartaric Acids, and other derivatives.

Amyl and Hexyl Compounds.—Valerianic and Citric Acid, &c. Mannite.

Fats and Oils.—Soap. Saponification.

Sugar.—Its varieties. Extraction of Cane Sugar. Sugar refining. Beet-root Sugar. Production of Sugar from cotton, paper, &c.

Starch.—From potato, wheat, rice, sago, tapioca, &c. Dextrine. Cellulose. Gun-cotton, its preparation and properties. Collodion.

Fermentation.—Alcoholic, lactic, butyric, mucous and acetous. Conditions necessary for fermentation and circumstances influencing it. Action of heat, acids, alkalies, &c. Wines and distilled spirits. Germination of Seeds. Malting and brewing.

Aromatic Series of Organic Compounds.—Theory of their constitution. Benzole and its derivatives. Aniline. Toluol, Xylol, Cumol, Cymol.

Naphtalene, Anthracene, &c.—Camphors, Essential Oils, Resins, Alkaloids, Coffee, Tea, Cocoa, Tobacco.

Coloring Matters.—Their general properties and preparation. Dyeing and Calico printing. Coal-tar dyes. Products of the destructive distillation of wood and coal.

Vegetable Chemistry.—Food of plant and its sources. Tissue of vegetable. Growth of plant and ripening of seed. Decay.

Animal Chemistry.—Chemistry of milk, blood and flesh. Excrementitious products. Putrefaction and disinfectants. Chemistry of tanning.

Text Book.—Selected portions from Bloxam's Organic Chemistry, pages 439 to 646. Notes from Lectures.

Practical Chemistry.

Qualitative analysis of substances containing a single metal and a single inorganic or organic acid.

Use of the blowpipe.

Flame reactions.

Exercises in writing out formulæ expressing reactions.

Qualitative analysis of a few mixtures.
————————————a few simple minerals.
————————————of gunpowder.
Analysis of substances insoluble in water and acids.
Text Book.—Bloxam's Laboratory Teaching.
Printed table of course of analyses of mixtures.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN GEOLOGY AND MINERALOGY.

ALLOTMENT OF MARKS.

1st Class.

Voluntary, 2,000.	Examinations,		1,800
	Notes and Recitations.		200

TEXT BOOKS.

Dana's Text Book of Geology, fourth edition.

Dana's Manual of Mineralogy, third edition.

SUMMARY OF INSTRUCTION IN GEOLOGY AND MINERALOGY.

CLASS I.—VOLUNTARY.

Relations of Geology.—Relations of Earth to the Universe.—Object of Geology.—Sub-divisions of Subject.

Physiographic Geology.—Earth's general contour. Form of earth and probable causes. Sub-divisions of its surface and character of its reliefs. Mountains, river systems, &c.

System in the surface form of Continents: Continents bounded by high borders, with comparatively low interiors and highest boarders facing deepest oceans.

System in Courses of Earth's Feature Lines; North-western and north-eastern trends.

System in Oceanic Movements and Temperatures; Oceanic currents; their courses, causes and effects.

Atmospheric Currents and Temperature. Climate. Effect of currents of air and ocean, on distribution of sterility and fertility. Forest regions, prairies, deserts, &c.

Lithological Geology.—Constitution of rocks. Elements composing minerals and minerals constituting rocks.

Silica and Silicates: Quartz and its varieties, feldspars, micas, hornblende, pyroxene, serpentine, &c. Mineral Carbonates, Sulphates and Phosphates. Materials of organic origin: Corals, coal, phosphates, &c.

Kinds of Rocks: Properties to be observed in the determination of rocks; texture; hardness; specific gravity, &c. Terms used in describing rocks.

Fragmental rocks: Conglomerate, sandstone, shale, &c.

Limestones: massive limestone, dolomite, chalk, marl, marble, &c.

Metamorphic Rocks: quartzite, granite, gneiss, mica-schist, syenite, &c.

Eruptive Rocks: Trachyte, dioryte, doleryte, &c.

Examination of specimens of principal minerals and chief varieties of rocks.

Condition, Structure and Arrangement of Rock Masses—

Stratified Rocks: nature of stratification. Structure and arrangement of strata. Natural positions and dislocations of strata, dip, strike, outcrop, faults, &c. Fossils.

Unstratified Rocks: veins, dikes, &c.

Short Sketch of Animal and Vegetable Life—

Historical Geology: Rocks, in order of their formation and contemporaneous events in geological history. Floras. Faunas. Geographical progress. Progress of life.

Dynamical Geology.—Forces at work in development o earth's crust.

Life.—Its protective, transporting and destructive effects, and contributions to rock formations. Peat and coal deposits. Coral islands and reefs.

Atmosphere.—Its rending and abrading effects. Transportation of inorganic matter and living species.

Water.—Fresh water rivers and lakes, their mechanical effects, erosion of soil and rocks; transportation of gravel, sand, &c., and distribution of material transported. Mechanical effects of subterranean waters. Land slides.

Oceanic Waters: their mechanical effects arising from (1) the general system of currents, (2) wind waves and currents, (3) tidal waves and currents, (4) earthquake waves; their effects in eroding, transporting and distributing material and in the formation of deposits.

Freezing Water: its disintegrating effects. Ice as a transporting agent. Icebergs. Glaciers: their nature, formation, cause, manner of movement and eroding and other effects.

Chemical effects of Water: in consequence of (1) its solvent properties, (2) the affinity of its elements, (3) substances taken into solution.

Heat.—Causes influencing its distribution. Sources of heat: (1) sun, (2) earth's interior, (3) chemical and mechanical action. Effects of heat in dilatation and contraction and metamorphosis of rocks.

Volcanoes.—Their nature and geographical distribution, varieties of volcanic cones, non-volcanic igneous eruptions. Heat of lavas and condition of volcanic action. Thermal waters, geysers.

Metamorphism.—Definition of the term; phenomenon due to action of heat and water, &c. Effects of metamorphism, as consolidation, crystallization, loss of vaporizable or soluble materials, &c. Origin of heat causing metamorphism—Local metamorphism.

Mineral veins, lodes and local ore deposits.—Positions, forms, structure; origin and filling of fissures.

Effects of the cooling of the earth on its crust.—Changes of level. Formation of mountains, origin of mountains. Results of action of mountain making force. Epochs of mountain making. Flexures, fractures and faults. Earthquakes.

Evolution of the Earth's fundamental features.—Continental borders and system of trends, how developed. Climatal developments.

Summary of Instruction in Mineralogy.

General characteristics of Minerals.

Crystallization. Systems of Crystallization in detail. Cleavage. Dimorphism. Measurement of Angles. Crystalline Aggregates.

Physical and Chemical properties of Minerals. Action of acids, blowpipe, &c.

Classification of Minerals. Description of Minerals in detail. Ores. Chemical composition of Minerals.

Methods of determination of Minerals.

Text Book.—Dana's Manual of Mineralogy and Lithology (third edition).

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION—FREEHAND DRAWING AND PAINTING.

ALLOTMENT OF MARKS,

			Total.
For entire course	Obligatory.....	2,600	3,500
	Voluntary.....	900	

4th Class.

OBLIGATORY—300 MARKS.

Drawing from copies and objects.	Examinations. (Annual,)	100
	Term work, 200.	

3rd Class.

OBLIGATORY—400 MARKS.

Drawing from copies and objects.	Examinations. (Annual,)	150
	Term work, 250.	

VOLUNTARY—100 MARKS.

Painting in monochrome from copies, objects and nature.	Term work, 100.

2nd Class.

OBLIGATORY—800 MARKS.

Drawing from copies, objects and nature, or Painting in monochrome from copies	Examinations. (Annual,)	150.
	Term work, 650.	

VOLUNTARY—300 MARKS.

Drawing from objects and nature, or Painting in colour from copies, objects and nature.	Term work, 300.

1st Class.

OBLIGATORY—1,100 MARKS.

Drawing from copies, objects and nature, or Painting in monochrome from copies objects, and nature.	Examinations. (Annual,)	200.
	Term work, 900.	

VOLUNTARY—500 MARKS.

Drawing from objects and nature, or Painting in colour from objects and nature	Term work, 500.

TEXT BOOKS USED.

Burchett's Perspective.

Redgrave's Catechism on Colour.

Warren's Artistic Anatomy of the Human Figure.

do do Horse.

Merrifield's Manual of Light and Shade, with reference to Model Drawing.

Green's Sketching from Nature. Part 1 and 2.

BOOKS RECOMMENDED TO BE READ.

Bonomi's Proportions of the Human Figure.

Ruskin's Modern Painters, Publishers, C. Robinson, London, W.C.; Smith & Elder, London, or Wiley & Sons, New York, U.S.

Ruskin's Stones of Venice. Publishers, C. Robinson, London W.C.; Smith and Elder, London, or Wiley & Sons, New York, U.S.

J. D. Harding's Principles and Practice of Art. Chapman & Hall, London.

Field's Chromatography. Winsor & Newton.

SUMMARY OF INSTRUCTION, FREEHAND DRAWING.

Grade 1.—(Obligatory),

Preliminary courses in linear perspective.
Freehand outline drawing from copies of ornaments, objects and models.
Freehand outline drawing from the round, models, objects and ornament.
Shading from flat examples or copies.
Shading from the round or solid forms.
Time sketching and sketching from memory.
Drawing the human figure and animal forms from copies in outline.
Drawing flowers, foliage and landscape details from nature.

Grade 2.

(Obligatory). Practical application of perspective to general drawing—landscape, architecture, &c.
(Voluntary). Studies of historic styles or ornament and applied design.
(Voluntary). Drawing in a given time the bones and muscles within the outline of the antique figure,
(Obligatory). Drawing the human figure and animals forms from the "round."
(Obligatory). Painting from flat examples and from the cast in monochrome and colour.
(Voluntary). Painting direct from nature in water colour, flowers or still like, landscapes and views of buildings.
(Obligatory). This grade to embrace a general knowledge of the principles and practice of art, *i e.*, light and shade compositions, omit and principles of harmonious colouring.

Grade 3.—(Voluntary).

Painting the human figure or animals in water-colour from copies and from nature.
Time studies from the living model.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN ENGLISH LANGUAGE AND LITERATURE.

ALLOTMENT OF MARKS.

For Entire Course.

Obligatory,	Examination (Annual)..... 600	1,600	3,000	
	Term Work..... 1,000			
Voluntary,	Examination (Annual) 600	1,400		
	Term Work..... 800			

Fourth Class.

Obligatory,	Examination (Annual)..... 300	800	
	Term Work..... 500		

Third Class.

Obligatory,	Examination (Annual).. 300	800	
	Term Work..... ... 500		

Second Class.

Voluntary,	Examination (Annual)..... 300	700	
	Term Work..... 400		

First Class.

Voluntary,	Examination (Annual)..... 300	700	
	Term Work..... 400		

TEXT BOOKS.

—o—

Shaw's "Students Manual of English Literature."
Bain's "English Rhetoric and Composition."
Marsh's "Lectures on the English Language."
Whately's "Rhetoric."

BOOKS RECOMMENDED TO BE READ.

—o—

Earle's "Philology of the English Language."
Max Muller's "Science of Language."
Mœtzner's "English Grammar."
Taine's "English Literature."

SUMMARY OF INSTRUCTION IN ENGLISH LANGUAGE AND LITERATURE.

Practice in writing letters, reports, and essays, and also in grammatical and critical exercises, form an important part of the Obligatory course of the 4th and 3rd Classes. Essays and criticisms of a higher order form a portion of the Voluntary course of the 2nd and 1st Classes.

4TH CLASS.

(OBLIGATORY.)

SECTION I.—On the philological relations of the English language.

SECTION II.—On the historical changes in the English language.

(1) From the inflected form in Anglo-Saxon.
(2) Through the influence of Romance and other languages.

SECTION III.—On composition.

(1) Philosophy of style.
(2) Formation of sentences.
(3) Figures of speech.
(4) Different style of writing illustrated by readings from various authors, viz :—Addison, Macaulay, Johnson, Alison, Sir James Stephens, Carlyle, Helps, Ruskin.
(5) Formation of a good style considered as Narrative ; Descriptive ; Didactic.

SECTION IV.—History of English Literature.

3RD CLASS.

(OBLIGATORY.)

SECTION I.—Poetry—different kinds :
(1) Epic ; (2) Lyric ; (3) Didactic.

SECTION II.—Different metres.

SECTION III.—Critical examination of poetical works :—Scott's "Lady of the Lake ;" Tennyson's "Princess ;" Byron's "Manfred ;" Shakespeare's "Hamlet" ; Pope's "Iliad."

2ND AND 1ST CLASSES.

(VOLUNTARY.)

SECTION I.—Early English — Spencer's "Faerie Queen," Book I; Chaucer's "Canterbury Tales," Prologue.

SECTION II.—(1) Anglo-Saxon Grammar.
(2) Beowulf.

SECTION III.—Rhetoric and Public speaking.

NOTE.—Cadets of the 2nd and 1st Classes who are at any time reported by the Professors as being deficient in knowledge of English may be *required* to continue in those Classes the practice of the obligatory course of the 4th and 3rd Classes. No marks will, however, be awarded for the lower course in the higher Classes.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN SURVEYING, MILITARY TOPOGRAPHY, AND PRACTICAL ASTRONOMY.

ALLOTMENT OF MARKS.

NOTE.—The proportion shown for Drawings, Examinations, &c., are not absolutely adhered to.

For Entire Course, 6,000	Obligatory, 4,000	Yearly and Intermediate Examinations		About 2,000
		Term Work.	Notes	About 2,000
			Drawings	
			Surveys	
	Voluntary, 2,000	Yearly and Intermediate Examinations		1,500
		Term Work		500.

3rd Class, 1,400	Obligatory, 1,400	Yearly and Intermediate Examinations		About 700
		Term Work.	Notes	About 700
			Drawings	
			Surveys	
	Voluntary—Nil.			
2nd Class, 1,600	Obligatory, 1,600	Yearly and Intermediate Examinations		About 800
		Term Work.	Notes	About 800
			Drawings	
			Surveys	
	Voluntary—Nil.			
1st Class, 3,000	Obligatory, 1,000	Examinations		about 500
		Term Work		about 500
	Voluntary, 2,000	Examinations		1,500
		Term Work		*500

* These marks are for drafting, and count for place, but not for "Pass" or "Honours."

TEXT BOOKS.

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Richards' Military Topography.

Heathers' Surveying and Astronomical Instruments.

Practical Astronomy and Geodesy, by Col. Oliver, R.A.

The Nautical Almanac.

The Manual of Dominion Land Surveys.

Books recommended for reference.

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Gillespie's Land Surveying.
Gillespie's Higher Surveying.
Deville's Examples of Astronomic and Geodetic Calculations.
Clarke's Geodesy.
Loomis' Practical Astronomy.
Chauvenet's Spherical and Practical Astronomy.
The U. S. Naval Academy Text Book on Surveying.
Whartons' Hydrographical Surveying.
Germain on Projections.

SUMMARY OF INSTRUCTION IN SURVEYING, MILITARY TOPOGRAPHY, AND PRACTICAL ASTRONOMY

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(The practical work ordinarily done by the Cadets is shown between brackets.)

3RD CLASS.

(OBLIGATORY).

SURVEYING AND MILITARY TOPOGRAPHY.

General principles of surveying and map making. The amount of accuracy expected in a survey dependent on the purpose for which it is made and the time available. Military sketches often hurriedly made against time.

Scales generally used, both in military sketches and civil surveys.

Conventional signs and colours used in map making. Copying plans by tracing, pricking off, squares, eidograph, and photography.

(After a little practice in conventional signs each Cadet makes from memory a map of some piece of country with which he is well acquainted.)

The necessity of a preliminary examination of the ground before commencing a survey.

Description of Gunter's and the 100-foot chain, the steel tape, surveyor's cross, and offset staff. Relative advantages of the two chains. The method of chaining a line. Precautions to be taken and amount of accuracy to be expected. Allowance for slopes. Chain surveying. Cutting up the ground into triangles. Necessity of getting good intersections to fix points. The details of the survey, how obtained.

Methods of calculating areas. (1) By measurement on the ground; (2) by measurements on the plan; (3) by division into squares; (4) by reducing a figure to a triangle; (5) by latitudes and departures.

Surveying by tie lines. Chain angles. Perpendiculars. Various methods of keeping the field book in chain surveying.

Ground problems in chain surveying. Erecting perpendiculars to a line. Running parallel lines. Passing obstacles. Interpolating points in a line. Finding the distance between points where the intervening space cannot be chained.

Methods of checking a chain survey by measuring proof lines and by the test of points that lie in a straight line.

(The Cadets are shown how to make and plot a small chain survey. They then survey and plot a fresh piece of ground, keeping and plotting from their own field books.)

The principles of angular surveying.

The limits of well conditioned triangles.

Measuring a base line and expanding a triangulation from it.

The construction and uses of the pocket sextant and prismatic compass. The adjustments of the sextant. The defects of each instrument. Their relative advantages and disadvantages. The variation of the compass and facts connected with it. Fixing points by interpolation.

(The Cadets are practised in taking angles with the sextant and bearings with the compass, and in plotting them. They then make a triangulation of a piece of ground from a measured base with the sextant, and afterwards fill in the details by the compass and pacing, each having first ascertained the length of his pace.

The Cadets next make a sketch survey by the compass and pacing alone. They afterwards do two examination surveys—one with the sextant, the other with the compass. In these surveys they are taken to a fresh piece of ground and given a certain number of hours to do it in, each working alone and the sketches being given in on the ground.)

Triangles plotted either by the angles or by the calculated length of the sides. How to construct a large paper or card protractor. Plotting angles by the scale of chords.

Forms of field-book used in angular surveying. Traversing with the compass. Local attraction—how to get rid of it in traversing. Restoring the magnetism of a compass. Changes in the variation. Surveying land by the compass and chain. Latitudes and departures—their use in checking, balancing, and plotting a survey. Given the bearings and lengths of the lines bounding a rectilineal figure, to calculate its acreage by the tables of latitude and departure. Supplying omissions. Describing bounds.

Contours—their nature and use. The horizontal equivalent. Use of the hand level and clinometer for contouring a plan roughly. Definition of "water course," "watershed" and "orthogonal." The different methods of showing slopes by shading. Horizontal hachuring, vertical hachuring, stump shading, and brush work. The light supposed to come from a little to the left. Uses of each method. The scales each is best adapted for—their employment on the Ordnance Survey. The scale of shade. Its uses. Mounting plans on calico.

(The Cadets are practised in copying plates of horizontal hachuring in Indian ink.

If time allows, instruction in the use of the Theodolite and Transit Theodolite is commenced.)

2nd CLASS.

(OBLIGATORY.)

SURVEYING AND MILITARY TOPOGRAPHY (*Cont.*)

The construction, adjustments, and uses of the theodolite and transit theodolite. How they give the horizontal and vertical angles. Taking a round of horizontal angles. Reason for reading both verniers. Repeating angles. Correcting the angles of a triangle when all three are measured. Methods of traversing with the theodolite. Plotting the traverse from meridians and the advantage gained by doing so. Use of the circular card protractor. Uses of the attached compass. Replacing broken level tubes and spider lines. Use of the theodolite in ranging out a base line and reducing the slopes to the horizontal. Measuring across obstacles (such as wide creeks) and up to the point immediately under an inaccessible object, such as the top of a church spire. Making a triangulation. Choice of trigonometrical stations. Plotting the triangles from the calculated lengths of the sides. Use of the beam compasses. Finding the points approximately by plotting the angles. Finding the relative heights of the stations, taking into account the allowances for curvature and refraction.

Method of plotting by means of rectangular co-ordinates. Proving the accuracy of a traverse by closing it on a known point. Proving a traverse by eastings and westings and northings and southings.

Making sections by the theodolite.

(The Cadets are practised in taking angles with the theodolite and in running a traverse. They afterwards plot a traverse from the field book, and also a given triangulation by the method of co-ordinates.

How to check a triangulation by calculating the same side from different triangles. Bases of verification. Methods of filling in the details of a triangulation. Plotting a triangulation on a lage scale. Expansion and contraction of paper. The scale to be laid down on the paper. Plotting on different sheets. How this is done by means of the calculated co-ordinates.

Principle and uses of the plane table.

(Survey with the chain and plane table.)

The omnimeter or other instruments of that class.

Problems in dividing up, parting off, and laying out land.

(The Cadets are practised in copying models of hills, putting in the slopes by horizontal hachuring, first in pencil and then in ink. They are afterwards given a contoured plan of a convenient piece of ground which they take out and hachure by scale of shade. Those who are sufficiently expert practice shading in brush work.)

The principles of layin g out roads with reference to the gradients.

The methods of laying out railway curves.

The principles of levelling, with the corrections for curvative and refraction. Construction and adjustments of the different kinds of level. The water level and reflecting level. Forms of field book used.

(A traverse is run with the transit theodolite and a section of it made by levelling.)

Surveying without instruments.

(Examination survey of a piece of ground without instruments.)

The principles of hydrographical surveying.

PRACTICAL ASTRONOMY.

Elementary facts of Astronomy. Apparent motions of the heavenly bodies. The seasons. Short description of the solar system, with a few facts as to distances. The celestial globe. The principal northern constellations. Explanations of the ordinary astronomical terms. The co-ordinates employed. Altitude and azimuth. Latitude and longitude. Declination and right ascension. Different methods of reckoning time. Civil and astronomical time. To convert one into the other. Apparent solar, mean solar, and sidereal time; reason of the difference between the two first. The equation of time. Hour Angles: their numerical expression in time and arc. Time at different meridians. To convert the apparent time at a given meridian into mean time, and *vice versâ*. Given the sidereal time at a certain instant to find the mean time. Given the mean time to find the sidereal time. To find at what time a given star will be on the meridian. Given the hour angle of a star at a given meridian to find the local mean time. Astronomical clocks. Use of the sextant and artificial horizon. How to measure the altitude of a heavenly body, both with the natural and artificial horizons. Corrections to be applied, index error, dip, refraction, parallax, semi-diameter.

Taking altitudes with the theodolite. Necessity of observations in reversed positions of the instrument. Night observations. Reasons for observing both north and south or east and west stars.

The Nautical Almanac, corrections for longitude, simple interpolation. Finding the latitude by a meridian altitude of the sun or star. Finding the latitude by an altitude of the pole star at any hour.

To find the time by equal altitudes of a fixed star.

From an observed altitude of a heavenly body to find its hour angle and thence the local mean time.

To find the longitude by comparing the local mean time with a chronometer showing Greenwich mean time.

Finding the longitude by differences of local time; the difference being ascertained either by signal or electric telegraph.

To find the azimuth of a heavenly body from its observed altitude, and hence (using the theodolite) the azimuth of a terrestrial mark: from which follows the true meridian and variation of the compass.

Other methods of finding the meridian, viz:

(1) By equal altitudes of the sun or a star.
(2) By the greatest elongation of a circumpolar star.
(3) By observation of the pole star at any time.
(4) By meridian transits of high or low stars.

Sundials, horizontal, vertical, and mean time.

The solar compass.

(The Cadets take and work out observations for latitude, time and azimuth, using both sextant and transit theodolite.)

1st CLASS.

(OBLIGATORY.)

Recapitulation of the principles of construction, adjustments, and uses of the various surveying and astronomical instruments, with a short account of the portable Transit Telescope and Zenith Telescope.

The method of laying out Canadian Public lands, with the regulations contained in the Manual of Dominion Land Surveys.

Deville's method of solving the following problems:

To find the convergence between two points; to find the difference of latitude and longitude of two points when their distance apart and the azimuth of the line joining them are known; to correct a traverse by the sun's azimuth; when running a line to correct it by azimuths; to lay out a figure on the ground; to lay out a parallel of latitude by chords and by offsets.

Lectures are given on the method of carrying out a triangulation on a large scale, the astronomical work involved, probable errors, and the elements of projection and map drawing.

(The cadets practise, as occasion offers, road traverses, triangulation, contouring, and hydrographical surveys. They also observe and keep registers of various meteorological instruments, and practise taking meridian transits and alt-azimuth observations.)

1st CLASS.

(VOLUNTARY.)

PRACTICAL ASTRONOMY.

Portable Astronomical Instruments.

The refracting telescope. Magnifying power and field of view. Brightness of images and intensity of their light. Spherical and chromatic aberration. Achromatic eye-pieces. Diagonal eye-pieces. To measure the magnifying power of a telescope. The micrometer. The reading microscope. The spirit level. To obtain the value of a division of the level. To find the level error. The chronometer—winding and transporting. Correction for temperature. Comparison of chronometers. The electro-chronograph.

The sextant and its adjustments.

The simple reflecting circle.

The repeating reflecting circle.

The prismatic reflecting circle and sextant.

The portable transit instrument. Its adjustments. The instrument in the meridian. Methods of correcting the deviation. To find the error due to inequality of pivots. To apply the level correction to an observation. To find the latitude by transits of stars across the prime vertical. Adjustment in the prime vertical. The meridian mark. The personal equation.

The zenith telescope and its use in finding the latitude by Talcott's method. To find the corrected latitude. To find the level correction. To find the value of a revolution of the micrometer screw. Reduction to the meridian. The correction for refraction. The transit instrument as a zenith telescope.

The altitude and azimuth instrument.

Additional methods of finding the latitude.

(1) By a single altitude taken at a known time.

(2) By circum-meridian altitudes.

Interpolation by second differences. To find the Greenwich time corresponding to a given right ascension of the moon on a given day. Interpolation by differences of any order. To find the longitude by transits of moon-culminating stars. To find the longitude by lunar distances. To find the longitude by an altitude of the moon.

To find the amplitude and hour angle of a given heavenly body when on the horizon. To find the equatorial horizontal parallax of a heavenly body at a given distance from the centre of the earth. To find the parallax in altitude, the earth being regarded as a sphere. General laws of refraction. Tables of refraction. Semi-diameters of celestial bodies.

Star catalogues and how to use them.

Differential variations of co-ordinates.

To find the correction for small inequalities in the altitudes when finding the time by equal altitudes of a star. Effect of errors in the data upon the time computed from an altitude. Effect of errors of zenith distance, declination, and time, upon the latitude found by circum-meridian altitudes.

The probable error; weight of observations and results.

GEODESY.

Meaning of the word "Geodesy." The true figure of the earth an oblate spheroid. Methods by which this has been proved. Measurements of arcs of the meridian at different latitudes. Pendulum observations. Abnormal deviations of the plumb line. How caused. Method of detecting them.

Definitions of "compression," "eccentricity," "geocentric latitude," "geographical" and "astronomical latitude," "reduction of the latitude."

To find the reduction of the latitude for the compression of the earth. Development of the expression for it in series. To find the radius of the terrestrial spheroid, the normal terminating in the axis, and the radius of curvature of the meridian for a given latitude. To find the length of a second of latitude and of a second of longitude at a given latitude.

Geodetical operations. Mapping a country by triangulation. Laying out the earth's surface in certain figures and tracing them on the ground. Expanding a triangulation from a measured base. Primary, secondary, and tertiary triangles. The usual size of each. Well-conditioned triangles. Bases of verification. Examples of the latter. Networks of triangulation. Intersecting chains of triangulation.

Account of the measurement of certain celebrated base lines. The different means and materials employed. Description of the American compensating bars. Bases for small surveys measured by steel tapes or pine rods.

Preliminary measurement and levelling of a base line. Division into sections. Permanent monuments. Correction for changes of temperature of rods. Reduction of inclined rods to the horizontal. Distance across a creek or other obstacle. The broken base. Measurement of bases by sound. Astronomical base lines. Reduction of the base to the sea level.

Triangulation. Selection of stations. Size of the principal triangles in various triangulations. Signals for flat countries. Stations to be selected so that they can be observed from, as well as to. Various forms of signals: tripods, poles, polished cones and hemispheres. Scaffoldings, towers, station marks. The heliostat. The electric light. The latter used successfully at very great distances.

Measuring the angles. Instruments employed. Various sizes of theodolites. Repeating and reiterating theodolites. Comparison between them. Method of repeating an angle.

To reduce a measured angle to the centre of a station. Correction for phase of signal. To reduce an inclined angle to the horizontal plane.

Calculation of the spherical excess. Correcting the observed angles of a triangle. Calculating the size of the triangles. Legendre's theorem.

Reduction of a difference of latitude on the spheroid to the corresponding difference of latitude on the sphere, the radius of which is equal to the normal of the spheroid for the mean latitude.

Calculating the latitudes, longitudes, and azimuths of the points of a triangulation, taking into account the ellipticity of the earth. The convergence of meridians. Co-ordinates of the points of a triangulation referred to the meridian and a perpendicular to it.

Given the latitude and longitude of two points to find their distance and the azimuth of the line joining them; given the latitudes of two points and the azimuth from one point to the other, to find their distance; given the latitude of a point, the azimuth from this point to another, and the difference of their longitudes, to find the distance between the two points.

Geodesic lines.

To find the area comprised between two meridians and two parallels (spherical solution).

To find the offsets to a parallel of latitude.

Methods of delineating a spherical surface on a plane. The orthographic, stereographic, gnomonic or central, globular, equidistant, Mercator's, conical, and ordinary polyconic projections.

Trigonometrical levelling by reciprocal zenith distances; by the zenith distance measured at one station; by the observed zenith distance of the sea horizon.

To determine the co-efficient of terrestrial refraction by means of reciprocal zenith distances.

The barometrical measurement of heights.

Measurement of heights by the temperature of boiling water.

General explanation of the use of the pendulum in determining the compression of the earth. Kater's reversible pendulum.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN MILITARY RECONNAISSANCE.

ALLOTMENT OF MARKS.

Entire Course, 1,500 — Obligatory. — Term Work — Sketches and Reports. 1,500

2nd Class, 700 — Obligatory. — Term Work — Sketches and Reports. 700

1st Class, 800 — Obligatory. — Term Work — Sketches and Reports. 800

N.B.—The Professors of Military Engineering and Military History assist the Professor of Surveying in awarding marks for Reconnaissances, but *only* as far as relates to their respective subjects of instruction.

TEXT BOOKS AND BOOKS OF REFERENCE.

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Those used in Courses of Instruction for Military Topography, Military Engineering, Military Administration, and Tactics.

SUMMARY OF INSTRUCTION IN MILITARY RECONNAISSANCE.

NOTE.—The Professors of Military Topography, of Strategy Tactics and Military Administration, and of Military Engineering will conjointly carry out the instruction in Reconnaissance.

Necessity of reconnaissances. General and special reconnaissances. The former usually made in peace time to ascertain all points necessary to be known in case of war; such as climate, topography, inhabitants, supplies, transport, fortresses, armed strength, &c. Special reconnaissances always required, and *any* officer may have to make them. Maps of a country generally on too small a scale and have to be enlarged, and details inserted. Besides, maps do not show the state and width of the roads, the depth and current of rivers, the nature of the soil, the kind of woods met with, and a host of other points that it is necessary to know; therefore a report must always accompany the sketch.

Scales ordinarily used for the sketches.

Reports to be written on foolscap with half margin.

Maps to be enlarged in preference to making a triangulation.

Pencil work of sketches to be neat and clean. Sketches for hasty reconnaissances to be in pencil, for deliberate reconnaissances to be in ink. Use of colored chalks. Different kinds of special reconnaissance. Roads, railways, rivers, woods, positions, encamping grounds, districts.

Road Reconnaissances.—Made either on foot or on horseback. A note book may be used and the work plotted in the evening. A few bearings taken and distances judged by the time occupied in traversing them. Rates of a horse's paces. Points to be specially observed. Form of sketch and report used. Estimate of accommodation afforded by villages and towns. Report to contain the following details:

1. Construction of road, present condition, materials obtainable for repair, defiles (bridges, streets, cuttings, &c).
2. Nature of adjacent country, cultivated or not; open or enclosed; woods; facilities for moving troops.
3. Halting places, including facilities for watering, and places where troops can file past.
4. Camping grounds, and for what force.
5. Positions suitable for advanced and rear guards adjacent to road.
6. Positions within range of road enemy may occupy.
7. Lateral communications.

River Reconnaissances.—*A.* When the course of the river is in the direction of the line of operations; the object of the report being to show how connection may be maintained on the march, or for action, by a force moving on both banks.

1. General nature of valley in which river lies, whether swampy, rocky, woody, &c.; proximity of heights.

2. Nature of stream, general direction, bends, rapidity of current, depth, liability to floods, banks, islands, fords.

3. Tributaries.

4. Nature of existing bridges, and materials for extemporizing others.

5. Boats, numbers available, &c.

6. Towns and villages on banks.

B. When the river is to be used as a defensive obstacle.

In addition to the above:

7. Nature of approaches, and points at which access by them may be barred by troops or obstacles.

8. Command and distances from the stream, of heights on either bank within cannon range.

9. Points and means for effecting inundations.

10. Points on either bank suitable for covering the passage of troops to further bank.

Railways.—(For points to be noted, *vide* p. 133, Jones's Notes on Administration; and for Railway Stations, p. 135.)

Arrangements for the despatch of given bodies of troops by rail, with plans and estimates of works necessary to enable them to entrain and detrain with the greatest facility, either at stations or elsewhere; with sketch of a railway station, showing approaches, platforms, arrangement of switches, additional temporary erections, &c.

Camps and Billets.—Selection of camping grounds for given bodies of troops of all arms, with sketches of the ground showing disposition of the troops, accompanied by reports.

Billeting of troops on the march in given villages and towns.

Outposts.—Covering a stationary force with outposts; sketch to show positions of line of sentries, piquets, supports and reserves, if any. Report to detail number and nature of troops required, general dispositions and action in case of attack.

Positions.—Both offensive and defensive; their selection (see Tactical Notes, p. 350.)

Sketches of ground to show dispositions of troops, clearances and obstacles, &c.

Reports to contain:

General description; length, depth, nature of soil, ground,

whether cultivated, fenced, wooded, slopes. View obtainable, flanks where resting, approaches to front and flanks; obstacles such as rivers, marshes, &c.; lateral communications, roads to rear and positions covering them.

2. General suitability to object in view, and to troops available.

3. Decisive points, weak points, enclosures, villages, woods, &c.

4. General position of first line, including main defensive line and advanced posts, showing allotment of troops and artillery positions.

5. General position of second line.

6. General positions of reserves, allotment of troops, facilities for counterstrokes.

7. General summary of works to be executed and allotment of tools and working parties.

8. Facilities for offensive returns, parts suitable for and positions suitable for enemy resisting the same.

9. Means of retreat and covering positions for artillery and rear guards.

10. Artillery positions, and approaches available to the enemy.

N.B.—A number of the foregoing reconnaissance schemes, both hasty and deliberate, will be given to Cadets of the 1st and 2nd classes as time and means may allow.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN MILITARY LAW.

ALLOTMENT OF MARKS.

For Entire Course, 800	Obligatory.	Yearly Examination..... 500 Intermediate do ... 200		700
		Term Work..	Notes. Recitations.	100
For 3rd Class, 600	Obligatory.	Yearly Examination..... 500 Intermediate do 300		500
		Term Work..	Notes. Recitation.	100
For 1st Class, 200	Obligatory.	Yearly Examination.....		200
		Term Work..	Notes. Recitations.	Nil.

TEXT BOOKS.

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TEXT BOOK ON MILITARY LAW.

(Major Douglas Jones, R. A.)

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Books recommended for reference:

The Army Acts.

Militia and Defence Act of the Dominion of Canada.

The Queen's Regulations and Orders for the Army.

Regulations and Orders for the Militia of Canada.

All Official Orders, Regulations, Rules of Procedure, and Official Instructions bearing upon the subjects specified.

SUMMARY OF INSTRUCTION IN MILITARY LAW.

Comparison between Military Law and Civil Law. Army Act contains written part of Military Law.

MARTIAL LAW.

Martial Law, contrasted with Military Law, when it may be proclaimed, and by what authority.

The classification of Martial Law under three heads :—

1. Applicable to Officers and Soldiers.
2. Applicable to Provinces during War.
3. Applicable to the whole community in time of Rebellion.

Lessons to be derived from the past and opinions of eminent Lawyers on the subject.

MARTIAL LAW.

Brief historical summary of the growth of a code of Military Law in England and causes which led to it.

Circumstances which led to the introduction of the first Mutiny Act.

Statutory Courts and Prerogative Courts.

Powers of the Crown as to Articles of War and Rules of Procedure.

Short description of the Army Act. Classification of Contents : Discipline, Enlistment, Billeting, General Provisions, Application of Military Law, Saving Provisions and Definitions.

Annual passing of the Army Act by Parliament.

Persons subject to Military Law.

Military Law as it concerns the Militia of Canada.

Maintenance of good order and military discipline; chain of responsibility.

Course of procedure on commisssion of offences.

Military custody.

Power of Commanding Officer, with remarks on the punishment he can award.

Duties of the Provost Marshal.

Courts Martial. Descriptions, warrants, convening, composition, jurisdiction, order for assembling.

Scale of punishments, when special punishments may be awarded and how combined.

Special application of the Army Act to warrant officers, non-commissioned officers, and to persons not belonging to Her Majesty's forces.

Preliminaries to trial, framing and investigation of charges, warning the prisoner for trial.

Responsibilities, duties, and privileges of persons attending Courts Martial:—President, Members, Prisoner, Prosecutor, Deputy Judge Advocate, Witnesses, Interpreter.

Description of proceedings at Courts Martial, rules as to challenges, arraignment of prisoner, rules for addresses, examination of witnesses, the finding and sentence.

Confirmation. Persons having authority to confirm. Duties and powers of the confirming authority.

Revision of findings and sentences. Quashing proceedings.

Persons having power to alter the sentences after confirmation.

Execution of sentence. Disposal of proceedings.

Exceptional Courts Martial. Special provisions relating to Field General Courts Martial and to Summary Courts Martial.

Crimes. Their classification and punishments for each. Crimes punishable only by Civil Law, with exceptions.

Definitions of some legal terms with explanations. Malice. Principal of the first and second degree. Accessories. Treason. Misprison of treason. Felony and misdemeanor. Homicide, theft, robbery, arson, forgery, &c., &c.

COURTS OF INQUIRY AND BOARDS.

1. Royal Commissions; 2. Courts held under the Statute; 3. Ordinary Courts assembled by a commanding officer.

How assembled, duties of members, order of proceedings, powers, &c.

EVIDENCE.

The five general rules as to the admissibility of evidence:—

1. Evidence as to character, and evidence in *res-gestæ*.

2. Direct and positive evidence, satisfactory evidence. Presumptions of the law, presumptions drawn from the evidence (circumstantial evidence.)

3. Evidence to be confined to the charge.

4. Hearsay evidence.

5. Documentary and secondary evidence, when admissible; public records, private writings, proof of handwriting. Confessions by prisoners. Depositions.

Witnesses. Number required, their competency; examination of witnesses.

Form of proceedings of Courts Martial, how recorded, &c.

Form of proceedings of Courts of Inquiry and Boards.

Oaths and solemn declarations.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN MILITARY ADMINISTRATION.

ALLOTMENT OF MARKS.

For Entire Course, 1200	Obligatory.	Yarly Examination..... 800 Intermediate do 300		1,100
		Term Work....	Notes. / Recitations.	100
For 3rd Class, 900	Obligatory.	Yearly Examination..... 500 Intermediate do 300		800
		Term Work....	Notes. / Recitations.	100
For 1st Class, 300	Obligatory.	Yearly Examination.....		300
		Term Work...	Notes. / Recitations.	Nil.

TEXT BOOKS.

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OPERATIONS OF WAR. Part 1.

(General Sir Edward Hamley, K.C.B., K.C.M.G.)

MILITARY ADMINISTRATION.

(Major Douglas Jones, R.A.)

REGULATIONS AND ORDERS FOR THE MILITIA OF CANADA.

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Books recommended, and sources from which information may be obtained:

The Queen's Regulations and Orders for the Army.

Regulations and Instructions for Encampments.

Army Circulars and General Orders.

Précis of Modern Tactics. Colonel Home.)

The Armies of Europe and Asia. (General Upton.)

Sir Garnet Wolsely's Soldier's Pocket Book.

Official Military Regulations governing the various branches of the Military Service both of Great Britain and of Foreign Countries.

SUMMARY OF INSTRUCTION IN MILITARY ADMINISTRATION.

General principles of the organization and maintenance of armies, and the special laws relating to soldiers.

Maintenance of discipline, and chain of responsibility.

British Military Units:—from companies, troops and batteries, up to army corps.

War Establishments of the different units of the British Army.

FORMATION AND MAINTENANCE OF ARMIES.

Systems of recruiting, terms of service, etc. Comparison between voluntary and compulsory enlistment; relative advantages and disadvantages of each system. Comparison between long and short service.

Rules of Enlistment in the British Army.

Reserves of the British Army.—Army reserve; militia reserve. Auxiliary forces—Militia, yeomanry, volunteers. Organization, composition, mode of recruiting or enrolment, training and exercise, bounty and allowances, numbers, and liabilities of each.

Organization of the Regular Army:

1. Combatant branches—Infantry, cavalry artillery, engineers.

2. Non-combatant branches—Commissariat and transport department, ordnance store department, army pay department, veterinary department—organization and general functions of each. Army medical department—organization in peace and war, field hospitals, general hospitals, convalescent depôts, transport and care of sick and wounded in war.

Pay and allowances, and a brief description of the accounts to be kept by the captain of a company. Gratuities and pensions.

Supply and Transport in time of Peace.—Rations, quarters, medical attendance, equipment, clothing, necessaries.

Sketch of different Military Systems.—Germany, France, Austria, Russia, Italy, United States, Canada, Switzerland.

Appointment and promotion of officers in different armies.

Organization and distribution of the Staff of the British Army.—Staff at headquarters, corps, divisional, brigade, and regimental staff.

The Prussian General Staff.

Subdivision of Duties.—Office work and method of conducting official correspondence.

CONDITIONS AND PRINCIPLES OF SUPPLY IN TIME OF WAR.

Supply of ammunition in the field; expenditure in battle. Reserves of ammunition. Equipment.—Arms, ammunition, etc. Rations—Amount of nutriment required, nutritious properties of different kinds of diet, daily rations per man and horse; how carried, and amount required by an army in the field.

SYSTEMS OF SUPPLY OF FOOD AND FORAGE BY AN ARMY IN THE FIELD.

1. From home magazines.
2. By contract to deliver at base or depôt of operations.
3. By purchase in the country.
4. By requisition or seizures.

Relative advantages and disadvantages of each system.

Billeting of troops, with calculations for billeting.

Forage and ration depôts; railway depôts.

The Prussian system of Supply.

MILITARY TRANSPORT.

1. Inland water transport, by means of navigable rivers, lakes and canals.

2. Railway transport, use of railways in war, construction of military railways.

3. Transport by means of wheeled vehicles.

4. Transport by means of pack animals and human carriers.

Comparison between the different methods, and their relative advantages and disadvantages.

Requisites of a good military carriage; relative merits of two-wheeled and four-wheeled vehicles. Traction engines.

ORGANIZATION OF TRANSPORT FOR AN ARMY IN THE FIELD.

1. "Regimental transport" of a battalion, regiment of cavalry and battery of artillery.

2. "Departmental transport" of different units from brigades to army corps. Organization and expansion of the Commissariat and Transport Corps. Calculation of length of road occupied by military transport. Difficulties of supply.

3. "General transport." Organization required. Advantages of working it on the stage system.

RAILWAYS.

Their value and use for concentration and supply at the outbreak of war, and for conveyance of troops and stores during the operations. Their influence on supply and the movements of armies.

Organization required for the working of railways. Administrative and executive staffs. Duties of officer in charge of a station.

Arrangements for forwarding a force by railway. Number of trains that can be despatched in one day. Entraining and detraining troops. Rate of travelling. Requirements of a railway station for military purposes.

THE LINE OF COMMUNICATIONS OF AN ARMY IN THE FIELD.

Duties and responsibilities of the Inspector General, and under him of the officers in charge of the Base of Operations, Advanced Depôt, and of the "Road Commandant."

Railways on the Line of Communications.

Force required for the defence of the Line of Communications.

ENCAMPMENTS, BIVOUACS, CANTONMENTS.

Military and sanitary requirements as well as principles for encampments. Spaces required by different units. Formations for encampments. Estimates of water supply required and watering arrangements.

Bivouacs. Prussian system.

Cantonments. Area over which troops can spread. Calculation as to number of troops that can be cantoned in a town or district, on the march or for lengthy occupation. Arrangements for cantoning troops and billeting on the line of march.

MARCHES.

Number of roads to be used by an army; selection of roads; rates of march; length of marches; general arrangements for a march; order of march in proximity to and at a distance from the enemy.

Length of column of route for British divisions and army corps. Calculations of space required. Considerations limiting the size of columns that can march on one road. Marching in "Echelon." Framing orders for a march.

EMBARKATIONS AND DISEMBARKATIONS.

Transport and freight ships. Vessels, how chartered and by whom. Boards of survey. Description of vessels most suitable for troops, capacity required. Fittings and interior arrangements of transports. Calculations as to the number of men and horses a ship will accommodate.

Operation of embarking troops and horses. Disembarkation in presence of an enemy, orders for. Selection of landing places.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN MILITARY HISTORY, GEOGRAPHY, STRATEGY, AND TACTICS.

ALLOTMENT OF MARKS.

For Entire Course, 4,500	Obligatory.	Yearly Examination.	2,700		4,100
		Intermediate do	1,400		
		Term Work.		Notes.	400
				Récitations.	
For 2nd Class, 2,000	Obligatory.	Yearly Examination.	1,400		1,800
		Intermediate do	400		
		Term Work.		Notes.	200
				Recitations.	
For 1st Class, 2,500	Obligatory.	Yearly Examination.	1,800		2,300
		Intermediate do	500		
		Term Work.		Notes.	200
				Recitations.	

TEXT BOOKS.

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MINOR TACTICS. (Lieut.-Colonel Clery.)

OPERATIONS OF WAR.
(Gen. Sir Edward Hamley, K.C.B., K.C.M.G.)

TACTICAL NOTES. (Major Douglas Jones, R.A.)

INFANTRY FIELD EXERCISE.

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Books recommended to be read and sources from which information may be obtained:

Précis of Modern Tactics. (Colonel Home.)

Great Compaigns in Europe. (Major Adams.)

Tactical Deductions from the War of 1870-71. (Colonel Boguslawski.)

Official Report on the conduct of the American Civil War.

Cavalry Regulations.

Instructions for Cavalry by General Von Schmidt. (Translated.)

German Official Accounts of the Wars of 1866 and 1870-71.

Russo-Turkish War. (Lt. Green, U. S. Engineers.)

War in Bulgaria. (General Baker.)

Daily News Correspondence of the Russo-Turkish War. (A. Forbes.)

War in Armenia. (Norman.)

Journal of the Royal United Service Institution.

R. A. and R. E. Institution Papers.

SUMMARY OF INSTRUCTION IN MILITARY HISTORY, AND GEOGRAPHY, STRATEGY AND TACTICS.

TACTICS.

Meaning of Tactics as distinguished from Strategy. Fighting tactics. Manœuvre tactics.

A brief account of the changes that have taken place in tactics at various periods, including tactics of the present day as modified by the experience of recent wars and the introduction of modern weapons, showing the nature and cause of the various modifications.

Tactical and fighting units of the different arms. General functions and characteristics of the various arms.

Calculations of time and space occupied in marches and formations of the three arms, separately and combined.

Relations of offensive and defensive in regard to tactics.

Principles of attack and defence.

Principles upon which the present tactics of European armies are based.

SECURITY AND INFORMATION.

The measures by which armies obtain security and information, whether at the halt or on the march.

Superiority when coming into collision with the enemy depends partly on timely information and partly on power of rapid concentration. Power of concentration dependent on mobility and supply. Difficulties of keeping an army concentrated entail necessity of early and accurate information of enemy's movements.

Outposts.—Their objects and duties. Their composition, and considerations which affect their strength. Infantry and cavalry outposts, separately and combined. Line of resistance. Distance of outposts from main body. Usual subdivision into sentries, picquets, supports and reserves; composition, relative strength, position, and duties of each. Different kinds of patrols and their object. Adaptation of outposts to ground. Resistance and retreat. Artillery with outposts. Outposts by night; modifications required.

Advanced Guards.—Their object, necessity, and duties Composition and strength, and causes affecting them. Formation and subdivision. Position of each arm. Distance from main body and the causes which regulate it. Duties and responsibilities of the Commander. Conduct on meeting the enemy, whether to hold his ground or retire on main body.

Rear Guards.—Of two kinds: 1. To an army advancing.

2. To an arm retreating. Their object, duties, strength, and composition in each case. General mode of action of a rear guard to a retreating army. Duty not to attack but delay the enemy. Manner of occupying positions, special care required on the flanks. Withdrawal in the presence of the enemy. General dispositions on the march. Retiring through a defile. Degree of resistance to be offered by Rear Guards.

Reconnoitring—Necessity for obtaining ample and accurate information about enemy, and surest manner of obtaining this. Importance of screening movements from enemy. How a considerable force of cavalry would be employed in screening and reconnoitring duties in advance of an army. Small reconnoitring parties, infantry and cavalry patrols, their composition and strength. Qualities required in commander. How information is obtained; transmission of intelligence to the rear. Points to be noted in country passed over. Reconnoitring the enemy's position.

GROUND IN RELATION TO TACTICS.

Character of ground best suited to each arm. How nature of ground affects the view and affords concealment. Danger of confounding cover from *view* with cover from *fire*. How nature of ground affects movements. Character of roads, nature of soil, &c.

TACTICAL EMPLOYMENT OF THE THREE ARMS.

Principles of employment of infantry in action, both in attack and defence. Modern infantry fire.

Principles of employment of cavalry in action. Offensive and defensive tactics. Dismounted service of cavalry. Mounted infantry.

Principles of employment of artillery in action. The positions and objective of artillery in attack and defence. Attack of field intrenchments. Development of artillery fire. Tactical employment of machine guns.

Principles of employment of the three arms in combination—in attack, in defence, in pursuit, in retreat.

DUTIES AND RESPONSIBILITIES OF A COMMANDER OF A MIXED FORCE.

TENDENCY OF MODERN TACTICS.

Principles to be kept in view in considering the tactics of the future.

OCCUPATION OF POSITIONS.

Principles on which ground should be occupied. Requirements of a good defensive position. The occupation of a position selected as a field of battle.

GENERAL COURSE OF AN ENGAGEMENT.

Attack and defence of positions. Night attacks. Counter attacks and offensive returns.

INCREASED USE OF FIELD FORTIFICATION BY THE ASSAILANT.

Issue of intrenching tools to soldiers has a direct bearing on tactics. Used by assailant to secure ground won, to contain defender in position, &c.

MARCHES.

Objects and requirements. Pace and halts. Length of marches dependent on the condition of the men, weight carried, nature of roads, etc. Length of column. Use of several roads. Importance of accurate timing of marches. Connection to be kept up between different columns. Place of each arm on the line of march. Discipline.

Flank Marches.—Their danger in presence of an enemy. Exposed flank to be protected. Distribution of force. Defiles on exposed flank to be guarded.

Night Marches.—Disadvantages attending them; precautions necessary.

RIVERS.

Defence of a river line, and general principles for distribution of force; active defence of a river line.

Forcing a river line; different methods. Selection of point of passage; what constitutes favorable points. Tributary streams. Islands.

Preparation of materials and assembly of troops. Secrecy and stratagem necessary. Covering party. Secondary crossings.

DEFILES.

Definition of a defile. Different kinds of defiles; their importance. Manner of defending defiles and of conducting a retreat through them. Mode of attacking defiles. Mountain defiles. Bridges. Fords. Causeways.

HOUSES AND VILLAGES.

Their importance and use. Conditions that affect their utility in a military sense. Isolated houses and villages form "tactical points," if in front, on the flank, in rear, or in the line of a position.

General mode of putting them in a state of defence. Importance of exterior line of defence, inner lines and citadel. Disposition of troops. Positions of artillery.

Attack of isolated houses and villages—1. by infantry alone; 2. by infantry supported by artillery.

WOODS.

Advantages afforded by woods to the defence or to the attack, according to their nature, extent, position. Disadvantages attending fighting within a wood.

Manner of putting woods in a state of defence.

Active defence of woods, and dispositions of the three arms.

Attack of a wood; disposition of troops for attack; movements of attacking force within a wood.

CONVOYS.

Different kinds of convoys, either by railway, road or water. Difficulty of conducting a convoy. Length of convoy. Causes governing strength and composition of escort.

Disposition of escort on the march; its duties. Advanced guard, main body, and rear guard. Conduct in case of attack. Mode of parking a convoy. Convoys by water.

Attack of a convoy; method of attack.

BATTLES.

The principles of tactics illustrated by the study of battles at different periods.

STRATEGY.

General principles of strategy, objects to be attained by strategic operations.

Difference between offensive and defensive war; advantages and disadvantages of each.

Success of strategy dependent on mobility, and the result of it on tactical success.

The difference in the art of strategy between the Feudal period and the present time. How the introduction of standing armies and civilization effected the change.

Improvement in the art of strategy by Napoleon.

THE THREE IMPORTANT PRINCIPLES OF STRATEGY.

1. The "*object.*" Selection of objective and theatre of operations. What generally must constitute the "object."

2. *Base of Operations.* The requirements of a base, extent, description, effects of configuration and position. Angular bases. Offensive and defensive bases.

3. *Line of Operations.* Necessary conditions for a line of operations. Distinction between single and double lines. Disadvantages of several lines, but difficulty of using one line. Independent lines. Limits of use of a single road for strategic purposes and advantages of operating by several roads.

Point of junction of different fractions of an army; danger of concentrating too near an enemy.

Combined armies operating from divergent bases, and armies operating on interior lines.

OFFENSIVE STRATEGY.

Offensive strategy classified under three heads:

1. Endeavour to turn a single flank.
2. The advance against the centre of a strategic line.
3. Operating against both flanks.

Advantage of compelling an enemy to form "front to a flank

An army throwing itself across the adversary's communications.

DEFENSIVE STRATEGY.

Direct and indirect defence. The evils of dispersion in defensive strategy. The strategical advantage gained by abandoning a certain amount of territory under certain circumstances. Employment of retarding forces.

LINES OF COMMUNICATION.

Influence of good communications, such as good roads, navigable rivers, canals and railways on strategical operations; also telegraphs.

Necessity of fortified points on the line of communications. The disadvantages of a long line of communications, and especially in the enemy's country.

OBSTACLES.

Influence of obstacles, such as mountain ranges and rivers, on offensive and defensive operations, when their general direction is parallel or perpendicular to the line of operations. Fortresses viewed as obstacles.

FORTRESSES.

The effects fortresses have on strategical operations. The cause of the establishment of fortresses. How they first affected strategy, causing sieges to be so numerous. The causes of sieges being reduced in these days in proportion to the number of battles.

CAMPAIGNS.

The science of strategy illustrated by the study of campaigns at various epochs.

GEOGRAPHY.

Special study of the theatre of war of such campaigns as may be selected. General study of the military geography of the Dominion of Canada.

N.B.—The campaigns and battles selected for study are varied from time to time, and no special text books are used for these, original lectures being given.

ESSAYS.

Original essays on the subjects of instruction will be required to be written according to the time available.

N.B.—In the examinations, as well as in essays which may be written on the subjects of instruction, great stress will be laid on clearness and conciseness of style and expression, legibility of handwriting, and correctness and precision in statement. Allowance will be made for those Residents of the Lower Provinces who may not be thoroughly acquainted with the English language.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN MILITARY ENGINEERING.

ALLOTMENT OF MARKS.

THEORETICAL PART.

Marks available for entire Course.

Obligatory, 6,000	Examination.	Yearly,	1,900	4,100
		Intermediate,	2,200	
	Term Work.	Notes, Exercises and Drawings,		1,900
Voluntary, 2,000	Examination.	Yearly,	1,200	1,200
		Intermediate	nil.	
	Term Work.	Notes, Exercises and Drawings,		800

PRACTICAL PART OR ENGINEERING DRILL.

Marks available for entire course.

Obligatory.	N. C. O's. and Cadets	500
	For imparting instruction, (N. C. O's. only).....	170

Voluntary, Nil.

Distribution of Marks by Classes. (*Theoretical part.*)

4th Class.

Obligatory. 1,000	Examination.	Yearly,	300	600
		Intermediate,	300	
	Term work.	Notes, Exercises and Drawings,		400

Voluntary, Nil.

3rd Class.

Obligatory. 1,500	Examination,	Yearly,	500	1,000
		Intermediate,	500	
	Term work,	Notes, Exercises, and Drawings,		500
Voluntary, 500	Examination,	Yearly,	300	300
		Intermediate,	Nil.	
	Term work,	Notes, Exercises and Drawings,		200

2nd Class.

Obligatory, 1,500	Examination,	Yearly,	500	1,000
		Intermediate,	500	
	Term work,	Notes, Exercises and Drawings,		500
Voluntary, 500	Examination,	Yearly,	300	300
		Intermediate	Nil.	
	Term work,	Notes, Exercises, and Drawings,		200

1st Class.

Obligatory, 2,000	Examination,	Yearly,	600	1,500
		Intermediate,	900	
	Term work,	Notes, Exercises and Drawings,		500
Voluntary, 1,000	Examination,	Yearly,	600	600
		Intermediate.	Nil.	
	Term work,	Notes, Exercises and Drawings,		400

Distribution of marks by Classes. (*Practical part.*)

4TH CLASS.....Nil.
3RD CLASS.....Nil.
2ND CLASS.....250
1ST CLASS.....250 and 170 for N.C.O's. only.

TEXT BOOKS.

The following is a list of the text-books in use:—

Guide to the Course of Military Engineering pursued at the R.M.C., Canada, by Major Walker, R.E., and Capt. Sankey, R.E.

Text-book of Fortification and Military Engineering, for use at the R.M.A., Woolwich. Parts I and II.

Instruction in Military Engineering, S.M.E., Chatham. Part III, Bridging; Part IV, Military Mining; and Part V, Miscellaneous.

Explosives, their use for Military Engineering Land Operations, and Electrical Measurements, by Captain Sankey, R.E.

Manual of Instruction in army signalling.

Books recommended to be read.

Instruction in Military Engineering, S.M.E., Chatham.
Lendy's Treatise on Fortification.
Professional papers of the Royal Engineers.
Sir Howard Douglas' Military Bridges.
Haupt's Military Bridges.
Von Scheliha's treatise on Coast Defence.
Journal of the Royal United Service Institution.
The defences of Washington, Barnard.
The Attack of Fortresses (R.E. prize essay), by Major Frazer, R.E.
The Defence of a Position (R.E. prize essay), by Major Fraser, R.E.
Brialmont's Hasty Intrenchments.
Brialmont's Traité de Fortification Polygonale.
Home's Precis of Modern Tactics.
Principes de Fortification, Noizet.
Fortification depuis Vauban, do.
Fortification du Champ de Bataille, Brialmont.
Nouvelles défences de la France, Tenot.

* Only those books at present in the Library at R.M.C., have been quoted.

SUMMARY OF COURSE OF INSTRUCTION IN MILITARY ENGINEERING.

The theoretical course of Military Engineering is partly obligatory and partly voluntary. The practical course, or Engineering drill, is entirely obligatory.

General Summary of Subjects.

Fortification,—
- Field Fortification.
- Permanent Fortification.
- Semi-permanent Fortification.
- Coast Defence.
- Attack and Defence of Fortresses.
- Mining.

Pioneer Duties,—
- Construction, demolition and restoration of communications. (*a*) For conveyance of men, horses and material. (*b*) For transmission of messages.
- Electricity applied to Military Engineering.
- Use of Explosives.
- Signalling.

Camp Duties,—
- Water supply, hutting, etc.

Method of Instruction.—The above subjects are taught theoretically, and, as far as possible, practical instruction is given in them. The theoretical instruction is carried out by means of lectures and personal instruction, explanatory of the text-books above quoted, and of other matter given in the form of notes from time to time, as required. The Cadets have to execute numerous plates and exercises, and to write out carefully the notes given to them.

The practical instruction, or Engineering drill, has to be carried out generally by executing the various works, in earth, timber, etc., to reduced scale, owing to want of time and labour; but, whenever possible, the work will be done full size. In this part of the course special attention will be given to instructing Cadets in superintending the execution of work.

The theoretical part of the course will be studied in all four classes.

The practical part will be taken up in the 1st, 2nd and 4th classes.

The following shows the portions of the subject studied in each class:—

Theoretical Part.

IV Class.—Field Fortification:—Nature and construction of the works required for the defence of a Position.
III Class.—Permanent and Semi-Permanent Fortification, and Coast Defence.
II Class.—Attack and defence of Fortresses, Mining, and Applied Field Fortification.
I Class.—Applied Field Fortification (continued.) Use of Field Fortification by the Attack, Pioneer duties, Camp duties.

Engineering Drill.

IV Class.—Field Fortification.
III Class.—
II Class.—Field Fortification; The attack and defence of Fortresses; Signalling.
I Class.—Use of explosives; Pioneer duties, Camp duties, Signalling.

4TH CLASS.

OBLIGATORY.

FIELD FORTIFICATION.

1*st Part.*

1. *Introduction.*—Influence of Tactics on Field Fortification. Sketch of the attack and defence of a Position. Principles of defence and deductions from them of the works required to defend a Position. Effects of the arms at present in use.
2. *Tools.*—Various kinds. Transport of tools.
3. *Materials.*—Raw: how obtained; earth, wood, brushwood, iron, &c.
   Manufactured: how made; pickets, fascines, gabions, hurdles, &c.
4. *Labour.*—Tasks and Reliefs. Working parties.
5. *Revetments.*—When required. How made. Anchoring. Comparison of the various kinds.

WORK TO BE DONE FOR THE DEFENCE OF A POSITION.

6. *Clearing the foreground.*—Object. Requirements and how fulfilled.
7. *Obstacles.*—Object. Divided into natural and artificial. Principles and requirements. Description of the various kinds of artificial obstacles used, namely: Abatis of various kinds,

Entanglements, Wire entanglement, Irregular pits with wire entanglement over them, Chevaux de frise, Palisades, Fraises, Military pits, Inundations, &c.

Cover for Troops.

For Infantry :—

8. To cover shooting line.—Requirements, and how generally fulfilled. Description of the various works used, namely: Shelter trenches, earthen breastworks (larger parapets under the head of redoubts), Log parapets, Stockades, Defensible walls, hedges, snake fences, &c.

9. To cover supports.—Requirements and how generally fulfilled. Descriptions of the various works used, namely: Adaptation of natural cover, deep trenches, blind trenches, field casemates, &c.

10. To cover reserves.—Requirements and how generally fulfilled. Description of the various works used, namely: Adaptation of natural cover, shelters, &c.

For Artillery : —

11. To cover the gun, gun detachment and ammunition.—Requirements and how generally fulfilled. Description of the various works used, namely: Adaptation of natural cover, gun pits, gun-epaulments (the placing of guns in Field Works is considered under that head.)

12. To cover Limbers.—Requirements and how generally fulfilled. Description of the various works used, namely: Adaptation of natural cover, Limber pits.

Blindages.

13. Specially considered.

Hasty Intrenchments.

14. Nature and object.

Methods of Flanking.

15. Object. Special requirements and how generally fulfilled. Description of the various special works, suitable for flanking, namely: Tambours, caponiers, &c.

Fortification of the Strong Points of a Position and of Isolated Posts.

16. Object and special requirements, various kinds, namely:

17. Field works. Trace, profile, details and execution. Garrion, &c.

18. Defensible knolls. Trace, profile, &c.
19. Defensible houses and villages.
20. Defensible woods.

Making and Destroying Communications in a Defensible Position.

21. Object and *statement* of work to be done.

PLATES.

I. Cover for shooting line.
II. Cover for supports and reserves.
III. Profiles of Field redoubt.
IV. Field Trace.
V. Defensible Kn
VI. Defensible Post.

These plates are varied from time to time.

EXERCISES AND FAIR NOTES.—On the above subjects.

SUBJECTS FOR EXAMINATION:—

December—Sections 1 to 6 inclusive.
March—Sections 1 to 14 inclusive.
June—The whole subject.

III CLASS.

OBLIGATORY.

PERMANENT FORTIFICATION.

A. INTRODUCTORY:—

Definition of permanent fortification.
Principles and object the same as in field fortification, and unchanging.
Details subject to change with the arms in use.
Situations in which permanent works are required.
Classification of fortresses with reference to the duties they perform.

B. REQUIREMENTS OF A FORTRESS—

a. *Absolute security* against attack with the means at the disposal of the enemy's field army, viz.:—

α. By surprise.
β. By open assault.
γ. By bombardment.
δ. By blockade.

b. *The maximum amount of security* against attack by regular siege.

Sketch of attack and defence under the above heads with the object of showing the general nature of the works necessary to give effect to these requirements.

C. Elements of Permanent Works—

The fortress, in its elementary idea, consists of an enclosed space, protected from the enemy's fire, and surrounded by an obstacle which secures it from assault. Requirements and how fulfilled.

a. *The ramparts* as a platform for artillery and musketry fire, and as affording protection to men and guns.

b. *Profile and plan of the obstacle*, to secure it from assault and provide flanking fire.

c. *Works outside the obstacle* to watch and defend it, and to secure the passage to the defenders.

d. *Retrenchments* or keeps, to prevent the enemy from securing his footing inside, even if the obstacle is forced.

a. α. The rampart; its object, command, thickness, terreplein, slopes, ramps.

β. The parapet; its object, command, thickness, form, slopes.

γ. Means for use of musketry and artillery fire; the banquette, barbettes, embrasures, Haxo casemates, Moncrieff pits, mortar casemates, iron shields, cupolas.

δ. Trace; for strong frontal fire, as straight as possible.

ε. Means for shelter for men and material; traverses, solid or hollow, parados, bomb-proof shelter; under rampart for men, in traverses for guns, bomb-proofs for reserves, their construction and position.

b. α. Conditions of defence which all profiles must fulfil.

β. Profile; with dry ditches, with wet ditch, width and depth of ditches in each case, comparative advantages of wet and dry ditches.

γ. Various kinds of revetments, their construction, comparative advantages and disadvantages of each kind.

δ. The trace to obtain flanking fire; why necessary, how obtained. Three systems—

1. The Tenaille.
2. The Bastioned.
3. The Polygonal.

Describe and compare these systems.

c. Under this head are included outworks, advanced works, detached works and communications.

α. Outworks—

1. Covered way and glacis, and ravelin, with their keeps, object, construction.
2. Counterguards; their objects, construction, defects, when useful.

3. Tenaillons and demi-tenaillons, mention only.

β. Advanced works—

Horn works, crown works, lunettes, flèches, their objects and traces.

Discuss the general objects of outworks and advanced works, and show that the accumulation of these works, formerly thought desirable, is now obsolete.

γ. Detached works—

Requirements, when used. (See also applied F. F.)

δ. Communications—

Requirements; simply, easy, safe, how carried out.

d. Retrenchment—

Requirements, how carried out.

a. Open works; cavaliers, gorge retrenchments, coupures.

β. Closed works; casemated keeps, interior glacis, iron plating.

γ. Citadels; how they differ from ordinary retrenchments, their requirements and how fulfilled.

D. Arrangement of the Elements in Fortresses.

General considerations which govern the combination of the above elements.

α. *Detached Forts.*

Requirements.

α. Good artillery positions.

β. Secure against assault.

How carried out.

b. *Enclosed Enceintes.*

α. When a regular attack is not possible.

1. Long simple fronts.
2. Simple outworks.
3. Escarps, caponiers, and keeps completely covered from view.

β. When a regular attack is to be anticipated.

1. Shorter fronts, more elaborate in detail.
2. Strong salient outworks. Countermines under glacis.
3. Escarps, caponiers and keeps, completely covered, hence masks, iron plating, interior glacis, the latter countermined.

c. *Combination of Enclosed Enceintes and Detached Forts*—

To form first-class modern fortresses.

α. The enceinte as in (D — *b* — β) above.

β. The detached forts.

1. The individual forts as in (C — *c* — γ) above.
2. Considerations which have brought into prominence in modern fortification, the combination of detached forts, with enclosed enceintes.

d. Examples of Modern Works—To illustrate the above.

E. Sketch of Progress of Permanent Fortification—*vide* voluntary course.

F. General Application.

Application of fortresses to the defence of a country, including a general sketch of coast defence. *
General strategical considerations: Method of frontier lines, its failure illustrated by examples.
Experience of the German invasion of France in 1870-71.
Discussion on the best method of defence.
Tactical use of Fortresses.
Distinction between a fortified place, or fortress, and a fortified position.

SEMI-PERMANENT FORTIFICATION.

A. Introductory—

Definition.
Objects to be attained. Requirements.
Means available for construction of semi-permanent works, including time.
Characteristics of semi-permanent works.
Cases in which they are applicable.

B. Application—

a. To semi-permanent detached forts.
b. To semi-permanent enceintes.
Requirements, and how carried out under each of the above heads.

C. Various Examples of the Application of Semi-Permanent Works.

PLATES.

I. Permanent profiles.
II. Plan of a Permanent work.
III. Sections and elevations of II.
IV. Details of Permanent works.
These plates are varied from time to time.

Fair Notes.—On lectures during the term.

Exercises.—Examples of permanent profiles and bastioned traces.

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*Coast defence is chiefly dealt with in the Voluntary Course.

SUBJECTS FOR EXAMINATION:—

December.—Sections A, B, C and D, Permanent Fortification.

March.—Section F, Permanent Fortification, and Semi-Permanent Fortification.

June.—The whole subject.

III CLASS.

VOLUNTARY.

PERMANENT FORTIFICATION.

E. SKETCH OF PROGRESS OF PERMANENT FORTIFICATION.

a. Permanent Fortification before the introduction of Gunpowder; methods of attack to which it was exposed and means taken to resist them. Show that the principles were the same as in modern fortification.

b. The Transition Period.

Effect of the introduction of cannon, and of mining with gunpowder.

On the site.

On the construction.

On the profile.

On the trace.

c. The early Italian, Dutch and French Schools.

Introduction of the bastioned trace in Italy.

Origin of the ravelin.

Paciotto's trace, the first regular bationed work.

Characteristics of the Dutch school, example Cœvorden.

Improvements by Coehorn, his principles and methods of construction.

c. The French School under Vauban and his Successors.

Vauban's systems, first and third. Cormontaingne's improvements; the school of Mezières; the school of Metz (modern French system.)

Later improvements in the bastioned system and its application to detached forts in France during the present century.

e. Rise of the Polygonal System in Germany.

What it owes to Montalembert, and to the early designs of Durer (16th century.)

Various examples of the application of this system in modern German works.

COAST DEFENCE.

* A. INTRODUCTORY—

Principles unaltered.
Considerations which influence the modifications in detail, characteristic of coast defences.
Considerations which influence the selection of the points to be defended.
Sketch of methods of attack to which such defences are liable.
Requirements and means of carrying them out.
a. By special arrangement of batteries—site.
b. By constructive details for protection of guns and facilitating their service.
c. By utilization of naturel obstacles and creation of artificial ones.

B. COMBINATION OF THESE PRINCIPLES IN WORKS FOR COAST DEFENCE—

Nature of defences :
a. Batteries.
b. Obstructions.
c. Submarine mines.
d. General discussion on method of defending coasts by the combination of the above.
a. Batteries.—Requirements and how fulfilled for the following :—
α. Earthen batteries with or without Moncrieff carriages.
β. do do with iron embrasure shields.
γ. Casemated batteries with do do
δ. Iron fronted batteries fixed or revolving.
Situations in which these batteries are suitable, respectively :—
b. Obstructions.—Requirements and how fulfilled for the following :—
α. Sunken obstructions.
β. Floating do
Situations in which they are suitable, respectively :—
c. Submarine Mines—Requirements and how fulfilled for the following :—
α. Defensive.
1. Mechanical.

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* Portions of Sections A, B and C, Coast Defence are included in Obligatory Course under Section F.

2. Electrical.

Situations in which they are suitable, respectively. Attack on submarine mines. (For explosives used, see Explosives).

β. Offensive (Torpedoes.)

1. Locomotive.
2. Outrigger.

Brief sketch of the use of torpedoes.

d. General discussion on method of defending coasts by the combination of the above.

C. General Military Operations for the Defence of Coasts.

PLATES.

V and VI. Coast Defences.

These plates are varied from time to time.

Fair Notes.—On lectures during the term.

II CLASS.

Obligatory.

ATTACK OF FORTRESSES.

A. Introductory.

Modes of dealing with fortresses—how determined.

Various methods of attack which can be carried out with the means at the disposal of a field army. When they are applicable respectively, and how carried out.

a. By Surprise.

b. By Open Assault.

Application in connection with the regular attack.

c. By Bombardment.

α. For destruction of arsenals, &c.

β. For obtaining possession of the place.

Application in connection with other methods of attack.

d. By Blockade.

Methods *a*, *b* and *c* may be used in connection with blockade.

Application of blockade in connection with the regular attack.

B. The Regular Attack.

a. Introductory.—When used, general sketch of the method of appoaching the fortress.

Corps of observation, necessity for.
Siege corps; its strength and composition.
Siege train; artillery and engineer.

b. Investment—

Object, strength and composition of the investing force.
Method of execution.
Sketch of the arrangement and fortification of the investing line. (See applied F. F.)

c. Preparation for the regular siege.

Choice of front of attack.
Project of attack.
Site and arrangement of siege parks.
Preparation of materials.
Preliminary batteries, discussion as to whether they are to be recommended.

d. The regular siege.

α. The first artillery positions; object, requirements of batteries, considerations affecting their site.
Type of battery employed, method of execution.

β. Progress of attack up to the formation of the first parallel.
Object of first parallel, requirements, former method of opening, present method.
Tracing and extending.
Execution by common trench work.
The approaches.
Extent of the parallel.
Covering troops.

γ. The second artillery position—
Its object; duties of the batteries; their sites; number of guns required, and their distribution; requirements of the batteries.
Type of battery used; modifications of typical battery; Screens; their object and mode of construction.
Communications to batteries.
Arming batteries and opening fire.

δ. Advance from first to third parallel.

1. The second parallel; its object and position.
Requirements, execution of the second parallel and its approaches, generally by flying trench work. Advance in front of second parallel, generally by sapping.
2. Definition of sapping and requirements.
Single saps shallow and deep; when used, how executed.
3. Demi-parallels; their object and position.
4. Third parallel; its object and position, requirements and method of execution.

ε. Advance to the covered way.

1. Special difficulties to be encountered in front of the third parallel.
2. Circular portions.
3. Mine attack necessary, if counter mines exist. (See Mining.)
4. Advance from circular portions by double sap on the capitals.
5. Demi-parallels; their object and position.
6. Fourth parallel; its object and position, and requirements.
7. Crowning the covered way by sap lodgments.
8. Double and cube saps; object, requirements, how executed.
9. Crowning the covered way by assault, when attempted.
10. Fifth parallel; its object, position and requirements.

ξ. Breaking into enceinte.

1. General arrangements, and usual order of procedure against the various works in succession.
2. Breaching escarp, position and range of the breaching batteries, method of forming the breach, observation of effect of fire. Batteries in the lodgments when required, position, execution and armament.
3. Breaching by mines, silencing flanks, descent into ditch, passage of ditch.
4. Occupation of the breach.
   By assault, preparations for assault, disposition of troops, execution.
   By gradual occupation, method of execution.
5. Further proceedings against retrenchments, if they exist.
   Breaching by distant curved fire if the escarps are not well covered.
   Attack by mining.

C. Examples—

a. Application to the attack of a front of the modern French system.
b. Probable course of attack on a polygonal front.
c. Attack on a chain of detached forts.

DEFENCE OF FORTRESSES.

A. Introductory—

Readiness to resist attack. State of preparation during peace with respect to works and stores.
Garrison; peace and war establishments.
Armament; guard and full, nature of pieces, amount of ammunition.

Engineer stores.
Provisions.
Preparations for defence if threatened; interior organization of the place.
Works which require to be carried out by the Engineers and Artillery.
Distribution of troops.

Measures required to resist attack.

By the enemy's field army under the heads given in syllabus of attack, section A, viz:

a and *b*. By surprise or open assault.
c. By bombardment.
d. By blockade.

B. AGAINST REGULAR ATTACK—

a. *Preparatory arrangements.*
b. *Resistance to investment.*
c. *Obstruction of the preparations of the regular siege.*
d. *Resistance to the operations of the regular siege.*

α. Against the first artillery position.
Modifications of armament. Retrenchment commenced.
Special for first class fortresses,—intermediate batteries between, and retrenchments behind, the detached forts.

β. Against progress of attack to first parallel.
Defence of advanced posts.
Lighting up ground at night and careful observation.
Firing on working parties; large sorties.

δ. Against the second artillery position.
Concentration of fire on batteries in succession.
Interruption of working parties if discovered by shrapnel fire.

δ. Against advance to third parallel.
1. Same operations against second parallel as against first.
2, 3 and 4. Against saps, demi-parallels and third parallel.
Fire upon sap heads. Small sorties. Counter approaches.

ε. Against advance to covered way.
1. Creation of difficulties; obstacle, mines.
2. Same as against other saps.
3. Countermines to oppose besiegers' mines. (See also, mining.)
4, 5, 6, 7 and 8. Against double saps, demi-parallels, fourth parallel, crowning covered way by sap.
Concentration of fire and small sorties as against other saps. Wall Pieces in place of Arms, plunging fire from Cavaliers.
9. Against crowning covered way by assault.
Concentration of fire as before; sorties on flank.

10. Against fifth parallel.
Same as against other saps.
9. Against breaking into enceinte.
1. General preparations.
2. Against breaching of escarp.
Concentration of fire, and sortie, against breaching batteries in lodgment, and gallery of descent, retaining possession of covered way as long as possible.
3. Against breaching by mines, &c.
Sorties and vertical fire in the ditch. Water manœuvres in wet ditch. Shells rolled over and flank fire against attached miner. Countermines under ditch.
4. Against occupation of the breach.
Scarp and countermine breach. Arrange obstacles. Retrenchments in the ditch and on rampart. Flanks restored. Concentration of fire on breach and approaches. Strong bodies of troops under cover close to breach. Strong fire from keep on breach.
5. Against attack on retrenchments.
Countermines under glacis, strong fire of musketry, facilities for counter attack with bayonet. Final defence of citadel or of a second fortress.

C. Examples of the Defence of Fortresses—

Various.

D. General Discussion—

On the relative gains and losses of the attack and defence under modern conditions, and on the probable course of the attack in the future.

MINING.

A. Introductory

Brief sketch of methods of mining in use before the application of gunpowder to this purpose.
Application of gunpowder to mining operations.
a. By the attack.
Object, to continue advance when sapping is stopped to breach escarps and blow in counterscarps.
Means of defenders to resist such attack; countermines, galleries behind escarp, under ditch, behind counterscarp.
b. Offensively by the defence.
Object, to blow up the enemy's works, and so delay his advance.
Measures taken for this purpose.

Countermines; galleries arranged systematically under the glacis, in one or more planes (undercharged mines.)
Measures taken by the attack to neutralize this means of defence.
Countermines offensive (overcharged mines.)

c. *Submarine mines.* (See Coast Defence.)

α. Defensive use, submarine mines proper.

β. Offensive use, torpedoes.

B. REQUIREMENTS.—Means for placing charges.

a. *Land mines;* offensive and defensive.

α. Shafts and galleries; object, dimensions, method of execution and lining. Tools, appliances and time required.

β Bored mines; object, dimensions and method of execution.

γ Ventilation of mines; requirements, method of carrying them out.

δ Preparation of charges, loading, tamping and firing mines. (See Explosives.)

b. *Submarine mines.*
See for details, Coast Defence, Section B, Sub-section c.

C. EXPLOSIVES GENERALLY USED.—Their different effects, and the quantity of each required.

a. *Explosives.*

α Gunpowder, gun cotton and dynamite; comparison of their effect, and when they should be used respectively. Sketch only.

β Calculation of charges, land mines; definitions; overcharged and undercharged mines; camouflets; radii of rupture. Rules for calculating the charges and effects of mines. Influence of the nature of the soil upon the charge.

γ For Submarine Mines, see Coast Defence and Explosives, as above.

For the application of mines, Syllabus of Voluntary Course.

FIELD FORTIFICATION.

2ND PART.

APPLICATION TO THE GROUND OF THE WORK TO BE DONE FOR THE DEFENCE OF A POSITION—

Object of defending a Position. Subdivision of the defence into two kinds: offensive-defensive and purely defensive.

Application of the different kinds of defence.
The positions of the works must conform to that of the troops.
Statement * of the tactical requirements and of the consequent distribution of the troops.
General arrangement of works to conform to this distribution, namely, Lines with Intervals. Comparison of Lines with Intervals and Continuous Lines. Influence of the kind of defence and of the object for which the Position is defended on the arrangement of the works.
Object of advanced works and of a second line of defence and general arrangement for each.
Choice of a Position.—The approximate site depends on strategical considerations, the accurate site mainly on tactical and slightly on technical considerations. General requirements. Special requirements according to the kind of defence. Defects that may occur in Positions, and how best to neutralize them. Description of various kinds of Positions.
Choice of site for works.—The site must be chosen principally on tactical and slightly on technical considerations. Requirements, and how fulfilled, in each of the following cases :—
a. Infantry : shooting line, supports and reserves.
b. Artillery : Guns and limbers.
c. Strong points : Advanced posts, Main line pivots. 2nd line pivots, Keeps of Position, Works covering retreat.
d. Flanks.
e. Communications, radial and lateral.
Order in which the various works should be executed.
Inquiry into the effect of intrenching on the field of battle.
Application of the foregoing to the defence of positions occupied for the following purposes, giving in each case the object of defending the Position, the *special* requirements and how they are fulfilled :—
1. Field of battle. Offensive-defensive and pure defensive.
2. Lines of investment.
3. Defence of the environs of a fortress.
4. Defence of defiles—bridge heads and mountain passes.
5. Intrenched camps, depots, &c.
6. Rearguard Positions.
Attack and Defence of field works.

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* The consideration of these tactical requirements belongs to the Course of Tactics.

PLATES.

I. The attack to the third parallel.
II. The attack to the summit of the first breach.
III. Defence.
IV. Mining, &c.
V. Applied field fortification (project).
These plates are varied from time to time.

FAIR NOTES.—On lectures during the term.

EXERCISES.—Journal of attack. Report on project.

SUBJECTS FOR EXAMINATION—

December—To end of attack.
March—To end of defence and mining. (Sections A to C inclusive.)
June—Attack, Defence, Mining, (Sections A to C) and application of field fortification to the defence of a Position.

2ND CLASS.

VOLUNTARY.

ATTACK.

SECTION B.—Obligatory course.

SUB-SECTION *d*,—α, γ, δ, ε, ς, more in detail.

MINING.

D. APPLICATION OF MINES—

a. To the Defence.

α. Defence of glacis: object, requirements, how carried out. Countermine systems for defence of glacis.

β Defence of breach, object, requirements, how carried out. Countermine systems.

b. To the Attack.

α. On countermines under glacis, tactics of assailant, ordinary method of attack by galleries, attack by shaft mines.

β. On countermines for defence of breach.

γ. On escarp and counterscarp revetments, to form breach.

c. To the demolition of permanent works after capture or during peace.

PLATES.

VI. } Siege Works.
VII. }
These plates are varied from time to time.

FAIR NOTES.—On lecture during the term.

EXERCISES.—Examples on application of mining; Journal of attack on countermines.

SUBJECTS OF EXAMINATION—

June—Whole subject.

1ST CLASS.

OBLIGATORY.

FIELD FORTIFICATION.

USE OF FIELD FORTIFICATION BY THE ATTACK.

Object.—The assailant may employ Field Fortification for two distinct purposes, namely: A purely offensive and a purely defensive use. Cases in which Field Fortification would thus be used.

Purely Offensive Use.

Nature of Works.—The same as those for defence, of a very hasty description. But includes, besides, the destruction of ennemy's works when captured; methods of doing this.

Application to the ground.—The sites of the works depend on the tactics of the attack. Statement of the tactics of the attack and deduction therefrom of the arrangement of the works.

Choice of sites for Works.—Very limited. Requirements and how generally fulfilled for Infantry, Artillery and communications.

Purely Defensive Use.

Nature of Works.—The same as those for defence, of a hasty description. But includes, besides, the adaptation of the ennemy's works, when captured, for defence against him; methods of doing this.

Application to the ground.—As in the defence of a position, and in some cases the choice of sites will be influenced by the tactics of the attack (see *a* and *b* below). Consideration of the following cases:—

a. Intrenching front to assist flank attack.

b. Securing captured position.

c. Preparing rear guard positions in case of reverse: connection between the above use of Field Fortification and the "regular" attack by means of siege works.

EXPLOSIVES.

THEIR USE FOR MILITARY ENGINEERING LAND OPERATIONS.

Qualities and capabilities of the various explosives used. Detonation.

Construction of magazines for the storage of explosives.

USE OF EXPLOSIVES.

Fuzes.—Electrical and for use with slow or instantaneous leader.

Preparation of Charge.—Primer; preparation of charges for various purposes.

Preparation of Firing Arrangements.—Slow and instantaneous leaders.

Firing by Electricity.—Voltaic batteries, quantity and tension dynamos, arrangement of circuit, jointing.

Testing.

Examination of explosives.

Electrical testing (with the apparatus contained in the Field Service Testing and Jointing box) of fuzes, firing apparatus, batteries, dynamos, calculation of battery power, Circuit, testing circuit wires and complete circuit.

PIONEER DUTIES.

Communications considered under three heads. Construction, Demolition and Restoration.

COMMUNICATIONS FOR THE CONVEYANCE OF MEN, HORSES AND MATERIALS.

CONSTRUCTION.

BRIDGING (Railway bridging omitted).—Object, requirements, methods of determining dimensions of opening, considerations regulating the class of bridge to be made according to the nature and dimensions of the opening, namely: Frame and suspension bridges for narrow, deep openings; Trestle bridges for shallow, wide openings; and floating bridges for wide openings containing deep water.

Approximate rules for rapidly calculating the dimensions of spars when the stress in them is known. * General considerations as regards the roadway, road-bearers, trussed beam and shore ends.

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* Accurate methods are given in the Mathematical and Civil Engineering Courses.

Methods of connecting spars together; lashing, tree-nails, spikes and dogs.

Plant used for bridging.—Tackle, Spanish windlass, derricks, shears, gyns, earth anchors of various holding power.

Frame bridging.—General description of such bridges. Materials required. Details of construction. Methods of erecting and calculation of stresses for the following kinds of frame bridges: Single lock, double lock, single sling, ordinary and stiffened treble sling; in each case with and without vertical frames at shore ends.

Trestle bridging.—General description of such bridges. Materials required. Details of construction. Method of making and calculation of stresses for the following kinds of trestles; Two-legged, four-legged and tripod. Advantages and disadvantages of each kind. Forming up into bridge.

Miscellaneous methods of obtaining points of support, crib piers, piles, &c.

Floating bridges.—General description of such bridges. Materials required. Details of construction. Calculation of dimensions and buoyancy required for floating bridges composed of pontoons, barrel-piers of various kinds, timber rafts of various kinds, and boats. Arrangements to be adopted at the shore ends: 1. When the water level does not alter or varies but little; 2. When there is a considerable variation of level.

Flying bridges.—Their requirements and construction.

Miscellaneous.—Rough bridges made of trees; passing weights across wide openings by means of shears, etc.

ROADS.—Object, requirements, method of construction of military roads, ordinary, hills over marshes, corduroy roads, road engines, repairing roads.

RAILWAYS.—Object of constructing military railways in time of war. Requirements, consideration as to selection of route, gauge, engines and rolling stock of military railways. † Adaptation of existing stations to military purposes.

Trench railway.—Object, requirements, considerations as to section of route, gauge, engines and rolling stock. Works required and how executed (bridging mentioned only).

DEMOLITION.

Object. Description of methods generally adopted: 1. By hand. 2. By use of explosives. 3. By fire.

ROADS.—Vulnerable points: bridges, cuttings and embankments. Demolition of each.

† The laying and construction of the road are not considered, being part of the Civil Engineering Course.

RAILWAYS.—Vulnerable points: bridges, cuttings, tunnels, embankments, permanent way, engines and rolling stock. Hasty demolition by cavalry, and deliberate demolition.

CANALS.—Vulnerable points: locks, cuttings and embankments. Demolition of each.

RESTORATION.

Object. General considerations.

ROADS.—Repairing bridges, or replacing the original structure by a temporary one. Repairing cuttings and embankments, or other works undertaken to replace them, if not repairable in time.

RAILWAYS.—General considerations only.

COMMUNICATIONS FOR THE TRANSMISSION OF MESSAGES.

CONSTRUCTION.

Object and general considerations.

SIGNALLING.—Object. Alphabet. Code. Cypher. Means of signalling: flags, lamps, shutters, heliograph. Selection and arrangement of signal stations and method of working them.

TELEGRAPHS.—Object. Short sketch of method of working without introducing technical matters.

Combination of cavalry scouts, signalling and telegraphy for the service of an army.

DEMOLITION.

TELEGRAPHS.—Breaking the circuit. Tapping the circuit.

RESTORATION.

TELEGRAPHS.—Same as making.

CAMP DUTIES.

WATER SUPPLY.—Sources of water supply. Purifying water. Distribution of water. Methods of obtaining water. Norton's Abyssinian tube wells. Boring for water.

HUTTING.—Requirements. Huts of various kinds. Bivouacs.

MISCELLANEOUS.—Field kitchens and ovens. Latrines.

PROJECTS.

I. Project for the defence of a position.
II. Demolition project.
III. Project for a military bridge.
IV.

These projects are varied from time to time.

FAIR NOTES.—On lectures during the term, when ordered.

EXERCICES.—Reports on projects.

SUBJECTS FOR EACH EXAMINATION—

December—Field and Permanent fortification; use of explosives and bridging, as far as trestle bridging, inclusive.
March—Attack and defence and remainder of pioneer duties.
June—Whole course for class.

1ST CLASS

VOLUNTARY.

ELECTRICAL TESTING.

General Considerations. Units to which these measurements are referred.

Instruments.—Description and method of using the following instruments: Contact keys, standard cells, galvanometers (detector, sine, tangent, Thomson's reflecting and Clark's differential galvanometers,) resistance coils, condenser.

Testing.—Various methods of obtaining measurements of resistance, (resistance of a conductor, of a galvanometer, of "earths," etc., internal resistance of a cell), difference of potential, electro motive force, strength of a current, and capacity.

(Part II of Explosives and Electrical measurements forms the voluntary Course).

PIONEER DUTIES.

COMMUNICATION FOR THE CONVEYANCE OF MEN, HORSES AND MATERIALS.

BRIDGING—

Suspension Bridges.—General description of such bridges. Materials required. Details of construction. Method of erecting and calculation of stresses, and dimensions for the following kinds: Ordinary suspension bridges, tension bridges, and strutted tension bridges.

Railway Bridges (temporary).—Object and requirements. Materials used. Details of construction. Method of erecting, and calculation of stresses and dimensions for the following kinds: Frame bridges for small openings, trestles for wide shallow openings, and trestles in tiers for wide deep openings.

COMMUNICATIONS FOR THE TRANSMISSION OF MESSAGES,

BALLOONING.—General considerations.

OBSERVATORIES.—Object, requirements and method of construction of various kinds.

PLATES.—Pioneering project.

FAIR NOTES.—On lectures during the term, when ordered.

EXERCISES.—Report on project.

SUBJECTS FOR EXAMINATIONS—June—The whole subject.

ENGINEERING DRILL.

4TH CLASS.

FIELD FORTIFICATION.

Preliminary.

Carrying tool drill and extending working parties. Field Geometry. Use of Field Level.

Obstacles.

Abatis ordinary. German bough abatis. Shallow military pits. Wire entanglements. Palisades. Fraises. Chevaux-de-frise, &c.

COVER FOR TROOPS.

Infantry.

Shooting Line.—Shelter pits and rifle pits. Shelter trench exercise. Blinded shelter trenches, defensible hedges, walls and snake fences. Log, hurdle and plank parapets. Stockades of various kinds.

Supports.—Deep shelter trenches. Blinded shelter trenches. Field casemates of various kinds.

Reserves.—Lean-to shed covered with earth.

Artillery.

Guns and Detachment.—Gun pits. Gun epaulments.
Ammunition.—Ammunition recesses in above.
Limbers.—Limber pits.

Use of Brushwood.

Making pickets, gabions, fascines and hurdles.

Revetments.

Made of the following materials:—Gabions, casks, fascines, logs, planks, hurdles, continuous hurdle work, sand-bags, bricks, stone, miscellaneous.

II CLASS.

Field Redoubt.

Tracing, profilling and defilading full size. Executing in model. The redoubt to contain splinter proofs, traverses and occasionally gun-banks.

ATTACK OF FORTRESSES.

First Artillery Position.—Execution in model of suitable batteries.

Up to 1st Parallel.—Common trench work for parallels and approaches.

Second Artillery Position.—Tracing of full size siege-gun battery and execution in model, with magazines, screen, platforms and approaches.

Up to 2nd Parallel.—Flying trench work.

Up to 3rd Parallel.—Single sap shallow and deep.

Advance to covered way.—Circular portions. Double saps. Blinded saps. Crowning the covered way.

Breaking into enceinte.—Batteries in lodgment on covered way. Descent into the ditch. Passage of ditch (1) when dry, (2) when wet. Occupation of breach.

Mining.—Sinking shafts with cases and frames.* Driving galleries with cases and frames. Preparing charge for mine.

Signalling.

Flag Drill.—Practice with flags. Lamp drill with dummy lamps. Practice with lamps. Practice with heliograph. Selecting stations. Transmission of messages.

I CLASS.

USE OF EXPLOSIVES.

Preparing charges of gunpowder, guncotton and dynamite for various purposes.

Preparation of firing arrangements.—Firing charges by means of slow or instantaneous leader and by electricity.

Testing.—Practical application of the theoretical course.

PIONEER DUTIES.

Bridging.

Preliminary.—Reconnoisance of site. Measuring width,

* The actual sinking of shafts, &c, will not, as a rule, be possible.

taking sections (boning and levelling). Knotting. Lashing spars. Making Derricks, Shears and Gyns. Trussed beams.

Frame Bridges.—Single lock, double lock, single sling.

Trestle Bridges.—Making two-legged, three-legged and four-legged trestles with various materials. Forming up into bridge.

Miscellaneous.—Points of support formed by gabions, casks, crib piers, &c.

Water bridging.—Barrel pier drill. Preparing boats. Forming the above into bridge.

Signalling.—2nd class work continued.

CAMP DUTIES.

Bivouacs. Field kitchens and ovens. Latrines, &c.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN PRACTICAL GEOMETRY AND ENGINEERING DRAWING.

ALLOTMENT OF MARKS.

Marks available for entire Course.

PLANE GEOMETRY AND ENGINEERING DRAWING.

Obligatory, 800	Examination,	Yearly,	300	500
		Intermediate,	200	
	Term work,	Notes, Exercises and Drawings,		300
Voluntary, 500	Examination,	Yearly,	240	240
		Intermediate,	Nil.	
	Term work,	Notes, Exercises and Drawings,		260

SOLID GEOMETRY AND ENGINEERING DRAWING.

Obligatory, 900	Examination,	Yearly,	300	500
		Intermediate,	200	
	Term work,	Notes Exercises, and Drawings,		400
Voluntary, 2,000	Examination,	Yearly,	750	1,050
		Intermediate,	300	
	Term work,	Notes, Exercises and Drawings,		950

4th Class.

PLANE GEOMETRY AND ENGINEERING DRAWING.

Obligatory, 700	Examination,	Yearly,	200	400
		Intermediate,	200	
	Term work,	Notes, Exercises and Drawings,		300
Voluntary, 500	Examination,	Yearly,	240	240
		Intermediate,	il.	
	Term work,	Notes, Exercises and Drawings,		260

3rd Class.

SOLID GEOMETRY AND ENGINEERING DRAWING.

Obligatory, 1,000 (Including 100 for revision in Plane Geometry.)	Examination,	Yearly,	G.D. 100 + D.G. 300	600
		Intermediate,	200	
	Term work,	Notes, Exercises and Drawings,		400
Voluntary, 500	Examination,	Yearly,	250	250
		Intermediate,	Nil.	
	Term work,	Notes, Exercises and Drawings,		250

2nd Class.

SOLID GEOMETRY AND ENGINEERING DRAWING.

Obligatory				Nil.
Voluntary, 1,500	Examination,	Yearly,	500	800
		Intermediate,	300	
	Term work,	Notes, Exercises and Drawings,		700

TEXT BOOKS.

Part I. Text Book, Fortification and Military Engineering, R. M. Academy, Woolwich.

Practical Geometry and Permanent Fortification, S. M. E, Chatham.

R. M. College notes on Practical Geometry.

The text book in use for the voluntary course in solid geometry is "Practical Geometry and Engineering Drawing," by G. S. Clarke, Lieut. R. E.

Books recommended to be read:

Heather's Descriptive Geometry, Weale's series.
Edgar and Pritchard's Solid or Descriptive Geometry.
Woolley's Descriptive Geometry.
De Rheim's Geometrical Drawing.

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* Only those books, at present in the Library at R. M. C., have been quoted.

SUMMARY OF THE COURSES OF INSTRUCTION IN PRACTICAL GEOMETRY AND ENGINEERING DRAWING.

Plane Geometry.—Only simple constructions are attempted in the Obligatory part of the course, those for the Voluntary part are more difficult. The course is throughout designed so as to teach ease, accuracy, and neatness in drawing with instruments.

Solid Geometry.—The Obligatory course consists of such simple problems as are necessary for Field and Semi-Permanent Fortification. The Voluntary course is of a higher nature, containing such problems as are useful for Civil and Mechanical Engineering.

Method of Instruction.

The instruction is carried on by means of lectures and personal instruction. The lectures will be explanatory of the text-book, and occasionally additional matter will be given, of which fair notes will be made. The Cadets will further be required to execute numerous plates and exercises.

The course of Plane Geometry and Engineering Drawing (Obligatory and Voluntary) will be studied in the 4th class, and the Obligatory course of Solid Geometry in the 3rd Class. The Voluntary course of Solid Geometry will be commenced in the 3rd class on completion of the Obligatory course and will be continued during the 2nd class.

The following is a syllabus of the courses for each class (fully detailed when no text book is available for reference).

4TH CLASS.

PLANE GEOMETRY AND ENGINEERING DRAWING.

OBLIGATORY.

General rules for the use of instruments, construction and use of ordinary, comparative and diagonal scales, and verniers. Explanation of the problems contained in the plates.

FAIR NOTES.—On such of the above subjects as are not contained in the printed notes and text book.

PLATES.

I. Printing plate.

II. To bisect a given angle. To draw a straight line through

a given point towards the intersection of two given straight lines, this intersection being unattainable. To divide a finite straight line into parts, having given ratios to one another.

III. Ordinary and comparative scales.

IV. To find third, fourth, and mean, proportionals to given lines; by various methods. To divide a given line in extreme and mean ratio. To determine straight lines representing given ratios. To plot an angle from its chord, sine &c.

V. On a given straight line to describe a segment of a circle to contain a given angle. To describe a circle about a given triangle, or to pass through three given points, centre attainable and unattainable. To inscribe a circle in a given triangle. To escribe a circle to a given triangle. To divide the circumference of a circle into equal parts, and inscribe regular polygons. To construct regular polygons on a given side.

VI. Colouring.

VII. Diagonal scales and verniers.

VIII. Colouring a lithographed drawing.

IX. To draw tangents to a circle; circles tangent to given straight lines and given circles, under various conditions.

X. To draw tangents to two given circles and to a given circular arc, centre unattainable. To reduce an irregular rectilinear figure to a triangle of equal area. To draw rectilineal figures of a given form and area.

XI. To draw an ellipse from conditions. To draw a tangent and a normal to an ellipse.

XII. Copying a Geometrical figure.

These Plates are varied from time to time.

EXERCISES. Various exercises to teach use of instruments and laying flat washes of colour. Simple geometrical problems.

SUBJECTS FOR EXAMINATION.

December—From beginning up to Plate V.
March—From Plate V to Plate VIII.
June—The whole course.

VOLUNTARY.

Explanation of the problems contained in the plates.
FAIR NOTES.—Of the above explanations.

PLATES.

XIII. To divide rectilineal figures into equal parts and into parts having given ratios to one another. To draw rectilineal and curved figures equal in area to the sum or difference of the areas of two or more given similar figures.

XIV. To draw a parabola and a hyperbola from conditions. To draw tangents and normals to these curves.
XV. To draw various curves or curved loci.
XVI. " " "
XVII. More difficult examples on the Obligatory course.
XVIII. Copying a drawing.
XIX. " "
These Plates are varied from time to time.
The drawings for Plates XVIII and XIX will be principally parts of machinery, and will sometimes be coloured.

EXERCISES.—

SUBJECTS FOR EXAMINATION.—There will only be one examination in June, and problems based on the obligatory and voluntary courses will be set.

3RD CLASS.

SOLID GEOMETRY.

OBLIGATORY.

Object of solid or descriptive geometry. Necessity for some means of representing points, lines, planes, etc., lying in space on a plane sheet of paper. Explanation of the two methods of doing this, namely the two-plane and indice method. Reasons why the indice method is more suitable for fortifications.
Definitions.
Notation.
Theorems of solid geometry required for the prosecution of the subject; stated only.
Proof of the following theorems and deductions therefrom:
I. The plan or elevation of any point must lie in a straight line, at right angles to the ground line.
II. The distance of the elevation of any point from the ground line is equal to the difference of level between the point and the horizontal plane containing the ground line.
III. The length of the projection of any finite straight line on any plane is equal to the length of the finite straight line multiplied by the cosine of the angle of inclination of the straight line to the plan.
Forty-two problems as given in Printed Notes, comprising problems on points, straight lines, and planes; principles of "constructing;" problems on intersections and measurment; and problems relating to ground.
FAIR NOTES —On subjects of lectures not in text-book.

PLATES.

I. Problems, various.

II. Contoured field work.
III. Problems relating to ground.
These plates are varied from time to time.
EXERCISES.—Numerous problems, a written explanation of process to be given.
SUBJECTS FOR EXAMINATION—
December—From beginning to problem 23 inclusive.
March—Problems 24 to 36 inclusive.
June—The whole course and revision of obligatory course of plane geometry.

VOLUNTARY.

Definitions of the terms required by two-plane methods. (Clarke, pp. 13, 16 and 21.)
Notation. (Clarke, p. 13 and notes.)
Theorems. (Clarke, theorems 1 to 26.)
Fundamental problems—Adaptation of the two-plane method to the fundamental problems given in the obligatory course. The following additional problems will be adapted to both methods.

1. To find the conditions that a straight line passing through a given point in a given straight line may make a given angle with this straight line.
2. To find the conditions that a straight line passing through a given point may make a given angle.
3. To find the conditions that a plane passing through a given point in a given straight line may have a given inclination to this straight line.
4. To find the condition that a plane may pass through a given point and make a given angle with given plane.
5. To find the horizontal and vertical traces of a cone, the position of whose axis and the angle at the vertex of which are given. (This problem is required for the solution of problems 1 to 4.)

Application of the above problems to the solution of problems on straight lines and planes, and to the projection of plane figures. (Clarke, chapters II and III.)
Translation of the indice method into the two-plane method and *vice versâ*. (Note.)
FAIR NOTES—Of such matter as is not given in text-book.

PLATES.

IV. Problems relating to straight lines and planes.
V. Problems relating to plane rectilineal figures.
VI. Problems relating to plane curved figures.

These plates are varied from time to time.

EXERCISES.—Various problems.

SUBJECTS FOR EXAMINATION.—There will only be one examination, in June, comprising the whole of the course.

2ND CLASS.

SOLID GEOMETRY.

VOLUNTARY.

Projection of solids. (Clarke, chapter V.) Description of the most usual solids. Projection of solids in simple positions. Proof that whatever be the data the problem resolves itself into the following: To find the projections of a solid given the plane of one face and the position of an edge lying in that face; solution of this problem and hence: Projection of solids in any position. (Notes.) Projection of right cylinders and cones. (*a*) When the position of axis is given. (*b*) When the inclination of plane of base is given. Projection of helices on right cylinders and cones, and hence projection of ordinary screws. Contouring a solid. (Note.)

Section of solids by planes. (Clarke, chapter VI.)

Interpenetration of solids. (Clarke, chapter VII.)

Development of surfaces. (Clarke, chapter VII).

Tangent planes to surfaces, such as spheres, cones, cylinders, and surfaces of revolution. (Clarke, chapter VIII.)

Projection of curved surfaces tangent to each other. (Note.)

Determination of shadows. (Clarke, chapter IX.)

To determine which faces of a surface, bounded by planes, are in shadow, and which in light. (Note).

Isometric projection. (Clarke, chapter XI.)

Perspective projection—Definition and use. Definition of the following terms: Object, vertex. Plane of projection. To show that the perspective projection of any point can be obtained from its orthographic projections, and hence to obtain the perspective projection of any object in any position from its orthographic projections. Variation of the method in the special case where there are systems of parallel straight lines. Vanishing point. Comparison of this method with the ordinary method. (Notes.)

FAIR NOTES.—Of such matter as is not contained in text-book.

PLATES.

VII. Orthographic projections and sections of solids.

VIII. Isometric projection.

IX. Interpenetration of solids.

X. Shadows.
XI. Perspective.

These plates are varied from time to time.

EXERCISES.—Various problems solved either by the indice or the two-plane method.

SUBJECTS FOR EXAMINATION—

December—Projection of solids.
March—Section of solids by planes. Isometric projection. Interpenetration of solids.
June—The *whole* course of solid geometry.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN INFANTRY DRILL, EQUITATION, AND MILITARY EXERCISES.

ALLOTMENT OF MARKS.

SECT. I.—INFANTRY DRILLS.

Total marks Cadets and N. C. O. (obligatory)	500
N. C. Officers	170
4th Class (obligatory)	200
3rd do	200
2nd do	100
1st Class, Communicating Drill (N. C. Officers only eligible)	170

SECT. II.—EQUITATION.

Total marks (obligatory)	300
1st Class (obligatory)	300

SECT. III.—GYMNASTICS.

Tota marks, 400	Obligatory	200
	Voluntary	200
4th Class (obligatory)		100
3rd do do		100
2nd do (voluntary)		100
1st do do		100

SECT. IV.—SWORDSMANSHIP.

Total marks, 400	Obligatory	200
	Voluntary	200
4th Class (obligatory)		100
3rd do do		100
2nd do (voluntary)		100
1st do do		100

SECT. V.—SWIMMING.

Total marks (obligatory)	100
4th Class, do	50
3rd do do	50

TEXT-BOOK.

Infantry Drill.—Field Exercise.

Rifle Exercises and Musketry Instruction.

Regulations and Instructions for Encampments.

Equitation.—Nil.

Gymnastics.—Nil.

Swordsmanship.—Infantry Sword and Carbine Sword-bayonet Exercises.

SUMMARY OF INSTRUCTION IN INFANTRY DRILL, EQUITATION AND MILITARY EXERCISES.

SECTION I.

INFANTRY DRILL.

4TH CLASS.

(OBLIGATORY.)

Squad Drill (E)—Instruction and communicating.* "Field Exercises," Part I.

Rifle Exercises—Instruction in manual, firing, and bayonet exercises. "Rifle Exercises and Musketry Instruction." Sec. 1 to 13 inclusive.

Company Drill—Instruction. "Field Exercises," Part II. up to Sec. 20 inclusive.

Miscellaneous—Guards. "Field Exercises," Part VII., Sec. 15 to 21 inclusive.

Musketry Instruction—Theoretical principles, preliminary drill, judging distance and target practice; firing 55 rounds as follows: vide notes 3 and 4.

INDIVIDUAL FIRING.

100 yards,	10 rounds.	Standing.
150 "	10 "	"
100 "	10 "	Kneeling.
500 "	10 "	Any military position.

VOLLEY FIRING.

200 for 300 yds.	(Reduced Target.)	5 rounds, Close order.
200 for 400 "	"	5 " Extended order.

INDEPENDENT FIRING.

200 for 400 yds. (Reduced Target) 5 rounds, Close order.

"Rifle Exercises and Musketry Instruction," Parts II, III, IV and V.

NOTE (1).—* "Communicating" means that each cadet is fallen out in his turn, and imparts instruction in the various drills, etc., to the remainder.

(2.)—The 3rd and 4th Classes, when in the ranks, obtain incidental instruction in Company and Battalion drill, and in advanced and rear guards, and in outpost duty, whilst the 1st and 2nd Classes are being instructed in, or are communicating these drills.

(3.)—The entire course of Rifle Instruction is necessarily determined by the range, and time, available to Cadets.

(4.)—The 4th Class Practice to be commenced after Christmas and to be completed before 30th April.

(5.)—The annual course of Rifle Instruction of the 3rd, 2nd and 1st Classes to be commenced 10th September, and be completed before 30th October.

(6.)—Examination—partly written, partly oral—will be held during, or at the end of, the Term, in the subject marked (E).

3RD CLASS.

(OBLIGATORY.)

Company Drill—Instruction in "Field Exercises," Part II, Sec. 21 to 28 inclusive. Revision of the whole of Company drill.

Advanced and Rear Guards, and Outposts (E)—Instruction, "Field Exercises," Part VI, Sec. 1 and 2, and paragraphs I, V, VI, VII, VIII and IX of Sec. 3.

Miscellaneous.—Tent pitching. "Regulations and instructions for encampments." Appendix, page 33. Cavalry sword exercise.

Musketry Instruction.—Preliminary drill, target practice, judging distance; firing 55 rounds, as follows: vide notes 3 and 5, page 181.

INDIVIDUAL FIRING.

150 yards.	10 rounds.	Standing	
200 "	10 "	Kneeling.	
500 "	10 "	Any military position.	
500 for 800 yds.	(Reduced Target)	10 rounds,	"

VOLLEY FIRING.

200 for 300 yds.	(Reduced Target)	5 rounds.	Close order.
200 for 400 "	"	5 "	Extended order.

INDEPENDENT FIRING.

200 for 400 yds. (Reduced Target) 5 rounds. Close order.

Judging distance from 100 to 1,000 yards.

Rifle exercises and Musketry Instructions." Parts III, IV and V.

2ND CLASS.

(OBLIGATORY.)

Company Drill (E).—Communicating. "Field Exercises," Part II.

Battalion Drill.—Instruction. "Field Exercises," Part III up to Sect. 35 inclusive.

Musketry Instruction.—As for 3rd Class.

1ST CLASS.

(OBLIGATORY.)

Battalion Drill E).—Instruction. "Field Exercises," Part III., Secs. 36 to 49 inclusive. Revision and communicat-

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NOTE (1).—When practising Route marching or Out-post duty, a cadet N. C. Officer will be detailed to make a brief report of the proceedings.

(2) —Cadets will be practised in marching on snowshoes as opportunity offers.

ing the whole of battalion drill. "Field Exercises," Part III. *Advanced and Rear Guards, and Outposts*, (E.)—Communicating "Field Exercises," Part VI.

Musketry Instruction.—As for 3rd Class.

SECTION II.

EQUITATION.

(OBLIGATORY.)

1ST CLASS.

Leading the horse.
Mounting and dismounting.
Extension and balance motions.
Seat while the horse is in motion.
Dressing.
Walking and trotting.
Riding in saddles without stirrups.
Saddling.
Bridling.
Fitting the stirrups.
Mounting and dismounting without stirrups.
Aids in turnings and paces.

Single Ride.

Formation of the ride.
Bending lesson.
Turns in the bending lesson.
The canter.
Position with stirrups.
Position of briddle hand with the bit.
Mounting and dismounting with stirrups.
Riding with swords.
Leaping.
Salute when mounted.

Double Ride.

Formation of the ride, &c.
Bending lesson.
Elementary instruction on care, management and veterinary treatment of horses.

Section III.

GYMNASTICS.

4th CLASS.

(Obligatory.)

Simple Exercises.

First Practice—Movements and positions.
Second " With dumb bells.
Third " With bar bells.
Running—To run at slow time short distances.
Vaulting Bar—To vault the bar, three movements.
" " " two "
" " " one movement.
Vaulting Horse—To vault on the horse, two movements, standing.
" To vault on the horse, one movement, standing.
" To vault on the horse, one movement, running.
" To vault over horse, running.
Parallel Bars—The single march, forwards.
" The double march "
" The single march, backwards.
" The double march "
" To clear the right bar by the front, oscillating.
" To rest on the right bar and clear the left by the front, oscillating.
" To rest on the right bar in the rear and clear it in front, oscillating.
Pair of Rings—The single circle, evoluting.
" " The double circle "
" " To turn with feet in the rings, evoluting.
The row of Rings—The single step.
Horizontal Bar—To march with right hand leading.
" To turn round the bar, raising above the bar.
" " " with the hands reversed, raising above the bar.
" To raise above the bar, right and left.
" " " both hands at once.
Bridge Ladder—To climb both hands at once, backwards.
" " " forwards.

Vertical Pole suspended—To climb hand over hand, with hands and feet.
" " To climb both hands at once, hands and feet.
" " The double step both hands at once, and feet.
Vertical Rope " To climb with right hand leading.
" " " left "
" " " hand over hand.
Indian Club Exercise.

3RD CLASS.

(OBLIGATORY.)

ADVANCED AND ARDUOUS EXERCISES.

Running—To run at speed short distance.
The Leaping Stand—To leap height, running.
The Vaulting Bar—To Vault over the bar by the back lift.
The Vaulting Horse—To vault to the right, running.
" " " left, "
" To leap clear over "
Pair of Rings—To form a straight line by the back.
" " " front.
Row of Rings—The single step back wards.
Bridge adder—To climb with both hands at once backwards, by the spars.
" To climb with both hands at once forwards, by the spars.
" To climb with right hand leading, by the sides.
" To climb with left hand leading, by the sides.
" To climb with both hands at once, by the sides.
Horizontal Bar—To form a straight line by the back.
" " " front.
" To clear circle and vault right and left.
" To form a balance by short arm.
" " " straight arm.
Parallel Bars—To form a straight line by the back.
" Balance at short arm and march forward.
" " straight "
" " " come slowly down and form a straight line by the back.

The Vertical Rope—To climb both hands at once.
The Vertical Pole " "
Indian Club Exercise.

Section IV.

SWORDSMANSHIP.

4th CLASS.

(Obligatory.)

Infantry Sword Exercise,

Extension motions and positions.
Preparatory instruction with sword.
Review and inspection exercise with sword.
Attack and defence.
Stick drill.

3rd CLASS.

(Obligatory.)

Infantry sword exercise—continued.
Stick drill.
Officer's salute (Infantry.)
Cavalry sword Exercise.

Fencing.

Foil *vs.* Foil.
Sword *vs.* Sword.
Sword *vs.* Bayonet.
Bayonet *vs.* Bayonet.
Quarter Staff.

Note—(1) Voluntary classes of 1st, 2nd, 3rd, 4th Classes are instructed in any branch of gymnastics, or, of defensive exercises, *i. e.*, sword, bayonet, boxing, &c.

(2) The annual competition for voluntary gymnastics and swordmanship in 2nd and 1st classes, will take place toward end of March.

Section V.

SWIMMING.

3rd AND 4th CLASS.

(Obligatory)

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN MATHEMATICS AND MECHANICS.

ALLOTMENT OF MARKS.

For Entire Course, 12,000.	Obligatory.	Yearly Examinations.... 4,500 Intermediate do 1,250		5,750
		Term Work.	Notes and Recitations.	250
	Voluntary.	Yearly Examinations.....		5,800
		Term Work (Notes & Recitations).		200
For 4th Class, 2,000.	Obligatory.	Yearly Examinations..... 900 Intermediate do 500		1,400
		Term Work.	Notes and Recitations.	100
	Voluntary—Yearly Examinations.....			500
For 3rd Class, 4,000.	Obligatory.	Yearly Examinations..... 1,600 Intermediate do 350		1,950
		Term Work.	Notes and Recitations.	50
	Voluntary.	Yearly Examinations.....		1.900
		Term Work (Notes & Recitations).		100
For 2nd Class, 4,000.	Obligatory.	Yearly Examinations..... 2,000 Intermediate do 400		2,400
		Term Work.	Notes and Recitations.	100
	Voluntary.	Yearly Examinations.....		1,900
		Term Work (Notes & Recitations).		100
For 1st Class, 1,500.—Voluntary—Yearly Examinations.				1,500

TEXT BOOKS.

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EUCLID (*Todhunter.*)

ARITHMETIC (*printed notes by Lt. Col. Kensington, R. A.*)—Together with Smith and McMurchy or any other approved text-book. Scales of notation and mercantile arithmetic are omitted.

ALGEBRA (*printed notes by Lt. Col. Kensington, R. A., Todhunter's Elementary;* and *Todhunter.*)—The latter only for the more advanced students.

LOGARITHMS (*Chambers' or other tables*)—Thorough practical use of Logarithms.

PLANE TRIGONOMETRY (*Todhunter.*)

SPHERICAL TRIGONOMETRY (*Todhunter.*)

CONIC SECTIONS (*Todhunter and printed notes by Lt. Col. Kensington, R. A.*)—This subject is taught almost entirely by lecture, geometrical proofs being given whenever practical and easy. The course is founded to some extent on Salmon's conic sections.

DIFFERENTIAL CALCULUS (*Williamson.*)

INTEGRAL CALCULUS (*Williamson.*)

STATICS AND DYNAMICS (*Todhunter's Mechanics for beginners*)—The most advanced students are instructed further by lectures grounded on Todhunter's Analytical Statics, Tait's Dynamics, and other standard works, free use being made of the calculus.

STATICAL PROBLEMS SOLVED BY CONSTRUCTION (*Tracts on Mechanics by Crofton and Kensington.*)

WORK AND ENERGY (*Tracts on Mechanics*)—Special reference to artillery problems.

ROTATIONS considered geometrically without text books up to the resultant motion of an elongated projectile.

HYDROSTATICS (*Besant's Elementary*)—Special machines used in the Royal Artillery. Higher course of lectures with the use of the calculus.

MENSURATION (*Printed notes by Lt. Col. Kensington, R.A.*)

APPLIED MECHANICS (*Crofton's Elementary*) — Higher course of lectures grounded on Rankine, Collignon, and other works.

MECHANISM (*Goodeve ; and lectures aided by models.*)

STEAM ENGINE—General principles only taught by lecture.

Note—The whole of the above course is taught by lectures and personal instruction, aided by text books as far as possible. Shorter and easier proofs than those in the text books are given whenever practicable. Notes of the lectures are taken by the cadets and revised by the instructors.

The Obligatory Examination at the end of each Term in each Section includes all back work in that section.

The Voluntary Course for the 1st Class is less detailed than that for the other classes, to admit of some elasticity, regard being had to the previous success of each cadet.

The whole Voluntary Course is purposely framed so as to be longer than can probably be completed by any, except cadets of unusual mathematical ability. Thus any cadet who wishes to devote himself more particularly to mathematics is provided with ample employment. Such portions of the Course as may be neglected without affecting the continuity of the whole are omitted at the discretion of the Professor subject to the approval of the Commandant.

BOOKS OF REFERENCE.

RULES AND TABLES (*Rankine.*)
EUCLID (*Potts.*)
GEOMETRY (*Pierce.*)
ARITHMETIC AND BOOK KEEPING (*Hadden.*)
ALGEBRA (*Hadden, Colenso.*)
TRIGONOMETRY (*Hann, Snowball, Hamblin-Smith.*)
MENSURATION (*Baker, Moore, Todhunter.*)
CONIC SECTIONS (*Salmon.*)
HIGHER PLANE CURVES (*Salmon.*)
STATICS AND DYNAMICS (*Baker, Goodwin, Tomlinson.*)
PRACTICAL MECHANICS (*Twisden.*)
MECHANICS OF CONSTRUCTION (*Fenwick.*)
APPLIED MECHANICS (*Rankine, Bovey.*)
STRENGTH OF MATERIALS (*Barlow.*)
COURS DE MÉCHANIQUE (*Collingnon.*)
LE CONSTRUCTEUR (*Reuleaux.*)
GRAPHIC STATICS (*Karl von Ott, Clarke.*)
PRACTICAL GEOMETRY (*Clarke.*)
SYNOPSIS OF RESULTS IN PURE AND APP'D MATH'CS (*Carr.*)

SUMMARY OF INSTRUCTION IN MATHEMATICS AND MECHANICS.

4TH CLASS

OBLIGATORY, 1,500 MARKS.

MATHEMATICS.

Arithmetic to Interest, Discount, Stocks, Proportional parts and extraction of square root and cube root. (*Printed notes and authorized text books.*)

Marks, March, 100; *June*, 300.

Euclid (*Todhunter*) to Book II.; III.

Algebraical explanations will also be given of the propositions in Book II. *Marks, Dec.*, 100; *March*, 100; *June*, 200.

Algebra (*Todhunter's for beginners, and printed notes*) to simple Equations, Chap. I—XXV, April; to Evolution XXXII, March. Progressions and Revision I—XL, June.

Marks, Dec., 100; *March*, 100; *June*, 200.

Plane Trigonometry (*Todhunter and lectures or printed notes.*) 1st. Initial line. Terminal line. Angles of any size. The rules of signs. Trigonometrical ratios. Reasons for their names. Elementary formulæ proved from definitions. Formulæ connecting each with every other. Construction of angles when the ratios are given, also by the table of chords. Changes of the ratios in sign and magnitude. Circular measure. Logarithms. Chaps. I to V, omitting § 5-9; proof of §14; § 24; proof of § 51; § 53; § 66-75, *Dec.* Formulæ of two angles, Chap. VI, omitting §79, 80. Chap. VII, § 95, 98. The angles 18°, 36°, 54°, 72°, Chap. VIII, § 107-10, and note process of 113. Relation of $\sin\theta : \theta : \tan\theta$, Chap. IX, § 116-18.; *March*. Revision I—XL. Solution of triangles, Chap XIII, XIV, omitting alternative methods § 231, 2, 7, and § 119-221, 238.

Marks, Dec., 50; *March*, 50; *June*, 200.

VOLUNTARY, 500 MARKS.

Qualification, one-third for any section.

SECTION A.

Euclid III, IV.—*Algebra*, (*Todhunter's, for beginners, and printed notes.*) Quadratics, Evolution, Indices, Surds, Ratio, Proportion and Variation, Progressions, Permutations and Combinations, Binomial Theorem, Interest. *Plane Trigonometry.*—Formulæ of two angles, ratios for 15°, 18°, &c. Solution of triangles; Chapters VI to XIV, omitting 219, 221, 231, 232, 237, 238.

Marks, Dec., 100.

SECTION B.

Euclid.—Definitions of Book V explained Algebraically; Book VI, omitting Props. XXVII to XXIX.

Marks, March, 100.

SECTION C.

Algebra (*Todhunter*).—Equations, Chap. XII; XIII; XIV. Anomalous forms XV to § 206. Indices XVIII to § 265, and proof of $(a^m)^n = a^{mn}$. Surds XIX, omitting § 296-8 and 307 to end. Quadratics XX to XXIV with special attention to XXII. Imaginary expressions XXV to § 364, and read over the rest of the chapter. Ratio, Proportion and Variation; practical applications only, XXVI to XXVIII. Logarithms XXXVIII; XXXIX, omitting § 549, and only reading over § 551:

Marks, March, 100.

SECTION C.

Plane Trigonometry (*Todhunter.*) Chapters II to XV, omitting XII from § 180.

Marks, June, 100.

SECTION E.

Conics and Analytical Geometry of two dimentions (*Todhunter and printed notes.*) Straight line, Chapter I to III, omitting § 27, 37, 48; examples 1 to 21. Change of co-ordinates, practical examples only, Chapter V. Circle. Chapter VI to § 99.

Marks, June, 100.

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3RD CLASS

(OBLIGATORY, 2,000 MARKS.)

MATHEMATICS AND MECHANICS.

Arithmetic.

4th Class Course.

Marks, March, 150.

Euclid (*Todhunter*)—Book IV. Definitions of Book V, explained algebraically. Book VI, omitting Props. XXVII to XXIX, and first proof of XXX.

Marks, Dec., 100; *June*, 300.

Algebra (*Todhunter's for beginners and printed notes*)—Complete Book, omitting scales of notation; December. 4th Class course, particularly Factors, Quadratics, Proportion, Variation, Series, and applications to Problems.

Marks, March, 100; *June*, 200.

Plane Trigonometry (*Todhunter and lectures or printed notes*) —Complete use of Logarithms and natural tables—Solution of triangles. Heights and distances, Chapter XV, § 239-241. Properties of triangles, Chapter XIV., omitting § 253-4. Inverse ratios without examples Chapter XVIII, § 263. December.

Mensuration (*lectures or notes to be printed*) —Construction of ratios as $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, $\frac{1}{\sqrt{7}}$, $\frac{\sqrt{3}}{2}$, $\sqrt{\frac{2}{3}}$, &c., and combinations of these. Rectilineal and circular areas and perimeters and combinations of these. Area of ellipse. Area of a parabola intercepted by any chord, proved geometrically. Polygonal approximation to the areas of curves. Simpson's rule. Weddle's approximation. *December.*

Marks (*Trigonometry and Mensuration*), *Dec.*, 100; *March, June*, 250.

**Spherical Trigonometry Todhunter*). Chaps. I, II, III, IV, omitting § 38, 39, 42, 50, 51, 53, to end of Chapter V. Solution of right angled triangle. Chap. VI. Solution of oblique angled triangles. Chap. VIII, omit § 98 to end.

Co-ordinate geometry, introduced only by lectures.

Marks, 150.

Statics (*Todhunter's Mechanics for beginners.*)

Chapter I. II.—Omitting proof of parallelogram of forces § 45 to end of Chapter.

Chapter III, IV, V.—Omitting § 78 to end.

Explanatory notes in lieu of Chapter VI. on the equilibrium of a body and the method of working examples. Constrained body and the principle of the lever.

Chapter VII.—§ 99; Statement of 100; § 102, 6, *March.* Centre of parallel forces. Chapter VIII to § 113. Short notes on § 114, 15.

Formula $\bar{x} = \frac{\Sigma(Px)}{\Sigma(P)}$. § 116-120

Centre of gravity, Chapter IX to § 135. Trapezoid, alternative proof for § 136. Results only for pyramid and cone § 137-140. § 141-3. Formula $\bar{x} = \frac{\Sigma(mx)}{\Sigma(m)}$, § 144-6, compared with § 114-5.

Properties of the centre of gravity, Chapter X, omitting

*Note.—This subject is obligatory for instruction. Marks counted will assist towards place "Pass," "Distinguished," "Honours," but if below minimum the subjects will be omitted from qualification for the same.

§ 154-6. Alteration of centre of gravity of a body or system when a portion is transferred to another position.

The lever and balances, Chapters XI, XII; omitting analytical proof of the requisites of a balance; § 173.

Machines; Chapter XIII; with a simpler view of a train of wheels, § 187, omitting all considerations of the size of the teeth. Machines in combination; product of their mechanical advantages.

Pulleys; Chapter XIV; omitting weights of pulleys, 202-6, and second case of Spanish Barton given erroneously in § 207.

Inclined Plane; Chapter XV.

The Screw; Chap XVI.

Compound Machines; Chapter XVII.

Friction. Co-efficient of friction. Angle of friction. Limiting angle of resistance. Chapter XIX; omitting § 255-7 and § 260.

Easy problems on the above course.

Marks, March, 100; *June*, 400.

Notes and Recitations 50

3RD CLASS.

VOLUNTARY, 2,000 MARKS.

Qualification,—one-third for any section.

SECTION F.

Euclid XI., to Prop: 21. *Marks, December*, 200

SECTION G.

Algebra (*Todhunter.*) Theory of quadratics and quadratic expressions, Chapter XXII. Simultaneous equations involving quadratics, XXIII, XXIV. Imaginary expressions. Ratio, Proportion and Variation; practical examples only, XXV to XXVIII. Progressions, including the sum of the squares, cubes, &c., of the first n natural numbers, and thence the summation of series having the last term rational and algebraic, XXX to XXXII, omitting § 456-8. Mathematical Induction, XXXIII. Permutations and combinations, XXXIV, omitting § 500. Binomial theorem, proof for positive integral exponent only, XXXV to XXXVI, omitting § 516-20, 523-25, and only reading over § 527. Logarithms, XXXVIII, XXXIX, omitting § 549, and only reading over § 551. Convergency of series,

only reading over the investigations and applying them to examples, XL. Interest, XLI. Annuities, XLIII, omitting § 589, 90, 97-99. Continued fractions, XLIV, XLV, omitting § 604-11 and 613-22. Indeterminate equations, XLVI to § 628. Partial fractions and indeterminate coefficients, XLVIII, with notes on partial fractions involving multiple and irrational roots. Summation of series, L, omitting § 661-4; 666, 670-1. Summation by finite differences without proof (*Notes*). Inequalities, LI to § 680. Note result of § 681.

Marks, December, 250.

SECTION H.

Plane Trigonometry (*Todhunter.*) I to XVI, omitting § 180—210, but reading them over for comparison with the Differential Calculus, and omitting XVI, § 251. Inverse Functions—Chapter XVIII, omitting § 264. Demoivre's Theorem. Chapter XIX, § 266-8.

Marks, March, 250,

SECTION K.

Conics (*Todhunter*) *and printed notes*) Straight Line—Chapter I to III. Transformation of co-ordinates; practical applications only, Chapter V.

Circle.—Chapters VI, VII, omitting § 119, except for definition and position of centres of similitude.

Parabola.—Chapter VIII—Notes, principally geometrical, as follows: Equations to the curve and tangent compared; $y\,y' = 2\,a\,(x + x')$; similarly for the circle and other conics. Equation to the normal.

Deduction of the general equation $(y - y')^2 = 4a\,(x - x')$ from the simplest equation $y^2 = 4\,ax$; similarly for all other curves, (x', y') being the origin for the simple equation.

Latus rectum as the parameter. Explanation of the constants in an equation, both those of size and form which are parameters and those of position which may be removed by choice of axes.

Construction of tangent; inclinations to axis and focal distance. Locus of the foot of the perpendicular from the focus. Portion of tangent intercepted between the point of contact and the directrix subtends a right angle at the focus. Tangents at the extremities of a focal chord are perpendicular and meet upon the directrix. $p^2 = ar$; $r = \frac{a}{\sin^2\theta}$; $r = a + x$.

Polar equation. Angle between two radii vectores is double that between the tangents. Sub-normal $= 2a$. Sub-tangent

$= 2x$. Curve bisects sub-tangent. Length of normal $= 2d$. Analytical investigation into diameters and their properties (alternative with § 147.)

Geometrical proof of the equation to the parabola referred to diameter and tangent, together with a proof that the chords parallel to the tangent are bisected, &c., (as in the obligatory course.

To draw a parabola, given any diameter and the tangent at its vertex and one other point.

To draw a parabola touching two intersecting straight lines at given points; also, to construct the focus and directrix, the latter by at least six points.

To draw a parabola, given its vertex, axis and one point; thence to draw it, given the axis and two points at different distances from the axis.

Construction of tangents from any external point; their lengths are proportional to the cosecants of their inclinations.

Intersections of Conics, straight lines and other curves.

Contact. Circle of curvature; 2ρ as limit of $\frac{y^2}{x}$ or $\frac{y^2}{x \sin \theta}$, $\therefore \rho = \frac{2a}{\sin^3\theta} = \frac{N}{\sin^2\theta} = \frac{N^3}{SL^2}$; thence construction of radius of curvature, and evolute.

Intersection of circle and conic, equal inclination of opposite chords; thence construction of radius of curvature, § 208.

Ellipse.—Chapter IX, X, omitting § 205.

Equation found from the definitions of an ellipse as the projection of a circle, as described by the trammel, and as $r + r' = 2a$, instead of that given in Todhunter. Geometric properties proved from the definition $r + r' = 2a$, as follows: Construction of a tangent; its equal inclinations to the focal distances; locus of the foot of the perpendicular from the focus. $pp' = b^2$; $\frac{p}{p'} = \frac{r}{r'}$; $p^2 = \frac{b^2 r}{r'}$.

Locus of intersection of tangent with the perpendicular at the focus to the radius vector; proof of Todhunter's definition of an ellipse; locus of intersection of tangent at the extremities of a focal chord; straight lines ae, $a\frac{}{e}$; $r = a \pm ex$.

Polar equation referred to both focus and centre. Equations to tangent and normal. Points where they cut the axes. The length e^2x' both analytically and geometrically.

Equation at the vertex becomes a parabola if $e = 1$ or $a = \infty$. Latus rectum $= 2\frac{b^2}{a} = 2e\left(\frac{a}{e} - ae\right)$, compared with

parabola. e is the tangent of the inclination of the tangent from the foot of the directrix. Other properties compared with the parabola. Relation $p^2 = a^2 \cos^2 a + b^2 \sin^2 a$ for perpendicular from centre on tangent; thence locus of intersection of perpendicular tangents.

General comparison of ellipse, parabola, hyperbola.

The eccentric angle; $x = a \cos \theta$; $y = b \sin \theta$. Locus of a point obtained by measuring $\frac{a+b}{2}$ at an inclination θ and then $\pm \frac{a-b}{2}$ at $-\theta$

Diameters investigated analytically as for parabola (alternative with § 187.) Conjugate diameters as the projections of two perpendicular diameters of the auxiliary circle; hence the properties of conjugate diameters and the equation to the ellipse referred to them (instead of § 198.)

$a'^2 + b'^2$ constant; $pb' = ab$.

Length of Normal $= \frac{bb'}{a}$; $\cos \psi = \frac{p}{r} = \frac{p'}{r} = \frac{p+p'}{2a'} = \frac{b}{b'}$

$PG.\ PG' = b'^2 = rr'$ and other properties.

Radius of curvature (as for parabola) $= \frac{b'^3}{ab} = \frac{N}{\cos^2 \psi} = \frac{N^3}{SL^2}$; thence construction of points on the evolute.

To construct the foci of an ellipse, given the axes; also to construct directrices and latus rectum.

Given an ellipse, to find the centre and axis.

Given either axis and one point, to describe the ellipse.

To construct an ellipse, given a pair of conjugate diameters.

If any tangent meet two conjugate diameters, the rectangle contained by its segments is equal to the square of the parallel semi-diameter; thence, given a pair of conjugate diameters, to construct the axes.

Hyperbola; Chapters XI, XII, omitting proof of equation referred to conjugate diameters § 252, also § 262-63; 265.

Notes as for the ellipse wherever practicable. Equation and properties deduced from the definition $r - r' = 2a$. Substitution of $-b^2$ for b^2 or $-a^2$ for a^2 in the equation to the ellipse. The same substitution in the case of properties involving b^2; geometrical meaning of the negative sign in each case. Diameters as for ellipse (alternative with 236.)

Asymptotes. The conjugate hyperbola. The equation $(a^2y^2 - b^2x^2)^2 = a^4b^4$. The four foci equidistant from the centre.

Equation referred to the asymptotes. Area between the asymptotes (as axes) and the co-ordinates of any point.

General equation of the 2nd degree; Chapter XIII. General acquaintance with the method and results of § 269 to 272. To trace a conic, easy examples only. Read over § 272, 280. Meaning of "discriminant of a conic."

Chapter XIV—General equation to a conic. Read over § 288-3. Pole and polar. Read over § 289-91. Equation referred to the tangents, § 293-4. Similar curves, 296-8.

Chapter XVI—Section of a cone; a different proof will be given showing the foci and directrices. Omit § 348-9. Anharmonic ratio; the ratios *AB. DC.* : *AC. DB.* : *AD. BC.* Harmonic pencil. Omit § 356-61.

Chapter XVII—Projections; § 362-89, and read over the rest.

Marks—December, 500.

SECTION I.

Differential Calculus (*Williamson, Ed.*, 1880.)

Chapter I—Proof of $d(x^n)$ by binomial theorem, instead of § 16-18. Differentials used equally with differential coefficients. Differential of the function of a function obtained directly without the investigation of § 19. Geometrical condition for $\frac{dy}{dx} \times \frac{dx}{dy} = 1$.

Chapter II—Successive differentiation; differential of the independent variable is constant. Omit § 39, 43 to end of chapter. Read over Liebnitz Theorem § 48.

Chapter III—Expansion of functions. "Remainder" noted but not used in applications of Taylor's and Maclaurin's Theorems. Expansion of $\tan^{-1}x$ by integration. Omit § 65-68. Read over § 73 with equations (27), (28), (29), (33). Interpretation of remainder to shew that if two points be taken on a curve, the chord joining them is parallel to the tangent at some intermediate point, § 76. Omit § 77 to end of chapter.

Chapter IV—Indeterminate forms; algebraic processes not necessary. Consider also $\infty - \infty$. Read over the proof in § 92.

Chapter V—Partial differentiation, § 95-6. Result only of §97. Omit § 98, 101. Result only of Euler's Theorem, §102. Read over § 103-4. Omit § 107, also § 110 to the end of chapter.

Chapter VI—Read over the first two pages and note results. Omit the rest except § 120.

Chapter VIII—Read over § 127 and note result.

Chapter IX—Maxima and Minima. Omit § 136-7, 143-7, 151 to the end of the chapter.

Chapter XII—Tangents and normals. Omit § 173-7, 185 to the end of the chapter except definition of inverse curves. Read over § 195.

Chapter XIII—Asymptotes. § 196-200 explained more simply. Exception when the asymptotes are impossible.

Chapter XIV—Brief explanation of multiple points. Nodes, cusps, conjugate points.

Chapter XV—Brief explanation of envelopes, and the general methods of determining them.

Chapter XVI—Convexity and concavity. Read over the analytical investigation in § 223.

Chapter XVII—Radius of curvature; Omit § 228. Omit § 232-3; 236. Read over § 239. Omit § 241-2. Read over § 243-8, and note conclusions. Omit § 249-54. Read over § 256, and study the approximations.

Chapter XVIII—Brief explanations and easy examples. The Limaçon and Trisectrix. Trisection of an angle. The conchoid § 270.

Chapter XIX—Roulettes § 271-7. Read over § 278. Geometrical proof of hypocycloid and hypotrochoid when the radius of the inner circle is half that of the outer, § 285.

Chapter XXI—Elimination of Constants and Functions, § 311-12.

Chapter XXI—Change of the Independent Variable, § 320, § 324-5.

Marks, June, 600.

SECTION M.

Integral Calculus.

This subject will be commenced as soon as the process of differentiation has become easy. The elementary formulæ as the reverse of differentiation, and easy variations of them. Substitution, and particularly trigonometrical substitution, $tan^{2n}\theta d\theta$. Integration by parts. The various cases of $sin^{m}\theta\ cos^{n}\theta d\theta$. Rational fractions. *Marks, March,* 100.

Notes on Voluntary Course..... ..... 100.

2ND CLASS.

OBLIGATORY—2,500 MARKS.

MATHEMATICS AND MECHANICS.

Marks.

Euclid (*Todhunter*)—3rd and 4th Class course..*March,* 300

Algebra—4th Class course.....*March,* 300

Mensuration (*Lectures or Notes to be printed*)

The bases of similar pyramids are in the duplicate ratio of their altitudes. Equality of pyramids (also prisms) on the same or equal bases, and having the same altitude, proved by equality of sections. Trisection of a prism into three equal pyramids. Volume of a pyramid or cone. Truncated right prism on a triangle or parallelogram as base, in terms of its mean altitude. Wedge regarded either as a truncated prism, or as a pyramid and right wedge or semi-parallelopiped. Volume of frustum of pyramid or cone. Volume of a prismoid (defined as a solid bounded by planes between two parallel ends) assumed to be divisible into prisms, piramids and wedges, all having the same altitude; mean section $\frac{A + 4M + B}{6}$. General definition of a mean. Application to calculations of earth work. Surface of pyramid or cone. Centre of gravity of pyramid or cone (both volume and surface), omitting proof for former. Surface of a sphere, zone or segment, and centre of gravity of each. Volume of a spherical sector proved by summing the volume between two consecutive sectors, considered as a conical volume. Volume of a sphere. Volume of prolate and oblate spheroids and of paraboloid of revolution (without proofs). Statement and use of Guldin's Theorems; thence determination of the centres of gravity of the arc and area of a semi-circle and quadrant.

Trigonometry, former course..... *Marks, Dec.*, 200.
..... *June*, 300

Statics, 3rd Class course, and *Graphic Statics* (*Tracts on Mechanics, Part II.*) Problems 1, 4, 6, 7, 8, 11, 12, 21.

Graphic, Statics. *Marks, March*, 100, *Statics, June*, 300.

Dynamics and work—(*Todhunter's Mechanics for beginners.*)

Velocity. Chapter 1.—Angular velocity in terms of circular measure. $v = ra$; $a = \frac{2\pi n}{t}$.

1st and 2nd laws of motion.—Chapter II.

Uniform acceleration and the equations of motion.—Chapters III, IV, omitting proof in § 37.

Parabola of projection.—Chapters V, VI, omitting § 72, 73, 75-7.

Mass and 3rd law of motion. Chapters VII, VIII. Acceleration obtained directly from $P = mf$, in § 89, 92.

Impact. Chapters IX, X. Omit § 109, proof of loss of Vis Viva in § 108-124, and continuous rebounds, § 122-3.

Motion of centre of gravity of a system $\bar{v} = \frac{\Sigma(mv)}{\Sigma(m)}$;

$\bar{f} = \frac{\Sigma(mf)}{\Sigma(m)}$, proved from $\bar{x} = \frac{\Sigma(mx)}{\Sigma(m)}$ Chap. XI.

Laws of motion and parallelogram of velocities. Chapter XII. Motion down a smooth curve, $v^2 = 2gh$, without proof, except for an inclined plane. The pendulum $t = \pi\sqrt{\frac{l}{g}}$ without proof. Second's pendulum. See chapter XII, § 147,152.

Centrifugal force $= \frac{v^2}{r}$, proved differently from Chapter XIV, § 163. Gravity the resultant of the earth's attraction and centrifugal force.

Work.—Chapter XVII; also (*Tracts on Mechanics, Part* I,) omitting calculation for fly-wheel, § 24, and calculations of Moments of Inertia, § 28. Moment of Inertia and radius of gyration to be learnt for simple cases of rectangle and circle; also the formula $M((h^2+k^2)$, without proof. Special attention to Example 16.

Marks—December, 200; *June*, 350.

Applied Mechanics—(*Crofton's Lectures*)

Introductory Chapter: Stability of Structures (Part I.) Frames. Roofs. Trussed beams. Chains and cords. Stability of walls.

Strength of Material (Parts II.) Stress and strain. Elasticity. Resistance to compression. Theory of beams. Bending moment expressed by the area of the diagram for shearing force. Culman's graphical method of treating stresses and finding centres of gravity. Moment of resistance for rectangular and cylindrical beams. Girders. Beams of uniform strength. Warren girder and lattice girder with diagrams. Method of sections. Partial loading. Allowance for weight of beams. Dead and live load. Sloping beams. Fixed beams.

Marks, June, 350.

Notes and recitations 100

Introductory Chapter.

2ND CLASS.

VOLUNTARY.—2,000 MARKS.

Qualification, one-third for any Section.

SECTION N.

Integral Calculus (*Williamson*).

Chapter 1—Compare (*e*) with § 3; (*f*) with § 5; also Ex.

(1), (2), § 13. Integrate forms involving $a + 2bx + cx^2$ or $\sqrt{a+2bx+cx^2}$ by completing the square. Compare § 4, 22, 23, 24 with 61-3. Omit § 8.

Chapter II—Rational fractions; easy examples only with explanatory notes.

Chapter III—Formulæ of reduction; easy examples only with explanatory notes. Read over § 63-73; omit 74 to the end of the chapter.

Chapter IV—Rationalization, § 77 and read over § 78.

Chapter V—Infinite series § 88.

Chapter VI—Integration as summation; more elementary proof of § 90. Read over 92-94. Omit 95-114. Double and treble integration § 115 with notes and examples. Omit § 116 to the end of the chapter.

Chapter VII—Areas, § 126-131, omitting 130 (*a*). Closed curve; easy examples. Read over 132-4. Polar areas, § 135, 139. Omit §136-8; 140-7. Areas by approximation § 148, Amsler's Planimeter § 149, or alternative investigation as given in Collignon. Asymptotic areas of rectangular hyperbola; hyperbolic logarithms.

Chapter VIII.—Arcs § 150-152, 155, 156, 167. Rectification of evolutes. Read over § 153-4.

Chapter IX—Volumes and surfaces § 168-175; 178-181. Note process in § 184-5; 187.

Chapter X—Moments of mertia. Special attention to §196-98. Read over § 206-207; 216-17. *Marks—December*, 500.

Section O.

Analytical Geometry of three dimensions (*by lecture and printed notes*). Equations of a point in space. Distance between two points. Projections of a straight line proportional to the direction cosines. $cos^2\alpha + cos^2\beta + cos^2\gamma = 1$. Equations to a surface; conditions of parallelism to one or two axes of co-ordinates. A line in space (or line of double curvature) as the intersection of two surfaces, usually two projecting cylindrical surfaces; particular case, a straight line. General equations to a sphere, ellipsoid, spheroid and cone, with principal axes parallel to the axes of co-ordinates. Equations to a straight line. To find the inclinations from the equation. Angle between two given straight lines. Definition of a plane (1) as described by a straight line moving parallel to one given straight line, and always intersecting another given straight line; (2) as the locus of a point equidistant from two given points. Equation to plane

found from each definition in terms; 1st, of the inclination of its traces and intercept on the axis of Z; 2nd, of the three intercepts on the axes; 3rd, of the perpendicular from the origin and its direction cosines. Length of a perpendicular from a given point on a given plane. Tangent to a curve; normal plane. Tangent plane to a surface; normal to a surface; Properties of radii of curvature of two perpendicular normal sections of a surface (without proof; section of spheroid, normal to a meridiam.

Marks—December, 200.

N.B.—The preference is given, throughout the course, to symmetrical equations.

Section P.

Statics and applications to Stresses. (*Todhunter's Mechanics for beginners.*) Harder examples and the omitted articles in the 3rd Class obligatory course. Alternative proof of § 155. Omit § 154; 156 to 158.

(*Lectures or notes to be printed*) Resolution and Composition—1st, of forces in space; 2nd, of couples. The six equations of equilibrium (*following the notation in Todhunter's Analytical Statics.*) Any system of forces reducible to two forces. Condition that there should be a single resultant. Equilibrium of a particle constrained to move; 1st, on a smooth curve; 2nd, on a smooth surface. Centre of parallel forces. Culman's graphical method. Alteration of the centre of gravity by transposition of a part of the body. Elementary methods of finding the centre of gravity of a circular arc, sector and segment. Centre of gravity of a small arc or segment respectively $\frac{2}{3}$ and $\frac{3}{5}$ of the distance from the chord to the arc. General formulæ for centre of gravity of area, arc, volume and surface of revolution. Guldin's Theorems. Attraction of a straight bar on a particle (1) in the direction of its length, (2) in any given position. Attraction of a circular lamina on a particle in a perpendicular axis through the centre. Attraction of a cone on its vertex; of a thin spherical shell on an internal particle; of a homogeneous sphere on an external or internal particle. Principle of Virtual Velocities. Proof in the cases (1) of any system of forces on a particle, whether free or restricted to a smooth curve or surface; (2) of a pair of particles connected by an inextensible rod or line; also of any number of particles similarly connected, that is, a rigid body; (3) when any pair are connected by an inextensible string round a fixed point or pulley, or round a point which is one of

the parts of the system. Converse of this principle. Applications of the principle of Virtual Velocities. If any system of particles be in equilibrium under the action of gravity, their centre of gravity is (generally) in a highest or lowest position; in the former position the equilibrium is unstable, in the latter stable. Condition for stability of a heavy curved body resting on a horizontal plane; also of a flat body on a rough surface. Elementary proof that the ends of a chain over a smooth pulley must rest in a horizontal plane, but in unstable equilibrium. Pressure on a curve produced by a string of given tension, wrapped round it. Relation between the tensions at the extremities of a string passing round an arc of a rough curve; application to obtain the advantage of passing the fall three times round the windlass of a *gyn*. Parabolic curve of the suspension bridge with vertical rods. The common catenary; its equation, length of arc, tension at any point, similarity to a parabola near the vertex; position of equilibrium of a heavy chain resting over two smooth pegs. Suspension rods of equal strength, equation to bounding curve. Catenary of equal strength. The problem of the traction of a carriage; the point of contact between the axle and the pipe-box; the angle of draught. The forces acting on a field gun carriage at the moment of discharge.

Marks—March, 400.

SECTION Q.

Dynamics (*Todhunter's Mechanics for beginners*.)—Harder questions on the obligatory course. Loss of Vis Viva after impact, § 108. Motion in a circle or conic section to be read over only, more advanced proofs being furnished. Chapters XIV, XV. Kepler's laws, § 178.

Notes.—The differential equations of motion. Application to rectilinear motion under the action of a force, (1) constant; (2) varying as the distance; (3) varying inversely as the square of the distance. Law of attraction outside and inside the attracting body. Simple harmonic motion. Motion of a heavy chain, (1) hanging over a smooth pulley, (2) placed with part hanging over a smooth table. Body moving vertically on a resisting medium, the law being as the square of the velocity; rectilinear motion, neglecting gravity, the law of resistance being as the cube of the velocity. Curvilinear motion, the parabola of projection. Given the general equations of motion in two perpendicular directions, to find the tangential and normal accelerations, also the equation of Vis Viva. Equal areas are described in equal times, under the influence of a central force. If the force varies as the inverse

square of the distance, the orbit is an ellipse, parabola or hyperbola according as the velocity $<, =, >$, the velocity of falling from infinity. Motion of a particle on a smooth curve; velocity acquired. Cycloidal pendulum, time of an oscillation; length of "second" pendulum; oscillation through a small circular arc. Conical pendulum. D'Alembert's Theorem. Angular acceleration. $\frac{\text{Sum of moments of impressed forces}}{\text{Moment of inertia.}}$.

Compound pendulum. Centres of oscillation and suspension. Kater's method of finding the equivalent simple pendulum. Expression for the alteration of angular velocity produced by impulses. Simple investigation into the pressure on a fixed axis, centre of percussion and axis of spontaneous rotation. Application of D'Alembert's principle to the motion of two equal heavy particles connected by a light rod and constrained to move on two axes, one vertical, the other horizontal; also, of two equal weights connected by a string over two horizontal pulleys, a third weight being suddenly attached midway.

Calculations of moments of Inertia, as in Sections P. R. Special attention to the equation of Vis Viva wherever it occurs. Work done in stretching an elastic rod. Vibration of a thin vertical elastic rod caused by a falling ring stopped by a projection at its lower end.

Any motion of a plane figure in its own plane represented by roulettes, combination of rotations, motion of a solid round a fixed point, rotations round intersecting axes, application to the rotation of the earth about an axis through the zenith at any latitude, application to the derivation of elongated projectiles.

Marks—March, 400.

SECTION R. $\left\{\begin{matrix} \text{A.} \\ \text{B.} \end{matrix}\right.$

A. Introductory chapter.

Chapter I—Omit the numbers and investigation in § 3. Alternative proof of § 10. Omit examples (11), (12).

Chapter II—Omit § 22, 29, 30.

Chapter III—Omit § 34, 35. Shorter proof of Ex. (5), § 48. Geometrical proofs of centres of pressure of the triangles in § 49.

Chapters IV, V—Omit § 80. Read over § 83. Omit § 87-9 and 93 to the end of the chapter.

Chapter VI—Omit § 98-101 and 108 to the end of the chapter.

B. *Notes*—Elementary investigation into the distribution

of pressures over a plane rectangular joint with application to reservoir walls; the two conditions for stability. Moments of Inertia of a square, rectangle, circle, ellipse, equilateral triangle, regular polygon and other figures, also of a sphere; of a lamina about a perpendicular axis. Proof and explanation of $I = M(h^2 + k^2)$. Radius of gyration. Application of the calculus to determine the whole pressure on a surface and the centre of pressure on a plane surface. Proof that the centre of pressure is generally below the centre of gravity. Metacentre; determination of height above the centre of flotation, condition for stability. Application to the flotation of simple solids. The various positions of stability of a square log of timber as its specific gravity varies from nothing to 1.

Law of pressure of gases. Fluids with densities varying according to different laws. Barometrical measurements of heights. Proof of $z = 26215 \log \frac{H}{h} = 262'5 . \frac{H-h}{h}$, approx. $z = 52430 \frac{H-h}{H+h}$. Height of the "homogeneous atmosphere."

Stresss on boilers and thin metal cylinders. Thin hollow sphere. Relation between pressure on a surface and the tensions in the directions of principal curvature. Thick hollow cylinder $t = \frac{R^2 + r^2}{R^2 - r^2}$ Resistance of tubes to collapsing under external fluid pressure.

Flow of water through pipes. Torricelli's Theorem. Vena contracta. Fluid friction independent of the pressure, proportional to the wet surface and to the square of the velocity. Calculation of the sizes of water pipes. Open channels.

Marks—June, { *A.* 150.
Notes on Voluntary Course, { *B.* 250

1ST CLASS.

VOLUNTARY—1,500 MARKS.

MATHEMATICS AND MECHANICS.

N.B.—Only Section V and so many of the others as make a total of 1,500 *may be taken up.*

SECTION S.

Algebra and Trigonometry. Re-examination on the former course, (Sections C, G, H). Probabilities (*Todhunter.*)

Chapter LIII to § 737 and examples 1-10. Theory of equations of all degrees. Transformation of equations to others having different roots. Solution of cubic equations by Horner's and other methods. Determinants; Factors by inspection; reduction to a lower order by addition of columns or rows or their multiples; application to solve simple simultaneous equations, and to processes of elimination. Demoivre's Theorem; some of the less difficult applications. (*Todhunter's Plane Trigonometry.*). Chapter XIX, § 266-72; 274-76; 78. Exponential values of sine, cosine, tangent. Gregory's series. Calculation of π. Chapter XXI, omitting § 298 to the end of the chapter. Summation of the series in Chapter XXII, § 303-4; 6-9, and others of the same nature. *Marks*, 250.

SECTION T.

Geometry with deductions, Co-ordinate Geometry and Conics. Re-examination on, and completion of the former course, (Sections A, B, F, K, O). Abridged Notation (*Todhunter*, Chapter IV.) *Marks*, 250.

SECTION U.

Differential and Integral Calculus. Re-examination on, and completion of the former course. Easy examples of tracing curves. Elementary notes of the solution of differential equations. Finite differences considered with reference to summing rational algebraical series; interpolation and correction. Summing areas. Weddle's approximation. Method of least squares. *Marks*, 250 or 500.

SECTION V.

Applied Mechanics. (*Crofton.*) Re-examination on and completion of Section P. (*Statics.*) Moments of Inertia. The elipse of Inertia. Momental ellipsoid. Principal axes. Graphical construction of Moments and Products of Inertia. Amsler's planimeter. Internal stresses in a plane lamina. Principal stresses; direction of pure shearing stress; Ellipse of stress. Internal stress in beams; moment of resistance; general formulæ and application to beams of symmetrical section. Shearing force the differential co-efficient of the bending moment; diagram of shearing force used to determine the bending moment. Distribution of shearing stress; application to girders. Theory of fixed beams; application to a beam fixed at both ends; (1) loaded at the centre; (2) uniformly

loaded. Beams on three supports; pressures on the supports; maximum bending moment. Distribution of pressure on a plane joint; intensity assumed to be a linear function of the co-ordinates of the point; general formula for the intensity at any point; application to rectangle, circle or ellipse, rhombus, circular or elliptic annulus. To find what force should be applied at any point of a rectangular joint in order that (1) the maximum intensity should not exceed a given amount, (2) the intensity should always be positive, *i. e.*, a pressure; application to the above simple joints.

Marks, 500.

Section W.

Dynamics and Hydrostatics. Re-examination on, and completion of the former course. Fluid under the action of any forces X, Y, Z. Rotating Fluid. Determination of approximate form of Earth. Pressure in a fluid in motion.

Marks, 250.

Section X.

Lecture attendance. Obligatory.—Examination. Voluntary.

Mechanism and the Steam Engine (*Goodeve, and a course of lectures aided by models and diagrams, Notes.*) Omit special applications such as those to weaving and mangling machines. Omit Chapter V on Teeth of Wheels. Action of D slide valve. Lap. Lead. Relative position of crank and eccentric. Elementary determination of faults in the engine by examination of the indicatordiagram.

Marks, 750.