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ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF THE COURSE OF INSTRUCTION.

SEPTEMBER, 1882.

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For 1st Class, \$2,000.  
 For 2nd Class, 4,500.  
 For 3rd Class, 4,000.  
 For 4th Class, For Entire Course, 2,000.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF INSTRUCTION IN MATHEMATICS AND MECHANICS.

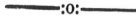
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For Entire Course, 12,000.	Obligatory.	Yearly Examinations .....	4,500	} 5,750	
		Intermediate do .....	1,250		
		Term Work. {	Notes and	} 250	
			Recitations.		
	Voluntary.	Yearly Examinations .....	5,800	}	
		Term Work (Notes & Recitations).	200		
	For 4th Class, 2,000.	Obligatory.	Yearly Examinations .....	900	} 1,400
			Intermediate do .....	500	
			Term Work. {	Notes and	} 100
		Recitations.			
Voluntary—Yearly Examinations.....		500			
For 3rd Class, 4,000.		Obligatory.	Yearly Examinations .....	1,600	} 1,950
	Intermediate do .....		350		
	Term Work. {		Notes and	} 50	
		Recitations.			
	Voluntary. {		Yearly Examinations.....	1,900	}
Term Work (Notes & Recitations).			100		
For 2nd Class, 4,500.	Obligatory.	Yearly Examinations .....	2,000	} 2,400	
		Intermediate do .....	400		
		Term Work. {	Notes and	} 100	
	Recitations.				
	Voluntary. {		Yearly Examinations .....	1,900	}
Term Work (Notes & Recitations).			100		
For 1st Class, 1,500.—Voluntary—Yearly Examinations.			1,500		

## TEXT BOOKS.



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—Without text book.

**APPLIED MECHANICS** (*Crofton's Elementary*)—Higher course of lectures grounded on Rankine, Collignon, and other works.

**MECHANISM** (*Goodeve*)—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 following shows the syllabus for each class in detail:

1st. Obligatory.

2nd. Voluntary.

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.

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## 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 other authorized text books.) *Dec., Marks 300.*

*Euclid (Todhunter)* to Book II.; III.; IV.

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 Quadratics and Evolution, *Dec.*; to Progressions, *April*; to Permutations and Combinations, Binomial Theorem and Interest, omitting scales of Notation and the harder examples in Quadratics. Capters I. to XXXII.; to XL.; to end.

*Marks, Dec., 100; June, 100; March, 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; proof of § 51, 53; § 66-75, *Dec.* Formulæ of two angles. Chap. VI, omitting § 79, 80. Chap. VII, § 95, 98; the angles  $18^\circ$ ,  $36^\circ$ ,  $54^\circ$ ,  $72^\circ$ . Chap. VIII, § 107-10, and note process of 113. Relation of  $\sin \theta : \theta : \tan \theta$ , Chap. IX, § 116-18. Complete use of Logarithms and the Natural Tables, *April*. Solution of triangles, Chap. XIII, XIV, omitting alternative methods § 231, 2, 7, and § 219-221, 238. *Marks, Dec., 50; March, 50; June, 200.*

Notes and recitations.

*Marks, 100.*

#### 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*.—Formulae of two angles; ratios for  $15^\circ$ ,  $18^\circ$ , &c. Solution of triangles; Chapters VI to XIV, with the same omissions as in the obligatory course. *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 D.

*Plane Trigonometry (Todhunter)*. Chapters I to XVI, omitting XII from §180 and XVI, § 254. *Marks, June, 100.*

## SECTION E.

*Conics and Analytical Geometry of two dimensions (Todhunter)*. 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.*

—o—

## 3RD CLASS.

(OBLIGATORY, 2,000 MARKS.)

## MATHEMATICS AND MECHANICS.

*Euclid (Todhunter)*.—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)*.—4th Class course, particularly Factors, Quadratics, Proportion, Variation, Series, and applications to Problems. *Marks, March, 50; June, 300.*



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Trigonometry.—  
&c. Solution of  
e omissions as in  
Marks, Dec: 100,

Algebraically ;  
Marks, March 100.

II; XIII; XIV.  
II to § 265, and  
§ 296-8 and 307  
al attention to  
and read over  
and Variation ;  
I. Logarithms  
reading over  
Marks, March, 100.

to XVI, omit  
Marks, June, 100.

ensions (Tod-  
§ 27, 37, 48 ;  
ical examples  
Marks, June 100.

explained  
to XXIX.  
; June, 300.  
ed notes)—  
Proportion,  
; June, 300.

*Plane Trigonometry* (Todhunter's, and lectures or notes to be printed)—Heights and distances, Chapter XV. § 239-241. Properties of triangles, Chapter XVI., omitting § 253-4. Inverse ratios without examples, Chapter XVIII. § 263. December.

Solution of spherical triangles without proofs ; polar triangles ; Napier's circular parts. June.

*Mensuration* (lectures or notes to be printed)—Construc-  
tion of ratios as  $\sqrt{2}$ ,  $\sqrt{3}$ ,  $\sqrt{5}$ ,  $\frac{1}{\sqrt{7}}$ ,  $\frac{\sqrt{3}}{2}$ ,  $\sqrt{\frac{2}{3}}$ ,  $\sin^2\theta$ ,  $\tan^2\theta$ ,  
 $\cot\frac{\pi}{8}$ , &c., and combinations of these. Rectilineal and circular

areas and perimeters and combinations of these. Construction of radius of curvature of ellipse, from its value  $N \sec^2\psi$ . Area of ellipse as the projection of a circle. Area of a parabola intercepted by any chord, proved geometrically. Polygonal approximation to the areas of curves. Simpson's rule. Weddle's approximation. Summation of shot piles. December.

*Marks* (*Trigonometry and Mensuration*), Dec., 100 ; June, 400.

*Conics and Analytical Geometry* (lectures or notes to be printed)—Rectilinear and polar co-ordinates. Distance between two points. Area of triangle. Equation to a line. Equation of the 1st degree. Principle of intersections. Equation to a circle (any rectangular axes). Intersections with a straight line, three cases. General definition (Todhunter's) of a parabola, ellipse, hyperbola. Sections of a right cone shewing foci and directrices. Equation to parabola ; construction of any point on a parabola by drawing a tangent. Equality of inclinations of tangent to axis and radius vector. Sub-tangent bisected by the curve. Tangents meeting on the axis. Definition of diameter as the bisector of chords parallel to the tangent at its extremity. Geometrical proof that any straight line parallel to the axis is a diameter, that the tangents at the extremities of any chord meet on the diameter which bisects it, and that the portion of diameter thus intercepted is bisected by the curve. Geometrical proof of equation referred to diameter and tangent. The distance of any external point from the parabola measured parallel to the axis varies as the square of the distance along the tangent. Ellipse defined as the projection of a circle, as described by the trammel and as the locus of  $r + r' = 2a$ . Equation proved from the two former definitions. Geometrical proof from the latter definition that the tangent is equally inclined to the focal distances. Locus of foot of the perpendicular from focus on tangent. Statement of

the lengths  $ae$ ,  $a$ ,  $\frac{a}{e}$ . Conjugate diameters as the projections

of perpendicular diameters of the auxiliary circle.  $a^2 + b^2 = a^2 + b^2$  and the circumscribing parallelogram  $= 4ab$ . Equation referred to conjugate diameters without proof. Hyperbola compared with the ellipse without proof. Asymptotes. Conjugate hyperbola. Conjugate diameters. Equation referred to the asymptotes without proof. Rectangular hyperbola. Similarity of curves; Newton's definition. Meaning of constants of position and constants of size and shape. Similarity of all circles and parabolas. Dissimilarity of ellipses and hyperbolas; similarity if  $\frac{b}{a}$  is constant.

Application of the test of magnifying. *Marks, March, 200. 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  $\bar{x} = \frac{\sum (Px)}{\sum (P)}$ . § 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  $\bar{x} = \frac{\sum (mx)}{\sum (m)}$  § 144-6, compared with § 114-5.

Properties of the centre of gravity, Chapter X, omitting § 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; Chapter XVI.

Compound Machines; Chapter XVII; proved by the principle of Virtual Velocities.

Virtual Velocities; definition and statement of principle;

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Chapter XVIII. Certain forces may be omitted from the equation of Virtual Moments.

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, 200.

#### SECTION H.

*Plane Trigonometry (Todhunter.)* I to XVI, omitting § 180—210, but reading them over for comparison with the

Differential Calculus, and omitting XVI § 254. Inverse Functions—Chapter XVIII, omitting § 264. Demoiivre's Theorem Chapter XIX, § 266-8. Marks, March, 200.

## SECTION J.

*Spherical Trigonometry (Todhunter.)* Chapters I to VI, omitting proof of Napier's circular parts. § 68, 69. Areas VIII, § 96 to 99. Marks, March, 200.

## SECTION K.

*Conics (Todhunter.)* 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;  $y^2 = 2a(x+x^1)$ ; similarly for the circle and other conics. Equation to the normal.

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  $= 2p$ . 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: Deduction of the general equation  $(y - y^1)^2 = 4a(x - x^1)$  from the simplest equation  $y^2 = 4ax$ ; similarly for all other curves,  $(x^1, y^1)$  being the origin for the simple equation. Analytical investigation into diameters and their properties (alternative with §147.) Construction of tangents from any external point; their lengths are proportional to the cosecants of their inclinations. 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.

Intersections of Conics, straight lines and other curves. Contact. Circle of curvature;  $2p$  as limit of  $\frac{y^2}{x}$  or  $\frac{y}{x \sin \theta}$

$\therefore \rho = \frac{2a}{\sin^3 \theta} = \frac{N}{\sin^2 \theta} = \frac{N^2}{SL^2}$ ; thence construction of radius of curvature, and evolute.

Intersection of circle and conic, equal inclinations 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.

$$pp' = b^2; \frac{p}{p'} = \frac{r}{r'}; p^2 = \frac{b^2 r}{r'}$$

Equations to tangent and normal. Points where the tangent cuts the axes.

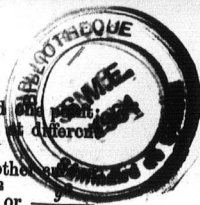
Locus of intersection of tangent with the perpendicular at the focus to the radius vector; locus of intersection of tangents at the extremities of a focal chord; proof of Todhunter's definition of an ellipse; the straight lines  $ae, a, \frac{a}{e}$ ;  $r = a \pm ex$ . Polar equation referred to both focus and centre. The length  $e^2 x'$  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  $p^2 = a^2 \cos^2 \alpha + b^2 \sin^2 \alpha$  for perpendicular from centre on tangent; thence locus of intersection of perpendicular tangents.

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  $\theta$  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.)

$$a'^2 + b'^2 \text{ constant; } pb' = ab.$$

$$\text{Length of Normal} = \frac{bb'}{a}; \cos \psi = \frac{p}{r} = \frac{p'}{r'} = \frac{p+p'}{2a'} = \frac{b}{b'}$$

*PG. PG' = b'^2 = rr'* and other properties.

Radius of curvature (as for parabola)

$$= \frac{b'^3}{ab} = \frac{N}{\cos^2 \psi} = \frac{N^3}{SL^2}; \text{ thence construction of points on the}$$

evolute.

To construct the foci of an ellipse, given the axes; also to construct directrices and latus rectum.

To construct an ellipse, given a pair of conjugate diameters.

Given an ellipse, to find the centre and axis.

Given either axis and one point, to describe the ellipse.

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 § 262-3; 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.)

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 § 279, 280. Meaning of "discriminant of a conic."

Chapter XIV—General equation to a conic. Read over § 281-3. 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  $AB \cdot DC : AC \cdot DB : AD \cdot BC$ . Harmonic pencil. Omit § 356-61.

Chapter XVII—Projections; § 362-89, and read over the rest. Marks—December, 500.

## SECTION L.

*Differential Calculus (Williamson.)*

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  $\frac{dx}{dy} \times \frac{dy}{dx} = 1$ .

Chapter II—Successive differentiation; differential of the independent variable is constant. Omit § 39, 43 to end of chapter. Read over Leibnitz 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) or Mr. Homersham Cox's variation of Lagrange's proof. 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, § 74. Omit § 75 to end of chapter.

Chapter IV—Indeterminate forms; algebraic processes not necessary. Consider also  $\alpha \rightarrow \alpha$ . Read over the proof in § 91.

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.

Chapter VIII—Read over § 127 and note result.

Chapter IX—Maxima and Minima. Omit § 136-7, 143-7. Read over § 151 to the end of the chapter.

Chapter XII—Tangents and normals. Omit § 173-7, 184 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 § 255, and study the approximations.

Chapter XVIII—Brief explanations and easy examples. The Limaçon and Trisectrix. Trisection of an angle. The conchoid § 270-71.

Chapter XIX—Roulettes § 272-7. Read over § 278. Geometrical proof of hypocycloid and hypotrochoid when the radius of the inner circle is half that of the outer, § 285.

Chapter XX—Elimination of Constants and Functions, § 302-3.

Chapter XXI—Change of the Independent Variable, § 311, 315-6. *Marks, June, 500.*

## SECTION III.

*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,  $\tan^2 \theta d\theta$ . Integration by parts. The various cases of  $\sin^m \theta$ .  $\cos^m \theta d\theta$ . Rational fractions. *Marks, March, 100.*  
*Notes, 100.*

## 2ND CLASS.

## OBLIGATORY—2,500 MARKS.

## MATHEMATICS AND MECHANICS.

	<i>Marks.</i>
Euclid ( <i>Todhunter</i> )—3rd and 4th Class course..	<i>March, 300</i>
Arithmetic—As for 4th Class.....	<i>March, 100</i>
Algebra—4th Class course.....	<i>March, 200</i>
Trigonometry—3rd and 4th Class course—in- cluding solution of spherical triangles, &c..	<i>June, 300</i>
Conics—3rd Class course.....	<i>June, 100</i>
Mensuration ( <i>Lectures or Notes to be printed.</i> )	

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-parallelepiped. 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, pyramids 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. *Marks, Dec., 100; June, 100.*

*Statics* ..... *Marks, June, 200.*

*Graphic Statics (Tracts on Mechanics, Part II.)* Problems 1-4, 6, 7 with alternative solution; 8, 11, 12, 21.

*Marks, March, 100.*

*Dynamics and Works*—(*Todhunter's Mechanics for beginners.*)

Velocity. Chapter I.—Angular velocity in terms of circular measure.  $v = r\omega$ ;  $\alpha = \frac{2\pi n}{t}$ .

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  $\bar{v} = \frac{\sum(mv)}{\sum(m)}$ ;

$\bar{f} = \frac{\sum(mf)}{\sum(m)}$  proved from  $\bar{x} = \frac{\sum(mx)}{\sum(m)}$  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. Seconds' pendulum. See Chapter XIII, § 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.

easy examples.  
of an angle. The

read over § 278.  
trochoid when the  
uter, § 285.

and Functions,

ndent Variable,  
Marks, June, 500.

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ions of them.  
al substitution,  
ious cases of  
ks, March, 100.  
Notes, 100.

Marks.

March, 300

March, 100

March, 200

June, 300

June, 100

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(ms) on the  
, proved by  
three equal  
ncated right  
terms of its  
tated prism,  
ed. Volume  
oid (defined  
allel ends)

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, 100; June, 300.

*Applied Mechanics—(Crofton's Lectures.)*

Introductory Chapter: Stability of Structures (Part I). Frames. Roofs. Trussed beams. Chains and cords. Stability of walls.

Strength of Materials (Part 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—December, 100; June, 200.

*Hydrostatics—(Besant's Elementary).*

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.

Chapter IV, V—Omit § 80. Read over § 83. Omit § 87-9 and 93 to the end of the chapter.

Chapter IV—Omit § 98-101 and 108 to the end of the chapter.

Marks—June, 200.

Notes and Recitations.....100.

2ND CLASS.

VOLUNTARY.—2,000 MARKS.

Qualification, one-third for any Section.

SECTION N.

*Integral Calculus (Williamson).*

Chapter 1—Compare (e) with § 9; (f) with § 5; also Ex. (1), (2), § 13. Integrate forms involving  $a + 2bx + cx^2$  or

*Mechanics, Part*  
calculations of  
and radius of  
angle and circle;  
Special atten-

100; *June*, 200.

res (Part I).  
cords. Stabi-

strain. Elastis-  
ams. Bending  
for shearing  
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ance for rectan-  
of uniform  
with diagrams.  
ance for weight  
ams. Fixed

100; *June*, 200.

ation in § 3.  
(12).

f of Ex. (5),  
f of the triangles

§ 83. Omit

the end of the

ks—*June*, 200.

.....100.

§ 5; also Ex.  
 $2bx + cx^2$  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—Rationalisation, § 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. Ansler'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 Inertia. Special attention to § 196-98. Read over § 206-207; 216-17. *Marks—December*, 500.

#### SECTION O.

*Analytical Geometry of three dimensions (by lecture or notes to be printed).* 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 straight line. To find the inclinations from the equation. Angle between two given straight lines. Equations to a surface; conditions of parallelism to one or two axes of co-ordinates. General equations to a sphere, ellipsoid, spheroid and cone, with principal axes parallel to the axes of co-ordinates. 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 inclinations 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. 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. 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. *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 of 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  $\frac{3}{8}$  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. 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. Parabolic curve of the suspension bridge with

perpendicular to a curve; normal to a December, 200. the course, to

er's Mechanics ed articles in a proof of § 155.

ion and Com- les. The six n Todhunter's ucible of two gle resultant. e; 1st, on a re of parallel of the centre Elementary circular arc, small arc or in the chord to of area, arc, s Theorems. the direction traction of a axis through Proof in the hether free or of a pair of ; also of any a rigid body; ensible string hich is one of ole. Applica- ny system of ravity, their r lowest posi- stable, in the rved body ly on a rough 'chain' over a t in unstable ridge with

vertical rods. The common catenary; its equation, length of arc, curve 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. 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. 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 § 103. Motion in a circle or conic; section to be read over only, more advanced proofs being furnished. Chapters XIV, XV. Kepler's laws, § 173.

*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. Motion of a heavy chain (1) hanging over a smooth pulley, (2) placed with part hanging over a smooth table. Body moving vertically in 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. Special attention to the equation of Vis Viva wherever it occurs. Work done in stretching an elastic rod. Vibrations 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.

*Hydrostatics—(Besant's elementary).*—Harder questions on the obligatory course, together with the omitted sections, Chapters I to VI. The units involved in  $W = Vsw$  and  $W = Vg\rho w$ .

*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 its 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  $z = 26215 \log \frac{H}{h}$ ;  $z = 26215 \frac{H-h}{h}$ ;

$z = 52430 \frac{H-h}{H+h}$  Height of the "homogeneous atmosphere."

Stresses 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, 400.

Notes, 100.

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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, J). 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. Demoiivre's Theorem; some of the less difficult applications. (*Todhunter's Plane Trigonometry*). Chapter XIX § 266-72; 274-6; 78. Exponential values of sine, cosine, tangent. Gregory's series. Calculation of  $\pi$ . 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. *Marks, 500.*

## SECTION V.

Applied Mechanics. (*Notes.*) Re-examination on and completion of Section P. (*Statics.*) Moments of Inertia. The ellipse of Inertia. 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.

*Hydrostatics.* Re-examination on, and completion of the former course. *Marks, 250.*

## SECTION X.

Mechanism and the Steam Engine (*Goodeve, and Notes.*) Omit special applications such as those to weaving and mangling machines. Omit Chapter III on Teeth of Wheels. *Marks, 750.*



## ROYAL MILITARY COLLEGE OF CANADA.

### SYLLABUS OF INSTRUCTION IN FORTIFICATION AND 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	
Voluntary, 500	Term work.	Notes, Exercises and Drawings,		500
		Examination.	Yearly,	300
		Intermediate,	nil.	300
	Term work.	Notes, Exercises and Drawings,		200

## 1st Class.

Obligatory, 2,000	Examination.	Yearly,	600	} 1,500
		Intermediate,	900	
Voluntary, 1,000	Term work.	Notes, Exercises and Drawings,		500
		Examination.	Yearly,	600
		Intermediate,	nil.	600
	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; and Part V, Miscellaneous.

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

*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 Schéliha'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 Fraser, 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.

500 }  
500 } 1,000  
and }  
500 }  
300 }  
nil. } 300  
and }  
200 }  
  
600 }  
900 } 1,500  
and }  
500 }  
600 }  
nil. } 600  
and }  
400 }  
il part.)

N.C.O.'s only.

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

## SUMMARY OF COURSE OF INSTRUCTION IN FORTIFICATION AND 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.

#### Pioneer Duties,—

Construction, demolition and restoration of communications for the conveyance of men, horses and materials, and for the transmission of messages.

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

The practical part will be taken up in the 1st and 2nd 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, including Mining, and Applied Field Fortification.  
 I Class.—Applied Field Fortification (continued.) Use of Field Fortification by the Attack, Pioneer duties.

*Engineering Drill.*

- II Class.—Field Fortification, and the Attack of Fortresses (excluding Mining.)  
 I Class.—Use of Explosives, Pioneer Duties and Camp Duties.

4TH CLASS.

OBLIGATORY.

FIELD FORTIFICATION.

1st Part.

1. *INTRODUCTION.*—Principles of Defence and deductions from them of the works required to defend a Position. Sketch of the defence and attack of a Position. Effect of the arms at present in use.

2. *Tools.*—Various kinds.

3. *Materials.*—Raw: how obtained; earth, wood, brush-wood, iron, &c.

Manufactured: how made; pickets, fascines, gabions, hurdles, &c.

4. *Revetments.*—When required. How made. Anchoring. Comparison of the various kinds.

WORK TO BE DONE FOR THE DEFENCE OF A POSITION.

5. *Clearing the foreground.*—Object. Requirements and how fulfilled:

6. *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, Chevaux de frise, Palisades, Fraises, Military pits, Inundations, &c.

*Cover for Troops.*

*For Infantry:—*

7. 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.

8. To cover supports.—Requirements and how generally

fulfilled. Description of the various works used, namely: Adaptation of natural cover, deep trenches, blinded trenches, field casemates, &c.

9. To cover reserves.—Requirements and how generally fulfilled. Description of the various works used, namely: adaptation of natural cover, shelters, etc.

*For Artillery:—*

10. 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-spaulments (the placing of guns in Field Works is considered under that head.)

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

*Blindages.*

12. Specially considered.

*Hasty Intrenchments.*

13. Nature and object.

*Flanks.*

14. 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.*

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

16. Field works. Trace, profile, details and execution. Garrison, &c.

17. Defensible knolls. Trace, profile, &c.

18. Defensible houses and villages.

19. Defensible woods.

*Making and Destroying Communications in a Defensible Position.*

20. Object and statement of work to be done.

PLATES.—The following is a list of the plates to be drawn:—

I. Various sections of blinded shelter trenches.

II. Various sections of blinded communications, etc.

III. Profiles of Field redoubt.

IV. Plan of Field redoubt.

V. Gun bank with Section.

VI. Defensible Knoll.

VII. Defensible House.

VIII. Defensible Village.

IX. Defensible Wood.

EXERCISES.—On the above subjects, principally numerical examples.

SUBJECTS FOR EXAMINATION :—

*December*—Sections 1 to 6 inclusive.

*March*—Sections 7 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 the 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 rampart* 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. a.* 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 banquettes, 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 materiel; 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. a.* Conditions of defence which all profiles must fulfil.
- β.* Profile; with dry ditches, with wet ditches, 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.
- a.* Outworks—
1. Covered way and glacis, and ravelin, with their keeps, object, construction.
  2. Counterguards; their object, 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; simple, easy, safe, how carried out.
- d.* Retrenchments—
- Requirements, how carried out.
- a.* Open works; cavaliers, gorge retrenchments, coupures.
- β.* Closed works; casemated keeps, interior glacis, iron plating.



- $\gamma$ . 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.

*a. Detached Forts.*  
Requirements.

$\alpha$ . Good artillery positions.

$\beta$ . Secure against assault.  
How carried out.

*b. Enclosed Enceintes.*

$\alpha$ . When a regular attack is not possible.

1. Long simple fronts.

2. Simple outworks.

3. Escarps, caponiers, and keeps completely covered from view.

$\beta$ . 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.

$\alpha$ . The enceinte as in (D —  $b$  —  $\beta$ ) above.

$\beta$ . The detached forts.

1. The individual forts as in (C —  $c$  —  $\gamma$ ) 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 encointes.

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. Bastioned trace.

III. Sections and elevations of the modern French system.

IV. Sections and elevations of the Antwerp enceinte.

V. Detached Fort.

\*VI. A semi-permanent work.

FAIR NOTES.—On lectures during the term.

EXERCISES.—Examples of permanent profiles and bastioned traces.

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.*

\* These plates are liable to alteration from time to time.

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 bastioned work.  
Characteristics of the Dutch school, example Coevorden.  
Improvements by Coehorn, his principles and methods  
of construction.

*d. The French School under Vauban and his Successors.*

Vauban's systems, first and third. Cormontaingne's im-  
provements; 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 de-  
tail, 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 natural obstacles and creation of arti-  
ficial ones.

B. COMBINATION OF THESE PRINCIPLES IN WORKS FOR COAST  
DEFENCE—

Nature of defences:

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\*Portions of Sections A, B and C Coast Defence are included in Obliga-  
tory Course under Section F.

- 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:—
      - a. 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.
          2. Electrical.
        - 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.*—VII, VIII, IX. Coast Defences.
- 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 approaching 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 position; 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.
- ζ. 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 escarpments 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. *Obstructions 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, *large sorties*.

Lighting up ground at night and careful observation.

Firing on working parties; large sorties.

γ. 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.
- e. Against advance to covered way.
1. Creation of difficulties; obstacles, mines.
  2. Same as against other saps.
  3. Counter mines 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.
- ζ. 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 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.)

$\alpha$  Defensive use, submarine mines proper.

$\beta$  Offensive use, torpedoes.

## B. REQUIREMENTS.—Means for placing charges.

a. *Land mines*; offensive and defensive.

$\alpha$  Shafts and galleries; object, dimensions, method of executions and lining. Tools appliances and time required.

$\beta$  Bored mines; object, dimensions and method of execution.

$\gamma$  Ventilation of mines; requirements, method of carrying them out.

$\delta$  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.*

$\alpha$  Gunpowder, gun cotton and dynamite; comparison of their effect, and when they should be used respectively. Sketch only.

$\beta$  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, see 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.

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\* The consideration of these tactical requirements belongs to the Course of Tactics.

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, etc.
6. Rearguard Positions.

*Attack and Defence* of field works.

PLATES:—

- I. The attack to the third parallel.
- II. The attack to the summit of the main breach.
- III. Siege Works.
- IV. Defence.
- V. Mining.
- VI. Applied field fortification (project).

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*, — *a*,  $\gamma$ ,  $\delta$ ,  $\epsilon$ ,  $\zeta$ , more in detail.

MINING.

D. APPLICATION OF MINES—

*a*. To the defence.

$\alpha$ . Defence of glacis: object, requirements, how carried out. Countermine systems for defence of glacis.

$\beta$ . Defence of breach, object, requirements, how carried out. Countermine systems.

- b. *To the Attack.*  
 α. On countermine systems under glacis, tactics of assailant, ordinary method of attack by galleries, attack by shaft mines  
 β. On countermine systems 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—

VII. Siege works.

VIII. Countermine systems.

IX. Attack on a system of countermine systems.

FAIR NOTES.—On lectures during the term.

EXERCISES.—Examples on application of mining; Journal of attack on countermine systems.

## 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 enemy'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 enemy'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.

The following paragraphs of the text-book on explosives form the obligatory course:—

§§ 1 to 126, 153 to 156, 163, 165, 167, 170, 189, 190, 199, 200, 203 to 213, 221, 234, 235, 241, 242, 244 to 248.

#### 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.

*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, cribs, 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 ordinary road (military) when 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).

\* Accurate methods are given in the Mathematical and Civil Engineering Courses.

† The laying and construction of the road are not considered, being part of the Civil Engineering Course.

## 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.

RAILWAYS.—Vulnerable points: bridges, cuttings, tunnels, embankments, permanent way, engines and rolling stock. Hasty demolition by cavalry, and deliberate demolition of each.

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. Morton's Abyssinian tube wells. Boring for water.

HUTTING.—Requirements. Huts of various kinds. Bivouacs.

MISCELLANEOUS.—Field kitchens and ovens. Latrines.

## PLATES:—

I. Project for the defence of a Position.

II. Demolition project.

III. Project for a military bridge.

## IV. Store gunpowder magazine.

**FAIR NOTES.**—On lectures during the term, when ordered.  
**EXERCISES.**—Reports on projects.

**SUBJECTS FOR EACH EXAMINATION—**

*December*—Field fortification; use of explosives and bridging, as far as trestle bridging, inclusive.

*March*—Permanent fortification and remainder of pioneer duties.

*June*—Attack and defence, and 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 galvano-meters,) 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.

The paragraphs in Text-book forming the Voluntary Course are § 127 to 243.

**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.—Project for a military bridge.

FAIR NOTES.—On lectures during the term, when ordered.

EXERCISES.—Report on project.

\* SUBJECTS FOR EXAMINATION—June—The whole subject.

## ENGINEERING DRILL.

### 2ND CLASS.

#### FIELD FORTIFICATION.

##### *Preliminary.*

Carrying tool drill and extending working parties. Field Geometry.

##### *Obstacles.*

Abatis ordinary. German bough abatis. Shallow military pits. Irregular pits with wire entanglement stretched over. Wire entanglements. Palisades. Fraises. Chevaux-de-Frise.

#### 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 epaulements.

*Ammunition.* Ammunition recesses in above.

*Limbers.*—Liber 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.

##### *Field Redoubt.*

Tracing, profiling and defilading full size. Executing in

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\*The details of Plates given for each class are subject to alteration from time to time.

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.

#### 1ST CLASS.

##### ATTACK OF FORTRESSES—(Continued.)

*Mining.*—Sinking shafts with cases and frames.\* Driving galleries with cases and frames. Preparing charge for mine.

##### USE OF EXPLOSIVES.

*Preparing charges* of gunpowder, guncotton and dynamite or 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.

###### *Signalling.*

*Flag drill.*—Practice with flags. Lamp drill with dummy lamps. Practice with lamps. Practice with heliograph. Selecting stations. Transmission of messages.

###### *Bridging.*

*Preliminary.*—Reconnaissance of site. Measuring width, taking sections (boning and levelling). Knotting. Lashing spars. Making Derricks, Shears and Gyms. Trussed beams.

*Frame Bridges.*—Single lock, double lock, single sling.

*Trestle Bridges.*—Making two legged, three legged and four

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\*The actual sinking of shafts, &c., will not, as a rule, be possible.

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.

*Camp Duties.*

Bivouacs. Field kitchens and ovens. Latrines.

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## ROYAL MILITARY COLLEGE OF CANADA.

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### SYLLABUS OF INSTRUCTION IN ARTILLERY.

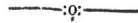
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#### ALLOTMENT OF MARKS.

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<i>For Entire Course.</i>  4,560	{	Obligatory .....	3,000									
		Voluntary .....	1,000									
		Drill .....	400									
		Communicating Drill (N. C. Officer's only).....	160									
<i>For 3rd Class.</i>	{	Obligatory—Yearly Examination....	1,000									
		Intermediate Examinations.....	500									
		Drill .....	200									
<i>For 2nd Class.</i>	{	Obligatory—Yearly and Intermediate Examinations .....	1,500									
		Voluntary—Yearly Examinations.:	<table style="display: inline-table; border: none; vertical-align: middle;"> <tr> <td style="font-size: 2em; padding-right: 5px;">{</td> <td style="padding-right: 5px;">A</td> <td style="padding-right: 5px;">400</td> </tr> <tr> <td></td> <td style="padding-right: 5px;">B</td> <td style="padding-right: 5px;">500</td> </tr> <tr> <td></td> <td style="padding-right: 5px;">C</td> <td style="padding-right: 5px;">100</td> </tr> </table>	{	A	400		B	500		C	100
{	A	400										
	B	500										
	C	100										
		Drill .....	200									
<i>For 1st Class.</i>	{	Communicating Drill (N. C. Officers only).....	160									

## TEXT BOOKS AND BOOKS OF REFERENCE.



## TEXT BOOKS:

*Practical and Theoretical Course.*

- Drill Book for the Field Artillery (Militia).  
 Manual of Siege and Garrison Artillery.  
 Notes on S. B. Ordnance.  
 Treatise on the Construction of Ordnance (Royal Gun  
 Factory).  
 Treatise on Ammunition (Royal Laboratory).  
 Treatise on Carriages (Royal Carriage Department).  
 Sladen's Gunnery (Voluntary).  
 Tracts on Mechanics (Voluntary).

## BOOKS OF REFERENCE:

- 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.

Each Cadet fires annually two rounds of Common, and one of Shrapnel, shell.

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. 12 Pr. and 7-inch guns.

## 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.

## NOTES AND CHAPTER III. OF TREATISE.

*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.

CHAPTER V.

Short sketch of the history of rifled ordnance.  
 Classification as *Guns, Howitzers and Mortars*.  
 Classification as *Rifled breech-loading and Rifled muzzle loading* ordnance.

CHAPTER VI.

Description of an Armstrong R. B. L. gun and its various parts and fittings, including sighting.  
 The modern construction of Breech-loaders.

CHAPTER VII.

List of Service B. L. R. Guns with weights and charges.  
 The purposes for which each nature is designed.

CHAPTERS VIII AND X.

General description of the construction and form of the Service R. M. L. Ordnance. Classification as:—

1. Mountain or boat guns.
2. Field, boat or Field marine.
3. Siege or position.
4. Medium.
5. Heavy.

List of Service Ordnance, weights and charges.

General construction of the converted guns in the service with their fittings and sights.

CHAPTER IX.

*Ordinary Sights.*

Sights for Woolwich, Armstrong and converted guns.  
 Number of sights used for 64 Prs. and upwards.  
 Number of sights used for 40 Prs. and under.



## SPECIAL SIGHTS AND MEANS OF GIVING DIRECTIONS.

1. Turret sights.
2. Moncrieff sights.
3. Chase sights.
4. Wood scales.
5. Index plates and readers.
6. Clinometers and quadrants.
7. Hanging scales.
8. Graduated arcs.
9. Experimental sights.

*Hind Sights.*

Tangent sights, centre hind sights.  
 Graduation of above for the various guns.  
 Peculiarities of Howitzer tangent scales.

*Fore Sights.*

Trunnion sights, centre fore sights and muzzle sights, for guns and Howitzers.  
 Description of the more important special sights and their uses.  
 List of modern B. L. guns, their fittings and sights.  
 Description and use of hanging scales and quadrants.  
 Capt. French's sights.  
 Shot bearers, muzzle derricks, common and spring spikes.

## CHAPTER XII.:

Examination, preservation and repairs of ordnance and stores.  
 Examination and condemnation of ordnance.  
 Periods of examination.  
 Mode of examination.  
 Examination of bore.  
 Defects to be looked for.  
 Importance of various defects under various circumstances.  
 Examination of vent.  
 Examination of R. B. L. fittings.  
 Examination of exterior.  
 Preservation of guns, sights and fittings.  
 Preparation for transport.

## AMMUNITION.

## CHAPTER I.:

Gunpowder, its ingredients and properties.  
 The various natures used.

Classification of gunpowder.  
 Method of packing and storing.  
 The chief points to be attended to in the selection of a material for a cartridge bag.  
 Various natures of cartridges for saluting, reduced, service and battering charges.  
 Lubricators, paper cylinders and wooden sticks.  
 Powder barrels, metal-lined cases, zinc cylinders.  
 Mode of packing and storing cartridges for rifled and smooth-bore guns, siege and garrison service.  
 Paper bags and packing in limbers.

#### PROJECTILES FOR S. B. ORDNANCE.

Solid, case, grape and sand shot.  
 Common, naval and mortar shells.  
 Hand grenades, carcasses, ground light balls.  
 Parachute light balls. Smoke balls.  
 Grummet wads. Wood bottoms. General service plugs.  
 Adapters, &c.

#### PROJECTILES FOR RIFLED GUNS.

##### CHAPTERS X., XI., XII., XIII., XIV.:

Solid shot. Palliser shot. Case shot.  
 Common, double, battering, Palliser, Shrapnel, Segment and Star shell. Carcasses.  
 Length and thickness of shells.  
 General form and construction of service projectiles.  
 Advantages gained by the use of elongated projectiles.  
 Peculiarities in the construction of Palliser and battering projectiles.  
 Gas checks, ordinary and driving.  
 Primers for Shrapnel shell and vent pieces.  
 Tin cups. Wedge wads, &c.

#### FUZES.

##### CHAPTER III.:

Fuzo-hole gauges.  
 General remarks on time-fuzes.  
 Causes which alter the time of burning.  
 Method of packing fuzes.  
 Causes of blind shells and premature bursts.  
 Time fuzes for S. B. ordnance.

Common, diaphragm, large and small mortar, parachute and hand grenade fuzes.

Time fuzes for R. M. L. and R. B. L. ordnance.—The difference between them.

Times of flight to which each fuze can be graduated.

The 5-seconds, 9-seconds, 15-seconds, 20-seconds and 30-seconds fuze.

Armstrong's E time fuze, the special time fuze for the new pattern Shrapnel shell.

Rules to find length of fuze for various ranges.

#### PERCUSSION FUZES.

##### CHAPTER V.:

The Pettman's land service and general service fuze.

Armstrong's plain percussion fuze.

Royal Laboratory, Marks I. and II.

Difference between the two last fuzes.

The direct action, the delay and the sensitive fuze.

#### MEANS OF FIRING ORDNANCE.

##### CHAPTER VIII.:

Copper friction tubes, quill tubes, electric tubes.

Port fires—common and slow.

Quick and slow match.

#### ROCKETS.

##### CHAPTER XVI.:

Hale's war rocket, signal and life-saving rockets.

Rocket troughs.

#### APPENDIX

Regulations to be observed in making up cartridges, filling shell or examining powder.

#### PART II.—MANUAL OF ARTILLERY EXERCISES.

Practical instruction in making up various natures of cartridges, in filling shell and in boring and fixing fuzes.

Hints on examination of ammunition.

Small arm and Gatling ammunition.

## SECOND CLASS.

(OBLIGATORY.)

## MILITARY CARRIAGES.

## FIELD AND SIEGE CARRIAGES.

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 12 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 wagon.

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 wagon and its fittings.

- The chief points of difference between the above carriages and those for the 16 Pr., 25 Pr., 40 Pr. and 6½ Pr.
- The overbank attachment and its uses.
- The carriages and beds for the 6.3-inch howitzer and 8-inch howitzer.
- Methods of checking excessive recoil in field and siege carriages.

#### SIEGE PLATFORMS, &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 wagons*, *general service wagons*, *forge wagons*, &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 carriage.
- The Elswick compressor.
- The double plate construction of sliding 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

## ELEMENTARY GUNNERY.

## 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 in the bore of a gun.
2. Quality of the ingredients.
3. Proportion 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 of wheels.
- Force and direction of wind.

## PRACTICAL GUNNERY—EFFECT OF PROJECTILES.

Common shell.  
 Shrapnel shell.  
 Battering projectiles.  
 Case shot.  
 Star shells.  
 Carcasses.

## ARTILLERY FIRE.

## PART I.—SECT. IV.—FIELD ARTILLERY.

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

## PART III, SECT. IX.—SIEGE ARTILLERY.

## METHODS 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.
- C. 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 III., SECT. X—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,"—

## 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.

## PART IV., SECT. IV.,—

The hydroclinometer for elevated batteries.  
 Arming batteries by night.  
 Hasty disablement and destruction of ordnance.

## MANUAL GARRISON ARTILLERY.

## 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.

## SECOND CLASS.

## SECTION A.—(VOLUNTARY.)

CONSTRUCTION AND MANUFACTURE OF ORDNANCE, CARRIAGES,  
AMMUNITION AND STORES.

## METALS USED in GUN CONSTRUCTION.

## CHAPTER I.:

Physical properties of metals generally.

Modes of measuring tenacity and elasticity.

Metals used for construction of ordnance.

*Bronze*, including "phosphor bronze," and "Uchatius  
bronze," and so called "steel bronze."*Iron*, including *cast iron*, *wrought iron* and *steel*.The peculiar properties of the above as applied to gun  
construction, drawing special attention to wrought iron  
and steel.Defects and advantages of each of the above pointed out.  
Tests applied to wrought iron and steel for gun purposes.

## GUN CONSTRUCTION GENERALLY.

## CHAPTER II.:

Casting and building up.

Tangential and longitudinal stresses.

System of initial tension and varying elasticities.

Armstrong principles. Arrangement of fibre, tangentially  
and longitudinally. Palliser guns.

Disposition of metal in service gun.

Construction of service Armstrong B. L. R. gun.

Frazer construction. Reasons for using steel for the  
barrels of Woolwich guns and wrought iron for the con-  
verted guns.

PRINCIPAL OPERATIONS IN THE MANUFACTURE OF OUR RIFLED  
ORDNANCE.

CHAPTER V.:

Machinery. Steam hammers and their power.  
Steel ingots. Testing of steel.  
Manufacture of bars. Coils and coiling. Welding.  
Solid forgings. Trunnion ring. Uniting coils to form a  
tube. Shrinking. Mode of cooling. Manufacture of a  
jacket. Centering. Turning. Boring. Broaching.  
Lapping. Rifling. Uniform twist. Increasing twist.  
Drilling. Screw cutting. Slotting and planing.  
Viewing and gauging.

DETAILS OF MANUFACTURE OF WOOLWICH GUNS.

CHAPTER VIII.:

Details of a 7-inch gun, Mark IV and upwards.  
Steel tube and its manufacture and treatment.  
The Breech Piece.  
I. B. Coil or Belt.  
B. tube.  
The Jacket.  
Building up the gun, or shrinking the parts together.  
The *casable*.  
The difference in the construction of 10-inch gun mark II,  
the 16-inch gun of 80 tons, and the 100 ton Armstrong  
gun.  
Construction of natures below 7-inch.  
10-inch Rifled M. L. Howitzer.  
8-inch R. M. L. Howitzer. 64 Pr., Mark III.  
40 Pr., R. M. L. gun, 25 Pr. and under.  
The 7 Pr. mountain gun of 200 lb. The screw gun.  
Processes before proof. The necessity for the shoulder on  
A tubes.  
Examination and proof.  
Processes after proof and before issue.

CONVERSION OF S. B. INTO RIFLED GUNS.

CHAPTER X.

Early experiments. Palliser's system.  
Nature of S. B. pieces converted.  
Mode of conversion.  
Process of conversion of an 8' S. B. gun of 65 cwt. into a  
M. L. R. gun of 71 cwt. throwing a shell of 64 lbs.

CONSTRUCTION OF CARRIAGES, &C., IN ROYAL CARRIAGE  
DEPARTMENT.

NOTES.

Notes on the various woods, British and Foreign, used in the construction of carriages, &c.  
Form and quality of iron used.  
Nature of Bronze used.  
Care and preservation of leather, &c.  
Sizes of cordage and uses.

MANUFACTURE OF PROJECTILES AND FUZES.

NOTES.

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 shells.  
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.

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 of 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

$$v = \frac{V}{1 + cVs}$$

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; Crusher 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 MILITARY LAW.

#### ALLOTMENT OF MARKS.

<i>For Entire Course.</i>  800	{ Obligatory. }	{ Yearly Examination.... 500 } Intermediate do ... 200 }  Term Work. { Notes. } Recitations. }	700   100
<i>For 2nd Class.</i>  600	{ Obligatory. }	{ Yearly Examination... 300 } Intermediate do ... 200 }  Term Work. { Notes. } Recitations. }	500   100
<i>For 1st Class.</i>  200	{ Obligatory. }	{ Yearly Examination..... }  Term Work. { Notes. } Recitations. }	200   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.

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.

## MILITARY 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 commission of offences.

Military custody.

Power of Commanding Officer, with remarks on the punishments 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.

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. Misprision 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 gesta*.
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, etc.

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.	Obligatory.	Yearly Examination.... 800	} 1100
1,200		Intermediate do ... 300	
	Obligatory.	Term Work. { Notes: }	} 100
		Recitations. }	
For 2nd Class.	Obligatory.	Yearly Examination... 500	} 800
900		Intermediate do ... 300	
	Obligatory.	Term Work. { Notes. }	} 100
		Recitations. }	
For 1st Class.	Obligatory.	Yearly Examination..... 300	} Nil.
300		Term Work. { Notes. }	
		Recitations. }	

## TEXT BOOKS.

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### 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 Wolseley'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 dépôt 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 dépôts; railway dépôts.

*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 stagesystem.

#### 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. Num-

ber 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.

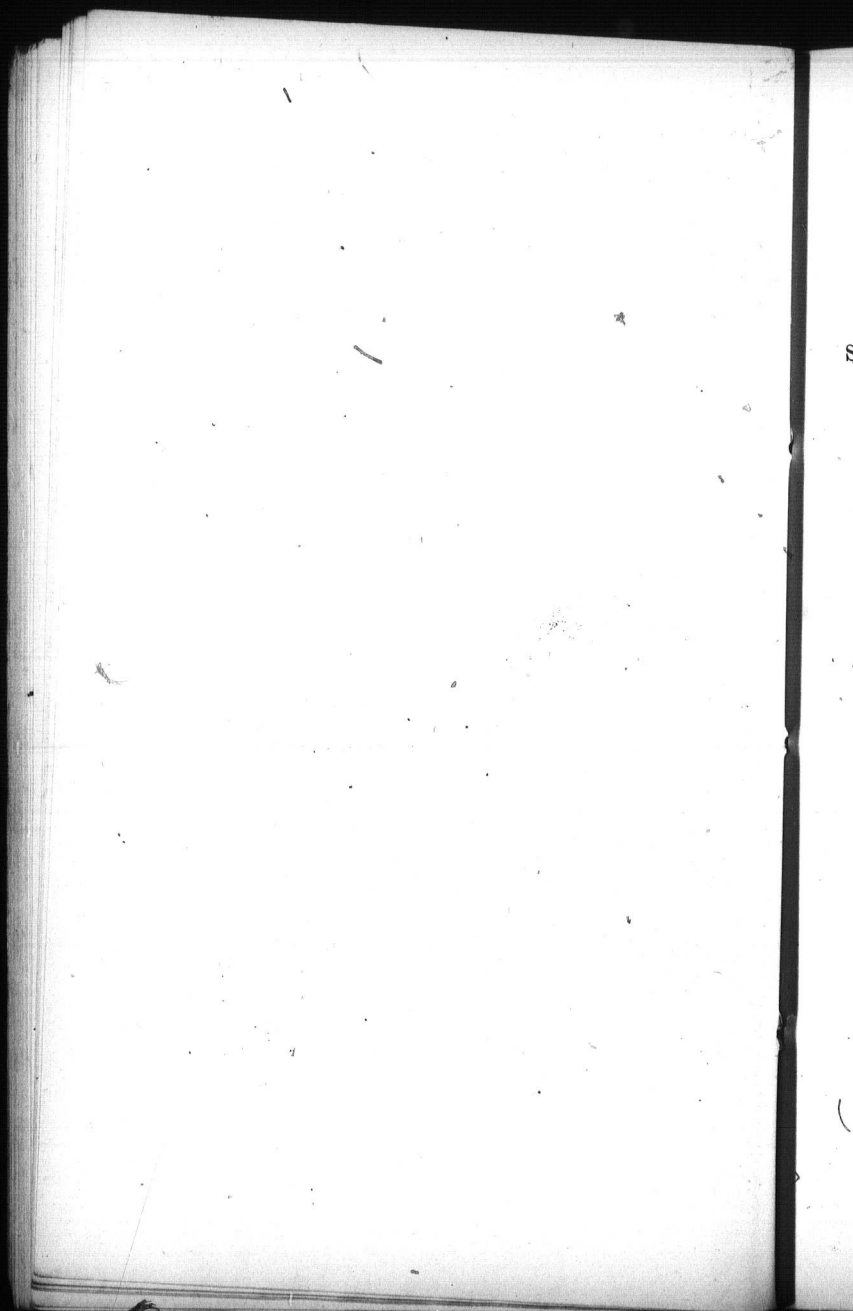
Number of roads to be used by an army; selection of roads; rates of march; length of marches; general arrangements for a march; order of march in proximity to and at a distance from the enemy.

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 ART, HISTORY, AND GEOGRAPHY.

### ALLOTMENT OF MARKS.

<i>For Entire Course.</i>	4,500	Obligatory.	Yearly Examination.....2,700	} 4,100
			Intermediate do ... 1,400	
			Term Work. { Notes. } 400	
			Recitations. }	

<i>For 2nd Class.</i>	900	Obligatory.	Yearly Examination... 1,200	} 1,800
			Intermediate do ... 500	
			Term Work. { Notes. } 200	
			Recitations. }	

<i>For 1st Class.</i>	2,500	Obligatory.	Yearly Examination... 1,500	} 2,300
			Intermediate do ... 800	
			Term Work. { Notes. } 200	
			Recitations. }	

## TEXT BOOKS.

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MINOR TACTICS. (Lieut.-Colonel Clerly.)  
 OPERATIONS OF WAR. (Gen. Sir Edward Hamley, K.C.  
 MG., C.B.)

INFANTRY FIELD EXERCISE.

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

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

- Précis of Modern Tactics. (Colonel Home.)  
 Great Campaigns 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 ART,  
HISTORY, AND GEOGRAPHY.

TACTICS.

Meaning of Tactics as distinguished from Strategy.

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 causes 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. The composition and consideration which affect their strength. Infantry and cavalry outposts, separately and combined. Line of resistance. Distance of outposts from main body. Usual subdivision into sentries, piquets, 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 army 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 presence of the enemy. General disposition 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 FORTIFICATIONS 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 defending and attacking. 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 citadels. 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.

Attacking 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 this 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 SURVEYING, MILITARY SKETCHING AND RECONNAISSANCE, AND PRACTICAL ASTRONOMY.

#### ALLOTMENT OF MARKS.

Note.—The proportions shown for Drawings, Examinations, &c., are not absolutely adhered to.

<i>For Entire Course,</i> 6,000	{	Obligatory, 4,500	{	Yearly and Intermediate Exami- nations.....	}	About 1,800
			{	Term Work. {	Notes.....	About
				{	Drawings, &c.....	2,700
				{	Recitations.....	
		Voluntary, 1,500	{	Yearly and Intermediate Exami- nations.....	}	1,500
			{	Term Work.....	}	Nil.
<i>3rd Class,</i> 1,400	{	Obligatory, 1,400	{	Yearly and Intermediate Exami- nations.....	}	About 700
			{	Term Work. {	Notes.....	About
				{	Drawings, &c.....	700
				{	Recitations.....	
		Voluntary—Nil.				
<i>2nd Class,</i> 2,300	{	Obligatory, 2,300	{	Yearly and Intermediate Exami- nations.....	}	About 1,000
			{	Term Work. {	Notes.....	About
				{	Drawings, &c.....	1,300
				{	Recitations.....	
		Voluntary—Nil.				
<i>1st Class,</i> 2,300	{	Obligatory, 800	{	Examinations.....	}	Nil.
			{	Reconnaissances .....	}	800
		Voluntary, 1,500	{	Examinations.....	}	1,500
			{	Term Work.....	}	Nil.

## TEXT BOOKS.

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- Roberts's Military Surveying.  
 Gillespie's Land Surveying.  
 Notes on Practical Astronomy by Lt.-Col. Oliver.  
 Deville's Examples of Astronomic and Geodetic Calculations.  
 The Canadian Manual of Survey.

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*Books recommended for reference.*

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- Heather's Surveying and Astronomical Instruments.  
 Gillespie's Higher Surveying.  
 Clarke's Geodesy.  
 Loomis' Practical Astronomy.  
 Chauvenet's Spherical and Practical Astronomy.  
 The U. S. Naval Academy Text Book on Surveying.  
 U. S. Coast Survey Reports.



## SUMMARY OF INSTRUCTION IN SURVEYING, MILITARY SKETCHING AND RECONNAISSANCE, 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 SKETCHING.

General principles of surveying and map making. The amount of accuracy expected in a survey dependant 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 lengths 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 a survey. Given the bearings and lengths of the lines bounding a rectilinear figure, to calculate its acreage by the tables of latitude and departure.

Contours—their nature and use. The horizontal equivalent. Use of the hand-level and clinometer for contouring a plan roughly. Definitions 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 SKETCHING (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. Measuring a base of verification. Methods of filling in the details of a triangulation. Plotting a triangulation on a large 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. The stadiometer. (Survey with the chain and plane table.)

Problems in dividing up, parting off, and laying out land. The regulations contained in the Dominion Manual of Survey.

(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 practise shading in brush work.)

The principles of laying 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.)

#### 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.

Use of the large sextant and artificial horizon. How to measure the altitude of a heavenly body, both by the natural and artificial horizon. Corrections to be applied:—dip, refraction, parallax, semi-diameter.

The Nautical Almanac.

Simple interpolation. Correction for longitude. Hour angles. Numerical expression of hour angles in time and arc. Time at different meridians. To convert the apparent time at a given meridian into mean time, and *vice versa*. Given the sidereal time at a certain instant to find the mean time. Given the mean time to find the sidereal time. The astronomical clock. To find at what time a given star will be on the meridian. To find the hour angle of a star at a given time at a given meridian. Given the hour angle of a star at a given meridian to find the local mean time. Finding 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 altitude.

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To find the azimuth of a heavenly body from its observed altitude.

Methods of finding the meridian and variation of the compass. 1. By finding the instant the pole or other star is on the meridian, and observing it; the instant being found either from the Nautical Almanac or from its being observed in the same vertical plane with certain other stars.

2. By equal altitudes of a star.
3. By the greatest elongation of a circumpolar star.
4. By transits of high and low stars.
5. By the sun's azimuth.

Finding the latitude by the meridian altitude of the sun or a star.

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

Sun dials, both horizontal and vortical.

Practical examples of the above problems.

All astronomical observations with the theodolite to be repeated in reversed positions of the telescope.

The Canadian method of laying out public lands.

(The cadets have to work out observations for time, latitude and azimuth, using both sextant and transit theodolite.)

#### MILITARY 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 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 to be neat and clean. Use of colored chalks. Different kinds of special reconnaissances. 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. Estimate of accommodation afforded by villages and towns.

*Railways.*—Points to be noted:

*Rivers.*—Points to be noted: Depth, rapidity of current, liability to floods, bends, fords, bridges, boats, banks, islands, &c.

*Woods.*—Points to be noted.

*Positions.*—Both offensive and defensive: Their selection. (The following reconnaissances are generally made by the 2nd class.)

1. A rapid pencil sketch, with report, of some convenient ground, such as the banks and islands of a portion of a river.
2. A rapid pencil sketch, with report, of about four miles of road.
3. A fair copy of No. 2 in ink and colours.
4. A more extended road reconnaissance, with a special report on any tactical positions it passes.
5. A sketch of a defensive position in sections, each Cadet taking a section.
6. A rapid sketch of a piece of country in sections.)

N. B.—Any work left unfinished in the 2nd Class is completed in the 1st Class.

#### 1ST CLASS.

(OBLIGATORY.)

#### RECONNAISSANCE (Cont.)

Selection and laying out of camping grounds. Points to be considered.

(A piece of ground on which to encamp a given force is selected by each Cadet, and a plan of the camp, with report, sent in.)

(Selecting base lines and stations for an extensive triangulation.)

(Extending the ordnance maps of the district round Kingston.)

Reconnaissances of districts, how carried out. Combining reconnaissance plans made by different individuals.

(An extended reconnaissance of country, if transport is available.)

*End of the Obligatory Course.*

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1ST CLASS.  
(VOLUNTARY.)

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 heliograph. The electric light. The latter used successfully at very great distances. Lamps.

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 sides 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.

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.

Methods of delineating a spherical surface on a plane. The orthographic, stereographic, central, globular, Mercator's, 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 from 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.

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## SPHERICAL ASTRONOMY.

To find the hour angle, zenith distance, and parallactic angle of a given star on the prime vertical of a given place.

Differential variation of co-ordinates. 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.

Star Catalogues.

Parallax—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. Astronomical refraction. Tables of refraction. Dip of the horizon. Semi-diameters of celestial bodies. Reduction of observed zenith distances to the centre of the earth.

Finding the time by meridian transits.

To find the correction for small inequalities in the altitudes when finding the time by equal altitudes of a fixed star. Effect on the time thus found by errors of latitude, declination, and altitude. Effect of errors in the data upon the time computed from a single altitude.

Time of rising and setting of stars.

Finding the latitude by reduction to the meridian when the time is given. To reduce an altitude, observed at a given time, to the meridian. Latitude by circum-meridian altitudes. Effect of errors in the time on the latitude thus found. Latitude by the transits of a star over the prime vertical. Longitude by portable chronometers. Chronometric expeditions between two points.

Longitude by moon culminations.

General description of the method of finding longitudes by lunar distances.

Finding the meridian line by single altitudes. Meridian by the angular distance of the sun from any terrestrial object. By the azimuth of a star at a given time. Meridian by transits of two stars, one near the pole, the other as far south as possible. Meridian by transits of two circumpolar stars of about 12 hours difference of right ascension. Meridian by the superior and inferior transits of a circumpolar star.

## ASTRONOMICAL INSTRUMENTS AND PRACTICAL ASTRONOMY.

The 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 measurement of angles and arcs in general. Circles. Micrometer. The vernier. The reading microscope. Error of runs. Eccentricity of graduated circles. To find the eccentricity.

The filar micrometer. To find the angular value of a revolution of a micrometer screw. The level. Instruments for measuring time. Chronometers. Winding. Transporting. Correction for temperature. Comparison of chronometers. Comparison by coincident beats.

Clocks. The electro-chronograph.

The large sextant. Adjustments of the index glass, horizon glass, and telescope. To examine the coloured glasses. Method of observing equal altitudes with the sextant.

The simple reflecting circle.

The repeating reflecting circle.

The prismatic reflecting circle and sextant.

The transit instrument; its general formulas.

To find the hour angle of a star on a given thread of the transit instrument in a given position of the rotation axis.

The transit instrument in the meridian.

Approximate adjustment in the meridian. Its equations in the meridian. Thread intervals. Reduction to the middle thread. Reduction to the mean of the threads. The level constant. The collimation constant. The azimuth constant.

Transits of the sun, moon, and planets.

Transits of the sun observed with a mean time chronometer.

The meridian mark. Personal equation. Personal scale.

Determination of the geographical latitude by a transit instrument in the prime vertical.

Approximate adjustment in the prime vertical.

To find the latitude from the observed time of transit of a given star over a given thread east and west of the meridian, the rotation axis being in the same position at both observations.

To find the latitude when the instrument is reversed between the east and west transits of the same star on the same night.

To find the latitude from the observed transits of a star over the prime vertical east and west of the meridian, when the instrument is reversed at each transit between the observations of the star on opposite sides of the prime vertical—(Struve's method.)

The altitude and azimuth instrument.

The zenith telescope.

Talcott's method of finding the latitude.

The correction for level.

Reduction to the meridian.

Selection of stars.

To determine the value of a division of the level.

To find the value of a revolution of the micrometer. Application of the portable transit instrument as a zenith telescope.

Definition of the term "probable error." Formula of the probable error (without demonstration.)

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## ROYAL MILITARY COLLEGE OF CANADA.

### SYLLABUS OF INSTRUCTION IN GEOMETRICAL DRAWING AND DESCRIPTIVE GEOMETRY.

#### ALLOTMENT OF MARKS.

*Marks available for the entire course.*

##### GEOMETRICAL DRAWING.

Obligatory, 600	{ Examination.	Yearly,	220	} 340
		Intermediate,	120	
Voluntary, 500	{ Term work,	Notes, exercises	and	} 260
		drawings,		
Voluntary, 500	{ Examination.	Yearly,	240	} 240
		Intermediate,	nil	
Voluntary, 500	{ Term work.	Notes, exercises	and	} 260
		drawings,		

##### DESCRIPTIVE GEOMETRY.

Obligatory, 400.	{ Examination.	Yearly,	100	} 200
		Intermediate,	100	
Voluntary, 2,500	{ Term work.	Notes, exercises	and	} 200
		drawings,		
Voluntary, 2,500	{ Examination.	Yearly,	1,000	} 1,300
		Intermediate,	300	
Voluntary, 2,500	{ Term work.	Notes, exercises	and	} 1,200
		drawings,		

#### 4th Class.

##### GEOMETRICAL DRAWING.

Obligatory, 500	{ Examination.	Yearly,	120	} 240
		Intermediate,	120	
Voluntary, 500.	{ Term work.	Notes, exercises	and	} 260
		drawings,		
Voluntary, 500.	{ Examination.	Yearly,	240	} 240
		Intermediate,	nil	
Voluntary, 500.	{ Term work.	Notes, exercises	and	} 260
		drawings,		

3rd Class.

GEOMETRICAL DRAWING AND DESCRIPTIVE GEOMETRY.

Oligatory, 500 (Including 100 for re- vision in Geometri- cal draw- ing.)	Examination,	{	Yearly,	D. G.	G.D.	}	300
			Intermediate,	100 +	100		
	Term work.	{	Notes, exercises	and		}	200
Voluntary, 1,000.	Examination,	{	Yearly,	500		}	500
			Intermediate,	Nil			
	Term work.	{	Notes, exercises	and		}	500
			drawings,				

2nd Class.

DESCRIPTIVE GEOMETRY.

Obligatory.....						Nil.	
Voluntary, 1,500	Examination,	{	Yearly,	500	}	800	
			Intermediate,	300			
	Term work,	{	Notes, exercises	and		}	700
			drawings,				

For the drawing no t notes.

The text tive geometr ing," by G.

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## GEOMETRY.

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## TEXT BOOKS.

For the obligatory part of the courses in geometrical drawing no text book is used; its place is supplied by written notes.

The text book in use for the voluntary course in descriptive 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. O., have been quoted.

SUMMARY OF THE COURSES OF INSTRUCTION  
IN GEOMETRICAL DRAWING AND  
DESCRIPTIVE GEOMETRY.

*Geometrical Drawing.*—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.

*Descriptive 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. Fair notes will be compiled by each Cadet from the lectures delivered for the Obligatory part of the courses, and for the Voluntary course in Geometrical Drawing. The lectures for the Voluntary course of Descriptive Geometry 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 Geometrical Drawing (Obligatory and Voluntary) will be studied in the 4th class, and the Obligatory course of Descriptive Geometry in the 3rd class. The Voluntary course of Descriptive Geometry will be commenced in the 3rd class 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.

GEOMETRICAL 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 the whole of the above subjects.

**PLATES.**—The following is a list of the plates:

- I. Printing plate.
- II. To bisect a finite straight line. To draw perpendiculars and parallels to a given straight line.
- III. To bisect a given angle. To draw a straight line

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through a given point to the intersection of two given straight lines, this intersection being unattainable. To plot an angle by means of a table of natural sines. To plot an angle equal to a given angle. To divide a finite straight line into  $n$  equal parts.

IV. Ordinary scales.

V. Comparative scales, diagonal scales and verniers.

VI. To draw a circle of given radius to pass through two given points. To draw a circle to pass through three given points. To inscribe a circle in a given triangle. To draw the segment of a circle, subtending a given chord, and containing a given angle.

VII. To draw a tangent to a given circle. To draw a tangent to two given circles. To draw circles tangent to given straight lines, various conditions.

VIII. To draw circles tangent to given circles, and straight lines, various conditions.

IX. To find a fourth, third, or mean proportional to given finite straight lines. To divide a given finite straight line in extreme and mean ratio.

X. To reduce an irregular rectilinear figure to a triangle of equal area. To inscribe a square, regular pentagon, or hexagon in a given circle. To draw the same regular polygons, given the length of side.

XI. To inscribe a regular polygon of any number of sides in a given circle. To draw a regular polygon of any number of sides, given the length of side. To circumscribe a regular polygon of any number of sides about a given circle. To draw a figure similar to a given irregular figure, given the proportion between the sides. To draw rectilinear figures of given area (explanation only).

XII. To draw an ellipse given the major and minor axes. To draw an ellipse given two conjugate diameters. To draw a tangent to an ellipse. To draw a normal to an ellipse.

XIII. Geometrical figure.

XIV. " "

EXERCISES.—Various exercises to teach use of instruments. Laying flat washes of colour.

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.—The following is a list of the plates:—  
 XVI. To draw a parabola. To draw a tangent to a parabola.  
 To draw an hyperbola. To draw a tangent to an hyperbola.  
 XVII. To draw various loci.  
 XVIII. Copying a drawing.  
 XIX. “ “ “  
 XX. “ “ “

The drawing for, Plates XVIII, XIX and XX will be principally parts of machinery, and will sometimes be coloured.

EXERCISES.—Nil.

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.

## DESCRIPTIVE GEOMETRY.

### OBLIGATORY.

Object of 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 fortification: (N.B.—The problems in the obligatory course will therefore be worked by the indice method.)

Definition of the following terms.—Plane of projection, projector, projecting plane of a straight line, ground line, projection of a point or a straight line, plan, elevation, end view, side view, unit, index of a point, figured plan of a point or of a straight line, horizontals of a plane and line of quickest descent, scale of slope of a plane, trace of a straight line, of a plane, contours, projection of a plane angle, inclination of a straight line to a plane, dihedral angle contained by two planes, usual meaning of inclination of a straight line, inclination of a plane.

#### 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.

\* The various plates will be subject to alteration from time to time.

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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 plane.

*Fundamental Problems - 1 to 23.*

1. To find the elevation of a point, on any given ground line, from its figured plane.
2. To find the elevation of a given straight line on any ground line. Corollaries: (a) To find the true length of a finite straight line. (b) To find the inclination of a given straight line.
3. To find the figured plan of a straight line, given; (a) The angle of inclination, (b) The true length and the difference of level between two points.
4. To find the vertical trace of a plane on a ground line parallel to the scale of slope. Corollary. To find the angle of inclination of a given plane.
5. To find the scale of slope of a plane of given inclination. Points fulfilling conditions.
6. To find the conditions that a point may lie in a given straight line.
7. To find the conditions that a point may lie in a given plane. Straight lines fulfilling conditions.
8. To find the conditions that a straight line may pass through a given point.
9. To find the conditions that a straight line may be parallel to a given straight line.
10. To find the conditions that a straight line may lie in a given plane.
11. To find the conditions that a straight line may be parallel to a given plane.
12. To find the conditions that a straight line may be perpendicular to a given straight line.
13. To find the conditions that a straight line may be perpendicular to a given plane.
14. To find the conditions that a straight line may pass through a given point and have a given inclination. Planes fulfilling conditions.
15. To find the conditions that a plane may pass through a given point.
16. To find the conditions that a plane may pass through two given points, or, contain a given straight line.
17. To find the conditions that a plane may be parallel to a given plane.

18. To find the conditions that a plane may be parallel to a given straight line.

19. To find the conditions that a plane may be perpendicular to a given straight line.

20. To find the conditions that a plane may be perpendicular to a given plane.

21. To find the conditions that a plane passing through a given point may have a given inclination.

Principle of "constructing" or exhibiting plane figures in their true form :

22. By finding the true lengths of the sides and diagonals.

23. By "turning down" into the horizontal plane.

*Combination of the above for the solution of the following problems: 24 to 43.*

24. To determine a straight line of given inclination, lying in a given plane; also when parallel to a given plane.

25. To draw a straight line through a given point perpendicular to a given plane.

26. To find a plane passing through three given points. Corollary. To find a plane passing through two intersecting straight lines.

27. To find a plane of given inclination containing a given straight line; also when parallel to a given straight line.

28. To find a plane containing a given straight line, and perpendicular to a given plane.

Problems on intersections :

29. To ascertain whether two given lines intersect.

30. To find the intersection of two given planes.

31. To find the intersection of a straight line and a plane.

Problems on measurement :

32. To measure the angle contained by two intersecting straight lines.

33. To measure the angle of inclination of a straight line to a plane.

34. To measure the dihedral angle contained by two planes.

35. To measure the distance between two parallel planes. Problems relating to ground.

36. To find the plan of a line of given uniform inclination, rising up the face of a hill.

37. To find the intersection of a plane with ground given by its contours.

38. To find the intersection of a straight line with ground given by its contours.

39. To determine a plane containing a given straight line and tangent to one hill.

40. To determine the conditions that a plane may be parallel to two given straight lines.

41. To determine the conditions that a plane may be perpendicular to a given straight line and a given plane.

42. To find the true length of a line.

(a) To find the true length of a line.

(b) To find the true length of a line.

FAIR NOTES  
PLATES.—

I. PRO

II. CON

III. PRO

EXERCISES  
written explanations

SUBJECTS

December

March—T

June—T

of geometry

Definition

(Clarke pp.

Notation.

Theorems.

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44. To find

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48. To find

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problems 4

Applicati

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40. To determine a plane containing a given point and tangent to two hills.

41. To determine the most commanding hill with reference to a given point.

42. To find the planes of defilade for a work.

(a) To be defiladed from one hill.

(b) To be defiladed from two hills.

FAIR NOTES.—On the whole of the above subjects.

PLATES.—The following is a list of the plates:—

I. Problems, various.

II. Contoured field work.

III. Problems relating to ground.

EXERCISES.—Numerous problems to be drawn in pencil, 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 geometrical drawing.

#### VOLUNTARY.

Definitions of the terms required by two-plane method. (Clarke pp. 13, 16 and 21.)

Notation. (Clarke, p. 13 and notes.)

Theorems. (Clarke, theorems 1 to 26.)

*Fundamental Problems*.—Adaption of the two-plane method to the fundamental problems given in the obligatory course. The following additional problems will be adapted to both methods:—

44. 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.

45. To find the conditions that a straight line passing through a given point may make a given angle.

46. To find the condition that a plane passing through a given point in a given straight line may have a given inclination to this straight line.

47. To find the condition that a plane may pass through a given point and make given angle with a given plane.

48. 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 44 to 48.)

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 versa*. (Note.)

FAIR NOTES.—Of such matter as is not given in text-book.

PLATES.—The following is a list of the plates:—

IV. Problems relating to straight lines and planes.

V. Problems relating to plane rectilineal figures.

VI. Problems relating to plane curved figures.

EXERCISES.—Various problems worked out in pencil.

SUBJECTS FOR EXAMINATION.—There will only be one examination, in June, comprising the whole of the course.

## 2ND CLASS.

### DESCRIPTIVE 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  
book.

PLATES.—  
VII. I  
VIII. S  
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X. P

EXERCISES  
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SUBJECTS  
December  
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solid  
June—

FAIR NOTES.—Of such matter as is not contained in text-book.

PLATES.—The following is a list of the plates:—

VII. Interpenetration of solids.

VIII. Shadows.

IX. Isometric projection.

X. Perspective projection.

EXERCISES.—Various problems solved either by the Indices or the two-plane method.

SUBJECTS FOR EXAMINATION—

*December*—Projection of solids.

*March*—Section of solids by planes. Interpenetration of solids. Development of surfaces.

*June*—The whole course of Descriptive Geometry.

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## ROYAL MILITARY COLLEGE OF CANADA.

### SYLLABUS OF INSTRUCTION—FREEHAND DRAWING AND PAINTING.

#### ALLOTMENT OF MARKS.

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

#### 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 from copies, objects and nature.....Term work, 100.

#### 2nd Class.

##### OBLIGATORY—800 MARKS.

Drawing from copies, objects and nature. { Examinations. (Annual), 100.  
Term work, 400.

Painting from copies..... { Examination, 50.  
Term work, 250.

##### VOLUNTARY—300 MARKS.

Drawing from copies, objects and nature. } Term work, 200

Painting from copies, objects and nature. } Term work, 100

#### 1st Class.

##### OBLIGATORY—1,100 MARKS.

Drawing from objects and nature. { Examinations. (Annual), 100.  
Term work, 500.

Painting from copies ..... { Examinations. (Annual), 100.  
Term work, 400.

##### VOLUNTARY—500 MARKS.

Drawing from objects and nature.....Term work, 200.  
Painting from objects and nature.....Term work, 300.

## TEXT BOOKS USED.

Burchett's Perspective.

Redgrave's Catechism on Colour.

Warren's Artistic Anatomy of the Human Figure.

do do do Horse.

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

Green's Sketching from Nature.

## 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 & 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.

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## SUMMARY OF INSTRUCTION, FREEHAND DRAWING.

### GRADE 1.—(OBLIGATORY).

Preliminary courses in linear perspective.  
Freehand outline drawing from copies of ornament, 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 of 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 animal 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 life, 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, science of color and principles of harmonious coloring.

### GRADE 3.—(VOLUNTARY).

Painting the human figure or animals in water-color from copies and from nature.

Time studies from the living model.

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# 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	}	3000
		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		

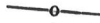
#### *First Class.*

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

## TEXT BOOKS.



## BOOKS RECOMMENDED TO BE READ.



- Earle's "Philology of the English Language."  
 Marsh's "Lectures on the English Language."  
 Max Muller's "Science of Language."  
 Mœtzner's "English Grammar."  
 Taine's "English Literature."  
 Bain's "English Rhetoric and Composition."

SUMM.

Practice in  
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SECTION I

SECTION II

SECTION III

SECTION

SECTION I

SECTION II

SUMMARY OF INSTRUCTION IN ENGLISH  
LANGUAGE AND LITERATURE.

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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 Romanic 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.

3RD CLASS.

(OBLIGATORY.)

SECTION I.—Poetry—different kinds:

- (1) Epic; (2) Lyric; (3) Didactic.

SECTION II.—Different metres.

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

## 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) *Bœowulf*.

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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.

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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.....200  
Notes and Recitations...300

3rd Class.

Marks (Obligatory)....600 { Examinations.....250  
Notes and Recitations...350

2nd Class.

Marks (Obligatory)....800 { Examinations.....350  
Notes and Recitations...450

1st Class.

Marks (Obligatory)...1,000 { Examinations.....500  
Notes and Recitations...600

Marie Queen,"  
bury Tales,"

any time reported  
may be required  
course of the 4th  
the lower course



TEXT BOOKS USED.

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- Contanseau's French Dictionary.  
do Grammar.  
French Classics, Gustave Masson.  
Horace, Corneille.  
Cinna do  
Les Ecrivains Militaires de la France, Karcher.  
~~Histoire de Charles XII par Voltaire.~~  
Frederick the Great, by Lord Macaulay.  
Le Page's "French Master for Beginners."  
do "Petit lecteur des colleges."  
do "Juvenile treasury of French conversation,"

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## SUMMARY OF COURSE OF INSTRUCTION IN FRENCH

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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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# ROYAL MILITARY COLLEGE OF CANADA.

## SYLLABUS OF INSTRUCTION IN THE GERMAN LANGUAGE.

### ALLOTMENT OF MARKS.

Total marks (Voluntary).....3,000

#### 4th Class.

Marks (Voluntary).....500 { Examinations.....375  
Notes and Recitations....125

#### 3rd Class

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

#### 2nd Class.

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

#### 1st Class.

Marks (Voluntary)...1,100 { Examinations....800  
Notes and Recitations....300

## SUMMARY OF COURSE OF INSTRUCTION IN GERMAN

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Grammar; reading; exercises for translating from German into English; German conversation; the construction of German sentences; critical examination of the works read; lectures on the philological connection of the German language.

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# ROYAL MILITARY COLLEGE OF CANADA.

## 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 .....800
	{ Recitations .....	200	
Voluntary.	{ Examinations.....	800	

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 that Class.



## TEXT BOOK.

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

## SUMMARY

Matter: its  
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Energy: it  
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## 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. Terrestrial 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. Atmosphere. 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 : Mariotte's bottle.

*Sound*—

Sound and noise. Cause of sound. Propagation, intensity, velocity, reflection and refraction of sound. Echoes and resonances. Speaking and ear trumpet. Stethoscope. 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. Vibra-

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. Transm-  
 itation of obscure rays. Application of properties of absorb-  
 ing, emitting, and reflecting heat. Radiometer.  
 Thermal unit. Specific heat. Dulong and Petit's law.  
 Steam engine. Double and single acting engines. Loco-  
 motives. 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. Ve-  
 locity of light. Laws of intensity. Photometer.  
 Reflection; its laws. Formation of images by plane mir-  
 rors. 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. Recombination of white light. Color.  
 Mixed and complementary colors. Spectrum and pigment  
 colors. Homogeneous light. Properties of spectrum. Spec-  
 troscope and its application.  
 Microscope, simple and compound.  
 Telescope, astronomical and terrestrial.  
 Camera obscura and lucida. Magic lantern. Solar micro-  
 scope. 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. Ophthalmoscope.  
*Magnetism.*—Definitions. Theories of magnetism. Magnetic  
 induction. Coercive force.  
 Directive action of earth on magnets. Terrestrial and mag-  
 netic couple. Declination and its variation. Mariner's  
 compass. Inclination. Astatic needle. Intensity of earth's  
 magnetism. Laws of attraction and repulsion. Magnetic  
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tion 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 portions) 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 applications. 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.

Vaporisation. 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 conditions.

and action of earth. Magnetism of iron ships. Magnetic battery. Circumstances influencing the power of magnets.

*Static 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. Chime and whorl.

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

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

*Dynamic Electricity.*—Galvani's and Volta's experiments. Electricity from chemical action. Voltaic couple. Electro-motive series. Electrodes. Voltaic pile. Wollaston's battery. Enfeeblement of current. Daniell's, Grove's, Bunsen's and Leclanché'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, dial and Morse-Sounder. Electric alarm and clocks. Electromotor.

Induction by currents. Lenz's law. Induction by magnets. Electric current. Properties and laws of induced currents.

Magneto-electrical machines; commutator. Rhumkorf'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  
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- Measurement of absolute and apparent expansion of mercury,  
and coefficient of expansion of glass. Corrections of barometric  
and thermometric readings. Determination of the expansion  
of gases and density of vapours. Laws of  
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. Trans-  
mission 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 mirrors. Heliostat.  
Measurement of index of refraction in solids, liquids and  
gases. Spherical aberrations. Caustics.  
Formulæ relating to lenses. Combination of lenses. Fluor-  
escence 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. Saccharometer.  
*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 in-  
duction. Specific inductive capacity.  
Armstrong's hydro-electric and Carré's dielectric machines.  
Limit 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 vol-  
tammeter. 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 10th

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# 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.

Voluntary.	{	Examinations.....	400	}	500
		Recitations.....	100		

#### For First Class.

Voluntary.	{	Examinations	{	Inorganic Chemistry..	650	}	2,000
				Organic Chemistry....	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.)

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 Solid, liquid and  
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## SUMMARY OF INSTRUCTION IN CHEMISTRY.

## CLASS II.

## INORGANIC CHEMISTRY—VOLUNTARY.

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, respiration, decay. Reciprocal character of 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

*Gun cotton.*—Abel's process of manufacture. Effect of tam-  
ing gun cotton compared with gunpowder. Theory of explo-  
sions.

*Bloxam's Inorganic Chemistry*, pages 1 to 146; 411 to 433;  
511 to 518.

CLASS I.

INORGANIC CHEMISTRY.

*Metalloids.*—*Their occurrence in nature and modes of prepara-  
tion 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 disinfect-  
ing properties. Applications in industrial arts. Hydro-  
chloric 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.  
Preparation and uses of chlorate of potash. Colored fire com-  
position. 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. Resem-  
blance 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. Hydro-  
fluosilicic acid.

*Review of Chlorine Group.*—Group characteristics and indivi-  
dual 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 vapors.

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*Carbonic Anhydride*.—Evolved in respiration, combustion, fermentation, putrefaction, &c. Effect on flame and life; 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; poisoning and other characters. Loss of heat by incomplete combustion; composition by volume and weight of carbonic oxide.

Marsh gas. Chemistry of explosions in coal mines; 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 flame 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 enameling 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 salts from the ammoniacal liquor of gas-works. Liquor ammoniac. 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.

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 experiments 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. Relations 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. Phosphorus fuze composition.

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

Phosphoric anhydride and acid. Meta, pyro, and orthophosphoric acid and salts. Uses and chemical tests for acids and salts.

Phosphorus anhydride and acid. Hypophosphorus 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. Arseniatted hydrogen. Marsh's and Rheinsch's test for arsenic.

*Antimony*.—Its sources and properties. Alloys. Oxides of antimony. Antimoniatted hydrogen. Tests for antimony. *Bismuth*.—Extraction, properties and uses. Oxides. Flake white and pearl white.

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*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, Cxysalts and Double Salts.* *Theory of Types. Principal Metallurgical Operations.*

#### METALS OF THE ALKALIES.

*Potassium.*—Caustic potash. Carbonate and bicarbonate. Nitro. Chlorate of potash.  
*Sodium.*—Common salt. Manufactures of carbonate of soda. Caustic soda. Borax. Soluble glass. Sulphate and phosphate of soda.  
*Ammonium.*—Its principal salts.  
*Lithium, Rubidium and Cesium.*—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 GROUP.

*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 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 lixiviation. 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 reactions of Alcohols. Methyl Ether and aldehyde. Formic Acid. Sulphur substitution products. Nitrogen derivatives; Amines, Amides, &c., Nitriles and Nitro compounds. Urea.

*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* and the glycerine. D

*Butyl Compounds* Acids and other

*Amyl and Mannitol* &c. Mannitol

*Sugar and Its refining*. B

*Starch*.—trine. Cellulose. Collodion.

*Fermentation* Conditions influencing it distilled spirits

*Aromatic constituents* Xylol, C

*Naphthalene* Resins, A

*Coloring matter* of the dye

*Vegetable products* of vegetable

*Animal products* Excrement

*Chemical Text* Chemist

*Qualitative and a series* Use of

*Flame tests* Experiments

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*Text*

*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. Beetroot 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.



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SYLLABUS OF INSTRUCTION IN GEOLOGY AND  
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## TEXT BOOKS.

Dana's Manual of Geology, third edition; pages 1 to 114  
and selected portions from pages 605 to 831.

Outlines of Historical Geology.

Dana's Manual of Mineralogy:—

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## 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 borders 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; 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, diorite, dolerite, &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 System 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 of earth's crust.

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

*Molecular Forces.*—Cohesion, crystallization, texture of rocks. Capillary attraction: effects on soils and rocks, efflorescent crusts, &c.

*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 of 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.

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## SUMMARY OF INSTRUCTION IN MINERALOGY.

General characteristics of Minerals.  
 Crystallization. Systems of Crystallization in detail. Cleav-  
 age. 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 Books.*—Dana's Manual of Mineralogy and Lithology  
 (third edition).

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 lumps, efflorescent

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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. }

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

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.

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## 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, calcareous, silicious, argillaceous, sedimentary, igneous, metamorphic, sandstones, limestones, granites, slates, trap.

Durability of stone—Hardness of stone, ultimate crushing loads per square foot of brick and stone.

Production of artificial stone and brick.

Limes—Air limes, water limes, cements. Physical characteristics of hydraulic limestones; calcination of limestone; lime-kilns; fuel; slaking of lime; manufacture of artificial hydraulic limes and Portland cement and puzzolanas.

Mortar—Sand; manipulation; proportions. Setting and durability of mortars. Theory of the hardening of mortars. Testing lime or cement mortars.

Concrete, Beton—Ingredients; proportions; applications.

Wood—Structure of timber; pine wood. Leaf woods; appearances of good timber.

Influence of climate and soil.

Age and season for felling.

Seasoning, natural and artificial.

Durability and decay and preservation.

Average ultimate crushing and tensile strength of woods.

Behaviour of timber under water.

Iron—Sources and classes of iron in general.

Impurities.

Cast iron. Source; processes.

Wrought iron. Source; processes.

Preservation of iron.

Crushing and tensile strength.

SUB-SECTION (B)—STRENGTH OF MATERIALS.

Strain; stress; working load; tests; set.

Factors of Safety; modulus of elasticity.

Resistance to shearing; to distortion.

Resistance to compression and direct crushing.

Crushing by cross breaking.

Long pillars—Resistance to collapsing.

Action of a transverse load on a beam.

Shearing stress; bending moment.

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Cross section  
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 Resistance of beams to cross breaking.  
 Exercises on moments of resistance.  
 Cross section of equal strength.  
 Modulus of rupture of cast iron beams.  
 Allowance for weight of beam.  
 Limiting length of beam.  
 Distribution of shearing stress in beams.  
 Deflection of beams.  
 Proportion of the greatest depth of a beam to the span.  
 Summary of the process of designing a beam.  
 Suddenly applied load; swiftly moving load.  
 Expansion and contraction of beams.  
 Beam fixed at both ends.  
 Beam fixed at one end.

SUBSECTION (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 Phoenixville truss and the Keystone truss.  
 Separation into systems.  
 Calculation of stresses on all members of the Phoenixville 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 bridges and roofs. Calculations of the Tay bridge.  
 Stresses on cranes.

## SECTION II.

### *Design and erection of structures.*

#### SUBSECTION (A)—PRINCIPLES OF ENGINEERING, FIELD AND OFFICE WORK AS APPLIED TO SURVEYS AND TO CONSTRUCTION OF RAILWAYS AND COMMON ROADS.

- Engineering Explorations—Selections of Route.  
 Organization of staff.  
 Methods penetrating country.  
 Aneroid explorations, air lines.  
 Traverses of roads and rivers.  
 Trial lines with compass and transit.  
 Topography, watersheds, summits.  
 Governing points, ruling gradients and curves.

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Approximate estimates off the trial line.  
 Projected locations—from the trial line.

Profile and alignment, cross sections.

Grade contours, compiled profile.

Approximate quantities.

Actual locations—Tangents, curves, gradients.

Limit of accuracy desirable.

Reduction of quantities of work by successive improvements of a location.

Balancing the excavations and embankments.

Borrowing, wasting.

Engineering office work.

Plans, profiles, cross-sections, estimate of quantities of the sections.

General drawings for structures.

Special drawing for each structure to suit local circumstances.

Estimate of gross cost.

Monthly measurements, estimates and returns

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

#### SUB-SECTION (B)—CONSTRUCTION AND DESIGN IN WOOD, STONE, EARTH, &c.

Carpentry—Framing of wood-work, mortised, scarfed, halved, &c., joints.

Built up beams.

Brick work—bond, string courses, chimneys mensuration.

Mason-work.

This comprises a full course of instruction on the specifications for the various classes of mason work used on the Government Railway Works of Canada, and is supplemented by excursions to inspect and explain existing railway structures on the Intercolonial or other railways.

Construction of the 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 and thickness of retaining walls.

Difference between "wing wall" abutments and "tower" abutments.

Methods of finding length of wing walls.

Methods of finding lengths of inclined or skew culverts on sloping or on level ground by the following methods:—  
 1. Experimentally. 2. By analytical geometry. 3. Graphically.

Principles of economizing mason work in culverts, by reducing their lengths, by use of wing walls and coping, &c.  
 Principles of economizing masonry in abutments by using cells and wells.

Foundations of structures.

General explanations of the nature of materials met with in forming foundations.

Principles governing the permanence of foundations, settling, scour, frost, springs, piling, platforms, concrete, sand piles, foundations under water.

Coffer dam, caissons, pneumatic processes.

Designing and executing earth and rock excavations and embankments, tunnels, slopes, ditches, drainage, fencing, snow. Crib-work, rip-rap stream diversions.

Railway permanent way, ballast, ties, rails, track laying, gauges, sidings, switches, stations.

Common roads or highways, surveys, gradients, cross-section, line excavation, drainage, road-bed, suitable materials for metalling, traction.

SECTION III.

*Estimating, setting out and supervision of Works.*

SUB-SECTION (A)—CONSTRUCTION AND USE OF TABLES OF EXCAVATION AND EMBANKMENT.

Information necessary before estimate of quantities can be made for earth and rock excavation on a line of railway or canal.

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

Construction of tables, MacNeils.

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 field.  
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 Gauging Discharge  
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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 economising 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.

#### GENERAL FORM FOR ESTIMATES OF 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.*

#### SUBSECTION (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 effects 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 flood 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.  
 Ratios of monthly 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,

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Practical effect upon storage.

SUPPLYING CAPACITY OF WATER SHED.

Estimate of available annual flow of streams.  
 Estimate of monthly available storage required.  
 Additional 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.  
 Formulae 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 columns 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.  
 Equations 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.

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Maximum velocity of the jet.  
 Factors of the co-efficient of efflux.  
 Experimental co-efficients, from Michellotti, Bossuot,  
 Rennie, Castel, Lespinesse, Ellis.  
 Co-efficients diagramed.  
 Effects of varying the head or 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 subdivision 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; con-  
 crete cut-off walls; treacherous strata; embankment core  
 materials; reconnoissance 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, relative, 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.  
Fly-wheel.  
Strength of  
Strength of

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Air pump-  
Pumps, co  
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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 analytically the work absorbed by the friction between a belt and a pulley.  
 Calculations to find work absorbed by friction of belt on a pulley.

(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.

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# 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— <i>Nature, Production and Use of Materials of Construction.</i>			
		Marks.....	1,900.
Sub-Section A— <i>Materials: Description and processes.</i>			
		Marks—Examinations.....	400
Sub-Section B— <i>Strength of materials.</i>			
Marks.....		{ Examinations .....	300
		{ Notes and Recitations.....	200
Sub-Section C— <i>Stresses on Framed Structures.</i>			
Marks .....		{ Examinations.....	500
		{ Notes and Recitations.....	500
Section II— <i>History and Principles.</i>			
		Marks.....	200.
Sub-Section A— <i>History and Principles.</i>			
		Marks—Examinations.....	200
Section III— <i>Design and Execution of Structures.</i>			
		Marks.....	700.
Sub-Section A— <i>Buildings, Domestic.</i>			
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.

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Sections I

TEXT BOOKS.

*Principally Lectures.*

Michells' Elements of Architecture.

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BOOK RECOMMENDED TO BE READ.

Ferguson's "History of Architecture."

## SUMMARY

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see Syllabus

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# 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, coursed rubble, 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, templates, discharging arches, lintels, construction of brick arches, general rule as to brick-work, tools used in brick-work.

#### 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.

#### CONSTRUCTING 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.

Behaviour 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.

SUB-SECTION (A)

Stone work  
shingling, paint

SECTION IV.

*Estimating and Supervision.*

SUB-SECTION (A)—METHODS OF ESTIMATING QUANTITIES IN BUILDINGS.

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

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# ROYAL MILITARY COLLEGE OF CANADA.

## SYLLABUS OF INSTRUCTION IN INFANTRY DRILL, EQUITATION, AND MILITARY EXERCISES.

### SECT. I.—INFANTRY DRILLS.

#### ALLOTMENT OF MARKS.

Total marks Cadets and N. C. O. (obligatory)...	500
N. C. Officers.....	170
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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.

Total marks, 400 {	Obligatory.....	200
	Voluntary.....	200
<hr/>		
4th Class (obligatory).....		100
3rd do do .....		100
2nd do voluntary.....		100
1st do do .....		100

### SECT. IV.—SWORDSMANSHIP.

Total marks (voluntary) .....	300
<hr/>	
2nd Class (voluntary).....	150
1st do do .....	150

### SECT. V.—SWIMMING.

Total marks (obligatory) .....	100
4th Class, do .....	50
3rd do do .....	50



## TEXT-BOOK.

57

*Infantry Drill.*—Field Exercises.

Rifle Exercises and Musketry Instruction.

Regulations and Instructions for Encampments.

*Equitation.*—Nil.

*Gymnastics.*—Nil.

*Swordsmanship.*—Infantry Sword and Carbine Sword.  
bayonet Exercises.

SUMMARY OF  
EQUITATION.

*Squad Drill*  
Exercises,"

*Rifle Exercises*  
exercises.  
Sec. 1 to 13

*Company*  
to Sec. 20

*Miscellaneous*  
to 21 inclu

*Musketry*  
drill, judg  
as follows:

100 yard

200 "

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Volley

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" Rifle  
IV and V

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SUMMARY OF INSTRUCTION IN INFANTRY DRILL,  
EQUITATION AND MILITARY EXERCISES.

SECTION I.

INFANTRY DRILL.

4TH CLASS.

*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 50 rounds as follows:

RECRUITS PRELIMINARY PRACTICE.

100 yards,	10 rounds.	Standing.
200 “	10 “	“
500 “	20 “	Any military position.
Volley firing,	5 “	} 200 yards. { (Reduced Target.)
Independent firing,	5 “	

“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 entire course of Rifle Instruction is necessarily determined by the range and time available to Cadets.  
(3).—The Recruit Practice to be commenced after Christmas and to be completed before 30th April.

## 3RD CLASS.

*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 36. Cavalry sword exercise.

*Musketry Instruction*.—Preliminary drill, target practice, judging distance; firing 50 rounds, as follows:—

200 yards.		10 rounds.	Standing.
500 "		10 "	Any military position.
500 "	{ (Reduced )	10 "	" "
	{ Target. }		" "
800 "		10 "	" "
200 "	{ (Reduced )	5 "	Volley firing.
	{ Target. }	5 "	Independent firing.

Judging distance from 100 to 1,000 yards.

Rifle exercises and Musketry Instructions." Parts III, IV and V.

## 2ND CLASS.

*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.

*Battalion Drill (E)*.—Instruction. "Field Exercises," Part III, Secs. 36 to 49 inclusive. Revision and communicating 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.

NOTE (1).—EXAMINATIONS partly written and partly oral will be held during, or at the end of the term, in the subjects marked (E). In addition to the above, 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 Class are being instructed in, or are communicating these drills.

(2).—The annual course of Rifle Instruction for 3rd, 2nd, and 1st Classes to be commenced 10th September, and be completed before 30th October.

Leading the  
Mounting a  
Extension of  
Seat while  
Dressing.  
Walking a  
Riding in a  
Saddling.  
Bridling.  
Fitting the  
Mounting  
Aids in tu

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Mounting  
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Formation  
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## SECTION II.

## EQUITATION.

## 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 bridle 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.

## SIMPLE EXERCISES.

*First Course—Introductory Exercises.*

First Practice—Movements and positions.  
 Second " With dumb bells.  
 Third " With bar bells.

*Second Class—Simple Exercises.*

- 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, evolving.  
 “ The double circle “  
 “ To turn with feet in the rings, evolving.
- 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 revers-  
 ed, 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.

Running—  
 The Leap  
 The Vault  
 The Vault

Pair of R  
 “  
 Row of R  
 Bridge L

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## 3RD CLASS.

## ADVANCED AND ARDUOUS EXERCISES.

*Third Course.*

- 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 backwards.  
 Bridge Ladder—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 “ “

*Supplementary Course.*

- Fencing.  
 Sword vs. Sword.  
 Bayonet vs. Bayonet.  
 Sword vs. Bayonet.  
 Quarter Staff.

NOTE.—Voluntary classes of I, II, III, IV Classes are instructed in any branch of gymnastics, or, of defensive exercises, i.e., sword, bayonet, boxing, &c.

**SECTION IV.**

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**SWORDSMANSHIP.***Infantry Sword and Sword-Bayonet Exercises.*

Extension motions and positions.  
Preparatory instruction with the sword and sword-bayonet.  
Review and inspection exercise.  
Attack and defence.  
Stick drill.  
Officer's salute.

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**SECTION V.**

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**SWIMMING.**

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## TEXT BOOKS USED.

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- Otto's Conversational Grammar and Exercises.  
Kramer's German Dictionary.  
"Das Jahr, 1813," (Clarendon Series).  
Schiller's Wilhelm Tell.  
Goethe's Egmont.