

ROYAL MILITARY COLLEGE OF CANADA.

Detail Roll of Gentlemen Cadets—Continued.

Regimental No.	Names. Alphabetically.	Date of Joining.	Age on Joining.	Rank and Date of Appointment to present Rank of N.-C. Officer.	Term.	Class.	No. of Marks coun- ted from date of Joining to June, 1880.	Company.	Half Company.	Section.	Mess Squad.	No. of Room.	No. of Study Desk.	Province from which Joined.
51	Duff, G.	Sept. 5, 1878.	15	Corporal, 29th July, 1880.	5	2 A	9,499	C	R	2	6	42	100	Ontario.
58	Duffus, G.	do 5, 1878.	15	do 1st May, 1880.	5	2 A	11,989	C	R	2	5	16	107	Nova Scotia.
26	Dunscomb, W.	April 2, 1877.	14	Sergeant, 1st August, 1880.	8	1 B	17,558	B	L	2	6	47	86	Quebec.
75	Evans, A.	Sept. 5, 1879.	17	Cadet.	3	3 A	2,697	C	R	2	6	48	17	Ontario.
33	Ford, E.	do 8, 1877.	15	Lance Corporal, 28th July, 1880.	7	1 C	11,168	C	R	2	7	54	105	do
19	Gibson, J.	Feb. 2, 1877.	17	Corporal, 28th July, 1880.	8	1 A	22,804	C	L	3	7	51	79	Quebec.
56	Gordon, S.	Sept. 5, 1878.	18	do	5	3 A	3,311	A	R	2	2	18	55	Ontario.
87	Gray, P.	Feb. 5, 1880.	16	Lance Corporal, 30th July, 1880.	2	3 C	2,166	D	R	1	8	N 5	15	Nova Scotia.
57	Greenwood, H.	Sept. 5, 1878.	17	do	5	2 A	8,315	C	L	3	7	27	103	Ontario.
32	Greig, W.	do 8, 1877.	18	Cadet.	7	1 C	9,218	A	R	2	3	10	106	do
107	Hearn, J.	do 9, 1880.	17	do	1	4	.....	A	B	2	4	2	44	Quebec.
80	Hecketh, J.	do 5, 1879.	15	do	3	3 A	2,857	D	R	1	8	2 N	19	Ontario.
46	Hodgins, A.	do 17, 1878.	17	Corporal, 2nd August, 1880.	5	2 A	8,612	A	L	3	3	17	101	do
40	Hogan, H.	Feb. 1, 1878.	15	Sergeant, 3rd August, 1880.	6	1 C	12,154	D	L	3	9	9 N	91	Quebec.
36	Hopper, E.	do 8, 1877.	16	Cadet.	4	2 C	6,332	D	R	2	8	6 V	66	do
63	Hubbell, E.	Sept. 8, 1877.	15	Sergeant, 4th August, 1880.	7	2 A	8,870	B	L	3	5	35	88	Ontario.
102	Holland, W.	do 9, 1880.	16	do	1	4	.....	A	L	3	3	21	11	Quebec.
69	Joly, A.	Feb. 5, 1879.	16	do	4	3 A	3,737	A	B	2	4	20	14	do
74	Kirby, F.	do 8, 1879.	17	do	3	3 A	3,415	D	R	2	8	2 N	7	Ontario.
48	Kirkpatrick, A.	do 5, 1878.	17	Corporal, 31st July, 1880.	5	2 A	8,863	C	L	3	1	53	102	do
71	Laidlaw, J.	Sept. 8, 1879.	18	Cadet.	4	2 A	4,392	C	L	3	1	55	9	do
116	Laidlaw, J.	do 9, 1880.	18	do	7	4	.....	C	L	3	1	57	20	do
89	Lambe, L.	Feb. 5, 1880.	16	do	1	2	2,285	C	B	2	4	30	31	Quebec.
79	Lang, J.	Sept. 5, 1879.	20	Lance Corporal, 7th August, 1880.	2	3 C	3,851	A	L	3	3	9	42	Ontario.
60	Latimer, F.	do 8, 1879.	18	Corporal, 1st August, 1880.	4	2 A	8,847	A	L	3	3	6	94	do
31	Laurie, R.	Feb. 8, 1877.	19	Sergeant, 28th July, 1880.	8	1 A	29,127	A	R	2	2	22	71	Manitoba.
86	Leonard, R.	do 8, 1880.	19	Cadet.	2	3 C	2,826	D	B	2	8	2 N	16	Ontario.
95	McDougall, J.	do 5, 1880.	16	do	2	3 C	1,688	D	B	2	5	5	37	do
44	McElhinney, W.	do 1, 1878.	15	Sergeant, 2nd August, 1880.	6	1 C	12,684	A	R	2	10	24	90	do

38	Mackay, H.	do	19	do 7th February, 1880.	6	1 C	17,377	C	R	2	7	89	62	Quebec.
78	Nanton, H.	Sept. 5, 1879.	16	Cadet.	3	3 A	2,774	D	C	2	9	1 N	52	Ontario.
84	Neyland, M.	Oct. 8, 1879.	18	do	3	3 A	2,750	D	C	2	4	7	45	do
65	Ogilvie, G.	Feb. 8, 1879.	19	do	4	2 C	5,770	D	L	3	9	1 N	63	do
64	Osburn, H.	do 8, 1879.	16	Lance Corporal, 8th August, 1880.	4	3 C	6,177	D	R	3	9	6 N	64	New Brunswick.
91	Powell, W.	do 5, 1880.	17	Cadet.	2	3 C	2,054	B	L	3	5	30	23	Ontario.
62	Robinson, W.	do 8, 1879.	15	Lance Corporal, 2nd Sept. 1880.	4	2 C	9,016	B	L	3	5	40	65	New Brunswick.
77	Rosenburg, V.	Sept. 2, 1877.	16	Br. Sgt.-Major.	3	3 A	3,694	D	L	3	5	5 N	25	Ontario.
22	Ross, A.	do 5, 1880.	16	Cadet.	8	1 A	25,040	D	L	3	1	56	80	do
94	Ryan, M.	do 9, 1880.	16	do	2	3 C	2,071	A	B	2	4	13	36	do
111	Sanders, G.	Sept. 9, 1880.	16	do	1	4	.....	A	L	3	5	31	48	British Columbia.
43	Sears, J.	Feb. 1, 1878.	17	Corporal, 1st May.	6	1 C	11,212	B	L	3	5	29	89	New Brunswick.
31	Shaw, G.	Sept. 8, 1877.	16	Sergeant, 31st July, 1880.	7	1 B	15,828	A	L	3	8	85	85	Quebec.
61	Skinner, F.	Feb. 8, 1879.	19	Corporal, 30th July, 1880.	4	2 C	9,323	A	L	3	9	8 N	68	Ontario.
110	Smith, E.	do 9, 1880.	16	Cadet.	1	4	.....	B	L	4	5	39	22	Quebec.
52	Stairs, W.	do 5, 1878.	15	Lance Corporal, 4th August, 1880.	1	2 C	6,995	A	L	3	3	11	72	Nova Scotia.
85	Stewart, W.	Feb. 5, 1880.	17	do	5	2 C	2,949	A	L	4	3	15	13	Ontario.
83	Strang, H.	Sept. 5, 1879.	20	do	3	3 A	2,391	C	R	4	7	60	10	Quebec.
45	Taylor, E.	do 5, 1878.	20	Corporal, 1st May, 1880.	3	2 A	10,627	D	C	1	8	2 N	110	do
66	Tomlinson, A.	Feb. 8, 1879.	19	Cadet.	4	2 C	6,083	B	L	4	10	32	73	Ontario.
88	Twining, P.	do 5, 1880.	17	do	2	3 C	2,056	A	L	4	10	7	32	Nova Scotia.
23	Van Strawbenzee, A.	April 2, 1877.	15	Co. Sgt.-Major, 29th July, 1880.	8	1 A	25,607	A	B	2	1	34	70	Ontario.
100	Van Strawbenzee, B.	Feb. 5, 1880.	15	Cadet.	2	3 C	2,293	B	L	4	10	31	49	do
109	Warner, W.	Sept. 8, 1880.	15	do	1	4	.....	L	L	4	5	39	24	Quebec.
101	Weller, J.	Feb. 5, 1880.	18	do	2	4	.....	B	D	3	9	2 N	46	Ontario.
68	Wetmore, A.	do 8, 1879.	17	Lance Corporal, 2nd August, 1880.	4	2 C	7,058	D	D	4	9	1 N	96	New Brunswick.
96	White, J.	do 5, 1880.	17	Cadet.	2	3 C	1,717	C	L	4	9	6 N	33	Ontario.
115	White, F.	Sept. 9, 1880.	16	do	1	4	.....	D	C	4	10	38	39	Quebec.
67	Wood, Z.	do 8, 1879.	18	Lance Corporal, 1st August, 1880.	4	2 C	7,161	D	L	4	10	9 N	60	Nova Scotia.
90	Woodman, J.	Feb. 5, 1878.	18	Cadet.	4	2 C	1,940	D	L	4	10	5 N	28	Ontario.
47	Wurtele, E.	do 5, 1878.	18	do	5	2 C	6,359	C	L	4	10	48	74	do
42	Yates, B.	Feb. 1, 1878.	18	Corporal, 1st May, 1880.	6	1 C	11,718	D	L	4	10	2 N	61	do

SEPTEMBER 15th, 1880.

E. O. HEWETT, Lieut.-Col.,
Commandant, Royal Military College.

APPENDIX F.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF MATHEMATICS—GENERAL SUMMARY OF SUBJECTS AND TEXT BOOKS.

Euclid (Todhunter.)

Arithmetic (printed notes by Major 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 Major 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.)—This subject is taught almost entirely by lecture, geometrical proofs being given whenever practical and easy.

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.

Rotation considered geometrically without text books up to the resultant motion of an elongated projectile.

Hydrostatics (Besants' 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, Rouleaux, Collignon, and other works.

Mechanism (Goodeve)—Steam Engine; general principles only taught by lecture.

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 more extensive than can possibly be taken, except by cadets of unusual mathematical talent, who might desire to continue the study of mathematics in lieu of other subjects. The marks allotted for this class are not intended to represent the adequate value of the course.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF MATHEMATICS AND MECHANICS, TOTAL MARKS, 12,000.

4TH CLASS—(OBLIGATORY)—TOTAL, 1,500 MARKS.

Arithmetic to Interest, Discount, Stocks, Proportional parts and extraction of square root and cube root. (*Printed notes and other authorized text books*) Dec., Mks. 300.

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

Algebraical explanations will also be given of the propositions in Book II:

Marks—December, 100; April, 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. Chapters I to XXXII; to XL; to end.....Marks, 100, 100, 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 definition. Formulæ connecting each with every other. Constructions 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°, 36°, 54°, 72°. Chap. VIII, § 107-9, and note process of 183. 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; April, 50; June, 200.

Notes and Recitations.....Marks, 100.

4TH CLASS—(VOLUNTARY)—TOTAL, 500 MARKS.

Qualification, one third for any section.

SECTION A.—*Euclid* III, IV. *Algebra*, (*Todhunter's, for beginners, and printed notes.*) Quadratics, Evolutions, Indices, Surds, Ratio Proportion and Variation, Progressions, Permutations and Combinations, Binomial Theorem, Interest.

Plane Trigonometry.—Formulæ of two angles; Ratios for 15°, 18°, &c. Solution of triangles. Chapters VI to XIV, with the same omissions as in the obligatory courseMarks—Dec., 100.

SECTION B.—*Euclid.* Definition of Book V explained Algebraically; Book VI, omitting Props. XXVIII to XXIX, and the first proof of XXX....Marks—April, 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—April, 100.

SECTION D.—*Plane Trigonometry (Todhunter.)* Chapters I to XVI, omitting XII.....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.

SYLLABUS OF MATHEMATICS—3RD CLASS—(OBLIGATORY) TOTAL, 2000 MARKS.

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—April, 50; 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

Mensuration (lectures or notes to be printed)—Construction of ratios as $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, $\frac{1}{\sqrt{7}}$, $\frac{\sqrt{3}}{2}$, $\sqrt{\frac{2}{3}}$, $\sin^2\theta$, $\tan^2\theta$, $\cot\frac{\pi}{8}$, &c., and combinations of these. Rectilinear and circular areas and perimeters and combinations of these. 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. Summation of shot piles. December

Marks (Trigonometry and Mensuration).....December, 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 proofs that any straight line parallel to the axis is a diameter, that the tangents at the extremity 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 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 the 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—April, 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 principle of the lever.

Chapter VII,—§ 99; Statement of § 100; § 102, 6, April.

Centre of parallel forces. Chapter VIII to § 113. Short note on § 114, 15.

Formula $x = \frac{\sum (Px)}{\sum (P)}$. § 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 consideration 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; 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—April, 100; June, 400.

Notes and Recitations.....50.

3RD CLASS. (VOLUNTARY)—TOTAL, 2,000 MARKS.

Qualification,—one third for any section.

Marks—December, 200.

SECTION F.—*Euclid* XI, to Prop. 21.

SECTION G.—*Algebra (Todhunter's)*. 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 § 626. 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; Inverse Functions—Chapter XVIII, omitting § 264. Demoivre's Theorem—Chapter XIX, § 266-7, omitting proof for fractional and negative values of the exponent...Marks—April, 200.

SECTION J.—*Spherical Trigonometry (Todhunter.)* Chapters 1 to VI, omitting proof of Napier's circular parts. § 68, 69. Areas VIII, § 96 to 99. *Marks—April, 200.*

SECTION K.—*Conics (Todhunter.)* Straight Line—Chapter I to III, omitting § 27, 37, 48. Transformation of co-ordinates; practical applications only, Chapter V.

Circle. Chapters VI, VII, omitting § 111, 115 to 118, and all but the definition in 119.

Parabola—Chapter VIII, omitting § 157. Notes, principally geometrical, as follows: 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. Equation to tangent $yy^1 = 2r(x + x^1)$ compared with the equation to the curve; similarly for the circle and other conics. 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.

Ellipse.—Chapter IX, X, omitting § 205, 8.

Notes.—Equation found from the definitions of an ellipse as the projection of a circle, as described by the trammel, and as $r + r' = 2a$ instead of that given in Todhunter. Geometric properties proved from the definition $r + r' = 2a$, as follows: Construction of a tangent; its equal inclinations to the focal distances; locus of the foot of the perpendicular from the focus. $pp' = b^2$; $\frac{p}{p'} = \frac{r}{r'}$; $p^2 = \frac{b^2 r}{r'}$.

Locus of intersection of tangent with the perpendicular at the focus to the radius vector; 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 θ and then $\pm \frac{a-b}{2}$ at $-\theta$.

Diameters investigated analytically as for parabola (alternative with § 187). Conjugate diameters as the projections of two perpendicular diameters of the auxiliary circle; hence the properties of conjugate diameters and the equation to the ellipse referred to them (instead of § 198).

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 axis.

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 $(a^2 y^2 - b^2 x^2)^2 = a^4 b^4$. 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, § 279.

Chapter XIV—General equation to a conic, § 281. Pole and polar, § 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 shewing the foci and directrices. Omit § 348-9. An harmonic ratio; the ratios $AB \cdot DC : AC \cdot DB$. $AD \cdot BC$. Harmonic pencil. Omit § 355-61.

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 co-efficients. Differential of the function of a function obtained directly without the investigation of § 19. Geometrical condition

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

Chapter II—Successive differentiation; differential of the independent variable is constant. Omit § 39-43 to end of chapter. Read over Liebnitz Theorem § 48.

Chapter III—Expansion of functions. "Remainder" noted but not used in applications of Taylor's and Maclaurin's Theorems. 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. 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. Omit § 75 to end of chapter.

Chapter IV—Indeterminate forms; algebraic processes not necessary. Consider also $\alpha - \alpha$. 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. Omit § 103. Consider § 104. Omit § 107, also § 110 to the end of the 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, 151-3-4.

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.
 Chapter XIV—Brief explanation of multiple points.
 Chapter XV—Brief explanation of envelopes, and the general methods of determining them.

Chapter XVI—Convexity and concavity. Omit the analytical investigation in § 223.

Chapter XVII—Radius of curvature; Omit § 228. Read over § 231; omit § 232-2; 234-6. Read over § 239. Omit § 241-2. Read over § 243-8, and note conclusions. Omit § 249-54. Read over § 255.

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 M.—*Integral Calculus.* This subject will be commenced as soon as the process of differentiation has become easy. The elementary formulæ as the reverse of differentiation, and easy variations of them. Substitution, and particularly trigonometrical substitution, $\tan^n \theta d\theta$. Integration by parts. The various cases of $\sin^m \theta$. $\cos^n \theta d\theta$. Rational fractions..... *Marks—April, 100.*

Marks for Notes...100.

SYLLABUS OF MATHEMATICS—2ND CLASS—(OBLIGATORY)—TOTAL MARKS, 2500.

	Marks.
Euclid (<i>Todhunter</i>)—3rd and 4th Class course.....	300
Arithmetic—As for 4th Class.....	100
Algebra—4th Class course.....	200
Trigonometry—3rd and 4th Class course—and selection of spherical triangles.....	200
Conics—3rd Class course.....	100
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 on the same or equal basis, 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 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, two of which are parallel, 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..... *Marks—Dec., 100; June, 200.*

Statics..... *Marks—June, 200.*

Graphic Statics (Tracts on Mechanics, Part II). Problems 1-4, 6, 7, with alternative solution; 8, 11, 12, 21..... *Marks—April, 100.*

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

Velocity. Chapter I.—Angular velocity in terms of circular measure.

$$v = ra; a = \frac{2\pi n}{t}$$

1st and 2nd laws of motion.—Chapter II.

Uniform acceleration and the equations of motion.—Chapters III, IV, omitting proof in § 37.

Parabola of projection. Chapters V, VI, omitting § 72, 73, 75-7.

Mass and 3rd law of motion. Chapters VII, VIII. Acceleration obtained directly from $P = mf$ in § 89, 92.

Impact. Chapters IX, X. Omit § 109, proof of loss of Vis Viva in § 108-124, and continuous rebounds, § 122-3.

Motion of centre of gravity of a system $\bar{v} = \frac{\sum (mv)}{\sum (m)}$; $\bar{f} = \frac{\sum (mf)}{\sum (m)}$ proved from $x = \frac{\sum (mx)}{\sum (m)}$ 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.

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. *December.*

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 Reiterations.....100.

2ND CLASS—(VOLUNTARY)—2,000 MARKS.

SECTION N.—*Integral Calculus (Williamson).*

Chapter I—Compare (e) with § 9; (f) with § 5; also Ex. (1), (2) § 13. Integrate forms involving $a + 2bx + cx^2$ or $\sqrt{a + 2bx + cx^2}$ by completing the square. Compare § 4, 22, 23, 24 with 61-3. Omit § 8.

Chapter II—Rational fractions; easy examples only with explanatory notes.

Chapter III—Formulae of reduction; easy examples only with explanatory notes. Omit § 63-7; 71 to the end of the chapter.

Chapter IV—Rationalisation, § 77 and read over § 78.

Chapter VI—Integration as summation; more elementary proof of § 90. Omit § 92 to the end of the chapter.

Chapter VII—Areas, § 126-131. Read over § 132-4. Polar Areas § 135. Omit § 136-147. Areas by approximation § 148. Omit § 149. Asymptotic areas of rectangular hyperbola; hyperbolic logarithms.

Chapter VIII—Arcs § 150-152, 155, 156, 167.

Chapter IX—Volumes and surfaces § 168-175; 178; 181.

Chapter X—Moments of Inertia. Special attention to § 196-8. Read over § 207-12. Omit § 212 to the end.....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. Equation to a surface; condition 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 the 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 to two forces. Condition that there should be a single resultant. Equilibrium of a particle constrained to move; 1st, on a smooth curve; 2nd, on a smooth surface. Centre of parallel forces. Culman's graphical method. Alteration of the centre of gravity by transposition of a part of the body. Elementary methods of finding the centre of gravity of a circular arc, sector and segment. Centre of gravity of a small arc or segment respectively $\frac{2}{3}$ and $\frac{2}{5}$ of the distance from the chord to the arc. General formulae 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 vertical rods. The common catenary; its equation, length of arc, tension at any point, similarity to a parabola near the vertex; position of equilibrium of a heavy chain resting over two smooth pegs. Suspension rods of equal strength, equation to bounding curve. Catenary of equal strength. 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 pipe-box; the angle of draught. The forces acting on a field gun carriage at the moment of discharge. Marks—April, 400.

SECTION Q.—Dynamics (*Todhunter's Mechanics for beginners*).—Harder questions on the obligatory course. Loss of Vis Viva after impact § 108. Motion in a circle or conic section to be read over only, more advanced proofs being furnished. Chapters XIV, XV. Kepler's laws, § 178.

Notes.—The differential equations of motion. Application to rectilinear motion under the action of a force, (1) constant; (2) varying as the distance; (3) varying inversely as the square of the distance. Law of attraction outside and inside the attracting body. 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 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.

Marks—June, 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 $W = Vgpw$.

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

$z = 26215 \cdot \frac{H-h}{h}$; $z = 52430 \cdot \frac{H-h}{H+h}$. 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 $t = p \frac{R^2 + r^2}{R^2 - r^2}$. 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.

1ST CLASS—VOLUNTARY—TOTAL MARKS, 1,500.

SECTION S.—*Algebra and Trigonometry*. Re-examination on the former course. Probabilities (*Todhunter*) Chapter LIII to § 737 and examples 1-10. Theory of equations of all degrees. Transformation of equations to others having different roots. Solution of cubic equations by Horner's and other methods. Determinants; Factors by inspection; reduction to a lower order by addition of columns or rows or their multiples. Application to solve simple simultaneous equations, and to processes of elimination. Demoivre's Theorem; proof only for a positive integer; some of the less difficult applications. (*Todhunter's Plane Trigonometry*). Chapter XIX § 266-7. Read over § 268 § 269-70; 72-6; 78. Exponential values of sine, cosine, tangent. Gregory's series. Calculation of π . Chapter XXI, omitting § 293 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.—*Co-ordinate Geometry and Conics*. Re-examination on, and completion of the former course. Abridged Notation (*Todhunter*, Chapter IV).....Marks, 250.

SECTION U.—*Differential and Integral Calculus*. Re-examination on, and completion of the former courses. Easy examples of tracing curves. Elementary notes on the solution of differential equations. Finite differences considered with reference to summing rational algebraical series; interpolation and correction. Summing areas. Weddle's approximation.....Marks, 250.

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 formulae 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 pressures 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 be 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.

N. B.—This section may be substituted for any three of the above sections, excepting Section V on applied Mechanics, in which case 750 Marks will be allotted to it.

APPENDIX F 2.

ROYAL MILITARY COLLEGE OF CANADA.

SYLLABUS OF THE COURSE OF MILITARY ENGINEERING.

Total Marks..... { Obligatory, 6,000.
Voluntary, 2,000.

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

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. (*In preparation*.)

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 purposes, including elementary electrical testing. (*In preparation*.)

General Summary of Subjects.

Fortification,—

Field Fortification.

Permanent Fortification.

Semi-Permanent Fortification.

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.

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, etc., to 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 during the two last years of residence (3rd and 4th terms).

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.
 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, and Pioneer duties.

Engineering Drill.

- 3rd Term (principally II Class).—Field Fortification, and the Attack of Fortresses, excluding mining.
 4th Term (principally I Class).—Mining, Electrical Testing, and Pioneer Duties.
 The following is a detailed syllabus of the course for each class:—

4th CLASS.

OBLIGATORY.

FIELD FORTIFICATION.

1. *INTRODUCTION.*—Sketch of the defence and attack of a position, showing the advantage of using field fortification and to obtain an insight into the works required. These works must conform to the principles of defence, which are unchangeable, but their nature will also depend on the effect of the arms in use. Consideration of the principles of defence. Effect of the arms at present in use.

2. *Tools.*—Various kinds and how carried.

3. *Materials.*—Raw: how obtained; earth, wood, brushwood, iron, &c.
 Manufactured: how made; pickets, fascines, gabions, hurdles, &c.

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

WORKS required 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: Abattis 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-epaulments (the placing of guns in redoubts 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.

12. *Blindages.*—Specially considered.

13. *Hasty Intrenchments.*—Nature and object.

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

15. *Tactical Pivots.*—Object and special requirements, various kinds, namely:

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

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

18. Defensible houses and villages.

19. Defensible woods.

20. *Making and Destroying Communications in a defensible position.*—Object and statement of work to be done.

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

- I. Various sections of shelter trenches.
- II. Do. do. do. do.
- 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 each examination.

December—Sections 1 to 9 inclusive.

March—Sections 10 to 16 inclusive.

June—The whole subject.

Marks:

For work during term.....	400
For examinations,—	
December	150
March	150
June	300
Total.....	1,000

3RD 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.

Application of fortresses to the defence of a country.

General strategical considerations; method of frontier lines, its failure illustrated by examples.

Exp 11ence of the German invasion of France in 1870-71; discussion of the best method of defence.

Tactical uses of fortresses.

Distinction between a fortified place, or fortress, and a fortified position.

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. APPLICATION OF THE PRINCIPLES ALREADY STATED TO 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.

e. *Countermines* to defend the approaches.

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

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

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

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

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

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

β. Profile, with dry ditches, with wet 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.

α. Outworks—

1. Covered way and glacis, and ravelin, with their keeps, object, construction.

2. Counterguards, their object, construction, defects, when useful.

3. Tenailions and demi-tenailions, 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.

α. Open works, cavaliers, gorge retrenchments, coupures.

β. Closed works, casemated keeps, interior glacis, iron plating.

γ. Citadels, how they differ from ordinary retrenchments, their requirements and how fulfilled.

e. Countermines (see mining).

D. ARRANGEMENT OF THE ELEMENTS IN FORTRESSES.

General considerations which govern the combination of the above elements.

a. *Detached Forts.*

Requirements.

α. Good artillery positions.

β. Secure against assault.

How carried out.

Where they may be suitably employed.

b. *Enclosed Enceintes.*

α. When a regular attack is not possible.

1. Long simple points.

2. Simple outworks.

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

β. When a regular attack is to be anticipated.

1. Shorter fronts, more elaborate in detail.

2. Strong salient outworks, not only to cover the communications across the ditch, but to provide large and safe places of assembly for troops outside the ditch, and to bring flank and reverse fire, on an enemy attempting to advance to the salients of the enceinte. Counter mines under glacis.

3. Escarps, caponiers and keeps, completely covered, not only from view, but also from distant curved artillery fire—hence masks, iron plating, interior glacis, the latter countermined.

c. *Combination of Enclosed Enceintes and Detached Forts*—To form first class modern fortresses.

α. The enceinte as in (D — b — β) above.

β. The detached forts.

1. The individual forts as in (D — a) above.

2. Considerations which have brought into prominence in modern fortification, the combination of detached forts with enclosed enceintes.

E. SKETCH OF PROGRESS OF PERMANENT FORTIFICATION with examples of best modern works in detail.

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.*

Effects of the introduction of cannon, and of mining with gunpowder.

α. On the site.

- β. On the construction.
 γ. On the profile.
 δ. On the trace.
 c. *The Italian School.*
 Introduction of the bastioned trace, origin of the ravelin. Paciotto's trace, the first regular bastioned work.
 d. *The Dutch School.*
 Its origin and distinguishing characteristics.
 Example Coevorden.
 Improvements by Coehorn, his principles and methods of construction.
 e. *Early French School, mention.*
 f. *French School under Vauban and his successors.*
 α. Vauban's systems, 1st and 3rd. Cormontaigne's improvements.
 β. The modern French system, school of Mezières, school of Metz.
 g. *Opposition to the bastioned system in France by Montalembert.* Sketch of his proposals, partly adopted by Carnôt. Method proposed by Carnôt.
 h. *Rise of the polygonal system in Germany.*—What it owes to Montalembert, and to the early designs of Dürer (16th century). The modern Prussian system. Antwerp, as an example of the latest design on the polygonal system.

SEMI-PERMANENT FORTIFICATION.

A. INTRODUCTORY—

- Definitions.
 Objects to be attained. Requirements.
 Means available for construction of semi-permanent works, including time.
 Characteristics of semi-permanent works.
 Cases in which they are applicable.

B. APPLICATION.

- a. To semi-permanent detached forts.
 b. To semi-permanent enceintes.
 Requirements, and how carried out under each of the above heads.

C. EXAMPLES OF SEMI-PERMANENT WORKS—

Various.

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 each examination.

December.—Sections A, B, and C. Permanent Fortification.

March—Sections D and E. Do. Do.

June.—The whole subject.

Marks:—

For work done during the term.....	500
For examinations, December.....	250
March.....	250
June.....	500

Total..... 1,500

3RD CLASS.

VOLUNTARY.

PERMANENT FORTIFICATION.

SECTION E OF OBLIGATORY COURSE—

Sub-sections *d, f, g* and *h*, in greater detail.

THE AMENDED BASTIONED SYSTEMS—

Chasseloup, Dufour and Choumara.

COAST DEFENCE.

A. INTRODUCTORY—

- Principles unaltered.
 Considerations which influence the modifications in detail, characteristic of coast defences.
 Considerations which influence the selection of the points to be defended. Sketch of methods of attack to which such defences are liable. Requirements and means of carrying them out.
 a. By special arrangement of batteries—site.
 b. By constructive details for protection of guns and facilitating their service.
 c. By utilization of natural obstacles and creation of artificial ones.

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

- Nature of defences:
- a. Batteries.
 b. Obstructions.
 c. Submarine mines.
 a. *Batteries.*—Requirements, and how fulfilled for the following:—
 α. Earthen batteries with or without Moncrief carriages.
 β. do do with iron submarine shields.
 γ. Casemated batteries with do do
 δ. Iron fronted batteries fixed or revolving.
 Situations in which these batteries are suitable, respectively.
 b. *Obstructions.*—Requirements and how fulfilled for the following:—
 α. Sunken obstructions.
 β. Floating do
 Situations in which they are suitable, respectively:
 c. *Submarine Mines.*—Requirements and how fulfilled for the following:—
 α. Defensive.
 1. Mechanical.
 2. Electrical.
 Situations in which they are suitable, respectively. Attack on submarine mines. (For explosive used, see Explosives):
 β. Offensive (Torpedoes.)
 1. Locomotive.
 2. Outrigger.
 3. Towing.
 Brief sketch of the use of torpedoes.
 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.

Exercises.—Project for an original work.

Subject for Examination.

June.—The whole subject.

Marks :—

For work done during the term..... 200
For examination, June..... 300

Total..... 500

2ND. CLASS.

OBLIGATORY.

ATTACK AND DEFENCE OF FORTRESSES.

ATTACK.

A. MODES OF DEALING WITH FORTRESSES determined by their importance strategically and their strength.

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, requirement 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-Lodgements.

8. Double and cube saps, object, requirements, how executed.

9. Crowning the covered way by assault, when attempted.

10. Fifth parallel, its object, position and requirements.

ζ. Breaking into *enciente*.

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 lodgements 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 escarp are not well covered. Attack by mining.

C. EXAMPLES—

Application to the attack of a front of the modern French system.

Probable course of attack on a polygonal front.

Attack on a chain of detached forts.

DEFENCE.

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. BY REGULAR ATTACK.—

a. Preparatory arrangements.

b. Resistance to investment.

c. Obstructions of the preparations for the regular siege.

d. Resistance to the operations of the regular siege.

a. 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 (see); large sorties.

Lighting up ground at night and careful observations.

Firing on working parties; large sorties.

Against the second artillery position.

Concentration of fire on batteries in succession.

Interruption of working parties if discovered by shrapnel fire.

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; sentries on flank.

10. Against fifth parallel.

Same as against other saps.

5. Against breaking into enceinte.

1. General preparations.

2. Against breaching of escarp.

Concentration of fire, and sortie against breaching batteries, in lodgement 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 glaces, 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 DISCUSSIONS—

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, underditch behind counterscarp.

b. Offensively by the defence.

Object, to blow up the enemy's works on the counterscarp, and so delay his advance.

Measures taken for this purpose.

Countermines, galleries arranged systematically under the glaces, 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.

α Defensive use, submarine mines proper.

β Offensive use, torpedoes.

B. REQUIREMENTS.—Means for placing charges.

a. Sand mines, offensive or defensive.

α Shafts and galleries, object, dimensions, method of execution and lining. Tools, appliances and time required.

β Bored mines, object, dimensions and method of execution.

γ Ventilation of mines, requirements, method of carrying them out.

δ Preparation of charges, loading, tamping and firing mines. (See also

b. Submarine mines.

See for details, Coast Defence, Section B, Sub-section C. (See also

C. EXPLOSIVES GENERALLY USED.—Their different effects, and the quantity of each required.

a. Explosives.

α Gunpowder, guncotton and dynamite, comparison of their effect, and when they should be used respectively.

β Calculation of charges, sand mines, definitions, overcharged and undercharged mines, camoufflets, 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 Defences and Explosives, as above.

For the application of mines see Syllabus of Voluntary Course.

APPLICATION OF FIELD FORTIFICATIONS TO THE DEFENCE OF A POSITION—

Object of defending a position. Subdivision of the defence into two kinds, active and passive. An active defence includes offensive, defensive and purely defensive actions. Application of the different kinds of defence. The positions of the works must conform to that of the troops (1st Principle of Defence), but a *slight* alteration may be made on technical grounds.

Statement* of the tactical requirements and 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.

Object of advanced works and of a second line of Defence and general arrangement for each.

Arrangement and nature of works according to the kind of defence: (1) Offensive, Defensive; (2) Active defence; (3) Passive defence.

Choice of 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 sites 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.

Number of troops required to defend a position according to the kind of defence. Distribution of troops.

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:

- a. Field of battle. Offensive, defensive and pure defensive. Inquiry into the effect of intrenching on the field of battle.
- b. Lines of investment.
- c. Defence of the environs of a fortress.
- d. Defile works—bridge heads and mountain passes.
- e. Intrenched camps, depots, etc.

Attack and Defence of field works.

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.

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

Application to the ground.—The sites of the works will 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, but 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 positions.
- 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.

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 each 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 applied Field Fortification.)

Marks:—

For work during the term.....	500
For examinations, December.....	250
March.....	250
June.....	500

Total..... 1,500

II. CLASS.—VOLUNTARY.

ATTACK.

SECTION B—Obligatory course.

SUB-SECTIONS *d*, α , γ , δ , ϵ , ζ , more in detail.

MINING.

D. APPLICATION OF MINES—

a. *To defence.*

- α . Defence of glacis object, requirements how carried out. Countermine systems for defence of glacis.

- β. Defence of breach, object, requirements how carried out.
Countermine systems.
- b. *To the Attack.*
- α. On countermines under glacis, tactics of assailant, ordinary method of attack by galleries, attack by shaft mines.
- β. On countermines for defence of breach.
- γ. On escarp and counterscarp revetments to form breach.
- c. *To demolition of permanent works after capture or during peace.*

Plates—

VII. Siege works.

VIII. Countermine systems.

IX. Attack on a system of countermines.

FAIR NOTES on lectures during the term.

EXERCISES—Examples on application of mining; Journal of attack on countermines.

SUBJECTS OF EACH EXAMINATION—

JUNE—Whole subject.

MARKS—

For work done during term.....	200
For examination, June	300
Total	500

1ST CLASS.

OBLIGATORY.

USE OF EXPLOSIVES FOR MILITARY ENGINEERING PURPOSES.

EXPLOSIVES generally employed. Consideration of these explosives from a military engineering point of view.

The nature, properties and manufacture of explosives is dealt with in the Artillery and Chemistry Courses.

Gunpowder—Size of grain most suitable for military engineering purposes.

Gun-cotton—Shapes and sizes in which the compressed gun-cotton is supplied and uses to which each shape and size is put. Advantages of the property of detonating unconfined, whether wet or dry. Primer of dry gun-cotton to detonate wet gun-cotton. Drying gun-cotton. Test for dryness of gun-cotton.

Dynamite—Cartridges in which usually supplied. Advantages of its property of detonating unconfined.

Fulminate of Mercury—Other explosives that may be used.

CONSTRUCTION OF MAGAZINES for the storage of explosives. Object. Requirements general and according as the magazine is intended for gunpowder or gun-cotton, and whether exposed to artillery fire or not. How fulfilled in each case.

METHOD OF USING EXPLOSIVES. (Land operations only.)

The charge proper. General remarks on making up.

The fuze, or the immediate cause of the explosion of the charge. Various kinds of fuzes, and how used.

Means of determining explosion of fuze—

By concussion.

Cases in which applicable and general arrangements to be adopted.

By slow or quick match.

Cases in which applicable.—Description of the various kinds of slow and quick match, and how used.

BY ELECTRICITY.

Cases in which applicable. Its general consideration. Sources of Electricity; distinguishing between those required for use of low tension fuses and those required for

high tension fuses, for the former galvanic batteries and quantity dynamos, for the latter tension dynamos and frictional machines. Method of using each kind. Calculation of battery power.

Circuit. Various arrangements of divided and continuous circuits. Jointing wires.

Connecting up and arrangements to be made for firing.

Statement of the testing (electrical or otherwise) to be performed to ascertain that everything is in working order.

Electrical testing (to the extent possible with the instruments contained in the "Field Service jointing and testing box").—Description and use of the instruments contained in this box, namely: Leads (making connections), 3-coil galvanometer, Firing resistance coils, Test cell, etc.

Testing source of electricity, batteries and quantity dynamos; testing strength and measuring internal resistance by the fusion of platinum wire. Tension dynamo, measuring length of spark by means of micrometer attached to machine; minimum length of spark allowable.

Testing line wire. For continuity and insulation resistance by means of 3-coil galvanometer. Detecting position of fault.

Testing completed circuit. Measurement of resistance of circuit by Wheatstone bridge attached to firing coils. Pricker test to locate a fault.

PRECAUTIONS to be adopted when using explosives and to ensure explosion.

APPLICATION. *Mining.*

Hasty demolitions. Walls, Houses, Bridges, Cutting down trees, Cutting through iron in various cases. Demolition of stockades.

PIONEER DUTIES.

Communications considered under three heads: Making, Destroying, Restoring.

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 beams, chesses, ribands, rack-lashings, 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; Detail of construction; method 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; detail of construction; method of making and calculation of stresses for the following kinds of trestles: Two-legged, four-legged and tripod. Advantages and disadvantages of each kind. Forming up into bridge.

Miscellaneous methods of obtaining points of support, crib piers, piles, &c.

Floating bridges.—General description of such bridges; materials required; detail of construction; method of making calculations of dimensions and buoyancy required for floating bridges composed of pontoons, barrel piers of various kinds,

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

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; various arrangements.

ROADS.—Object, requirements, method of construction of ordinary (Military) when over marshes and corduroy roads, road engines, repairing roads.

RAILWAYS.—Sketch of the use of railways in war. Object of constructing military railways in time of war. Requirements, considerations as to; selection of route, gauge, engines and rolling stock of military railways.* Adaptation of existing stations to military purposes. Carriage of troops.

French Railway.—Object, requirements, considerations as to section of route, gauge, engines and rolling stock. Works required and how executed (bridging mentioned only.)

DEMOLITION.

Object. Description of methods generally adopted. 1. By hand. 2. By use of explosives. 3. By fire.

ROADS.—Vulnerable points: bridges, cuttings, 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 description of this class of communication.

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.]

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

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 defence of a position.

II. Demolition project.

III. Project for a military bridge.

FAIR NOTES.—On lectures during the term.

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.

MARKS—

For work done during term.....	500
For examinations, December.....	300
March.....	300
June.....	900
Total.....	2,000

1ST CLASS.

VOLUNTARY.

ELECTRICAL TESTING.

Consideration of the measurements that have to be made for military engineering purposes and of the units to which these measurements are referred.

Instruments.—Method of using the following instruments: Contact keys, galvanometers (detector Clark's differential, sine galvanometer, tangent galvanometer, Thomson's reflecting galvanometer,) precautions to be taken when working with galvanometers, methods of obtaining good readings, constant of galvanometer, calibration, resistance coils, condenser, standard cells.

Testing.—Various methods of obtaining measurements of: resistance, external resistance of a conductor of a galvanometer of "earths," etc., internal resistance of a cell, difference of potential, currents and capacity.

PIONEER DUTIES.

Communications for the Conveyance of Men, Horses and Materials.

BRIDGING.

Suspension Bridges.—General description of such bridges. Materials required. Detail construction. Method of erecting and calculation of stresses for the following kinds: Ordinary suspension bridges of various kinds, tension bridges and strutted tension bridges of various designs.

Railway Bridges (temporary).—Object, requirements, materials used, detail construction, method of erecting, and calculation of dimensions for the following kinds: Frame bridges for small openings; trestles for wide shallow openings, and trestles in tiers for wide deep openings.