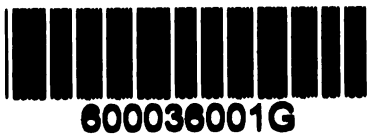

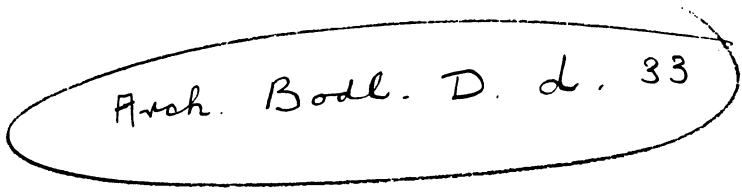

A GUIDE

TO THE

MATHEMATICAL STUDENT

IN READING, REVIEWING, AND

WORKING EXAMPLES.

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PART I.

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PREFACE.

THE object of the following pages is twofold :—

First, to exhibit, in a compendious form, the whole subject-matter of Pure Mathematics, arranged in the order in which it would usually be advisable that the student should go through it. This Syllabus may be useful as an aid in laying out plans of reading and reviewing, and in shewing the student at a glance where he is on his course, how much is done, and how much remains to be done.

Secondly, to furnish a guide for working examples in the whole subject, so arranged as to secure that the most important subjects shall have the largest share of attention. The Cycle intended for this purpose consists of two columns: one containing the numbers from 1 to 1702, the other, references to the Syllabus. It is intended that the student using it should turn to the Syllabus for each reference, and work two or three examples in the subject there indicated, (of course passing over all references to subjects he has not read,) and at the end of each day's work mark what point in the Cycle he has reached.

PREFACE.

In the Syllabus, the small figures to the left of the line indicate how often each subject is referred to in the Cycle: so that if the teacher should consider that the examples assigned to any subject are either too many or too few, he can remedy the defect by erasing references in the Cycle, or by inserting additional ones.

The present attempt is, no doubt, deficient and faulty in many respects: and any suggestions from Mathematical teachers for remedying its defects will be gratefully received by the compiler.

Christ Church, Oxford,
December, 1864.

GENERAL LIST OF SUBJECTS.

30	A. Arithmetic.
20	B. Euclid I, II.
75	C. Algebra; to Quadratic Equations.
23	D. Euclid III, IV.
45	E. Algebra; from Quadratic Equations to Binomial Theorem.*
16	F. Euclid V, VI.
114	G. Linear Algebraical Geometry. Plane do. to end of Trigonometry (1st time).
45	H. Geometrical Conic Sections.
100	I. Algebra; from Binomial Theorem to Theory of Equations.
45	J. Higher Plane Pure Geometry.
110	K. Plane Algebraical Geometry; from end of Trigonometry to Quadratic Loci (constructed from Geometrical properties).
24	L. Plane Algebraical Geometry; Trigonometry (2nd time).
120	M. Plane Algebraical Geometry; Quadratic Loci (constructed from Equations).
135	N. Differential Calculus (1st time).
19	O. Calculus of Finite Differences (1st time).
20	P. Euclid XI, XII, and higher Solid Pure Geometry.
22	Q. Solid Algebraical Geometry; to end of Stereometry.
65	R. Solid Algebraical Geometry; from end of Stereometry to Quadratic Superficial Loci (constructed from Geometrical properties).
37	S. Higher Plane Algebraical Geometry.
135	T. Integral Calculus (1st time).
45	U. Solid Algebraical Geometry; Quadratic Superficial Loci (constructed from Equations).
77	V. Higher Algebra.
145	W. Differential Calculus (2nd time).
102	X. Integral Calculus (2nd time).
25	Y. Calculus of Finite Differences (2nd time).
35	Z. Calculus of Variations.

* i. e. From Quadratic Equations *exclusive* to Binomial Theorem *inclusive*. The same rule of interpretation applies to J, K, &c.

SUBJECTS SUBDIVIDED.

A.

Arithmetic.

1	1. Addition, Subtraction, Multiplication, and Division ; (Simple.)
2	2. Greatest Common Measure and Least Common Multiple.
2	3. Square root and Cube root.
3	4. Vulgar Fractions ; addition, subtraction, multiplication, and division.
3	5. Decimal Fractions ; addition, subtraction, multiplication, and division.
2	6. Circulating Decimals.
1	7. Reduction from one denomination to another.
1	8. Addition, Subtraction, &c. (Compound).
3	9. Reduction of Fractions (vulgar and decimal) of higher denomination to lower ; and of lower denomination to fractions (vulgar and decimal) of higher.
1	10. Practice.
2	11. Mensuration, Superficial and Solid.
1	12. Duodecimals.
2	13. Rule of Three ; Direct, Inverse, and Double. Proportional parts.
2	14. Interest, Simple and Compound. Discount. Equation of payments. Stocks.
4	15. Miscellaneous, viz. : Exchange. Profit and Loss. Partnership, &c.

B.

Euclid I, II.

	1. Book I.
	2. Book II.
6	3. Deductions from Book I. Problems.
7	4. do. do. Theorems.
3	5. Book II. Problems.
4	6. do. do. Theorems.

C.

Algebra; to Quadratic Equations.

2	1. Addition, Subtraction, Multiplication, and Division.
2	2. Greatest Common Measure and Least Common Multiple.
5	3. Fractions.
3	4. Involution and Evolution.
4	5. Fractional Indices.
9	6. Equations, one unknown quantity; Simple.
10	7. do. do. Quadratic.
6	8. do. two or more unknown quantities; Simple.
6	9. do. do. Quadratic.
	Problems leading to Equations,
5	10. One unknown quantity; Simple.
6	11. do. Quadratic.
5	12. Two or more unknown quantities; Simple.
6	13. do. Quadratic.
2	14. Theory of Equations (1st time).
4	15. Miscellaneous.

D.

Euclid III, IV.

	1. Book III.
	2. Book IV.
6	3. Deductions from Book III. Problems.
8	4. do. do. Theorems.
4	5. do. Book IV. Problems.
5	6. do. do. Theorems.

E.

Algebra; from Quadratic Equations to Binomial Theorem.

2	1. Inequalities.
6	2. Ratio, Proportion, and Variation.

9 | 3. Series; Arithmetical, Geometrical, and Harmonical.
9 | 4. Permutations and Combinations.
5 | 5. Binomial Theorem.
6 | 6. Logarithms, use of.
4 | 7. Chances (1st time).
4 | 8. Miscellaneous.

F.

Euclid V, VI.

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1. Book V.
2. Book VI.
8 | 3. Deductions from Book VI. Problems.
8 | 4. do. do. Theorems.

G.

Linear Algebraical Geometry.

Plane do. to end of Trigonometry (1st time).

Linear Algebraical Geometry.

5 | 1. Representation and discussion of lengths absolute.
2. do. do. do. with direction.
3. do. of positions of Points by means of lengths; and discussion of such lengths.
3 | 4. Interpretation of Equations; and discussion of Points.

Plane Algebraical Geometry.

5 | 5. Representation and discussion of magnitudes absolute.
6. do. do. do. with direction.
7. Goniometry: i. e., representation of angles, with direction, by means of ratios; and discussion of such ratios.
12 | 8. Angles; relations between goniometrical ratios of an angle.
6 | 9. do. goniometrical ratios of particular angles.
18 | 10. do. relations between goniometrical ratios of two or more angles.

7	11. Angles; inverse function.
5	12. do. elimination of goniometrical ratios.
	13. Theory of Projection (Plane).
18	14. Trigonometry; properties of Triangles.
6	15. do. do. Quadrilateral Figures inscribed in Circles.
5	16. do. do. regular Polygons.
16	17. Heights and distances.
8	18. Miscellaneous, viz., Subsidiary angles, &c.

H.

Geometrical Conic Sections.

	1. Ellipse.
	2. Hyperbola.
	3. Parabola.
4	4. Problems on Parabola.
5	5. Theorems do.
5	6. Problems on Ellipse.
8	7. Theorems do.
5	8. Problems on Hyperbola.
8	9. Theorems do.
5	10. Miscellaneous, viz., mechanical methods of tracing curves, &c.

I.

Algebra; from Binomial Theorem to Theory of Equations.

6	1. Evolution of Binomial Surds.
12	2. Indeterminate Coefficients.
6	3. Continued Fractions.
10	4. Indeterminate Equations, (1st and 2nd degree).
7	5. Partial Fractions.
3	6. Scales of Notation.

7 | 7. Properties of Numbers.
7 | 8. Vanishing Fractions.
6 | 9. Converging and diverging Series.
4 | 10. Logarithms, construction of.
7 | 11. Interest, Discount, and Annuities.
6 | 12. Chances (2nd time), and Life-Annuities.
11 | 13. Theory of Equations (2nd time).
6 | 14. Miscellaneous.

J.

Higher Plane Pure Geometry.

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4 | 1. Anharmonic and Harmonic Proportion.
5 | 2. Anharmonic ratio of a Pencil. Harmonic Pencils.
5 | 3. Geometrical Involution.
4 | 4. Poles and Polars in relation to Circles.
4 | 5. Methods of Reciprocation.
5 | 6. Radical Axis and Centres of Similitude.
5 | 7. Principle of Continuity.
5 | 8. Projection.
8 | 9. Miscellaneous.

K.

Plane Algebraical Geometry; from end of Trigonometry to Quadratic Loci (constructed from Geometrical properties).

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1. Determination of positions of Points, Lines, and Circles, by means of magnitudes; and discussion of such magnitudes.
2. Interpretation and classification of simple Equations.
4 | 3. Interpretation of Pairs of Equations. Representation and discussion of Points.
4. Investigation of Locus of single Simple Equations. Representation of Lines.
10 | 5. Lines; Problems.
3 | 6. do. Theorems.

7	7. Rectilinear Figures; Problems.
2	8. do. Theorems.
3	9. Pencils; Problems.
9	10. do. Theorems.
7	11. Representation of Loci of Points fulfilling certain conditions.
	12. Representation of Pairs of Lines. Criterion that Quadratic Equation should represent Pair of Lines.
3	13. Pairs of Lines; Problems.
2	14. do. Theorems.
	15. Representation of Circles. Criterion that Quadratic Equation should represent Circle.
12	16. Circles; Problems.
6	17. do. Theorems.
	18. Representation of Parabola. Criterion that Quadratic Equation should represent Parabola.
4	19. Parabola; easy Problems.
4	20. do. Theorems.
	21. Representation of Ellipse. Criterion that Quadratic Equation should represent Ellipse.
6	22. Ellipse; easy Problems.
8	23. do. Theorems.
	24. Representation of Hyperbola. Criterion that Quadratic Equation should represent Hyperbola.
6	25. Hyperbola; easy Problems.
8	26. do. Theorems.
6	27. Miscellaneous.

L.

Plane Algebraical Geometry; Trigonometry (2nd time).

4	1. Circular measure. Area of Circle, &c.
6	2. Demoivre's Theorem; and theorems involving powers of goniometrical ratios.
4	3. Summation of series of goniometrical ratios.
4	4. Relations betwcen angle and its goniometrical ratios. Gregorie's Series. Euler's and Machin's Series for π.
6	5. Miscellaneous; viz., resolution of $\sin\theta$ and $\cos\theta$ into factors, &c.

M.

Plane Algebraical Geometry; Quadratic Loci (constructed from Equations).

6	1. Interpretation and classification of Quadratic Equations. Quadratic Locus;
8	2. General. Problems.
6	3. do. Theorems.
12	4. do. when $B^2-4AC \neq 0$, i. e. Central Locus; Problems.
8	5. do. do. Theorems.
16	6. Central, when $B^2-4AC < 0$, i. e. Ellipse. Problems.
10	7. do. do. Theorems.
12	8. do. when $B^2-4AC > 0$, i. e. Hyperbola. Problems.
8	9. do. do. Theorems.
16	10. General, when $B^2-4AC = 0$, i. e. Non-central Locus, or Parabola. Problems.
10	11. do. do. Theorems.
8	12. Miscellaneous.

N.

Differential Calculus (1st time).

	1. Elements of subject.
3	2. Differentiation from first principles.
3	3. Differentiation of functions connected by addition, &c.
9	4. do. algebraical functions.
8	5. do. compound functions.
8	6. do. circular functions.
5	7. do. functions of many variables.
4	8. Successive differentiation. Leibnitz's Theorem.
4	9. Maclaurin's Theorem.
4	10. Theory of equicrescent variable. Taylor's Theorem.
6	11. Elimination of constants and functions by differentiation (1st time).

12. Relations between functions and derived functions; viz.

$$\frac{F(x_0+h)-F(x_0)}{f(x_0+h)-f(x_0)} = \frac{F'(x_0+\theta h)}{f'(x_0+\theta h)}, \text{ \&c.}$$

6 13. Order of Infinitesimals.

7 14. Evaluation of quantities of the form $\frac{0}{0}$, &c.

8 15. Maxima and minima of explicit functions of *one* variable.

11 16. Geometrical application to end of do.

17. Symbols of direction extended.

8 18. Cissoid, Witch, &c.

10 19. Tangents &c. of plane curves.

5 20. Direction of curvature. Hessian.

5 21. Multiple points.

6 22. Tracing curves.

4 23. Curvature of plane curves.

5 24. Evolutes and involutes.

6 25. Miscellaneous.

O.

Calculus of Finite Differences (1st time).

---

2 1. Differentiation of functions.

2 2. Integration of functions by indeterminate coefficients.

3. do. product of n terms in $A.P.$, and of reciprocal of the same.

2 4. Resolution of rational algebraical functions into these 2 forms.

2 5. Supplying deficient factors.

5 6. Integration of circular, exponential, and other functions.

6 7. Summation of Series by general methods.

P.

Euclid XI, XII, and higher Solid Pure Geometry.

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1. Book XI.

2. Book XII.

2 3. Deductions from Book XI. Problems.

3 4. do. do. Theorems.

5. Deductions from Book XII. Problems.
6. do. do. Theorems.
7. Sections of Cone.
8. Problems on do.
9. Theorems on do.
10. Higher Solid Pure Geometry.
11. Problems on do.
12. Theorems on do.

Q.

Solid Algebraical Geometry; to end of Stereometry.

1. Representation and discussion of volumes absolute.
2. do. of magnitudes with direction.
3. Theory of Projection in Space.
4. Spherical Trigonometry; i. e., properties of solid angles.
5. Napier's Analogies.
6. Gauss' Theorems.
7. Solution of spherical Triangles; inscribed Circles; area of triangle and lune, &c.
8. Cagnolis' Theorem. Llhuillier's Theorem.
9. Stereometry; i. e. properties of plane-sided Solids; inscribed Spheres; volume and diagonal of Parallelepipedon, &c.
10. Miscellaneous.

R.

Solid Algebraical Geometry; from end of Stereometry to Quadratic Superficial Loci (constructed from Geometrical properties).

1. Determination of position, in Space, of Points, Lines, Planes, Spheres, and Cylinders, by means of certain magnitudes; and discussion of such magnitudes.
2. Interpretation and classification of Simple Equations.
3. do. do. Pairs of Equations.
4. do. of sets of 3 Equations.

4	5. Representation and discussion of Points.
	6. Investigation of Locus of single Simple Equations. Representation of Planes.
6	7. Planes. Problems.
6	8. do. Theorems.
3	9. Plane-sided Solids. Problems.
4	10. do. Theorems.
3	11. Representation of Superficial Loci of Points fulfilling certain conditions.
	12. Representation of Pairs of Planes. Criterion that Quadratic Equation should represent Pair of Planes.
2	13. Pairs of Planes. Problems.
2	14. do. Theorems.
	15. Investigation of Locus of Pairs of Simple Equations. Representation of Lines.
6	16. Lines. Problems.
4	17. do. Theorems.
	18. Representation of Spheres. Criterion that Quadratic Equation should represent Sphere.
4	19. Spheres. Problems.
5	20. do. Theorems.
	21. Representation of Cylinders. Criterion that Quadratic Equation should represent Cylinder.
2	22. Cylinders. Easy Problems.
3	23. do. Theorems.
	24. Representation of Cones. Criterion that Quadratic Equation should represent Cones.
2	25. Cones. Easy Problems.
3	26. do. Theorems.
6	27. Miscellaneous.

S.

Higher Plane Algebraical Geometry.

2	1. Eccentric angles.
2	2. Similar Conic Sections.
4	3. Contact of Conics. Osculating circle. Centre of curvature, and Evolutes.
5	4. Anharmonic properties of Conics.

4	5. Method of reciprocal Polars.
4	6. Involution.
	7. Pascal's Theorem.
	8. Tangential coordinates.
	9. Discussion of Locus of nth degree.
	10. Interpretation and classification of Cubic Equations.
3	11. Discussion of Cubic Loci.
	12. Interpretation and classification of Biquadratic Equations.
3	13. Discussion of Biquadratic Loci.
4	14. Discussion of Transcendental Loci.
6	15. Miscellaneous.

T.

Integral Calculus (1st time).

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	1. Elements of subject.
4	2. Integration from first principles.
8	3. Definite integration.
12	4. Integration of rational algebraical functions.
14	5. do. irrational do.
8	6. do. do. do. by rationalization.
7	7. do. do. do. by reduction.
9	8. do. exponential and logarithmic functions.
10	9. do. circular functions.
15	10. Definite integrals and their properties.
10	11. Rectification of plane curves.
10	12. Quadrature of plane surfaces.
8	13. do. surfaces of revolution.
8	14. Cubature of solids of revolution.
12	15. Miscellaneous.

U.

Solid Algebraical Geometry; Quadratic Superficial Loci (constructed from Equations).

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	1. Interpretation and classification of Single Quadratic Equations.
4	2. General Quadratic Superficial Locus. Problems.
3	3. do. Theorems.

3	4. Reduced Quadratic Locus, ($Px^2 + Qy^2 + Rz^2 + Sx + Ty + Vz + W = 0$,) when neither P, Q, nor R = 0; i. e. Central Quadratic Locus. ($Px^2 + Qy^2 + Rz^2 + H = 0$).	Problems.
3	5. do.	Theorems.
2	6. Central Quadratic Locus, when H = 0, i. e. Cone.	Problems.
2	7. do.	Theorems.
3	8. Central Quadratic Locus, when P, Q, R, and H have the same sign; i. e. Ellipsoid, and Prolate and Oblate Spheroid.	Problems.
3	9. do.	Theorems.
1	10. Central Quadratic Locus, when one of them has a different sign from the other three; i. e. Hyperboloid of one sheet.	Problems.
1	11. do.	Theorems.
1	12. Central Quadratic Locus, when two of them have a different sign from the other two; i. e. Hyperboloid of two sheets.	Problems.
1	13. do.	Theorems.
2	14. Central Quadratic Locus, when either P, Q, or R = 0; i. e. the Axicentral Locus, or Central Cylinder.	Problems.
2	15. do.	Theorems.
2	16. Reduced Quadratic Locus, when one or more of the three, (P, Q, and R,) = 0; i. e. Non-central Locus.	Problems.
2	17. do.	Theorems.
2	18. Non-central Locus, when *one* of the three, (P, Q, and R,) = 0; i. e. Paraboloid.	Problems.
2	19. do.	Theorems.
1	20. Non-central Locus, when *two* of the three (P, Q, and R,) = 0; i. e. Parabolic Cylinder.	Problems.
1	21. do.	Theorems.
2	22. Miscellaneous, (e. g. Cono-cuneus).	Problems.
2	23. do.	Theorems.

V.

Higher Algebra.

4	1. Theory of equations (3rd time).
3	2. Transformation of equations.
2	3. Equal roots.
3	4. Limits of roots. Separation of roots.
2	5. Commensurable roots.
2	6. Depression of equations.

1 7. Reciprocal equations.
2 8. Binomial do.
3 9. Cubic do.
3 10. Biquadratic do.
2 11. Sturm's Theorem. Fourier's Theorem.
2 12. Lagrange's and Newton's methods of approximation.
1 13. Horner's method.
3 14. Symmetrical functions of roots.
1 15. Sums of powers of roots.
6 16. Determinants.
5 17. Elimination.
4 18. Expansion of functions in series.
5 19. Invariants. Covariants. Emanants. Evectants.
2 20. Contravariants.
3 21. Hyperdeterminant Calculus. Hermite's Law of Reciprocity.
2 22. Canonizants.
2 23. Binary Quantics, Quadrics, &c.
2 24. Ternary Quantics, Quadrics, &c.
3 25. Discriminants, &c.
2 26. Commutants.
5 27. Miscellaneous.

W.

Differential Calculus (2nd time).

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3 1. Trigonometrical expressions. Roots of $+1$ and -1. Imaginary logarithms.
2 2. Limits of Maclaurin's and Taylor's Theorems.
5 3. Change of equicrescent variable.
4 4. Successive differentiation of functions of many independent variables.
2 5. Euler's Theorem of homogeneous functions.
3 6. Successive differentiation of implicit functions.
2 7. Bernoulli's Numbers.
2 8. Lagrange's Theorem.
2 9. Laplace's Theorem.

	10. Extension of Maclaurin's Theorem.
10	11. Elimination of constants and functions (2nd time).
5	12. Transformation of differential expressions into their equivalents in terms of other variables.
	13. Expansion of functions of one variable. Acccurate proofs of Maclaurin's and Taylor's Theorems.
4	14. Expansion of functions of two or more variables.
	Maxima and minima
6	15. Of implicit functions of 2 independent variables.
7	16. Of explicit do. do. do.
5	17. Of functions of 3 or more do. do.
5	18. do. do. not independent do.
5	19. Properties of Curves of the nth degree.
3	20. Contact of curves (plane).
6	21. Envelopes do.
2	22. Theory of reciprocation.
3	23. Caustics.
10	24. Curved surfaces, tangent planes, &c.
4	25. Singular points of curved surfaces.
8	26. Curves in space, tangents, &c.
3	27. Geodesic lines, &c.
2	28. Curved surfaces generated by right lines. Ruled surfaces.
2	29. do. do. Conical do.
2	30. do. do. Cylindrical do.
2	31. do. do. Developable do.
2	32. do. do. Skew do.
2	33. do. do. Conoidal do.
2	34. do. by circles. Surfaces of revolution.
2	35. do. do. Tubular do.
1	36. Curves in space. Curvature-angle of contingence.
1	37. do. Torsion.
1	38. do. The polar surface.
1	39. do. The osculating sphere.
1	40. do. Complex flexure.
1	41. do. The osculating surface.
1	42. do. The rectifying surface and line.
1	43. Curved surfaces. Curvature. Euler's Theorem.
1	44. do. Umbilics.
1	45. do. Lines of curvature.
1	46. do. Dupin's Theorem.
1	47. do. Osculating surfaces.

48. Calculus of operations, Elements of.
49. Laws of commutation, distribution, and iteration.
50. Law of total differentiation.
6 51. Miscellaneous.

X.

Integral Calculus (2nd time).

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3 1. Successive integration.
3 2. Rectification of non-plane curves.
2 3. Determination of the equation to a curve by means of a relation between the length and the coordinates to any point on it.
3 4. Involutes of plane curves.
3 5. Quadrature of curved surfaces.
3 6. Cubature of solids bounded by any curved surface.
2 7. Properties of multiple integrals.
1 8. Transformation of multiple integrals.
2 9. Curvilinear co-ordinates. Gauss' System. Lamé's System and Jacobi's modification.
2 10. Variation of definite integrals due to variation of parameters involved in element-function.
2 11. Variation of definite integrals due to variation of parameters involved in element-function and in the limits.

Differential equations.

12. General principles.

First order.

4 13. Exact total differential equations.
4 14. Homogeneous equations of 2 variables.
4 15. The first linear differential equation.
4 16. Partial differential equations of 1st degree.
2 17. Integrating factors of differential equations.
2 18. Singular solutions of do.
4 19. Differential equations of higher degrees.
3 20. Particular processes.

Differential equations (*continued*).

Higher orders;

	21.	First degree; general properties.
3	22.	do. linear differential equations.
3	23.	do. do. with constant coefficients.
3	24.	do. do. with variable coefficients.
3	25.	Higher degrees; total differential equations.
3	26.	do. partial do.
4	27.	Geometrical Problems involving diff. equations. 1st order.
4	28.	do. do. 2nd do.
	29.	Simultaneous differential equations. General principles.
3	30.	do. Linear. 1st order.
2	31.	do. do. Higher orders.

Integration of differential equations by series.

2	32.	Application of Taylor's and Maclaurin's Theorems.
2	33.	Method of undetermined coefficients.
2	34.	Solution of Riccati's Equation.
4	35.	Application of Integral Calculus to Theory of Probabilities.
5	36.	Elliptic Integrals.
6	37.	Miscellaneous.

Y.

Calculus of Finite Differences (2nd time).

2	1.	Solution of equations of differences. 1st order.
2	2.	do. do. 2nd order.
1	3.	do. do. *n*th order.
2	4.	do. mixed differences.
3	5.	Summation of Series; by particular assumptions.
2	6.	do. by differentiation.
2	7.	do. of recurring Series.
3	8.	Interpolation of Series.
2	9.	Generating functions.
6	10.	Miscellaneous.

Z.

Calculus of Variations.

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1. General principles.

2. Variation of $\int_0^1 \mathrm{F}(x, dx, d^2x, \ldots y, dy, d^2y, \ldots)$.

2. Variation of $\int_0^1 \mathrm{F}(x, y, y', y'', \ldots)$.

2. do. $\int_0^1 \mathrm{F}(x, dx, d^2x, \ldots y, dy, d^2y, \ldots z, dz, d^2z, \ldots)$.

2. do. $\int_0^1 \mathrm{F}(x, y, y', y'', \ldots z, z', z'', \ldots)$.

1. Variation of a variation.

1. do. of a product of differentials.

1. do. of a definite double integral due to the variations of the limits.

Maxima and minima.

9. Critical values of definite integrals, whose element-functions involve variables and their differentials; general principles.

3 10. do. relative max. and min.

2 11. do. absolute do.

3 12. Geodesic lines; equations to.

2 13. do. properties of.

14. Critical values of definite integrals, whose element-functions involve derived functions; general principles.

3 15. do. particular cases.

16. Discriminating conditions; general principles.

17. do. requisite data.

18. do. proof that $\delta \int u\,dx$ is an exact differential: its integral, &c.

2 19. do. particular cases.

20. Critical values of a double definite integral; necessary criteria.

3 21. do. application of.

6 22. Miscellaneous.

CYCLE

FOR WORKING EXAMPLES.

			37	W	11	75	G	14	113	K	17
			38	R	20	76		11	114	V	25
1	M	6	39	X	27	77	I	5	115	X	6
2	W	16	40			78	J	6	116	R	10
3	L	3	41	Y	1	79	T	10	117	B	6
4	V	1	42	M	4	80			118	W	12
5	T	6	43	T	11	81	M	2	119	S	4
6	G	10	44	Z	10	82	A	6	120		
7		17	45	V	23	83	W	14	121	Y	10
8	H	7	46	N	6	84	K	19	122	C	3
9	X	13	47		19	85		7	123	T	13
10	K	16	48	G	15	86	N	5	124	M	10
11		10	49	J	1	87		24	125	N	15
12	N	16	50	W	29	88	V	12	126	O	5
13		10	51	U	8	89	D	3	127	A	9
14	C	12	52	Z	2	90	X	37	128	U	6
15	M	11	53	T	4	91	U	3	129	X	14
16	W	1	54	M	7	92	C	6	130	I	2
17	O	7	55	O	6	93		3	131		3
18	J	8	56	X	1	94	T	3	132	W	27
19	R	7	57	Q	4	95	M	6	133	Q	9
20			58	W	19	96	F	3	134	F	4
21	T	5	59	E	3	97	W	51	135	T	15
22	I	7	60			98	R	16	136	G	10
23		2	61	E	2	99	Z	10	137		18
24	U	2	62	K	26	100			138	V	4
25	X	32	63		5	101	I	10	139	Z	11
26	D	4	64	N	4	102		1	140		
27	W	4	65		11	103	G	8	141	M	1
28	A	1	66	V	17	104	X	36	142	E	7
29	M	10	67	H	10	105	H	9	143	W	23
30	V	16	68	M	5	106	L	1	144	K	16
31	T	9	69	T	8	107	W	8	145		28
32	L	5	70	C	11	108	I	12	146	X	25
33	B	4	71	W	24	109	M	8	147	C	9
34	N	25	72	R	5	110	T	14	148	R	8
35	K	27	73	P	4	111	J	4	149	T	3
36	C	8	74	X	19	112	K	23	150	H	6

151	S	15
152	N	13
153	V	27
154	W	43
155	M	9
156	J	3
157	X	18
158	U	9
159	I	13
160		
161	T	12
162	G	17
163	W	26
164	S	6
165	N	18
166	V	21
167	D	6
168	M	12
169	T	5
170	K	11
171		25
172	C	7
173	W	28
174	L	2
175	F	3
176	X	4
177	R	13
178	Z	22
179	V	14
180		
181	M	4
182	T	9
183	H	4
184	S	1
185	W	2
186	I	4
187		8
188	U	4
189	X	30
190	J	9
191	T	10
192	A	15
193	M	11
194	C	10
195	W	11
196	K	10
197		22
198	B	6
199	N	16
200		

201	R	27
202	V	20
203	X	16
204	G	14
205		1
206	T	4
207	Y	5
208	M	6
209	W	17
210	I	14
211	U	14
212	H	7
213	Z	15
214	S	11
215	T	11
216	C	13
217	W	25
218	M	7
219	V	19
220		
221	X	9
222	K	5
223		27
224	N	9
225		22
226	E	4
227		6
228	Q	7
229	T	7
230	J	7
231	R	22
232	W	16
233	I	11
234		9
235	X	28
236	M	10
237	D	4
238	T	6
239	V	5
240		
241	G	10
242		16
243	W	24
244	L	4
245	A	4
246	N	8
247	U	5
248	X	3
249	C	5
250		4

251	P	12
252	T	8
253	M	8
254	I	2
255		7
256	W	21
257	K	26
258		16
259	H	8
260		
261	N	7
262		19
263	R	23
264	X	15
265	V	16
266	S	3
267	W	18
268	J	5
269	M	3
270	T	15
271	C	6
272	G	4
273		8
274		14
275	Z	5
276	F	4
277	X	23
278	U	19
279	Y	2
280		
281	W	6
282	M	5
283	B	4
284	T	4
285	Q	10
286	V	6
287	N	14
288		6
289	R	11
290	Z	12
291	O	7
292	K	3
293		13
294	W	30
295	I	5
296		13
297	T	14
298	M	2
299	H	9
300		

301	X	35
302	S	2
303	C	15
304	W	15
305	U	15
306	E	3
307		5
308	T	10
309	G	17
310		5
311		9
312	N	4
313		23
314	V	18
315	M	6
316	X	2
317	J	2
318	R	7
319	W	32
320		
321	O	1
322	T	5
323	K	23
324		6
325	D	5
326	N	21
327		5
328	M	4
329	C	8
330	X	24
331	L	5
332	A	13
333	W	3
334	G	10
335		11
336	T	12
337	I	4
338		6
339	P	6
340		
341	S	15
342	N	16
343	M	10
344	V	9
345	W	41
346	R	17
347	T	4
348	Q	4
349	X	5
350	I	1

351	I	12
352	U	18
353	N	25
354	H	5
355	M	9
356	W	7
357	C	7
358	K	7
359		17
360		
361	T	9
362	J	8
363	X	13
364	A	14
365	Q	1
366	V	17
367	W	11
368	M	11
369	T	3
370	R	20
371	Y	8
372	N	15
373	G	18
374		14
375	X	26
376	C	11
377	S	4
378	W	26
379	E	8
380		
381	T	11
382	M	7
383	B	3
384	N	20
385	K	10
386		5
387	V	1
388	W	51
389	U	2
390	I	2
391		3
392	X	36
393	R	16
394	T	13
395	C	12
396	F	3
397	M	8
398	Z	21
399	J	9
400		

401	L	3
402	W	19
403	V	2
404	X	27
405	K	16
406		11
407	H	10
408	T	15
409	M	12
410	C	9
411	W	24
412	R	19
413	A	7
414	N	18
415	G	17
416		8
417	X	17
418	I	8
419		11
420		
421	D	3
422	T	10
423	M	6
424	V	27
425	W	36
426	U	10
427	P	11
428	X	31
429	S	5
430	T	5
431	C	3
432		6
433	K	19
434		25
435	W	12
436	J	6
437	M	1
438	N	11
439	R	8
440		
441	E	2
442		4
443	T	8
444	B	6
445	W	4
446	G	10
447		12
448		15
449	V	8
450	X	19

451	Q	7
452	H	7
453	N	2
454		19
455	M	10
456	I	13
457	T	6
458	U	7
459	W	40
460		
461	Y	10
462	S	14
463	X	11
464	C	14
465	N	10
466		13
467	M	4
468	J	6
469	T	7
470	R	14
471	O	6
472	W	9
473	K	26
474	V	10
475	X	20
476	L	2
477	T	4
478	Y	6
479	M	3
480		
481	W	16
482	D	4
483	S	6
484	N	24
485	C	7
486	X	7
487	G	14
488	H	9
489	W	20
490	Q	10
491	I	14
492	T	12
493	M	5
494	A	2
495	Z	13
496	R	27
497	X	14
498	V	3
499	J	1
500		

501	K	22
502		9
503	W	14
504	U	22
505	C	13
506		1
507	T	2
508	M	2
509	B	4
510	N	4
511		16
512	G	16
513		17
514	F	4
515	W	37
516	I	4
517		7
518	Q	4
519	T	9
520		
521	P	3
522	S	13
523	X	22
424	E	3
525	M	6
526	N	6
527		14
528	D	6
529	W	21
530	A	5
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532	V	24
533	T	10
534	K	23
535		27
536	J	3
537	X	1
538	M	8
539	W	11
540		
541	C	8
542		2
543	U	12
544	T	5
545	I	5
546		2
547	G	10
548		1
549	N	22
550	V	16

551	Z	22
552	M	10
553	H	4
554	W	17
555	R	10
556	T	15
557	Y	9
558	K	5
559		16
560		
561	X	25
562	C	5
563		11
564	N	5
565	M	7
566	W	15
567	I	10
568		9
569	U	8
570	T	11
571	V	19
572	F	3
573	L	1
574	X	16
575	O	7
576	W	24
577	M	11
578	J	4
579	T	3
580		
581	G	8
582		14
583	E	6
584		1
585	P	9
586	N	3
587		15
588	R	9
589	A	15
590	W	26
591	M	9
592	T	14
593	V	11
594	B	3
595	X	37
596	K	10
597		7
598	N	19
599		7
600		

601	C	6
602	U	3
603	H	8
604	W	1
605	M	4
606	T	13
607	I	12
608	S	15
609	X	28
610	D	3
611	W	18
612	V	25
613	R	7
614	N	23
615	J	7
616	T	4
617	M	12
618	C	7
619	Z	19
620		
621	G	18
622		9
623	W	5
624	K	14
625		20
626	I	13
627	X	33
628	U	16
629	T	8
630	Y	4
631	M	6
632	N	18
633	V	22
634	W	34
635	L	5
636	F	4
637	X	15
638	R	26
639	O	2
640		
641	T	10
642	M	1
643	E	4
644		5
645	W	25
646	K	17
647		11
648	N	8
649	Z	4
650	C	9

651	S	3
652	X	24
653	J	9
654	G	17
655		10
656		5
657	T	5
658	I	1
659		8
660		
661	W	51
662	M	10
663	N	25
664	R	16
665	V	4
666	T	12
667	U	9
668	A	3
669	W	3
670	K	26
671		16
672	X	35
673	C	15
674	B	5
675	M	8
676	T	9
677	Q	9
678	I	4
679	W	22
680		
681	G	11
682		14
683	D	4
684	N	16
685		4
686	S	4
687	X	6
688	V	17
689	M	5
690	T	15
691	J	2
692	R	25
693	W	27
694	Y	10
695	U	4
696	N	11
697		21
698	P	12
699	X	36
700		

701	A	9
702	M	2
703	C	12
704		3
705	W	11
706	K	25
707	H	7
708	T	6
709	L	4
710	V	21
711	N	6
712		20
713	R	20
714	X	10
715	I	2
716		11
717	M	7
718	W	16
719	T	11
720		
721	E	3
722		2
723	G	16
724		8
725	N	13
726	S	11
727	Z	10
728	C	13
729	W	23
730	M	6
731	V	14
732	T	4
733	K	23
734		5
735	X	23
736	O	6
737	U	17
738	W	19
739	J	8
740		
741	G	10
742		17
743		15
744	N	14
745		5
746	I	3
747		14
748	T	7
749	M	4
750	F	3

751	X	13
752	R	8
753	V	18
754	W	24
755	K	22
756		10
757	A	11
758	S	5
759	T	10
760		
761	E	7
762	Q	7
763	H	5
764	N	19
765	M	10
766	C	10
767	W	33
768	K	3
769		13
770	J	5
771	X	32
772	R	17
773	T	5
774	V	27
775	G	14
776		12
777	W	12
778	D	6
779	M	11
780		
781	N	24
782	I	7
783		13
784	U	2
785	T	3
786	B	4
787	X	26
788	L	2
789	P	4
790	C	7
791	W	26
792	M	9
793	H	9
794	N	15
795	R	27
796	V	1
797	T	14
798	K	27
799		7
800		

801	W	8
802	Y	5
803	G	18
804		10
805	X	34
806	I	5
807		6
808	N	16
809	M	3
810	J	6
811	O	7
812	T	13
813	S	14
814	V	12
815	W	21
816	U	5
817	C	6
818		4
819	X	27
820		
821	N	22
822	Z	3
823	E	4
824		6
825	M	8
826	T	8
827	D	5
828	R	23
829	W	6
830	I	2
831	X	5
832	K	16
833		25
834	H	10
835	T	15
836	G	8
837		17
838	V	16
839	W	35
840		
841	M	12
842	A	4
843	X	4
844	Q	4
845	T	12
846	Y	7
847	J	9
848	S	15
849	W	31
850	L	3

851	V	26
852	N	18
853	M	6
854	B	6
855	Z	7
856	R	19
857	W	15
858	C	8
859	T	9
860		
861	K	11
862		26
863	P	8
864	G	14
865		9
866	X	37
867	I	4
868		9
869	M	5
870	F	4
871	W	4
872	A	10
873	U	20
874	V	5
875	T	10
876	Q	10
877	H	6
878	W	11
879	M	10
880		
881	Y	8
882	X	19
883	R	13
884	N	9
885		4
886	E	3
887		8
888	K	16
889		6
890	Z	22
891	T	5
892	V	19
893	W	17
894	G	11
895		1
896		10
897	J	3
898	X	8
899	M	4
900		

901	C	11
902	T	4
903	S	6
904	I	12
905	W	29
906	K	5
907		19
908	X	30
909	V	20
910	M	7
911	N	10
912	Z	15
913	O	4
914	D	4
915	R	7
916	W	14
917	Y	10
918	T	11
919	U	6
920		
921	H	7
922	X	14
923	M	11
924	C	10
925	B	3
926	W	24
927	K	23
928	A	6
929	T	6
930	G	4
931		17
932	N	25
933	V	23
934	F	3
935	X	22
936	M	2
937	I	8
938		1
939	W	51
940		
941	L	5
942	J	1
943	T	2
944	R	11
945	N	23
946		7
947	C	9
948	S	1
949	Z	2
950	M	6

951	W	18	1001	W	26	1051	D	6	1101	V	27
952	V	2	1002	O	6	1052	N	13	1102	H	5
953	K	17	1003	N	5	1053	M	7	1103	W	21
954		10	1004		21	1054	P	11	1104	S	5
955	T	7	1005	R	5	1055	Y	3	1105	C	15
956	X	2	1006	T	5	1056	T	9	1106	X	35
957	G	14	1007	K	27	1057	G	8	1107	M	8
958		8	1008		7	1058		11	1108	B	5
959		5	1009	V	17	1059	W	20	1109	N	22
960			1010	X	3	1060			1110	R	20
961	E	2	1011	M	1	1061	S	15	1111	T	5
962		4	1012	A	15	1062	X	15	1112	I	5
963	W	16	1013	W	3	1063	V	10	1113		10
964	U	23	1014	U	13	1064	R	8	1114	G	17
965	H	8	1015	N	14	1065	H	4	1115		9
966	P	6	1016	C	6	1066	T	13	1116	W	12
967	T	3	1017	H	9	1067	M	6	1117	J	9
968	M	8	1018	G	17	1068	W	25	1118	Q	1
969	I	13	1019		14	1069	C	13	1119	X	18
970	N	6	1020			1070		3	1120		
971		19	1021	T	12	1071	N	18	1121	Y	2
972	R	16	1022	L	1	1072	K	26	1122	M	11
973	X	20	1023	W	28	1073	I	4	1123	T	15
974	S	4	1024	M	12	1074	Z	11	1124	F	4
975	W	7	1025	B	4	1075	L	2	1125	W	47
976	V	9	1026	I	2	1076	T	11	1126	K	23
977	T	15	1027		7	1077	V	15	1127	P	12
978	K	9	1028	X	28	1078	M	5	1128	V	16
979		22	1029	S	13	1079	W	19	1129	N	3
980			1030	T	8	1080			1130		19
981	D	3	1031	E	5	1081	E	6	1131	R	22
982	N	11	1032		3	1082		1	1132	X	1
983		16	1033	R	10	1083	J	2	1133	S	14
984	M	10	1034	W	2	1084	R	27	1134	C	10
985	C	5	1035	K	5	1085	X	9	1135	W	15
986		7	1036		11	1086	T	6	1136	M	3
987	W	39	1037	N	15	1087	G	14	1137	T	14
988	G	10	1038	Z	21	1088	A	8	1138	G	16
989		18	1039	V	6	1089	D	4	1139		10
990	Y	1	1040			1090	W	24	1140		
991	X	16	1041	M	4	1091	M	10	1141	N	16
992	Q	9	1042	T	4	1092	Z	22	1142	O	7
993	T	10	1043	J	4	1093	K	16	1143	I	14
994	I	11	1044	X	36	1094		10	1144	Z	5
995		3	1045	G	15	1095	A	5	1145	U	15
996	S	3	1046		12	1096	N	4	1146	H	7
997	Z	12	1047		10	1097		20	1147	W	30
998	J	7	1048	C	12	1098	U	19	1148	K	25
999	M	9	1049	W	11	1099	T	10	1149		8
1000			1050	U	14	1100			1150	V	8

1151	T	3
1152	M	2
1153	E	4
1154	N	24
1155	R	9
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