A Mathematical Notes

A1 The tangent lines to two curves are conjugate polar lines with regard to a sphere. Prove that

$$\rho^2 p^5 / \sigma \gamma^4 = p_1^2, p_1^3 / \sigma, \gamma^4$$

or that $\gamma \gamma_1 /(\sigma.\sigma_1)^{0.5}$ =rad. of sphere

A2 Tangent lines to two curves are polar reciprocals with regard to $ax^2 + by^2 = 2z$

A3 Equation A and Equation B

A4 In connection with Gaussian representation of surface in terms of two variables u, r, we have seen that three quadratic forms i) (E, f, g,)(x, y)^2 , ii) L μ, N)(x, y)^2 iii) (Δ_ll.c)(x.y)^2 are absolute invariants for any variables (x. y), which obey the same linear transformation as δυ ,δv.

A5 Neville. L. M. S. 1917 p. xxvii

A6 Binary form.

A7 Derived magnitudes of any order.

A8 Laguerre's and Darboux's formulae for orthogonal curves.

A9 Laguerre's formulae. Includes: Application of Laguerre's formula.

A10 Laguerre's formula with an example.

A11 Curves of superosculation.

A12` Forsyth's derived magnitudes of the fourth order (Extension of Laguerre's formula)

A13 Functions of the third order in differential coefficients of ϕ transforming as P Q R S.

A14 Tensor analysis.

A15 Bertrand curves.

A16 Examples of Helix as Indicatrix curve.

A17 Families of curves.

A18 Bateman's curve.

A19 A pair of Bertrand curves derived from the P. N. Indicatrix

A20 Curves F (p.σ) = 0

A21 Darboux's applications.

A22 Two Bertrand curves given by

$$1/c = 1/p + (\cot w/\sigma)1^2 = -1/p + (\cot w/\sigma^1)1^2$$

A23 All these four cases, curve under the same ground rule.

A	**Mathematical Notes** (cont.)
A24	Family of curves given by F (p,σ) = 0
A25	Alternative (to Frenet's equations) for finding circumference and tortuosity of a derived curve. Includes Bonnet's Formulae, Bonnet's equation by resolution of spins, Loxodrome on Catenoid
A26	Orthogonal Trajectories of singly infinite family of spheres.
A27	Orthogonal Trajectory of singly infinite family of planes.
A28	Surface envelope of single infinite family of spheres.
A29	Fundamentals of surfaces: envelope of spheres.
A30	Geodesics on Paraboloids.
A31	Theory of curves and surfaces. Includes Developables associated with Curve, Frenet Serret formulae, Formulae in oblique axes, Application of Frenet's equations, Curvature of projection of curve, Theory of Evolutes, Rectifying developable, Involute of a curve.
A32	Helices. Includes: Spherical helix, Helix on hyperboloid of revolution of one sheet, Helix on any surface, Helices Jolliffe's theorem, Helix on elliptic cone, Helices on cone of second order, Helix on hyperboloid of one sheet.
A33	Determination of curve from its intrinsic equations. Includes: Conical helix, Imaginary algebraical helices, Characteristic Eq^n for curves. Curve determined from its curvature and tortuosity.
A34	Eisenhart p. 18 and Bianchi vol. I chapt. II differential quadratic forms
A35	Differential invariants and Christoffel's symbols.
A36	Christoffel 3 index symbols.
A37	Curvilinear Coordinates.
A38	Conjugate lines.
A39	Curves on surfaces.
A40	Congruencies.
A41	Derived surfaces.
A42	Surfaces with one system of plane lines of curvature. Includes: Line element of Pseudosphere.
A43	Pseudospherical Helicoids.
A44	The functions of direction which involve the rates of change of the Normal curvature & Geodesic torsion.
A45	Geodesics on a right cone.
A46	Generators of a hyperboloid in confocal coordinates.

A **Mathematical Notes** (cont.)

A47	Nature of a [line].	
A48	Geodesics on Hyperboloid.	
A49	Hyperboloid of two sheets.	
A50	Geodesic lines on Paraboloids.	
A51	Geodesics on surface of revolution generated by a tractrix [?] about the axis.	
A52	Geodesics on a Catenoid.	
A53	Surface generated by straight lines.	
A54	Minima surface	
A55	If a surface of revolution be deformed into a minimal surface.	
A56	Surfaces of Revolutions applicable to a sphere.	
A57	Surface by moving axes.Includes: Torsion and curvature of the asymptotic lines. Centre of spherical curvature. Surface of Centres. Radii of curvature of the sequential and concomitant curves on the surface of centres. In the Weierstrassian notation. Radii of curvature of a paraboloid. Confocal paraboloids. Curves on a sphere. Transformation.	
A58	Curvature of quadrics.	
A59	Surface in terms of two parameters and Solid Geometry VIII and Solid Geometry III.[examination questions]	
A60	Tripos and college examination questions [97 items]	c1884-1924
A61	Differential geometry.	
A62	I. Serret’s formulae for edge of regressions. II. Salmon’s Theorems. III, Richmond's cubic geodesics. Cesàro’s problem	
A63	Nul lines.	
A64	Illustration of the use of Beltrami’s apparatus	
A65	Surface by use of moving axes. Includes: Geodesics torsion. Bonnet's theorem on integral curvature.	
A66	Bonnet’s theorem.	
A67	Surface: Normal curvature. Includes: Christoffel equations and symbols. The Gauss and Codazzi relations. Frobenius form of Gauss.	
A68	Curve on surface. Includes: Bonnet’s formula. Note on Geodesic curvature. Geodesic torsion	
A69	Lines of a curvature near an Umbilic.	
A70	Weingarten surfaces.	

A **Mathematical Notes** (cont.)

A71	Surface referred to conjugate curves.
A72	Inversion preserves lines of curvature.
A73	Surface of centres.
A74	Surface referred to lines of curvature.
A75	Analytical calculation of centre surface.
A76	Elementary proof of Laguerre.
A77	Bianchi's complementary surface.
A78	Ribaucour's surfaces.
A79	Conjugate directions in tangential and in homogeneous coordinates.
A80	Darboux proceeds to find all surfaces possessing plane conjugate curves
A81	Darboux’s theorem on plane conjugate curves
A82	Surface with plane lines of curvature.
A83	Surface with circular lines of curvature.
A84	Orthogonal cubic cyclides.
A85	To find the Weingarten surfaces with plane lines of curvature.
A86	Inversion of cyclide.
A87	Dupin’s cyclides in confocal coordinates.
A88	Quotes from Eisenhart on lines of curvature.
A89	Polar reciprocation.
A90	Conjugate curves.
A91	Spherical representation. Includes: Possibilities of spherical representation, Surface referred to asymptotic curves
A92	The equation for the form is: [?] plus 2 pages of examples. Includes: The sequential curve is geodesic on the first sheet.
A93	P.N. Indicatrix.
A94	Combescure's transformation.
A95	Examples of ruled surfaces applicable to hyperbolic paraboloid.
A96	On a surface of given line element let an asymptote line be given and also the radii of curvature along it.
A97	[DeMarques’?] surfaces

A **Mathematical Notes** (cont.)

A98	Deformation of surfaces preserving lines of curvature.
A99	Deformation of hyperbolic paraboloid.
A100	Examples of ruled surfaces derived from hyperbolic paraboloid.
A101	Can the lines of a curvature of ruled surface form an isothermic system?
A102	Application to deformation of hyperboloid.of one sheet.
A103	Forsyth p 407.
A104	Examples of Eisenhart.
A105	Helicoid applicable to Catenoid.
A106	Forsyth p 509.
A107	Ruled surfaces applicable to a surface of revolution.
A108	Deformation of hyperboloid of revolution.
A109	Darboux' simplification.
A110	Hyperboloid [deferred?] to generators.
A111	Can a given curve C be the base of two applicable ruled surfaces.
A112	Pseudosphere and Parabolic type.
A113	Ruled surfaces. Includes: Possible ruled surfaces with the same line element, Deformation of ruled surfaces, Deformation of hyperboloid of revolution, Mobius cubic surface and examples.
A114	On a surface of given line element, let two [?] curves be asymptotic lines.
A115	Skew ruled surfaces.
A116	Determination of a ruled surface from its line of striction.
A117	Cyclides.
A118	Pentaspherical coordinates, Darboux I ch vi
A119	Anallagmatic surfaces.
A120	Darboux. Chapter ii and iii. Includes: Darboux’s characteristic equation, Forsyth, Darboux’s theorem, Orthogonal surfaces of revolution, Combescure transformation.
A121	Triply orthogonal surfaces. Includes: Reciprocal of Dupins theorem and Bianchi's theorem.
A122	Orthogonal surfaces. Includes: Dupin's theorem, Darboux’ theorem.

A **Mathematical Notes** (cont.)

A123 Cayley's version of Lamé condition. Includes: Cayley vol. viii, Cayley's view of orthogonal surface.

A124 Lamé surfaces.

A125 Normal cyclic congruences.

A126 Darboux' theorem vol. iv. p 143

A127 A congruence of circles drawn in the tangent planes to a given surface can be a normal cyclic system?

A128 Special problems.

A129 To obtain the lines of curvature on any w surface. We must group the circles (orthogonal to it) moving along a line of curvature of the originating surface.

A130 Analytical investigation of lines of curvatures on w surface.

A131 Special forms of φ.

A132 Orthogonal cyclides, given by one cyclide and circles orthogonal to it and to sphere $p^2=b^2$.

A133 A family of circles can be a normal system.

A134 Lines of curvature on quadrics. Includes: Rectifying lines, Confocal paraboloids, Indicatrix for paraboloids

A135 Oblique sections.

A136 Properties of lines of curvature.

A137 Parabolic curve on a surface.

A138 Normal curvature.

A139 Hyperboloid referred to generator as axis of x and the centre point on it as origin.

A140 To form the differential equation of the lines of curvature for a surface given in cylindrical coordinates.

A141 Lines of curvature on cylindroid 2z=csin 2q.

A142 Radii of curvature &c on skew surface

A143 Radii and lines of curvature on a right conoid.

A144 Lines of curvature. Includes: Osculating planes of a line of curvature, Surface in tangential coordinates, Surface in terms of two parameters, Dupin's theorem.

A145 Lines of curvature in the rectn. hyperbolic paraboloid xy=az

A146 The indicatrix.

A **Mathematical Notes** (cont.)

A147 Umbilics

A148 Curvature of quadrics.

A149 Orthogonal trajectories of the circle. Includes: Surface ref. and its lines of curvature, Surface with spherical lines of curvature.

A150 [Three equations]

A151 The geodesics on Liouville's surfaces form an easy example on moving axes.

A152 Salmon's integral for geodesics.

A153 Critical geodesics on helicoid. Includes: Paraboloid of revolution, Geodesics on central quadrics of revolution, In elliptic function.

A154 In line of curve v V_1 V_2 are [.] foci.

A155 Osculating plane of umbilical geodesic on [?]

A156 Geodesics on hyperboloid of two sheets.

A157 Hyperboloid of one sheet.

A158 Generators of hyperboloid. x2/a+y2/a+z2/c=1

A159 Hyperboloid of one sheet.

A160 Case ii. h=-c

A161 Umbilical geodesics on ellipsoid.

A162 Expansion of coordinates in terms of geodesic polar coordinate.

A163 Geodesic coordinates.

A164 Umbilical geodesics on ellipsoid.

A165 In the discussion of umbilical geodesics on the ellipsoid. We show that the irrationalities,,,.

A166 Geodesics

A167 Tangent lines to a family of geodesics on a given surface can be.cut at [right angles] by a family of parallel surfaces and this property is peculiar to geodesics. Includes: Confocal coordinates in space, Liouville's surface.

A168 Geodesics and their orthogonal trajectories.

A169 Geodesic parallels.

A170 The shortest distance between two points on a surface.

A171 Bonnet’s application of Sturm’s theorem.

A172 Sturm’s theorem.

A **Mathematical Notes** (cont.)

A173 Surfaces such that a relation exists between their given radii of curvature. Weingarten surfaces. Includes: Surface of constant mean curvature, Surface of constant specific curvature.

A174 Surfaces whose lines of curvature are all plane.

A175 Orthogonal circles on the sphere.

A176 An example from u, v to p, q as coordinates to prove algebraically.

A177 The arguments that can occur in covariantive [function] are 17. Includes: Normal and geodesic curvature of the orthogonal trajectory, Concomitants of two curves.

A178 Geometry of families of curves on a surface.

A179 Bonnet's formula for geodesic curvature and orthogonal curves.

A180 Direct verification of $kg = k^1/k$

A181 The second differential parameter of a family of curves.

A182 Transformation of third differential of ϕ.

A183 Parabolic curve on a surface.

A184 On double surfaces.and B. M. Sen's offprint of same title
See description of B5

A185 8 Tripos and college examination questions 1889-1897

A186 Two orthogonal systems of small circles project stereograph onto orthogonal systems of circles.

A187 Surface with lines of curvature of constant geodesic curvature.

A188 Surface for which the lines of curvature have constant geodesic curvatures.

A189 Bianchi chapter xxi. Includes: Surface with one family of lines of curvature circles, A surface is the envelope of a family of spheres, Surfaces having one set of lines of curvature plane and the other set circles, Pseudo-spherical surface with a system of plane lines of curvature, Surface of constant positive curvature, with one set of lines of curvature [?], Pseudo-spherical helicoids of Dini, General surfaces of Monge, Molding surfaces, Surface of Monge with conical direction, Surface of Joachimstahl

A190 Dupin cyclides derived from two parabolas.

A191 Dupin's cyclides.

A192 The tangential plane of a surface in $\gamma x + \mu y + vz = p$ Includes: Polar reciprocation.

A193 Surface of constant specific curvature with one family of lines of curvature spherical. Includes: Darboux, Plane lines of curvature, Isothermic Joachimsthal surfaces.

A	**Mathematical Notes** (cont.)
A194	The cyclide, Clerk Maxwell; Dupin's cyclide
A195	The cyclide - construction of the cyclide, Cyclide of revolution and Confocal Cyclide.
A196	The parameters of three orthogonal surfaces being ($\alpha\beta\gamma$). Includes Confocal quadrics, Spins on the Ellipsoid and confocal cones.
A197	Four spheres in general have a radical centre.
A198	Isometric coordinates.
A199	Necessary and sufficient coordinates that the surfaces be isothermic.
A200	Surfaces whose line of curvature are isothermal.
A201	Isothermic surfaces.
A202	Isothermic surfaces. Bour and Christoffel's theorem.
A203	Curvilinear coordinates in 3 dimensions.
A204	Notes on calculus of variations.
A205	Riemann's minimal surface.
A206	Surface generated by circles.
A207	Tangential equation of Weierstrass' variable. Includes: Lies double surfaces.
A208	Eisenhart.
A209	Real algebraic minimal double surfaces. Includes minimal surfaces.
A210	Bonnet's example.
A211	Tangential equation of minimal surfaces.
A212	Helicoidal minimal surfaces.
A213	Appell's surfaces. Bonnet's surfaces.
A214	Goursat's surfaces.
A215	Deformation of minimal surfaces.
A216	Associate surfaces.
A217	Minimal surfaces.
A218	Minimal surface in terms of lines of curvature.
A219	Geodesics.
A220	Geodesics on helicoid.

A	**Mathematical Notes** (cont.)
A221	Geodesics on quadric cone.
A222	Geodesics on the paraboloid.
A223	Lie’s theorem.
A224	Asymptotic lines.
A225	Gauss and Codazzi.
A226	Applicability of surfaces. Includes: Tests for applicability of surfaces, Helicoidal deformations, Deformation of surfaces, Deformation operator, Darboux' theorem, Bonnet’s form, Deformation of paraboloid, preserving lines of curvature.
A227	Darboux Vol. III. Includes: Legendre's theorem on Geodesic triangles, Area of geodesic triangle ABC.
A228	Gauss and Legendre's Theorems
A229	Illustration of Codazzi: The Pseudosphere.
A230	Bianchi's surfaces.
A231	Geodesic circles.
A232	Deformation of surfaces.
A233	Gnomonic representation of sphere. Beltrami variables.
A234	Surfaces of revolution of specific curvature.
A235	Numerical values, Barrel form.
A236	On construction of nodoid.
A237	Specific case gives unduloids
A238	Surfaces of revolution of constant mean curvature. Nodoids and Unduloids
A239	Geodesic circles.
A240	Latitude and longitude coordinates on pseudosphere.
A241	Geodesics on tractroid.
A242	Geodesics orthogonal on tractroid to given geodesics.
A243	Pseudosphere.
A244	Geodesics polar coordinates.
A245	Geodesic circles.
A246	Hourglass. [Includes graphs.]

A **Mathematical Notes** (cont.)

A247 Pseudosphere III. Hyperbolic type of revolution.

A248 Helicoidal surfaces of constant specific curvature.

A249 Dini's helicoids: pseudospheres.

A250 Deformation is continuous. Includes: Deformation of surfaces, Weingarten's mean surface, Asymptotic lines, Deformation of ruled surface without preservation of generators.