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## 5 Mathematical-Software: symbolic packages written

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Title: **Differential Geometry**  
Purpose: Co-authored with Ian Anderson. Commands and subpackages for computations in the areas of calculus on manifolds (vector fields, differential forms and transformations); tensor analysis; calculus on jet spaces; Lie algebras and Lie and transformation groups. .  
Found at: The Maple system since 2007 as the DifferentialGeometry package.

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Title: **Differential Algebra**  
Purpose: Co-authored with François Boulier. Differential elimination in Maple interfacing with the Bibliothèques Lilloises d'Algebre Differentielle (BLAD) from the Laboratoire d'Informatique Fondamentale de Lille, France. .  
Found at: The Maple system since 2010 as the DifferentialAlgebra package.

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Title: **PDEtools**  
Purpose: Tools for studying and solving partial differential equations, including a complete module for symmetry methods for partial differential equations (see 3.2.17).  
Found at: The Maple system since 1997 and related updates to today as the PDEtools package.

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Title: **pdsolve**  
Purpose: Closed form solutions for (systems of) Partial Differential Equations.  
Found at: The PDE-solver of the Maple computer algebra system since 1997 and related updates to today.

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Title: **ODEtools**  
Purpose: Calculation and use of integrating factors and Lie symmetries for solving first and higher order ODEs (see 3.2.9, 3.2.10, 3.2.12, 3.2.8). Includes work by Austin Roche and Theodore Kolokolnikov for Abel equations integrating factors and linear symmetries.  
Found at: The Maple system since 1997 and related updates as the DEtools-Lie package.

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Title: **dsolve**  
Purpose: Closed form solutions for (systems of) Ordinary Differential Equations.  
Found at: The ODE-solver of the Maple computer algebra system since 1997 related updates to today - includes work by Mark van Hoeij for linear ODEs.

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Title: **Physics**  
Purpose: A computational environment for symbolic computations in Physics covering from undergraduate courses - Classical and Quantum Mechanics, Electrodynamics, Relativity - to grad courses like advanced General Relativity and Quantum Field theory.  
Found at: The Maple 11 computer algebra system since 2007.

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Title: **Grassmann**  
Purpose: Symbolic computation with anti/non-commutative variables (see 3.2.11).  
Found at: The Maple Applications Center, now part of the Maple Physics package.

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Title: **Partials**  
Purpose: Computation with tensor fields and functional differentiation (see 3.2.21).  
Found at: The Maple Applications Center , now part of the Maple Physics package.

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Title: **Vectors**  
Purpose: Vector analysis using *algebraic* vectors and differential operators.  
Found at: The Maple 11 computer algebra system since 2007.

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Title: **ThreePlusOne**  
Purpose: General Relativity software package implementing computational representations and related operations for the 3+1 decomposition and the ADM formulations used in Numerical Relativity.  
Found at: The Maple 2019 computer algebra system since 2019.

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Title: **Tetrads**  
Purpose: General Relativity software package implementing computational representations and related operations for classifying metrics (Petrov, Plebanski-Petrov and Segre, classifications) and computing with tensors in a local system of references (the tetrad system).  
Found at: The Maple 2019 computer algebra system since 2019.

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Title: **Database of Solutions to Einstein's Equations**  
Purpose: Co-authored with Denitsa Staicova. A Maple database digitalizing the 991 spacetime metrics found in the book "Exact Solutions to Einstein's Field Equations" by Stephani, H.; Kramer, D.; MacCallum, M.; Hoenselaers, C.; and Herlt, E, including searching capabilities, automatic setting of tetrads, and full computable integration with the General Relativity commands of the Physics package.  
Found at: The Maple computer algebra system since 2019.

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Title: **FeynmanDiagrams**  
Purpose: Particle Physics software to compute an expansion of the Scattering matrix for a model in coordinates representation, or the Scattering matrix element in momentum representation, and the corresponding Feynman Diagrams.  
Found at: The Maple 2021 computer algebra system since 2021.

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Title: **FeynmanIntegral**  
Purpose: Particle Physics software to compute the Feynman integrals appearing in the expansion of the Scattering matrix in momentum representation.  
Found at: The Maple 2021 computer algebra system since 2021.

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Title: **StandardModel**  
Purpose: Software that implements computational representations for the mathematical objects formulating the Standard Model in particle physics.  
Found at: The Maple 2021 computer algebra system since 2022.

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Title: **MathematicalFunctions**  
Purpose: A package of symbolic and numerical tools for elementary and advanced algebraic and numerical computing with mathematical functions. Includes the FunctionAdvisor Maple command.  
Found at: The Maple computer algebra system since 2015.

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Title: **The conversion network for mathematical functions**  
Purpose: This package implements a net of conversion routines in the Maple computer algebra system permitting the expression of any of the 190 mathematical function in terms of another one, whenever that is possible as a finite sum of terms with rational coefficients.  
Found at: The Maple help system since 2010.

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Title: **MathematicaTranslator**  
Purpose: A translator of Mathematica expressions to Maple expressions and also translating Mathematica notebooks to Maple worksheets.  
Found at: The Maple 9 computer algebra system.

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Title: **LaTeX**  
Purpose: A translator from Maple to LaTeX, both interactively (expressions) or exporting whole Maple worksheets.  
Found at: The Maple 2020 computer algebra system since 2021.

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## 6 Mathematical-Software: numerical packages written

Title: **PDEplot: project and supervision of development**  
Purpose: Coding by Austin Roche, numerical computation and plotting of solutions for non-linear first order Partial Differential Equations (characteristic strip method).  
Found at: The *PDEplot* command of the Maple system since 1997.

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Title: **DNA**  
Purpose: Fast numerical computation of solutions for ODE systems.  
Found at: Co-authored with Allan Wittkopf, experimental routines for ODE numerical solving, evolved into the *dsolve/numeric* of the Maple system since 2001.

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Title: **Poincare**  
Purpose: Plotting of Poincare sections of Hamiltonian dynamical systems (see 3.2.14).  
Found at: The *DEtools-Poincare* package of the Maple system since 1997.

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Title: **Numerical computation of Elliptic functions**  
Purpose: Numerically evaluate the 18 Jacobi and 13 inverse Jacobi elliptic functions.  
Found at: Subroutines of the Maple *evalf* command of the Maple system since 2001.

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Title: **Numerical computation of the Heun functions**  
Purpose: Numerically evaluate the 23 Heun functions solving linear ODEs of 2nd order with 4 singularities and their confluent cases.  
Found at: Subroutines of the *evalf* command of the Maple system since 2017.

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Title: **Numerical computation of the Appell doubly hypergeometric functions**  
Purpose: Numerically evaluate the four Appell functions.  
Found at: Subroutines of the *evalf* command of the Maple system since 2020.

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Title: **Numerical computation of the Integral Transforms**  
Purpose: Numerically evaluate the 11 integral transforms of the mathematical language.  
Found at: Subroutines of the *evalf* command of the Maple system since 2021.

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Title: **Numerical routines for specialized functions of Particle Physics: Project and supervision of development**  
Purpose: Numerically evaluate the Polylog, Multi Polylog and Multi Zeta functions.  
Found at: Subroutines of the *evalf* command of the Maple system since 2018.

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Title: **Evalf**  
Purpose: A package of commands for the numerical evaluation of mathematical expressions and functions, numerical experimentation, and fast development of numerical algorithms.  
Found at: The Maple computer algebra system since 2015, Evalf is now part of the hybrid *MathematicalFunctions* package (see 5).

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## 7 Technical writing

Title: **Computer Algebra Interactive Handbook of Ordinary Differential Equations**  
Purpose: Classification and Information about Ordinary Differential Equations, their properties and methods of solution.  
Found at: The *odeadvisor* command of the Maple system since 1977.

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Title: **Computer Algebra Interactive Handbook of Mathematical Functions**  
Purpose: Information about and computation of properties and identities for the mathematical functions.  
Found at: The *FunctionAdvisor* command of the Maple system since 2003.

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Title: **Mini-Course, Computer Algebra for Physicists**  
Purpose: A practical mini-course of 127 pages teaching computer algebra for physicists.  
Found at: The Maple system since 2018.

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Title: **A Complete Guide for performing Tensors computations using the Physics package**  
Purpose: A 110 pages electronic hyperlinked textbook presenting how to perform varied tensor computations.  
Found at: The Maple system since 2020.

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Title: **Physics Courseware Support: Mechanics**  
Purpose: A 126 pages electronic hyperlinked pedagogical material about Mechanics using computer algebra, including solved exercises.  
Found at: The Maple system since 2022.

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Title: **Examples in Physics**  
Purpose: A 145 pages electronic hyperlinked pedagogical material illustrating, with solved examples, the use of computer algebra in Physics, from Vector Analysis to General Relativity and Quantum Field theory.  
Found at: The Maple system since 2017.

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Title: **The Appell double-hypergeometric functions**  
Purpose: A 10 pages electronic hyperlinked presentation of the Appell functions.  
Found at: The Maple help system since 2017.

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Title: **The Heun functions**  
Purpose: A 10 pages electronic hyperlinked presentation of the Heun functions.  
Found at: The Maple help system since 2010.

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Title: **The Elliptic, Jacobi and Inverse Jacobi functions**  
Purpose: A 40 pages electronic hyperlinked presentation of this set of elliptic functions.  
Found at: The Maple help system since 2015.

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Title: **The Maple help pages for the packages: Physics, Differential Geometry, Differential Algebra, PDEtools, DEtools, dsolve and pdsolve**  
Purpose: Approximately 500 pages electronic hyperlinked presentation of the each of the commands of these Maple packages.  
Found at: The Maple help system since 2001.

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## 8 Supervision of students

### 8.1 Scattering Amplitudes: from Geometry to Experiment, Europe

1. Kays Haddad, SAGEX, July/2021 - December/2021.  
*Keywords:* Software development for the computation of Feynman integrals and dimensional regularization (see 4.1).
2. Davide Polvara, SAGEX, July/2021 - December/2022.  
*Keywords:* Software development for the computation of Feynman diagrams in coordinate and momentum representation and related graphical representations (see 4.2).
3. Andrea Cristofoli, SAGEX, July/2021 - December/2021.  
*Keywords:* Pedagogical material for applications of General relativity using a 3+1 decomposition.
4. Hjalte Frellesvig, SAGEX, July/2018 - December/2018.  
*Keywords:* Software development for the computation of the GeneralizedPolylog and Multizeta functions.
5. Lucia Hosekova, SAGEX, July/2013 - December/2013.  
*Keywords:* Software development in the C language for computing the kernel of Feynman diagrams in momentum representation.

### 8.2 Doctorate

1. Luis Guilherme Silva Duarte, Federal University of Rio de Janeiro, March/96 - July/97.  
*Keywords:* Lie symmetry methods, symbolic computation (see 3.2.12, 3.2.10).

2. Austin D. Roche, Faculty of Mathematics, Simon Fraser University, since January/03 - June/10.  
*Keywords:* Abel type ODEs classes with no constant invariants (see 3.1.1, 3.2.3). Co-supervision with Peter Borwein from the Mathematics Department at Simon Fraser University.

### 8.3 Master

1. Katherina von Bülow, University of Waterloo, Faculty of Mathematics, Aug/97 - April/00.  
*Keywords:* Second order linear ODEs, Classical invariant theory, Hypergeometric solutions, Symmetries.
2. Danilo Teixeira, CBPF, July/94 - August/96.  
*Keywords:* Supersymmetry, gauge invariance, symplectic method (see 3.2.20 and 3.2.24 ).
3. Felipe de Medeiros, CBPF, July/94 - August/96.  
*Keywords:* Quantum fields, perturbative methods, divergences (see 3.2.22).

### 8.4 Undergraduate '97 - '2001

1. Lemmus Chan, Department of Mathematics, Simon Fraser University, Apr/2001 - Sep/2001.  
*Keywords:* Hypergeometric solutions for linear second order ODEs, symbolic computation.  
Comments: This project explored an equivalence approach under compositions of Moëbius and arbitrary power transformations in order to compute hypergeometric solutions when a Liouvilian solution is not available. A computer algebra implementation of the algorithm was incorporated to the Maple system for its 2001 release.
2. Austin Duncan Roche, Faculty of Mathematics, University of Waterloo, Jan/97 - Jul/99.  
*Keywords:* Integrating factors, non-linear second order ODEs, Abel first-order ODEs, numerical solutions for non-linear first-order PDEs, symbolic computation .  
Comments: Four publications resulted from the supervision of Austin's work (see 3.2.3, 3.2.6, 3.2.8, 3.2.9). Austin's report-work on numerical solutions for non-linear first order PDEs was awarded in the Applied Mathematics Department - first term - 1997. The resulting software is currently the numerical PDEplot routine of the Maple system.
3. Theodore Kolokolnikov, Faculty of Mathematics, University of Waterloo, Sep/96 - Sep/97.  
*Keywords:* Symbolic solutions, Lie symmetry methods, Abel and Riccati type ODEs, symbolic computation.  
Comments: Theodore continued his work on Lie methods and Abel ODEs started in the U.Waterloo, by doing his Master - same subjects - with Prof. Bluman, at the University of British Columbia.
4. Katherina von Bülow, IME-UERJ, March/94-March/96.  
*Keywords:* PDE solving methods, separation of variables, symbolic computation.  
Comments: Katherina's work resulted in one National Award in Brazil, by the "Sociedade Brasileira de Matematica Aplicada e Computacional", SBMAC 1994, one publication, one software package constituting the core of Maple's pdsolve algorithm for separating variables. This work resulted in presentation in conferences (see 3.2.17. 3.2.18, 3.3.33 and 3.3.35).