

## Algebraic and Semi-Algebraic Reasoning in Formal Methods

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**Location:** IMDEA Software Institute, Madrid  
**Dates:** July 7 - 18, 2025

Proving properties of programs and cyber-physical systems requires us to reason about nonlinear arithmetic. In the 1920s Tarski developed an automated decision procedure that demonstrated decidability of the nonlinear arithmetic over reals and developed a quantifier elimination procedure. Later work by Collins made numerous algorithmic improvements. More recently, deeper connections have been discovered between the problem of proving algebraic and semi-algebraic properties of systems and areas such as convex optimization and measure theory.

We will present some of these approaches and discuss their power when it comes to proving properties of programs and differential equations. Topics include:

- **Algebraic reasoning:** Hilbert's nullstellensatz, Grobner bases and Application.
- **Semi-algebraic reasoning:** Positive polynomials, Sum of Squares programming, moment problems and alternatives.
- **Applications:** Proving properties of programs, cyber-physical systems and control systems.

**Logistics:** Timing and precise location TBD.

**Pre-requisites:** Basic mathematics at the undergraduate level. The course is particularly suited for audience with interest in formal methods (including logic/automated reasoning), control theory, robotics or dynamical systems.

**Questions:** Email [srirams@colorado.edu](mailto:srirams@colorado.edu).



David Hilbert



Alfred Tarski



George E. Collins



Bruno Buchberger