Lester R. Ford Awards for 1998

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LESTER R. FORD AWARDS FOR 1998

The Lester R. Ford Awards, established in 1964, are made annually to authors of outstanding expository papers in the MONTHLY. The awards are named for Lester R. Ford, Sr., a distinguished mathematician, editor of the MONTHLY (1942–46), and President of the Mathematical Association of America (1947–1948).

Winners of the Lester R. Ford Awards for expository papers appearing in Volume 105 (1998) of the MONTHLY are:

Yoav Benyamini, Technion–Israel Institute of Technology, Applications of the Universal Surjectivity of the Cantor Set, pp. 832–839

A classical theorem due to Alexandroff and Hausdorff states that every compact metric space is the continuous image of the Cantor set. In this paper Yoav Benyamini presents striking applications of this result to diverse areas of mathematics. Each of these applications involves an existence theorem that Benyamini shows us how to prove using the universal surjectivity of the Cantor set. Some of these results are well known, such as the existence of space-filling curves and the isometric identification of every separable Banach space with a subspace of $C([0,1])$. Other results are more unusual, such as the existence of a compact convex subset of $\mathbf{R}^{n+2}$ whose faces include congruent copies of all compact convex subsets of the unit cube in $\mathbf{R}^n$. Other results are even more counter-intuitive, such as the existence of a continuous real-valued function f on $\mathbf{R}$ with the property that for every bounded sequence (a_n) of real numbers, there exists $t \in \mathbf{R}$ with $f(t+n) = a_n$ for all n. Benyamini ties all these results together in a pretty package with the common theme that the Cantor set and its universal surjectivity lurk behind many strange phenomena.

Jerry L. Kazdan, University of Pennsylvania, Solving Equations, an Elegant Legacy, pp. 1–21

The paper discusses various types of equations: polynomial equations in one and several variables, linear and nonlinear differential equations, diophantine equations, and congruences. The overriding idea is that familiar procedures for solving equations, often viewed as "tricks", can be seen as belonging to broad themes that, in turn, yield new insights on equations. Among the themes are: exploiting symmetry, finding a related problem, understanding the family of all solutions, finding obstructions when an equation has no solution, using variational methods, and reformulating a problem. An extensive discussion of symmetry is an important unifying thread. It bears on complex conjugation, linear differential equations, Markov chains, Lie's "Galois" theory of differential equations, and Pell's equation. Kazdan's article is an instructive and wide-ranging tour of the mathematician's workshop in important classes of equations.

Bernd Sturmfels, University of California, Berkeley, Polynomial Equations and Convex Polytopes, pp. 907–922

How many complex zeros can d polynomials in d variables have? In the case of the bivariate system

$$a_1 + a_2x + a_3xy + a_4y = b_1 + b_2x^2y + b_3xy^2 = 0$$

with nonzero real coefficients, Bezout's theorem gives an upper bound of six solutions. But it has exactly four. To achieve this better estimate, we use an idea of Newton. To a bivariate polynomial $\Sigma x^u y^v$, associate its *Newton polygon*, the convex hull of the vertices (u, v). The mixed area $\mathscr{M}(P, Q)$ of two planar polygons P, Q is defined by

$$\mathscr{M}(P, Q) = \text{area}(P + Q) - \text{area}(P) - \text{area}(Q).$$

In 1975, David Bernstein proved a general theorem that for two equations in two unknowns shows that the number of solutions of a system of two bivariate polynomial equations is equal to the mixed area of the two corresponding Newton polygons. Sturmfels outlines an algorithmic proof devised by B. Huber and himself in 1995 that leads to a numerical approximation for the solution. The author deftly avoids getting overwhelmed by algebraic and geometric detail by using examples and organizing his account of the proof of Bernstein's theorem around three key steps. The case of real zeros has been seriously investigated for only the past twenty years and little is known. Sturmfels brings us into the cut and thrust of current research with its distance between conjecture and reality and its open questions, leaving much to do that is of interest to combinatorialists, algebraic geometers, and applied mathematicians.