My Promotion Statement- Jesús Antonio De Loera.

I joined UC Davis as an assistant professor in 1998 and was promoted to full professor in 2005. I built my career here and it has been an exciting journey. The Academic Personnel Manual (APM) 220 states that this promotion requires *"an overall career review and is reserved for the most highly distinguished faculty"*. I am proud to list the many achievements that show I am a highly distinguished scholar, teacher, and that I serve my community with dedication. I trust you will see my advancement to the above-scale level is clearly justified.

First, APM 220 states on research *"(1) whose work of sustained and continuing excellence has attained national and international recognition and broad acclaim reflective of its significant impact; "*. I am a world-class computational mathematician. While my favorite tools are combinatorial, my research is diverse, large, and impactful. I have published more than 100 refereed papers in top journals. My mathematical publications range, from the pure (commutative algebra, discrete geometry, geometry of numbers, combinatorial topology, algebraic combinatorics) to the applied (discrete optimization, operations research, symbolic computation, data science). I also wrote 2 large graduate textbooks. As evidence of the high international distinction of my work I was elected fellow of both AMS (American Math. Society) and of SIAM (Society of Industrial and Applied Mathematics). In fact, I am currently the only active UC Davis faculty with both honors. I also won two top prizes in my core field of Optimization, first the INFORMS Computing Society Prize (2010) and most recently the Farkas Prize (2020). I have brought to UC Davis more than 4.5 million dollars in grants from NSF, NSA, IBM, the Gates Foundation, and CONACYT (Mexico). I have been invited plenary or semi-plenary speaker at dozens of international meetings (see CV).

Second, APM 220 states *"(2) whose University teaching performance is excellent*. Teaching and mentoring are the reasons I work at a university. Evidence that my teaching and mentoring are successful includes my winning (only since my promotion to full professor) the following awards: Let me mention some details and then the latest last promotion: The 2018 College of letters and Science Teaching Award, The 2017 Golden Section Teaching Award given by MAA (Mathematical Association of America), The 2013 Chancellor's award in undergraduate research mentoring. (for the many successful undergraduate students who have worked with me over the years), The 2007 UC Davis, Award for excellence in service to graduate students, UC Davis Graduate Student Association. (for my contributions to Ph.D mentorig, training and funding, a campus wide award). 2006 UC Davis, Principles of community and Diversity Award. (for my support of minority students and women in science). As I will explain below my mentoring is particular notable and I am a popular advisor in three Ph.D. programs (Math, Applied Math, CS). Since my last promotion I received the 2020 ADVANCE CAMPOS scholar award.

Third, APM 220 states on service *"(3) whose service is highly meritorious."* I serve my community with dedication, empathy and energy. For example, on Campus, I served as Chair of the Faculty for the College of Letters and Science during the transition to a single-dean. I previously was Faculty assistant to the dean of Math and Physical Science (MPS) for undergraduate education. I also served in various campus-wide committees such as the Senate Undergraduate Committee. In my department, I have served in many committees as chair, e.g., I was chair of our Undergraduate program committee. Very recently I finished my three year term as chair of the Graduate Group of Applied Mathematics, most it during the COVID19 pandemic with considerable hardships. As a summary of my service outside UC Davis, I have served in the editorial board of four journals (two continue today) and I am the chief-editor of a book series. I contribute to all three of the major mathematical societies: American Mathematical Society (AMS), Society of Industrial and Applied Mathematics (SIAM) and the Mathematical Association of America (MAA). I am member of the Scientific board of AIM and served in the scientific board of ICERM. In 2021 I was elected as Vice-President of AMS.

I addressed the three main points of APM 220. It further states *"There must be demonstration of additional merit and distinction beyond the performance on which advancement to [Step 9 or 9.5] was based."* Thus next I add some details and highlight success I achieved since my last advancement.

RESEARCH: My research has been consistently strong. In my narration below I number papers as in my list of publications in my website or in my CV (`https://www.math.ucdavis.edu/~deloera/currifull-profDeLoera.pdf`). See more details on all papers at `https://www.math.ucdavis.edu/~deloera/researchsummary/`

I am proud to be a broad mathematician contributing to more than one area of mathematics and I am proud of my creative mixing of fields. For instance, in 2010, when my collaborators and I received the INFORMS-ICS prize, the award was for the novel use of tools from algebraic geometry to certifying combinatorial statements in practical computation for optimization. I have written innovative papers in many other areas beyond my core interests. I truly enjoy collaboration. My recent contributions to commutative algebra were significant as they were among the first papers written that use probabilistic methods to predict average behavior of rings of polynomials and they were published in top journals [84,85,88]. We proved several theorems about the probability distributions of ideals with given Hilbert function, dimension, Betti numbers, random toric varieties, and a lovely stochastic version of the Hilbert Syzygy theorem. Similarly, I continue to be highly productive in my publications within convex discrete geometry (see e.g., my 90 page monograph published in the Bulletin of the AMS). We proved novel variations of the classical results of Helly, Carathéodory and Tverberg (see [86]).

I have been invited plenary or semi-plenary speaker at many major scientific conferences. Three examples are my plenary presentations in 2021 at SIAM annual

meeting, 2019 the Joint Mathematics Meeting plenary, (the largest mathematical meeting in the world). For a broader public I gave the first ever bilingual lecture for the National Mathematics Festival 2020 (online). You can see a full list in my CV. My funding has been very strong since my first grant in 2000, I am currently funded by NSF and NSA.

Beyond my last advancement: My distinguished research has continued strong since my last promotion: I became a SIAM fellow (2019) and I won another international prize in Optimization, the 2020 INFORMS Farkas Prize. I explain some mathematical results that were cited when I won these international awards. Fields medalist Steven Smale listed the problem of finding a strongly polynomial algorithm for linear programming, as one of the key mathematical problems in the 21st century. I fully agree, thus I have worked in the geometry of linear optimization algorithms (see papers [48,50,53]). But my favorite algorithm for linear optimization is the simplex method. This is an algorithm to solve linear optimization problem (optimizing linear function over linear conditions). The simplex method, uses the fact the region of possible solutions is a polyhedron and, starting at an initial vertex, it traces a path on the graph of the polyhedron until it finds an optimum. SIAM selected the simplex method in 2000 as one of the top 10 most influential algorithms in the 20th century due to its practical and theoretical influence. I have written important papers analyzing the geometry of the simplex method.

First, the problem of bounding the number of iterations of the Simplex algorithm motivates my papers [98,102] we investigated the possible lengths of monotone paths followed by the Simplex method inside the oriented graphs of polyhedra (oriented by the function we optimize). We considered bounds for the shortest and the longest monotone paths. Our bounds are applicable in many situations. We proved that computing a shortest (monotone) path to an optimal solution on the 1-skeleton of a polytope is NP-hard, and it is even NP-hard to approximate within a factor better than 2. Studying the simplex method in special families of polyhedra can have important consequences. In a major breakthrough former postdocs Borgwardt, Finhold, and I showed in [69,80] the graph diameter of a network-flow polytope, for a network with n nodes and m arcs is never more than $m+n-1$. This was a significant result because this bound is not true for general polytopes and network-flow problems are of great importance in Computer Science and Operations Research. An lovely mathematical result is that the set of monotone paths of a linear program has a nice topological structure, a polyhedral complex homotopic to a ball. It is called *monotone path complex or Baues complex*. Its vertices are precisely all the possible monotone paths on the linear program. This follows from the work of Billera-Kapranov-Sturmfels on fiber polytopes. In paper [97] (with Athanasiadis and Zhang) we looked at the 1-dimensional skeleton of this the topological structure and found extreme values for the number of vertices of the Baues complex and their diameter in terms of the input data of the input linear program.

Second, the performance of the simplex method depends on a *pivot rule* that decides which path to follow in the graph search. A pivot rule chooses how to trace the path to the optimal solution. It is a famous open question whether there is a pivot rule that can always choose a polynomial-length path. Trying to approach this important problem in [106] my co-authors and I constructed a "moduli space of pivot rules" based on prior Fiber polytope constructions and [97]. For this purpose we identified that, among all pivot rules, the *normalized-weight (NW) pivot rules* are fundamental for the following reasons: First, their pivots are governed only by local information and the union of all paths traced form an arborescence. Second, many of the most used pivot rules are NW pivot rules, and third, we show this subclass is critical for understanding the complexity of all pivot rules as they have the shortest paths of all pivot rules. Thus if there is a efficient pivot rule, there will be one that is an NW pivot rule. Our main theorem is that the normalized-weight pivot rules can be parametrized in a natural continuous manner and show there exists a *pivot rule polytope*, whose vertices are in bijection with all normalized-weight pivot rules of a linear program. We explain their face structure and compute upper bounds on the number of vertices of our pivot rule polytopes. We presented in [102,105] new pivot rules for the Simplex method for LPs over 0/1 polytopes where the number of non-degenerate steps taken using these rules is strongly polynomial and even linear in the dimension or in the number of variables.

Since my last promotion I also began to work on the foundations of Machine Learning and Statistical Inference. My recent work contains several powerful situations where famous theorems in discrete geometry answered natural questions from machine learning and statistical inference. For instance in papers [101,106] we showed the problem of deciding the existence of Maximum likelihood estimator in multiclass logistic regression, is equivalent to stochastic versions of Tverberg's theorem in combinatorial geometry.

TEACHING: I have been teaching for more than 35 years and I have experience teaching all kinds of courses for students of different levels (from freshmen to Ph.D). My student evaluations have been consistently in the very good to excellent range. My peers have kindly nominated me and I have been the winner of several teaching and mentoring awards (mentioned earlier).

Beyond my last promotion: I received one of the 2020 ADVANCE Scholar Awards. This award recognizes outstanding scholarship and outreach to underserved communities and/or mentorship of under-represented students. It is no secret I enjoy mentoring very very much and I am very proud of the success of my former students. More than 60 undergraduates have worked with me on research and honors theses. I typically include them as part of a bigger project so that they can learn the big picture and learn to be good team players. They are all giving weekly oral presentations that make their communication skills strong. My record as supervisor is excellent with 15 former Ph.D. students all with great jobs in industry (Google, Facebook, IBM, etc) and in academia (former students have tenure track jobs or are

already tenured at U. Wyoming, U. Wisconsin Lacrosse, Cal Poly Pomona, Harvey Mudd College, Naval Postgraduate School, Naval Academy, etc). I am proud four more Ph.Ds are will be ready to graduate in June 2023, one with a job offer already. I am also proud I am creating a legacy as my own Ph.D students have had Ph.D students of their own. My research seminar CCACAOO is popular among graduate students.

SERVICE: I care for others. I have served the university and the mathematical community with dedication and energy. Since becoming a full professor, I served for two years in the Faculty Executive Committee, College of Letters and Science, first as vice-chair and then as chair, having to lead and organize a lot of the business of the college, to appoint all the Faculty Senate committees, and myself serving in the Undergraduate Council. For more than seven years I was the faculty mentor of CALESS (Chicano and Latino Engineers and Scientist Society) helping and advocating for latinx students on campus. I was also involved with many committees in my home department, for instance as vice-chair of undergraduate studies, as chair of the faculty representative committee, in hiring committees of faculty and staff, etc. Outside UC Davis, I have been editor of four journals (SIAM Discrete Mathematics, SIAM Applied Algebra and Geometry, Boletin de la Sociedad Matematica Mexicana, Discrete Optimization) and I served in committees for all three of the mathematical societies, including prize committees for SIAM and MAA and the executive council and the Education committee for AMS.

Beyond my last promotion: I added significant new service: On campus I took over as chair of the graduate group in Applied Mathematics. This is a large graduate program with more than 65 faculty and 75 graduate students. I was in charge of leading admissions, recruitment, retention and oversight of the progress, evaluation and funding of all the students. This is hard work even in normal times, but the COVID pandemic made problems multiply and the logistics were harder. I also was in charge of the seven year program review. Outside UC Davis, I am member of the Scientific board of AIM and served in the scientific board of ICERM, two leading institutes. In 2021 I was elected as a vice-president of AMS. In 2021, I was an external reviewers of the Division of Mathematical Sciences at NSF. These three services demonstrate that many of my colleagues worldwide value my opinion and ideas. I am still editor for SIAM Discrete Mathematics and the Boletin de la Sociedad Matematica Mexicana and since 2019 I am the chief editor of the SIAM-MOS book series Optimization. In addition I referee six to ten papers each year for other journals. I wrote external evaluations for hiring and promotion for dozens of top universities. I organized dozens of workshops and conferences for my community benefiting young people (see lists in CV).

Thank you for reading this. I am grateful for the opportunities and support I received from my mentors, colleagues, collaborators, and students throughout the years. Thanks for sharing your mathematics and your humanity with me!