William T. and Idalia Reid: His Mathematics and Her Mathematical Family

John A. Burns

Interdisciplinary Center for Applied Mathematics

2010 SIAM NATIONAL MEETING
July 14, 2010
History of the Prize

The W.T. and Idalia Reid Prize in Mathematics is awarded annually for research in, or other contributions to, the broadly defined areas of differential equations and control theory. Each prize may be given either for a single notable achievement or a collection of such achievements.

A generous trust and gift from Mrs. Reid to SIAM will fund the prize.

Approved by the SIAM Council and Board in June, 1985

Mrs. Reid and her (only) nephew, John Narciso, worked with SIAM to create and fund the prize. Dr. Narciso was very close to Dr. and Mrs. Reid and he played a central role in establishing the prize, working out the details (including precise wording of the prize statement) and stewarding the prize to completion.

Mrs. Reid and Dr. Narciso first proposed the annual prize would begin after her death so that her trust and estate could be settled to fully fund the prize.
History of the Prize

However, in 1993 Dr. Narciso approached SIAM and offered to personally finance the prize every other year so that the first prizes could be awarded before Mrs. Reid’s death. Thus, the first three prizes were awarded in:

1994 to Wendell H. Fleming
1996 to Roger W. Brockett
1998 to Jacques-Louis Lions

Since Mrs. Reid’s death in 2000, the prize is awarded annually at the SIAM National Meeting.

SIAM and the mathematics community owe a debt of gratitude to Mrs. Reid and Dr. Narciso for their gifts and tireless efforts to establish and fund this prize in mathematics.

As one of Dr. Reid’s students it is a special honor to receive this prize.
BEFORE I START

TERRY HERDMAN & GENE CLIFF
BEFORE I START

MY OLD POSTDOC MENTOR

MY YOUNG COLLEAGUES AT ICAM
William Thomas Reid

Entered The University of Texas, Austin in 1926

Received his Ph. D. in 1929 at the age of 21
Gronwall – Reid – Bellman Inequality


**Gronwall (1919)**

\[ 0 \leq x(t) \leq \int_{0}^{t} (a + bx(s)) ds \Rightarrow x(t) \leq ate^{bt} \]

**Reid (1929) Dissertation - page 296**

\[ k(s) \geq 0, \quad a \leq s \leq b \]

\[ x(t) \leq \phi(t) + \int_{a}^{t} k(s)x(s) ds \Rightarrow \]

\[ x(t) \leq \phi(t) + \int_{a}^{t} \exp \left\{ \int_{a}^{s} k(\mu) d\mu \right\} k(s)x(s) ds \]

Re-discovered by Bellman in 1943
Frances Idalia (Steere) Reid

John Narciso’s dad
and Idalia
1913

John Narciso’s sister
and Idalia
1920

IDALIA MET REID AT U T

THEY MARRIED ON JULY 8, 1929

Chicago 1930

EACH HAD 2 LOVES ...

W. T. - Idalia and mathematics

IDALIA - W. T. and his students / colleagues ( & maybe the cat)
William Thomas Reid

Born October 4, 1907, near grand Saline, Texas;
Parents: David Garfield Reid, father and
Laura Jane (Burton) Reid, mother
Married Frances Idalia Steere July 8, 1929; no children

THE MARRIGE “DEAL”

Dr. Reid is allowed to buy
1 math book per month
after the wedding.

First purchase ...

Roaring Springs High School, 1923
B. A., 1926, Simmons University, Abilene, Texas
M. A., 1927, The University of Texas, Austin, Texas
Ph. D., 1929, The University of Texas, Austin, Texas

His advisor was
Hyman Joseph Ettlinger
Some Genealogy

**Students of Ettlinger**

- Eugene Lumberg
- J. Sturtevant
- William Whyburn (1927)
- William Reid (1929)
- Olan Hamilton
- Herman Smith
- Mohammed Al-Basam
- John Barrett (1951)
- Mark Clarkson
- Clair Abraham
- Paul Culwell
- Ben Fitzpatrick, Jr. (1958)
- Don Tucker
- Edmund Deaton
- Sister Mary Sparkman
- Lynn Tulloch
- Dale Walston
- Ettore Infante (1962)
- Clement Falbo
- A. Stewart
- Ralph Whitmore
- Virgil Kowalik
- Bennie Williams
- Manoug Manougian
- Robert Northcutt

**Students of Reid**

**University of Chicago**

- Evelyn Wiggin (1936)
- Herman Goldstine (1936)
- Carl Denbow
- Malcolm Smiley
- Augusto Bobonis
- Joseph Levin
- Hyman Zimmerberg

**Northwestern University**

- Vincent Harris
- Robert Sternberg
- Donald Austin
- Richard Von Holdt
- Frank Sloss
- Richard Driscoll

**Iowa University**

- John Bradley
- John Holt
- Junius Kegley

**University of Oklahoma**

- John Hooker
- William Lakin
- Calvin Ahlbrandt
- William Frawley
- Larry Bennett
- Churl Kim
- Charles Williams
- Bartholomew Ng
- John Bennett
- John Burns (1973)
- William Denny, III (1974)
- Terry Herdman (1974)
Chicago Years 1929 - 1959

University of Chicago: 1929 - 1944

Northwestern University: 1944 - 1959
Research at Chicago

Research Interest and Activities:
Personal research has been almost exclusively in the fields of differential equations, the calculus of variations and optimal control, with special attention to the interrelations between the theory of differential equations and extremum principles.

Reid was a part of the Chicago school in the calculus of variations

Students of Bliss

- L. M. Graves - 1924
- E. J. McShane - 1930
- M. R. Hestenes - 1932

CO-Advisor with Reid

- H. H. Goldstine - 1936
Chicago - Summer of 1939

Notices AMS, 1939

During recent years the Department of Mathematics of the University of Chicago has planned to place emphasis on a particular field each Summer Quarter. Algebra was stressed in 1938, and analysis will be emphasized in the summer of 1939. A feature of the program will be a seminar on the calculus of variations conducted by G. A. Bliss. Other members of the summer staff who will participate in the seminar are Max Coral, L. M. Graves, M. R. Hestenes, E. J. McShane, W. T. Reid, and M. F. Smiley.

SOME THINGS CHANGE …. SOME THINGS DO NOT.

All mathematicians who may be interested are cordially invited to attend the Conference and the preparatory lectures in the seminar. Housing accommodations have been arranged near the University. A limited number of rooms will be available in Judson Court for the week of the Conference at the moderate charge of $2.75 per day for room and board. Judson Court is a conveniently located and modern residence hall facing the Midway Plaisance. Reservations and requests for information should be addressed to M. R. Hestenes, Eckhart Hall, University of Chicago.
Powerful Mathematics

- 1927: Graves - MAXIMUM PRINCIPLE
- 1927: Hildebrandt & Graves - Implicit Function Theorem
- 1935: Graves - Taylor’s Theorem in normed spaces
- 1938: Goldstine - Multiplier Rule in abstract spaces (Reid’s 2nd)
- 1939: McShane - LMR ... separation theorems
- 1950: Hestenes - MAXIMUM PRINCIPLE

- Hestenes – Conjugate gradient optimization
- McShane – Stochastic integrals (McShane Integral)

AND REID’S MOST NOTABLE STUDENT

Herman H. Goldstine
Herman Heine Goldstine (September 13, 1913 – June 16, 2004), mathematician, computer scientist and scientific administrator, was one of the original developers and managers of the ENIAC project, the first of the modern electronic digital computers.
The First Draft

The First Draft of a Report on the EDVAC was an incomplete 101-page document written by John von Neumann. Von Neumann intended this to be a memo to the study group, but Goldstine typed it up into a 101 page document that listed von Neumann as the sole author. On June 25, 1946, Goldstine forwarded 24 copies of the document to those intimately involved in the EDVAC project; dozens or perhaps hundreds of mimeographs of the report were forwarded to von Neumann's colleagues at universities in the U.S. and in England. It contains the first published description of the logical design of a computer using the stored-program concept, which has controversially come to be known as the von Neumann architecture.

Goldstine joined von Neumann at Princeton.
He was the founding director of the Mathematical Sciences Department at IBM's Watson Research Center in Yorktown Heights, New York.

GOLDSTINE HAD “THAT VISION THING”
Hellinger and the Reids

Ernst David Hellinger
September 30, 1883 - March 28, 1950

On 13 November 1938 Hellinger was arrested, first taken to the Festhalle and then put into Dachau concentration camp. His sister, Hanna Meissner, was in the United States and Carl Siegel wrote to her to say that Hellinger had been sent to the concentration camp. Fortunately, friends were able to arrange a temporary job for Hellinger at Northwestern University at Evanston in the United States. He was released from the Dachau camp after six weeks on condition that he emigrate immediately.

He emigrated to the United States in late February 1939.

Dr. Reid was one of the friends that arranged to have Hellinger come to Northwestern and they became close friends. Mrs. Reid once said that Hellinger was “... perhaps the most remarkable man she ever knew.”

http://www-history.mcs.st-and.ac.uk/Biographies/Hellinger.html
II C 13. INTEGRALGLEICHUNGEN UND GLEICHUNGEN MIT UNENDLICH VIELEN UNBEKANNTEN.

VON
ERNST HELLINGER UND OTTO TOPELTZ
IN TAUERN A. M.

Verlängerung. Der Artikel will in der Praxis die bis 1. Januar 1923 erschienenen Literatur berücksichtigen, jedoch glauben wir alles wesentliche, was noch zu ein schönen Arbeiten erschlossen ist, noch erlaubt zu haben. Im Einklang mit den von der Redaktion getroffenen Dispositionen behandeln wir nur die Theorie selbst, während ihre Anwendungen an anderen Stellen der Ency-
klopädie zur Stelzung gebraucht sind.

Wenn dabei die Tatsachen der Theorie ihre Methoden gleichberechtigt zur Seite gestellt werden, um, was verschiedenen Stellen dieses Encyclopädie-
artikels zugeordnet werden (allerdings nur solche, die, ihrem Wesen nach fundamental, in der Literatur bisher keine genug zu handhabende Dar-
stellung gefunden haben), so glauben wir, daß sich dies zum mindesten aus
der ausgesprochenen Eignung der Integralgleichungstheorie rechtfertigt, die
er Tatsachenbestand hat sich im letzten Dezennium in seinen Grundzügen nicht
der Tatsachenbestand hat sich im letzten Dezennium in seinen Grundzügen nicht
durch eine praktische Eignung in den Grundzügen nicht
und Methoden durch, die, wie über den engen Rahmen
der klassischen Theorie hinausgeführt werden, noch zu weiteren Wirkungen be-
rufen erheben. Der Artikel ist dementsprechend im Gegeensatz zu der bisher
er Zerlegung der Gleichungen nach Integralgleichungen und unendlich
der Veränderlichen vielfach nach einem nachholenden Gesichtspunkt gegliedert
und zwar ist dasjenige Prinzip, das überhaupt die methodische Grund-
lage der ganzen Theorie darstellt, nämlich die Analogie der Algebra der
linearen und quadratischen Gleichungen, die dem Gesamtsystem der
Gleichungen zugrunde gelegt worden; ebenso, wie der im Betracht kovariierende Abschnitt des
Algebra einsetzt mit der in der Auffassung der linearen Gleichungen und in
der Transformation der quadratischen und binären Formen ausläuft, ist hier
in Auffassungstheorie (Kap. II) und Eigentheorie (Kap. III) geschieden.

Der Artikel beschreibt sich aber nicht auf die mathematische Seite des Gege-
standes, d. h. auf seine Tatsachen und auf seine Methoden, sondern er will zu-
gleich auch die dem Gemeinwesen gegenüber, so wenig er eine Eignung der Integral-
gleichtungstheorie setzt will, will er doch die Entwicklung ihrer Probleme in sich
enthalten. Diese Absicht erreicht ausnahmsweise die Gefahr in sich, daß derjenige Leser,
der zur Tatsachen oder zur Methoden sucht, durch genetische Entwicklungen
behindert wird, die ihrer Erfahrung nach subjektiver und oft verwirklicht sind. Um
The Book: Hellinger and Topeltz
The Book: Hellinger and Topeltz
Hellinger had found a 4 leaf clover and placed it inside his copy of the book.

When the book was given to Dr. Reid by Hellinger’s sister, Hanna Meissner, the 4 leaf clover was still there.
Riccati Equations

In 1939 Reid turned his attention to the Riccati differential equation. His interest was first motivated by the paper


Between 1939 and 1977 he wrote more than 20 papers dealing with some aspect of Riccati equations ... and the book

_W. T. Reid, Riccati Differential Equations, Academic Press, 1972._

AS ONE OF REID’S STUDENTS IN 1968, I SHOULD HAVE PAID MORE ATTENTION TO THIS TOPIC
The Riccati Equation


The Legendre differential equation in the calculus of variations

\[ \dot{W}(t) + W(t)A(t) + D(t)W(t) + W(t)B(t)W(t) = C(t) \]

\[ a < t \leq b, \quad W(a) = W_0 \]


\[ \dot{\Sigma}(t) = A\Sigma(t) + \Sigma(t)A^* - \Sigma(t)C(t)^*C(t)\Sigma(t) + G(t)G(t)^* \]

\[ 0 < t \leq b, \quad \Sigma(0) = \Sigma_0 \]

EVERYTHING HERE IS INFINITE DIMENSIONAL

and Dr. Reid would have been proud ... finally
Working for Dr. Reid

“Read this and let's talk about it.”
A New Approach to Linear Filtering and Prediction Problems

The classical filtering and prediction problem is re-examined using the Rice-Shannon representation of random processes and the "state-transition" method of analysis of dynamic systems. New results are:

1. The formulation and methods of solution of the problem apply without modification to stationary and non-stationary statistics and to growing-memory and infinite-memory filters.

2. A nonlinear difference (or differential) equation is derived for the correlation matrix of the optimal estimation error. From the solution of this equation the coefficients of the difference (or differential) equation of the optimal linear filter are obtained without further calculations.

3. The filtering problem is shown to be the dual of the nonlinear regulator problem. The new method developed here is applied to two well-known problems, conforming and extending earlier results.

The discussion is largely self-contained and proceeds from first principles; basic concepts of the theory of random processes are reviewed in the Appendix.

Introduction

An important class of theoretical and practical problems in communication and control is of a statistical nature. Such problems are: (1) Prediction of random signals; (2) estimation of random signals from random noise; (3) detection of signals of known form (e.g., sinusoids) in the presence of random noise.

In his pioneering work, Wiener [1] showed that problems (1) and (2) lead to the so-called Wiener-Hopf integral equations, he also gave a method (optimal factorization) for the solution of this integral equation in the practically important special case of stationary statistics and random spectra.


A somewhat different approach along these lines has been given recently by Wiener [10]. For extensions to sampled signals, see, e.g., Freidlin [11], Lax [12]. Another approach based on the eigenfunctions of the Wiener-Hopf equation (which applies also to nonstationary problems when the preceding methods are in general don't) has been pioneered by Davis [13] and applied by many others, e.g., Bickley [14], Bucy [15], Paget [16], Rabiner [17].

In all these works, the objective is to obtain the specification of a linear dynamic system (Wiener filter) which accomplishes the prediction, estimation, or detection of a random signal.

Purcell's methods for solving the Wiener problem are subject to a number of limitations which seriously curtail their practical usefulness:

1. The optimal filter is specified by its impulse response. It is not a simple task to synthesize the filter from such data.

2. Numerical determination of the optimal impulse responses is often quite involved and purely suitable to computer computation. The resulting noise rapidly vanishes with increasing duration of the problem.

3. Important generalizations (e.g., growing-memory filters, nonstationary prediction) require new derivations (frequency of nonstationary difficulty in the noncausal).

4. The mathematics of the derivations are not transparent. Fundamental assumptions and their consequences tend to be obscured.

This paper introduces a new look at these whole process of problems, sidestepping the difficulties just mentioned. The following are the highlights of the paper:

1. Optimal Estimates of Unknown Processes. The Wiener problem is approached from the point of view of stochastic distributions and expectations. In this way, the novelty of the Wiener theory is obviated; the corner and the fundamental assumptions appear abruptly. It is seen that all statistical calculations and results are based on the first and second order averages, no other statistical data are needed. The infinities (4) are eliminated. This method is well-known. The stability theory (see pp. 72-78 and 145-150 of Denk [18]) of the theory has been obtained. It has not yet been used extensively in engineering.

2. Stability for Random Processes. Following is a particular Bode and Linnik [19] arbitrary random signals are approximated (up to second order average statistical properties) as the output of a linear dynamic system excited by independent or correlated random signals ("white noise"). This is a stroke back in the engineering applications of the Wiener theory [20-23]. This approach taken here differs from the conventional methods in the way in which linear dynamic systems are derived. We shall emphasize the concept of state and state transfer, in other words, linear systems will be specified by systems of first-order difference (or differential) equations. This point of view is...
Working for Dr. Reid

“Read this and let’s talk about it.”

... 54
LOOKING BACK NOW IT IS CLEAR THAT DR. REID WAS “GENTLY” SUGGESTING I SHOULD PAY ATTENTION TO THIS IMPORTANT CLASS OF EQUATIONS BUT I IGNORED HIS ATTEMPTS AND WROTE A THESIS TOTALLY UNREALTED TO ANY OF THESE PAPERS ....

Proof that Dr. Reid had infinite patience with young people.
Dr. & Mrs. Reid’s Mathematical Family

... WHO CARVED IDALIA A WALKING STICK DURING A LONG HIKE IN NEW MEXICO
Mrs. Reid adopted his friends & colleagues
Like a mother to his students

... EVEN WHEN WE LOOKED LIKE THIS
IN 1973 BEFORE I LEFT OKLAHOMA TO GO TO BROWN, DR. REID CALLED ME INTO HIS OFFICE AND GAVE ME THE FOLLOWING (VERY SPECIFIC) CAREER ADVICE:

- **THE WORLD IS CHANGING AND YOUR MATHEMATICS MUST CHANGE TOO**
- **YOU SHOULD LEARN TO COMPUTE** – COMPUTERS WILL TRANSFORM THE WAY WE DO SCIENCE AND MATHEMATICS
- **STATISTICS AND STOCHASTICS WILL BECOME MORE IMPORTANT** BECAUSE THE REAL WORLD IS FULL OF UNCERTAINTIES
- **PAY ATTENTION TO APPLICATIONS** – NOT THE CLASSICAL APPLICATIONS, BUT LOOK AT NEW AREAS LIKE MATHEMATICAL BIOLOGY, COMMUNICATION SYSTEMS OR COMPUTER SCIENCE

I AM NO W. T. REID .... BUT I DO HAVE A SUGGESTION FOR YOUNG PEOPLE
Energy and Buildings

WHY BUILDINGS

AND NOT THIS
Impact of Energy Efficient Buildings

HUGE

- A 50 percent reduction in buildings’ energy usage would be equivalent to taking every passenger vehicle and small truck in the United States off the road.

- A 70 percent reduction in buildings’ energy usage is equivalent to eliminating the entire energy consumption of the U.S. transportation sector.

84% of energy consumed in buildings is during the use of the building

REQUIRES COMBINING - MODELING, COMPLEX MULTISCALE DYNAMICS, CONTROL, OPTIMIZATION, SENSITIVITY, HIGH PERFORMANCE COMPUTING … THINGS THAT SIAM PEOPLE DO!
Whole Buildings Are Complex System

A whole building system is a complex system because:

1. The system components do not necessarily have mathematically similar structures and may involve different scales in time or space;

2. The number of components may be large, sometimes enormous;

3. Components can be connected in a variety of different ways, most often nonlinearly and/or via a network. Furthermore, local and system wide phenomena may depend on each other in complicated ways;

4. The behavior of the overall system can be difficult to predict from the behavior of individual components. Moreover, the overall system behavior may evolve along qualitatively different pathways that may display great sensitivity to small perturbations at any stage.

In addition to the above definition, even a single room can be a complex system if one is concerned with multi-physics dynamics such as coupled (chemically reacting) air flows, thermal profiles, energy flows, air quality, room geometry and the supervisory (closed-loop, possible human in the loop) control.
Whole Buildings Are Complex System

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MATHEMATICAL DEFINITION OF A COMPLEX SYSTEM


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MY ADVICE TO YOUNG PEOPLE

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- YOU SHOULD LEARN TO COMPUTE – COMPUTERS WILL TRANSFORM THE WAY WE DO SCIENCE AND MATHEMATICS
- STATISTICS AND STOCHASTICS WILL BECOME MORE IMPORTANT BECAUSE THE REAL WORLD IS FULL OF UNCERTAINTIES
- PAY ATTENTION TO APPLICATIONS – NOT THE CLASSICAL APPLICATIONS, BUT LOOK AT NEW AREAS LIKE
  --- BIO-MEDICINE AND BIOINFORMATICS
  --- HIGH PRODUCTIVITY COMPUTING
  --- ENERGY EFFICIENT BUILDINGS

GO TO CLAS JACOBSON’S TALK IC9 AT 8:30 ON FRIDAY
W. T. AND IDALIA REID

THANKS