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James Henry Michael 1920–2001

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Professor James Henry ('Jim') Michael 1920–2001 was elected to the Australian Academy of Science in 1973. Born in Port Augusta, Jim saw active service during the Second World War. Returning to Adelaide, he completed a PhD in pure mathematics and began a distinguished career as an international expert in mathematical analysis. As well as being a mathematician, Jim was a keen golfer and shooter. Jim is remembered as a quiet, gentle man of few words but great integrity. A devoted family man, he is survived by his wife Pat, his daughter Mary Jane, his son Philip and his two grandchildren Ian and Tim Michael.

Biography

Early Life and Army Service

Jim Michael's great-grandfather James Michael was born in Truro, Cornwall in 1811. He migrated to Adelaide with his wife Mary, arriving aboard *Cleveland* in 1839. One of their eleven children, Jim's grandfather John Henry Michael, was born in Gumeracha in the Adelaide hills in 1854. With his wife Mary, John Michael settled on land near Stirling North in rural South Australia after it was opened for selection in 1881. The property was called 'Nangari', an aboriginal word meaning 'A Quiet Place', and located sixteen kilometres east of Port Augusta (on the old Port Augusta to Wilmington Road) at the foot of the Flinders Ranges and overlooking Spencer Gulf. Nangari was 2,400 hectares and used for some mixed farming but mostly sheep. Jim's father Charles took over the property after his marriage in 1918 on his return from serving in the First World War. In 1953 the property was sold when Charles retired to Adelaide.

Jim Michael was born at Port Augusta on 3 April 1920 to Charles Michael and Susan Victoria May Michael (nee Willoughby). He was the second in a family of four children and had one brother and two sisters. Jim attended the Stirling North Primary School from 1926 to 1932 and the Port Augusta Higher Primary School in 1933. Jim left school at 14 years of age to work on his family's property. He completed his intermediate Mathematics 1 and 2 by correspondence in 1938.

Jim enlisted for service in the Second World War on 22 July 1940 in Adelaide. He served with the 2/7th Australian Field Regiment (artillery) in Australia, Egypt, Syria and Palestine and later at Tarakan in the Pacific. He earned the Africa Star with clasp for his service in the Middle East and the Pacific Star for service at Tarakan and was honourably discharged on 21 November 1945.

While on service Jim completed further education courses with his Demobilisation Procedure Book recording Mathematics 1 and 2 to Leaving level in 1944 and Mathematics 1A through the University of Adelaide in 1945. He took the examination for that latter course while on the ship home from Tarakan; he was most amused that the authorities insisted it be held at

precisely the same time as the examination in Adelaide.

Jim's interest in mathematics suited him well to being in the artillery and his family still have his meticulously drawn range graphs and artillery calculations as well as a star chart drawn in the trenches at El Alamein. He created amusement amongst his fellow soldiers by lying in the trenches reading four-figure mathematical tables.

On returning to Adelaide, Jim commenced full-time training at the Commonwealth Reconstruction Training Scheme (CRTS) special school in 1946. The CRTS was introduced in March 1944 to provide educational and vocational training for those who had served in Australia's armed services during the Second World War.

On 16 August 1952 Jim married Patricia Hartley, whom he had met through mutual friends. They had two children, Mary Jane born on 17 May 1954 and Philip James born on 15 May 1957.

After his CRTS training, Jim went on to the University of Adelaide where he was awarded a BSc with first-class honours in mathematics in 1950. Professor George Szekeres recounted the story of one examination that Jim sat where he attempted only one question on the paper. But it was a very hard question and he solved it, so Szkeres decided to pass him. For his Master's degree, which he gained in 1953, Jim carried out research into *A general form of Cauchy's theorem* [1]. In 1953 and 1954 Jim was a part-time Lecturer in the Mathematics Department at the University of Adelaide and lectured in both pure and applied mathematics.

His PhD from the University of Adelaide on *Integration over Parametric Surfaces* [2] was supervised by Szekeres and completed some time in early 1955. Jim was Szekeres' first student and he was so pleased with the work that he spoke about it on overseas trips to Europe. In 1955 Jim was awarded a Nuffield Foundation Dominion Travelling Fellowship and spent October 1955 to September 1956 at the University of Manchester working under Professor M.H.A. Newman. Newman was the external examiner for Jim's thesis which had been completed and examined internally by this time and Szekeres urged him to ask Newman how the examination of his thesis was proceeding. The PhD was subsequently awarded in 1957 and Jim was the first PhD graduate in Mathematics at the University of Adelaide. Jim's time at Manchester was followed by a year at the University of Glasgow as a Research Fellow. While at Glasgow he taught a postgraduate course on 'Singular Homology Theory' which he later repeated at the University of Adelaide.

Career at the University of Adelaide

After his time at the Universities of Manchester and Glasgow, Jim returned to Adelaide in 1958 to take up an appointment as a Lecturer in the Mathematics Department. He was promoted, in turn, to Senior Lecturer in 1959, Reader in 1965, and to a personal Chair in Mathematics in 1967. As a Lecturer and Reader at the University, Jim continued work on parametric and non-parametric surfaces until 1966. After that he became interested in variational problems and partial differential equations. He became Head of the Mathematics Department in 1969.

Jim was an inspiring teacher, both in the classroom and especially as supervisor to graduate students. He lectured at all levels, in the large lecture theatres at level 1 to the small groups of (level 4) Honours students. In general a quiet man of few words, at the blackboard in front of a class he was confident, clear and compelling. In lectures he did not try to cover too much material; instead he covered the fundamental concepts very thoroughly. He had a slow, deliberate style of lecturing that reflected the thought and careful preparation he gave to his lectures. The lecture material and assignments were carefully integrated with the questions selected to reinforce and give maximum insight into the main principles. He preferred problems that had a geometric interpretation or that illuminated and enriched the central ideas from the lectures, rather than questions of a formal, abstract nature. Jim tended not to give the standard presentation of material as found in text books. Instead, after much careful deliberation, he presented the material in the way he believed to be the right way. As a result the lectures were given with authority and their clarity and insight were a constant inspiration to his students. He had the unusual gift of being able to make difficult concepts accessible to students, especially in mathematical analysis.

He relinquished his Personal Chair in 1970 due to his dislike of the professorial administrative obligations, reverting to being a Reader in the Department of Mathematics. However despite relinquishing his professorial title, he continued as Head of the Department of Mathematics. Jim continued to fulfill a leadership role in mathematics at Adelaide until his retirement in 1983. In particular, he served two terms as Head of the Department of Pure Mathematics following its establishment in 1971. He made continuing major contributions to all aspects of the academic work of the Department, to its smooth running, and to its research standing both national and international.

Jim was a member of the Australian Mathematical Society from 1958 and served on its Council during 1966–7. He was also a member of the American Mathematical Society from 1961 and the Mathematical Association of South Australia from 1960.

Jim Michael was elected to the Fellowship of the Australian Academy of Sciences in 1973 as one of the leading world experts on surface integrals and the theory of measure on parametric surfaces. His citation said, 'He is not a prolific writer, but each one of his papers is an important and deep contribution to the subject.'

Jim's research achievements and personal philosophy were influential, both at his home university in Adelaide and elsewhere in Australia, particularly in the analysis community. He supervised the following PhD students who have gone on to successful mathematical careers:[1]

1966 Dennis John Clague: *New Classes of Synchronous Codes.*
1966 Kenneth Pearson: *Topological Semirings.*
1971 Leon Simon: *Interior Gradient Bounds for Non-Uniformly Elliptic Equations.*
1971 Phil Howlett: *Approximation to Summable Functions.*
1974 Thomas James Cooper: *Centres, Fixed Points and Invariant Integration.*
1975 Barbara MacLeod: *A Basic Operational Calculus for q-functional Equations.*[2]
1976 John van der Hoek: *A General Theory for Linear Parabolic Partial Differential Equations.*
1976 Graham Williams: *The Existence of Solutions for Non-Linear Obstacle Problems.*
1985 Alan Kennington: *An Improved Convexity Maximum Principle and Some Applications.*

Jim retired from his academic duties in Adelaide, but not from mathematics, at the end of 1983. In July 1984, a mini-conference on Nonlinear Analysis in his honour was held at the Centre for Mathematical Analysis at the Australian National University, Canberra. He continued his research activity in a fruitful collaboration with Professor William P. Ziemer of Indiana University, producing four papers between 1985 and 1991. His research led in all to 29 publications, the last being a joint paper with Ziemer in 1991. In addition Jim supported the Pure Mathematics Department by giving several lecture courses after his retirement.

Shortly after his retirement, the J. H. Michael Prize, awarded to the highest placed candidate for Level II Pure Mathematics, was established in honour of his teaching and contributions to mathematics at the University of Adelaide.

Jim the Person

Jim had a long and distinguished involvement with rifle shooting. He was captain of the University Rifle Club for two years and shot in three Intervarsity competitions, gaining his University Blue. He continued competitive rifle shooting to the end of his life and competed successfully in the Queen's Medal Shooting competitions.

He also became an avid golfer in his later years and often enjoyed a game with colleagues after work. He loved P. G. Wodehouse's golf stories and Jim's wonderful dry sense of humour was often in evidence while playing golf with his colleagues.

We illustrate some aspects of Jim's personality with recollections from Leon Simon and Bill Ziemer. First an example [Simon 2003] of Jim's sense of humour:

> While still a graduate student, Jim had driven several of us to Flinders University (about 20 kilometres from the University of Adelaide) and on the way back the most extraordinary thing happened in that the gear lever of Jim's car snapped clean off. Rather than getting perturbed

[1] We note also Robin Wittwer who died in 1984 while still a PhD student of Jim Michael.

[2] Barbara McLeod was initially supervised by Dr W. H. Abdi and only at a late stage did Jim become involved.

> about such a singular event, Jim found it most amusing and, without missing a beat, albeit having to change gears with the vestigial remains of the lever, proceeded to relate a story of which the present event reminded him. It was a story of a man in the USA who was pulled over by the police for erratic driving and was found to be sitting with a large pair of pliers which he was using in lieu of the steering wheel (the latter being entirely absent) to control the direction of the car.

The second story [Ziemer 2013] is also car-related and underscores Jim's fierce self-reliance and independence:

> Jim was returning to Canberra after spending a skiing weekend in the nearby Snowy Mountains. As he approached the outskirts of Canberra his car had a mechanical failure and was rendered undriveable. Jim always carried a tool box with him with an extensive array of tools that would allow him to repair nontrivial failures. In this case, the repair was indeed nontrivial and it took Jim several hours to fix the car at the roadside. After Jim related the story to me the next day, telling me of his misfortune, I asked, "Jim, since you were so close to Canberra, why didn't you hike into the city to a repair shop and have a mechanic tow your car to the shop for repair?" Characteristically, he simply replied, "Because he wouldn't do it right."

The third story, also from [Ziemer 2013], illustrates Jim's quiet, thoughtful nature and intellectual depth:

> Jim and I were having dinner at the University House at ANU. That day I had found a new way to approach a problem that we had been working on in our joint research project. I was eager to tell Jim about this and so I took the liberty of doing so during our dinner together. The approach I had in mind was a bit technical and long-winded but I was determined to tell Jim the entire story because of the excitement I had for this particular approach. As I was relating the details to Jim during dinner, Jim said absolutely nothing and I felt that either he was not fully understanding my explanation or that he was not particularly interested in hearing about the details at that time. However, at the end of my lengthy monologue, I paused for some response, and he simply said, "sounds reasonable" and made no further comment. I was certain then, that he didn't bother to follow the details and replied out of courtesy. The next day he came to my office very early in the morning. He went straight to the blackboard and said, "Is this what you had in mind?" He then proceeded to write out the details of my ideas from the previous evening and made some additions and improvements as well.

Jim Michael was a quiet, gentle man who commanded the respect of colleagues, students and all who knew him. He was a forthright, plain-spoken man of very few words with no hidden agenda. Jim devoted meticulous care to every activity he undertook, whether mathematical, administrative or recreational. His colleagues, both in Adelaide and beyond, remember him with affection and with deep respect for his integrity and his concern for others as well as his outstanding mathematical achievements. Jim was devoted to his family. He died on 17 April 2001 and was survived by his wife Pat, his daughter Mary Jane, his son Philip and his two grandchildren Ian and Tim Michael. His funeral was conducted at St George's Anglican Church, Magill and he is buried in the grounds.

Research

The mathematical contributions of Jim Michael are well summarized by the dedication [Trudinger 1984] in the proceedings of the mini-conference held in his honour at the ANU shortly after his retirement from the University of Adelaide on 31 December 1983.

> Jim Michael's work, while perhaps not large in volume, has always been very thorough and in several cases has presented new ideas which have turned out to be very significant in the later development of the theory. These include, in particular his study of Lipschitz approximations of variational integrals [14], his fundamental paper with Leon Simon on Sobolev inequalities on submanifolds [17] and his innovative approach to elliptic equations through interior estimates [19].

Michael's research career began with his Master's thesis [1] *A general form of Cauchy's theorem*, followed by his PhD thesis [2] *Integration over parametric surfaces* completed under the supervision of Professor George Szekeres. These formed the basis of his early research including his first published paper [3] in the *Journal of the London Mathematical Society* of which Simon [Simon 2003] says:

> Jim's first published paper, which appeared in the Journal of the London Mathematical Society

in 1955, concerned a new method of approximating rectifiable curves, including the first proof of the Cauchy integral theorem for holomorphic functions under conditions of optimal generality. This paper was one of the references I needed to look at for my undergraduate Honours project at Adelaide University (on applications of the topological degree, written under Jim's supervision). It was in fact the first research paper that I had read, and in retrospect I can clearly see how very fortunate this was for me. The paper was brief, but with a very simple yet ingenious idea—a fresh and important observation in an area where many others had looked without success.

In commentary provided to Professor Neil Trudinger, Professor Wendell Fleming sets the context for and reflects on Jim's early mathematical work [Fleming 2004]:

> During the middle of the 20th century there was a very active effort to develop a theory of surface area and integration over surfaces, for a wide class of surfaces that need not be piecewise smooth. This effort was motivated in part by the need for a framework in which the existence of a minimum could be proved for broad classes of multiple integral problems in the calculus of variations. Earlier existence results of this kind had been obtained for Dirichlet type nonparametric integral problems and for the Plateau (least area) problem. J.H. Michael's early work in the 1950's and 1960's was at the forefront of these developments.
>
> In area theory, an n-dimensional parametric surface was typically defined in terms of continuous mappings f from some n-dimensional parameter space M into k-dimensional R^k ($k \geq n$). The n-dimensional Lebesgue measure $L(f)$ was defined as the lower semicontinuous extension, under uniform convergence, of classically defined n-dimensional area for smooth maps. The theory of surfaces of finite area required a kind of Gauss–Green theory for maps $g: M \to \mathsf{R}^n$, under weak assumptions about g. Michael's 1957 paper [5] provides such a result. As was typical in Lebesgue area theory, the proof required a delicate blend of topological ideas (degree theory) and measure theoretic considerations. For the case $n = 2$ Cesari and Cecconi obtained related results under different assumptions. Paper [7] was a continuation of the earlier paper [5]. Still earlier [3] Michael dealt with the Gauss–Green theorem when $n = 1$.
>
> A nonparametric n-dimensional surface is defined by a real-valued function F on some region Q in R^n. Michael's 1963 and 1964 papers, [12, 14] were deep contributions to the theory of integration over nonparametric surfaces. These papers provided a solution to a 1953 conjecture of Goffman concerning the approximation of nonparametric surfaces of finite area by Lipschitz surfaces. Michael's results involve approximating a function F by a Lipschitz continuous function G in the following sense. It is required that $F(x) = G(x)$ except for x in a subset of Q of arbitrarily small area a. Moreover, $I(G)$ is no more than $I(F) + a$, where for G Lipschitz $I(G)$ is the integral over Q of a convex function of $\bigtriangledown(G)$. For non-Lipschitz F, $I(F)$ is defined via lower semicontinuous extension in the L^1 topology. This result is true for a large class of convex integrands including the area integrand.
>
> Integral currents provide an alternative setting for studying geometric problems of the calculus of variations, such as the multidimensional least area problem. During the 1960's there was active interest in connecting Lebesgue area theory with the (then new) theory of integral currents. [While making] … this connection serious technical difficulties, both topological and geometric-measure theoretic, are encountered. The following question was of particular interest. Suppose that f is a continuous mapping of finite Lebesgue area $L(f)$. If a sequence of Lipschitz mappings with bounded n-dimensional areas converges to f uniformly, do the corresponding integral currents converge in the weak topology? This question was addressed by Federerer and by Michael [11, 15]. The answer is yes if $n = 2$. However for dimension $n > 2$, Federer and Michael [11] required the technical condition that the range of the mapping f have $n + 1$ dimensional Hausdorff measure 0. In [15] Michael replaced this unwelcome technical condition by a more appealing condition involving a bound on $n - 1$ variations for the approximation sequence of Lipchitz maps.

Jim spent ten months' study leave as Visiting Associate Professor from September 1960 till June 1961 at Purdue University and as a Research Associate at Brown University in August 1961. As well as holding a normal teaching load at Purdue he collaborated on research on surface area with Goffman, Silverman and Neugebauer, running a research seminar on that topic.

In January 1961 he attended the annual winter meeting of the American Mathematical Society in Washington DC and gave a talk on convergence of surface measures that was later to appear as [11] in the *Transactions of the*

American Mathematical Society. This was the first time he met his future collaborator Bill Ziemer who comments [Ziemer 2013]:

> I knew Jim by reputation as he had just established a new result that created a good deal of excitement among the workers in the theory of surfaces and Lebesgue area. In this work, [12], he settled a difficult question posed by Casper Goffman in 1953.

Jim completed [12] while at Brown. From September 1964 until August 1965 Jim took leave without pay from his position at Adelaide and was a Visiting Professor funded by Purdue University.

Other research during this period includes [14] of which Simon [Simon 2003] says:

> Many of his later papers contained similar fundamental insights including his important paper on Lipschitz functions which appeared in 1964.

In the late 1960s Jim's interests turned to partial differential equations. Simon [Simon 2003] comments that:

> one of his first contributions was his realization that some aspects of classical potential theory, leading to monotonicity identities and related inequalities, can be carried out on minimal surfaces (an observation made independently by Allard at about the same time). This insight ultimately led to our proof of the Sobolev and mean-value inequalities on arbitrary submanifolds of Euclidean space, and it is again an example of Jim's ability to come up with the powerful and basic idea.

The joint work referred to here with Simon on Sobolev inequalities [17] was typical of Jim's clarity of exposition and its reviewer for *Mathematical Reviews* commented [Kinderlehrer 1973] that:

> The work is practically self-contained, in particular, it does not require knowledge of the isoperimetric inequality. The treatment here is recommended for its exceptional clarity of exposition.

Jim continued work on problems related to partial differential equations throughout the 1970s and 1980s. This included a particularly fruitful collaboration with Ziemer that produced four publications between 1975 and 1991. The first of these [23] was completed during a period of study leave taken at Ziemer's home institution, Indiana University. In his report of that leave, Jim notes that he spent it working with Ziemer on problems related to partial differential equations and Sobolev functions and that they were able to considerably improve on his earlier approximation results for Sobolev functions. Ziemer [Ziemer 2013] recounts that this work

> dealt with a problem posed by Casper Goffman involving Sobolev functions that was similar to Goffman's conjecture in surface theory. Lusin's Theorem states that a measurable function on a compact interval agrees with a continuous function except perhaps for a closed set of arbitrarily small measure. By analogy, it seems plausible that a Sobolev function $u \in W^{k,p}(Q)$ should agree with a function of class $C^k(Q)$ except for a set of small measure. Fon Che Liu [Liu 1977] proved this result. If the requirement concerning the degree of smoothness is lessened, perhaps it could be expected that there is a larger set on which there is agreement. That is, one could hope that u agrees with a function of class $C^l(Q)$, $0 \leq l < k$, except for a set of small $B_{k-l,p}$-capacity. Finally, because Sobolev functions can be approximated in norm by functions of class $C^k(Q)$, it is also plausible that the Lusin-type approximant could be chosen arbitrarily close to u in norm. The purpose of [23] is to show all this is possible. Our paper appeared in a volume dedicated to the celebration of Goffman's 65th birthday.

The second paper with Ziemer [27] deals with the regularity of the solutions to the problem of minimizing the variational integral

$$I(v) = \int_Q F(x, v(x), \nabla v(x))dx$$

among all functions v (in a Sobolev space) having given boundary values in a suitable way and lying above an obstacle ψ ($v \geq \psi$ in Q). This kind of obstacle problem is well known in the linear case: $F(x, v(x), \nabla v(x)) \sim |\nabla v(x)|^2$. The setting here applies to a wide class of nonlinear problems. It is shown that if the obstacle is Hölder continuous, then so is the solution. In a general setting upper semicontinuous obstacles ψ on Q are considered that satisfy the approximate continuity condition $\underline{\psi}(x) = \lim_{\rho \to 0^+} |B(x,\rho)| \int_{B(x,\rho)} \psi(\xi)d\xi$ for all $x \in Q$. Then the corresponding solution to the obstacle problem is continuous on Q. Here the generalized version of the classical Wiener criterion is used to ensure continuity of the solution at a point.

Lindqvist [Lindqvist 1973] writing in *Mathematical Reviews* commented of this paper that:

> The authors have succeeded in treating quite general nonlinear cases, and their result on the local Hölder continuity of the solutions to this kind of obstacle problem is a breakthrough.
>
> Taken as a whole, the authors' paper is a significant contribution towards the understanding of nonlinear variational inequalities and obstacle problems.

The third collaboration with Ziemer [27] deals with the Dirichlet problem for a wide class of quasilinear elliptic equations with C^1 coefficients in divergence form. The main result is that if Q is an arbitrary bounded open subset of R^n and φ is a continuous function defined on the boundary of Q, then there exists a solution to the equation in Q that assumes the boundary data continuously at all points at which a generalized Wiener condition is satisfied. This condition is satisfied at all points of the boundary except perhaps for a set of capacity zero.

In [30] the question of existence of solutions to variational inequalities of the type considered in [27] is pursued. By employing pseudomonotone operators, it is shown that solutions exist to a large class of operators considered in [27].

In concluding our discussion of Jim Michael's mathematical contributions we refer again to the citation at the time of Jim's election as a Fellow of the Australian Academy: 'He is not a prolific writer, but each one of his papers is an important and deep contribution to the subject.' In our rapidly changing "publish or perish" world, Jim Michael's mathematical life provides us with an impressive alternative model.

Acknowledgements

The preparation of this biographical memoir has relied extensively on earlier work listed in the references, in particular the obituary [Potts 2001a] prepared by the late Professor Ren Potts FAA with the assistance of Drs Jane Pitman and John van der Hoek. We have listed all other relevant sources although many of them have clearly relied on [Potts 2001a]. We are grateful also to the University of Adelaide for access to their files on Jim, particularly his fascinating study-leave reports, and to the Australian Academy of Science for access to their bibliographical data. Additional assistance and contributions have come from Professors Leon Simon, William P. Ziemer, Neil Trudinger, Graham Williams and Phil Howlett and Associate Professor John van der Hoek. We have also made use of two Michael family history websites at http://topperwien.com/genealogy/trees/people/p0000j4k.htm and http://community.fortunecity.ws/rainbow/dinosaur/107/. We thank the referees, particularly Associate Professor John van der Hoek, for many useful comments. Finally we thank Pat Michael for her helpful answers to our many queries and access to photos of Jim and other memorabilia.

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