Foreword

At the end of the 1996 racing season, the handful of GM of Canada-sponsored teams running in the CASCAR Series had been struggling to maintain their winning ways. As then-Manager of Motorsports Technical Activities, it fell to me to kick their game up a notch, so I proposed to the Marketing Manager whose budget I intended to plunder that a vehicle preparation/racecraft seminar be held to bring the teams up to concert pitch. To my considerable surprise he agreed, and with the start of the season fast approaching, I embarked on a precipitous search for the "Professor" who could impart a couple of decade's worth of experience in two days.

Recalling the glory years of the Player's/GM Motorsports Camaro/Firebird series five years previous, I remembered a persistent phenomenon in our Western Series, where several teams in succession rose from the ranks to win races and a championship in this ultra-competitive series, only to subside again into mediocrity. The common cause of their rocketing performances proved to be the peerless guidance of one Warren J. Rowley, Crew Chief/Race Engineer Extraordinaire, and their equally meteoric descent the result of his "firing" each team in turn for failing to live up to his exacting standards. This, then, would be my Professor, literally so in that he was a Professor of Music at the University of Calgary. (He has since retired because: "I can make more money in three months working with race teams than I could in twelve as an academic.")

Negotiations were quickly completed, and on the appointed day Warren appeared at GM's Oshawa headquarters with mountains of handouts, reference materials, suspension models and innumerable other teaching aids. He proceeded to mount a two day, multi-media blitz that left these top teams slack-jawed over the depths of their former ignorance and pleading: "Please sir, may we stop now? Our brains are full!" Sessions spilled over into dinner and beyond, many napkins were covered with illegible diagrams, and plans made for further consultations and track sessions. Once they had absorbed all they had drunk (albeit through a fire hose!) from this fountain of knowledge, the teams all agreed it had been a most amazing exercise, one that would have huge long term benefits for their programs.

Reviewing the project afterwards with Warren, two main themes emerged. He said: "There is so much more I needed to tell them! A week wouldn't be nearly enough!" His second comment was: "I can't believe how much I learned; far more than I taught them! Every time I wrote down something I 'knew', to be true, I ended up back in the shop, building new models, proving or disproving accepted 'facts'. This has been an astounding learning experience for me."

My observation was: "You realize, Warren, that since you're just bursting to share all this lore and data you have amassed, you absolutely must write the last definitive book of the century on race car design and preparation?" His reply: "Absolutely not! Never! Will Not Happen!"

In the ensuing years, Warren has designed and redesigned many racecars, done increasingly high-tech consultations for an ever-growing list of teams in many of the top North American series (none of whom would appreciate having their names mentioned here) and as we now learn, writing ceaselessly. A mere 6 years later, you are holding the Book That Would Not Be; the product of so much sweat, tears, blood and midnight oil that it ought to be printed in muddy red ink. He tells me he has learned so much more in the writing that at least four more volumes are circling his brain, pounding on the walls and screaming to be let out...

William Wordsworth wrote:

"And now I see with eye serene
The very pulse of the machine."

Warren is the possessor of that all-seeing orb, and we readers will be the beneficiaries of its vision. Enjoy!

-Bill Ball, October, 2003

AN INTRODUCTION TO RACE CAR ENGINEERING

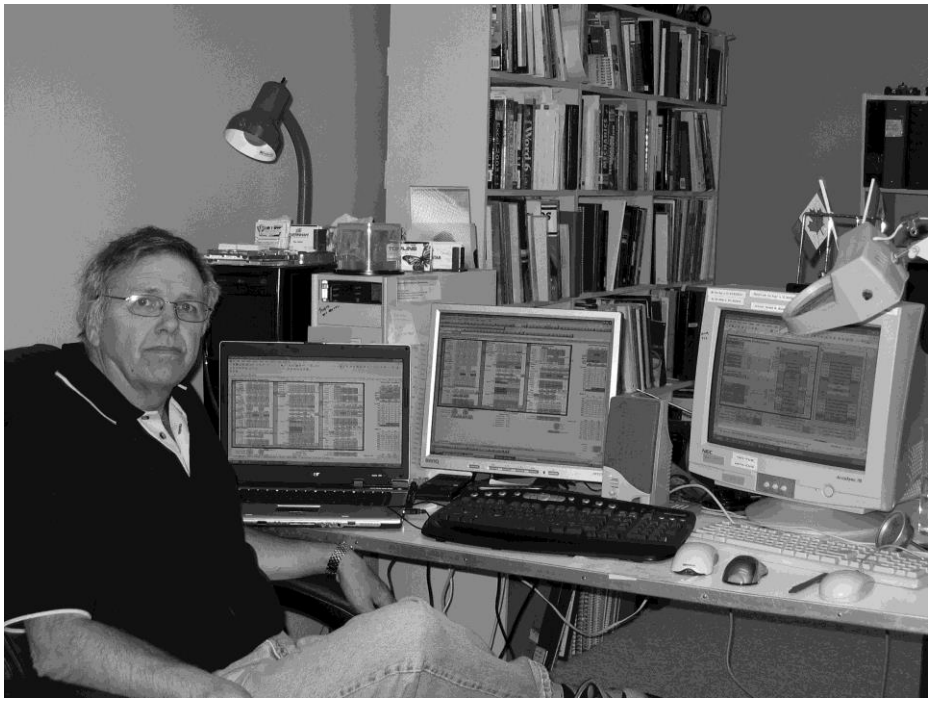
BOOK ONE

THE BASICS OF VEHICLE DYNAMICS

by: WARREN ROWLEY

This book is the first in the series of five books written for the race engineer.

Where applicable, it covers stock car, sports car and open wheel technology.



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- This 67 page chapter presents and thoroughly explains all of the equations and algorithms used to develop the Wan31 vehicle dynamics software. It does so in a carefully designed sequential order that will allow the user to understand the basics of dynamic simulation and lays the groundwork for the user to begin expanding the software to fit his/her unique software needs.

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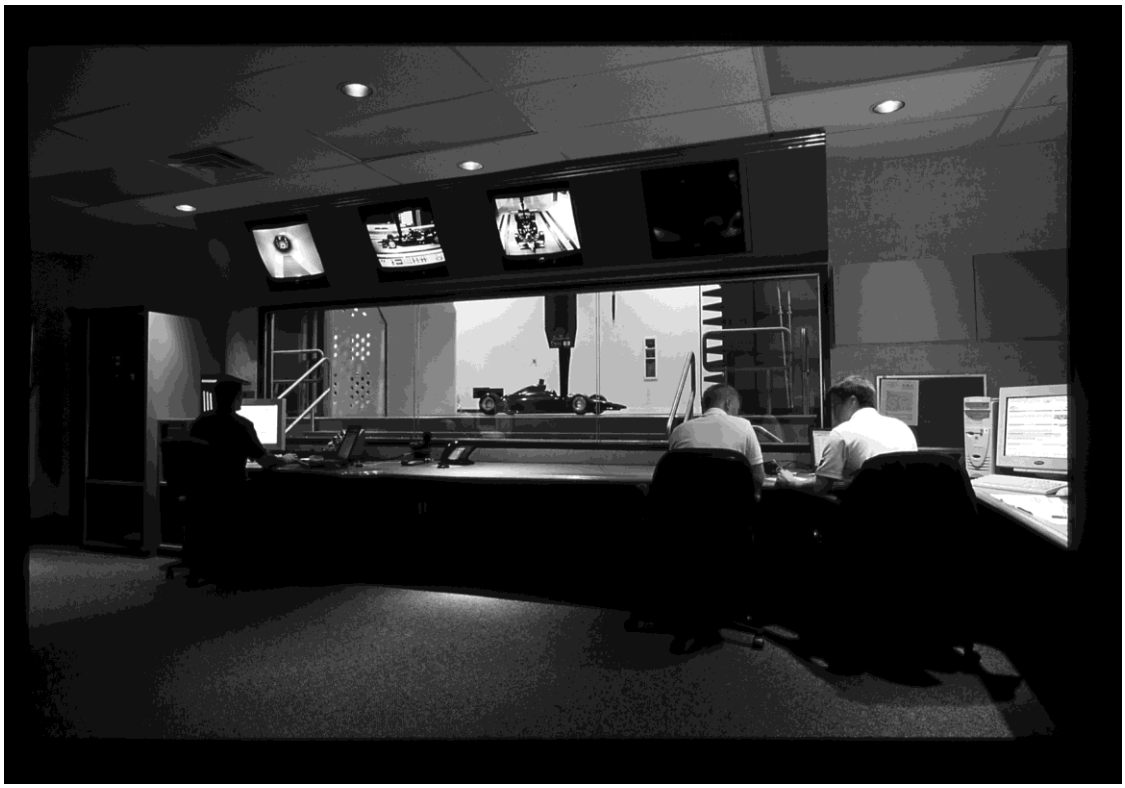
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Picture compliments of **Penske Technology Group**

DEDICATIONS

To my wife, Cheryl, and my children, Kara & Michael

You are my life and an endless source of inspiration. Love you!

Many Thanks:

Bill Ball - Thanks for your friendship, your encouragement, your technical brilliance, your acerbic editorial comments and for making me write this book - - for those hundreds of hours I spent writing Book One without any remuneration. I also need to thank you for protecting my technical accuracy, for example when I used the word, "vortex," when I meant to write, "venturi," etc. It has been very comforting having you look over my shoulder to help cut down on the "how dumb was that" mistakes.

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To the many great drivers, teams and racing individuals with whom I have had the privilege of working over the years. I have thoroughly enjoyed working with each and every team – well, except for one.

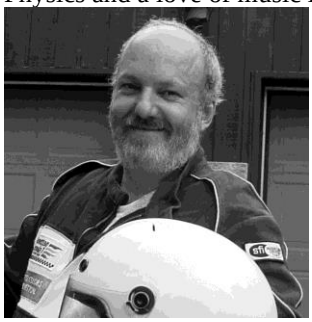
Disclaimer – On behalf of the author's wife, **Cheryl**, and friend, **Bill Ball**: Any typing errors etc. not ferreted out before the first printing are certainly not the fault of my two prized editors. It seems no matter how many times the aforementioned typing errors were fixed, my dyslexic nature found new ways to slip in an abundance of fresh ones. Sorry guys.

Additional 3rd Edition Editing - Claude R. Fortier

One of the most thankless jobs involved in producing a book of this type is in the editing of the mathematics.

Much to my great relief, Claude R. Fortier, without remuneration, undertook to carefully review each and every Wan31 example found in the dynamics chapters – Chapter 13 to 21. I owe Claude a great debt of gratitude for his help. If the remaining books within this series are ever to be published I suspect Claude's help in developing the mathematical models will play a key role in this endeavor. In this regard, you may wish to encourage his help. cfortier@sota.ca

Claude Fortier received his Ph.D. in Particle Physics for research done at Lawrence Berkley Laboratory in California. Physics and a love of music led to acoustics and loudspeaker design for recording studios. This eventually got developed into a successful acoustical consulting practice called State of The Art Acoustik. Claude has been a life-long racing enthusiast, a passion which started while making custom slot cars as a child and then from a visit to the Canadian Formula 1 race in 1968 as a teenager, the first aero year. Can-Am cars followed. A love of Newton's scientific discoveries fuelled a passion for equations and the love of cars a need to relate them to race car set up. Claude enjoys driving and modifying his own cars on various road racing circuits in eastern Canada and the US.



Thanks to Matthew Bastin for finding the math typo in Chapeter 15, page 52.

A very big thank you to Roger Dowden of Swansea Institute for his endless amount of help.

About the Book

This book is written to be used in sequential order where one section logically leads to the next section.
Not doing so seriously diminishes the value of the book.

The book was written to help the serious racer develop his/her craft. It was not written for "The Bench Racer" *who will spend much time debating the correct use of an abbreviation, but, will never be able to grasp what the book actually has to offer*, or, that strange animal, "The Idiot Racer", *who believes anyone who takes a serious, studied and scientific approach to making a car go fast is in fact the idiot*.

I have no time for bench racers and seriously dislike all idiot racers.

The Cover Picture

The front cover picture is courtesy of John Moloney and the **Penske Technology Group (PTG)**. The PTG motorsports research center boasts one of the most advanced and up-to-date facilities of its type in the world today. It is staffed by many of the most knowledgeable vehicle dynamic's and aerodynamic's personnel currently working in the motorsport industry. Additional PTG pictures can be found throughout the book.

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The PTG wind tunnel is a commercially available open jet wind tunnel for the testing of 40% - 50% scale vehicle models. The tunnel provides a moving ground plane and boundary layer control to accurately simulate real-world

conditions. The tunnel is combined with a sophisticated control and data system to produce accurate, repeatable results in the minimum number of runs. A variety of advanced tools and methods are available to the customer to assist with their aerodynamic testing needs.

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PTG personnel possess the tools and talent to help place its customers at the front of their field. From conceptual design and manufacturing along the way, PTG will be able to assist in all aspects to solve any problems.

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Cover Design by Michael Rowley

One small concession to the Bench Racers – Just so you don't have to count them; there are 2387 different examples given in this book.