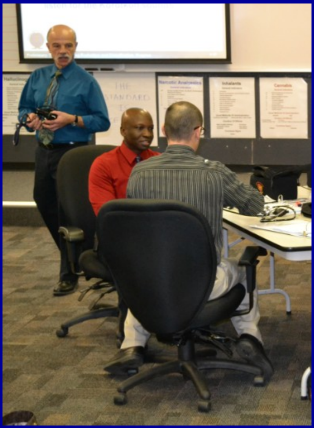
POLICE

ARIZONA POLICE SCIENCE JOURNAL



Volume 3, Issue 1

February, 2013

Arizona Police Science Journal

A publication of the Arizona Governor's Office of Highway Safety

Inside this issue:

Truth in Science

Moving Forward!

Welcome to the fourth issue of the Arizona Police Science Journal. The Governor's Office of Highway Safety (GOHS) has continued to actively support this publication over the last three years since its inception.

In 2012, awareness of the APSJ has grown tremendously. The "Journal" has been presented to the National Highway Transportation Safety Administration, the International Association of Chiefs of Police, and many law enforcement and public safety agencies throughout the Southwest.

Officers and attorneys throughout the state have expressed their appreciation for training and updates, such as Case Law Review and Legal Updates, and technical scientific articles such as those provided by Dr. Rudy Limpert and the DPS Crime Laboratory. Much of this training and information is not easily accessible outside of the metropolitan areas in the state.

This Journal serves not only as a training and information sharing medium, but also as an avenue for officers and criminalists to publish and share information. We invite you to submit your work and research, or timely training content for publication.

Daven Byrd

Executive Editor, APSJ

THE ARIZONA GAME AND FISH DEPARTMENT OFF-HIGHWAY VEHICLE (OHV) PROGRAM

Jimmy Simmons, OHV Law Enforcement Program Manager

Abstract:

OHV recreation is one of the fastest growing activities on public lands in the nation. The challenges that this recreational activity has presented to land management agencies and conservation agencies are vast. As stewards of wildlife and the habitats that they dwell in, the Arizona Game and Fish Department (AGFD) must meet the challenge of managing OHV recreation through dedicated efforts in law enforcement, information and education and habitat management. Additionally, the AGFD has taken the responsibility to proactively form collaborative alliances with a common goal of decreasing the number of OHV injuries and fatalities in Arizona.

The Growth of the OHV Industry

The OHV industry has grown dramatically in the past 20 years. New technology and machines appear on the market just about every year. Fueled by the American culture to have the latest and greatest, the fastest selling OHV machines are the sport side-by-side models that are rated at speeds over 60 miles per hour with 1000 cc motors and incredible suspension systems. Bigger engines and structural design improvements now allow previously unforeseen high travel speeds over rough terrain. Some of the newer machines have unbelievable capabilities and they are only getting more advanced. To demonstrate the growth of OHV's in Arizona, Figure 1 contains registration and titling data from the Arizona Motor Vehicle Department.

Arizona Game and Fish Department

OHV Program Philosophy

To be the leader in Arizona off highway vehicle education and habitat protection efforts by providing effective information and enforcement programs that promote safe, ethical and responsible OHV use across Arizona

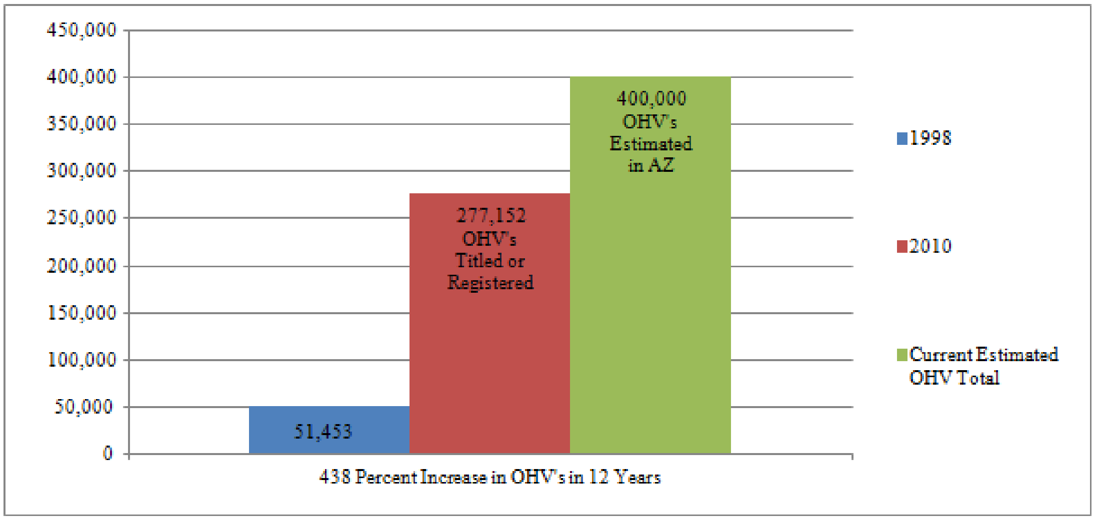


Figure 1 – The increase in titled and registered OHV's in AZ in 12 years.

In December 1998, there were 51,453 All Terrain Vehicles (ATV's) & All Terrain Cycles (ATC's), better known as quads and three wheelers in Arizona. In December 2010, there were 277,152 ATV's & ATC's titled or registered in Arizona, a 438% increase in 12 years. Current Arizona Game and Fish Department and MVD estimates indicate there are in excess of over 400,000 OHV's in Arizona, and that number is growing just as rapidly as the industry meets the demand.

OHV Injuries in Arizona

The rapid growth in the OHV industry and overwhelming public attraction to OHV recreation has resulted in a statewide increase in injuries and fatalities. According to the Arizona Department of Health Services (ADHS) data, between 2003 and 2010, there were 209 OHV-related fatalities (an average of 30 per year), 500 inpatient hospitalizations and 1,921 emergency department visits (not including data from federal or tribal hospitals). Many of these injuries and fatalities may be attributed to a lack of OHV safety education for the operators, riding beyond an operator's ability, inability for land management agencies to manage OHV recreation at a pace consistent with growth, a shortage of law enforcement officers specific to OHV management and a lack of appropriate OHV laws that enable officers to enforce irresponsible, unsafe OHV operation.

Other Concerns

In addition to the public safety concerns, irresponsible, unsafe OHV operation creates habitat damage and a proliferation of roads across the landscape. In reaction to these types of operation, state and federal land management agencies have or are in the process of re-evaluating their travel management rules which will undoubtedly result in some of the existing access on United States Forest Service (USFS) and Bureau of Land Management (BLM) lands to be redefined, limited or closed indefinitely. This is in addition to those lands that have already been closed or access that has been limited due to prior actions by these agencies in response to OHV recreation. The AGFD is heavily involved in OHV recreation management because of its associated impacts to the environment and because the agency's public trust responsibility to protect Arizona's diverse wildlife resources.

Legislation and Funding

Until Senate Bill 1167 passed in June 2008 and became effective January 2009, the AGFD's efforts to protect wildlife resources from OHV damage and to provide programs for safe OHV recreation in Arizona were limited. Senate Bill 1167 amended Article 20 of Arizona Revised Statutes by adding several statutes that allow AGFD and other law enforcement agencies statewide to effectively enforce unsafe and irresponsible OHV operation. The legislation also created the OHV user indicia, more commonly referred to as the "OHV Decal". The legislation requires that an OHV decal must be displayed on all vehicles that are specifically designed by the manufacturer for travel over unimproved terrain, having an unladen weight of 1,800 pounds or less, while the vehicle is being operated on public or state trust lands.

Funding from the $25.00 decal goes to the OHV Recreation Fund which is divided between the Arizona State Parks Department (60%), Arizona State Land Department (5%) and the AGFD (35%). The 35% appropriated to the AGFD is used to provide OHV information and education programs related to OHV safety, OHV impacts on the environment and responsible OHV use, as well as implementing and supporting a statewide OHV law enforcement program.

The AGFD is mandated by state statute to employ seven full-time law enforcement officers to enforce OHV laws statewide. To date, the AGFD has employed the seven full-time officers and has hired two additional officers that are partially funded from other sources to assist in OHV law enforcement efforts across the state.

New Officers and Their Duties

To train and equip these officers, the AGFD purchased trucks, bullet proof vests, firearms, home office equipment, and patrol equipment, including fully marked law enforcement OHV's to allow officers to patrol remote OHVareas.

The authorities granted by the legislation and subsequent deployment of specific OHV law enforcement officers has expanded the AGFD role as a resource conservation agency. Historically, the AGFD has only enforced Arizona Revised Statutes (A.R.S.) Title 17 (Game and Fish) and A.R.S. Title 5 (state boating laws) but the new legislation was primarily placed within A.R.S. Title 28 (Transportation and Traffic Laws). Enforcing boating laws is somewhat similar to Title 28 and has long required AGFD officers to become proficient in the use of Horizontal Gaze Nystagmus (HGN) and other seated field sobriety tests to detect impaired operation although, AGFD officers rarely took traffic enforcement actions unless an immediate public safety threat occurred in their presence (i.e. reckless driving or DUI). Even then, AGFD officers generally requested officers from other agencies such as DPS, county, or municipal agencies to take disposition of these cases because it was not within the scope of the agency's eligible or allowable duties. Subsequent to the new legislation, AGFD recognized the necessity to educate and train officers in the subject matter of Driving Under the Influence (DUI) enforcement and civil traffic law and has taken several steps towards this goal.

Recently, the AGFD collaborated with the Department of Public Safety (DPS) to train 25 AGFD officers in the Advanced Roadside Impaired Driver Enforcement (ARIDE). Additionally, eight AGFD officers have become Drug Recognition Experts which will enable the AGFD to better detect and apprehend drugged boaters and OHV users.

Adapting Through Training

The AGFD has transitioned from an agency that traditionally only enforced wildlife conservation laws to a statewide recreational law enforcement organization. AGFD has embraced the role and responsibility of being the lead boating enforcement and OHV enforcement agency for the State.

Because of this expanding role, more and more conservation officers throughout the United States are facing lethal force encounters. The equipment and officer safety and situational awareness training that AGFD officers receive allow them to operate alone, in remote settings, while maintaining safety and dependability.

New OHV enforcement officers and wildlife managers attend a 40 hour OHV Law Enforcement School as part of their post academy training and prior to heading to the field with Field Training Officers. Officers receive training in basic riding safety skill, OHV laws and legalities, DUI, natural resource violation, evidence collection, tactical firearm courses from an OHV, and OHV breakdowns and maintenance. These classes culminate in a final day of advanced riding skills, including an all day ride with as many challenges as possible to strengthen the students riding abilities.

The AGFD currently requires officers and employees to be trained in the basic ATV Saftey Institute (ASI) four hour riding course. This training is also provided to other law enforcement and conservation agency personnel by the Department. An Arizona specific on-line safety course is currently available on the AGFD website at www.azgfd.gov/ohv and a public hands-on OHV safety course is currently being developed. The AGFD is committed to being the best state wildlife conservation agency through continuous evaluation and improvement of its programs and through professional development of its employees.

Safety and Education

Ensuring safe OHV recreation requires committed collaborative efforts to assure a culture of safety by the state's recreational OHV community. By forming alliances with groups such as the Arizona Department of Health Services (ADHS), Injury Prevention Advisory Council (IPAC), Southwest Alliance for Recreational Safety (SWA4RS), OHV Ambassadors (OHVA), the National OHV Conservation Council (NOHVCC) and the OHV Advisory Group (OHVAG), the AGFD and partners will continue to educate the public about safe, responsible OHV use. Although each of these groups have unique missions, all share the common goal to promote OHV safety and education at a level that will significantly reduce OHV injuries and fatalities in Arizona. AGFD will continue to work closely with these groups and others to inform OHV users about the importance of wearing proper OHV safety equipment (goggles, helmets, etc.) as well as safe, responsible riding practices.

Final Considerations

The AGFD recognizes that OHV recreation and related industry will continue to grow and become more popular across the nation and although the challenges in OHV law enforcement and safety education are large, the

agency is committed to its mission.

The AGFD will strive to proactively meet those challenges by effectively reducing OHV collisions and working with OHV users and land management agencies to maintain public access for safe, responsible OHV riding practices.

References

1. Forty-Eighth Legislature (2008). *Senate Bill 1167*, State of Arizona Senate, Second Regular Session.

2. Matthew Bender & Company, Inc. (2010). *Arizona Criminal and Traffic Law Manual* (2010-2011 Edition).

3. *Point in Time Vehicles Registered by County* (July 31, 2011). Retrieved October 20, 2011, from http://www.azdot/mvd/statistics/registeredVehicles.asp

4. Schacter, Alana (October 26, 2011). Arizona Department of Health Services (ADHS), *Off-Highway Vehicle Injuries Among Arizona Residents,* Power Point for the Arizona Game and Fish Department, Off-Highway Vehicle Conference.

Jimmy Simmons has served in law enforcement for over 18 years, both with the Arizona Game and Fish Department and the Arizona Department of Public Safety as an officer, and is currently the Off Highway Vehicle Law Enforcement Program Manager at the Phoenix Headquarters of the Arizona Game and Fish Department. Jimmy is also an Advisory Board Member for the Arizona Police Science Journal.

Governor's Office of Highway Safety

Impaired Driver Program

Bridget Reutter, Impaired Driver Programs Coordinator

We would like to take this opportunity to thank you for continuing the fight against impaired driving. The time you all spend on the road during regular enforcement and special details during DUI Task Force events counts. The time you endure away from your families and personal lives to attend training or teach counts. The time you take to make sure every impaired driver faces justice in court counts. Time spent training, enforcing and prosecuting impaired drivers continues to reinforce the dedication you all have toward making city, county, and state roadways safer for our communities as well as for each other. The effort to maintain high standards in DUI enforcement and seek additional ways to enhance the process to the benefit of the victims as well as prevention of the crime provided encouragement to our state lawmakers fueling the desire to construct the toughest DUI/Impaired Driver laws in the nation. Every stride made toward stricter DUI laws in Arizona is a result of your collective enforcement effort.

Arizona law enforcement personnel exhibit a high level of expertise in impaired driver recognition for two main reasons: training and adherence to program standards. We cannot overstate the importance of recognizing the impaired driver. Nor can we overstate the importance of adherence to program standards associated with impaired driver recognition.

Expectations remain high for those attending HGN/SFST, ARIDE and DRE training, and not just from a practical standpoint. The training classes associated with impaired driver recognition carry the expectation of maintaining strict standards at the National and State level.

Knowing and understanding the purpose of the training as well as the training standards is imperative. In light of the recent decision from courts to apply the *Daubert* standard, recitation of your training, knowing the background of the impaired driver recognition programs associated with your training, and adherence to the training standards are pertinent to your ability to provide effective (and admissible) testimony. Someone is relying on your knowledge, skills and ability to recognize impairment, know and follow training standards, and articulate the facts of a case. A victim or victim's family is relying on you to exemplify integrity in testimony.

A requirement to increase training hours to retain certification assists in securing the premier status Arizona continues to maintain among the states. Recent revisions to the State Standards reflect the desire to ensure Arizona law enforcement personnel receive the most current training available in the area of impaired driver recognition. The Governor's Office of Highway Safety maintains a high level of support for the programs, participants and practitioners as well as the ultimate responsibility for ensuring program accountability.

Tire-Road Friction, Drag Factor and Deceleration

Rudy Limpert and Dennis Andrews

www.pcbrakeinc.com

Introduction

Many years ago when SAE International sold our reconstruction software LARM2 software, I received a phone call from a Reconstructionist who had bought the program. He stated that he was very disappointed that LARM2 did not provide any drag factors for vehicles after impact. When I asked him what the case was all about, he did not know – he just needed the numbers. When I told him that the after-impact drag factor depends on the run-out dynamics including information on wheel(s) locked, terrain, grade, secondary energy such as impact with trees, rolling resistance, drag sled factor, skid tests, etc. he was surprised.

After-impact decelerations are of critical importance when calculating impact speeds. They are used to compute speeds immediately after impact, which then are used in the impulse analysis to compute speeds immediately before impact. Before-impact decelerations are extremely critical for travel speed calculations and causation and accident avoidance analysis.

Basic Physics

Only the fundamentals are reviewed here. Vehicle Motion Analysis is discussed in "Motor Vehicle Accident Reconstruction and Cause Analysis", 7th edition by Rudolf Limpert, 2012, LexisNexis Publisher.

The MARC1 software programs discussed in this paper are available from www.pcbrakeinc.com as a fully functioning no-charge MARC1-2013 download.

A vehicle slows its speed when it decelerates. Deceleration is velocity change or decrease divided by the time period during which the vehicle decelerates.

$$\text{Deceleration } a = (V_2 - V_1) / (t_2 - t_1);\ \text{ft/sec}^2$$

Subscript 1 designates beginning of braking, subscript 2 end of braking. No matter, what terms are used, a vehicle slows only when its velocity measured in ft/sec changes its value per unit time, measured in seconds. When coming to a complete stop and assuming deceleration is constant, the distance is:

$$\text{Stopping Distance } S = V^2/(2a);\ \text{ft}$$

Deceleration a is measured in ft/sec^2, velocity V in ft/sec.

Many motion equations use these two terms and other coherent measuring units. Coherent units means that the left side of the equation {feet} relates directly in a one-to-one relationship to the right side of the equation $\{(\text{ft/sec})^2/(\text{ft/sec}^2) = \text{feet}\}$ However, for short-term convenience, stopping distance equations are often used where velocity is measured in miles per hour, deceleration in g-units, and distance in feet. An example of a popular and widely used incoherent equation is $S = V^2/(30f)$ where velocity V is measured in mph, f in g-units and distance S in ft. The number 30 is a conversion number deriving from using an incoherent mixture of units. *See* page 20-41 of the 7th edition for derivation details. Matters become confusing when concepts are used where coherent units must be used such as in energy balance which is measured in lb/ft.

Case 1: The Accident Scene

We will discuss an actual accident illustrated below in the police scene photograph. A pickup truck impacted a boy riding a bicycle. The bike came from the right side of the truck with the truck traveling south.

The left front tire skidded approximately 88 feet, the right front 86 feet. No rear tire skid marks were observed at the scene. The bike was impacted by the left front corner of the truck approximately 9 feet before the truck came to rest. The legal speed limit was 30 mph. The truck had the legal right-of-way. The rider of the bike was a young 7-year old boy.

Inspection of the accident scene photographs clearly show the front tire skid marks with darker tread edge markings of the right front tire. The tire marks continued to the rest position of the truck's front tires. No rear tire skid marks were shown in any of the photographs.

An inspection of the 1982 Dodge flatbed pickup truck showed that one rear brake was leaking thus not producing any rear braking force. The static front and rear axle loads, wheel base were measured, the empty center-of-gravity height estimated.

We must compute the most probable speed of the truck at the beginning of skid marks, the travel speed, the impact speed against the bike, and perform an accident avoidance analysis. To do that, we must determine the probable deceleration or drag factor of the subject truck at the time of the accident.

Case 1: Dodge Accident Site Tire Road Friction Coefficient

At the time of our accident site inspection no case-specific tire marks were visible. The truck was not available for skid measurements. Consequently, our first job is to determine the "stickiness" of the accident site where the skid marks were measured by the police. It is important to make any tire-road friction coefficient measurements under conditions similar to those existing at the time of the accident. Using a common drag boot frequently employed by investigating officers and experts yielded the following: an average drag force of 37 lb in five tests for a drag boot weight of 50 lb resulted in an average drag boot factor of 37/50 = 0.74. All we have accomplished thus far is giving the road a name in terms of a 0.74 drag boot factor existing at the time of our inspection. This number does not tell us anything about the deceleration the truck actually experienced at the time of the crash. However, in many cases the "stickiness name" of the road measured with a drag boot is all we have to start with!

At the accident site we also used a pickup truck to conduct maximum braking effectiveness stops from a speed of 35 mph using a G-analyst resulting in an average deceleration of 0.84g in five skid tests. In each test the ABS system began to modulate on all four brakes. Now we have given the accident site an additional name indicating an average deceleration of 0.84g with all four brakes ABS modulating with our truck tires.

What tire-road friction coefficient the braked tires of the subject truck experienced depends upon how our truck tires compare to the subject tires, and how much difference exists between a locked tire (Dodge) and peak friction tire (our truck). However, we safely assume that it is larger than the drag boot and lower than the ABS value. Braking force/slip (μ-slip) curves typically show little difference between peak and sliding friction for dry roadways (Figure 22-3 of 7th edition). Consequently, we assign a tire-road friction coefficient of $f_{\text{site}} = (0.74 + 0.84)/2 = 0.79$ to the subject road at the time of the accident. Consequently, assuming no other case-specific data become available, we must support and defend in court an accident-site specific tire-road friction coefficient of 0.79. As we will see from the speed analysis, in this particular case an accurate probable drag factor is more important than if the skid mark length had been 200 feet instead of only 88 feet.

Comparing the measured tire road friction coefficient of 0.79 to typical values published in the literature shows ranges 0.65 – 0.9 for sliding and 0.80 to 1.00 for peak friction on concrete/asphalt, polished to new, dry (Table 22-3 of 7th edition).

State highway departments regularly measure wet skid resistance of highways for inventory and statistical analysis. Test method and equipment are covered by standard ASTM E 274 (American Society of Testing and Materials). The test tires to be used with the skid trailer are specified in ribbed (treaded) ASTM E 501, and smooth (bald) in ASTM E 524. From a reconstruction view point, these numbers only give a particular highway a " wet friction" name and may not indicate what the wet friction of a specific tire may have been. However, depending upon the accident, it may be an additional data source.

Case 1: Deceleration of the Dodge Pickup Truck

We must now determine how much of the tire-road friction of 0.79 did the Dodge actually use at the time of the accident. Experts often stumble around by quoting braking efficiencies and other short cuts, especially for commercial vehicle equipped with air brakes.

The deceleration of a vehicle is determined from Newton's second law of motion as well as specific vehicle dimensions and static load distribution. Newton's second law states that the deceleration or drag factor is equal to all slowing forces acting on the vehicle divided by vehicle weight:

$$a/g = \Sigma F/W = F_{\text{frontBrake}}/W; \text{ g-units}$$

The driver-only Dodge flatbed truck had static axle loads of front 3200 lb and rear 3100 lb, wheel base 11.8 ft and center-of-gravity height 29 inches estimated.

The front braking force based on the static front axle load is:

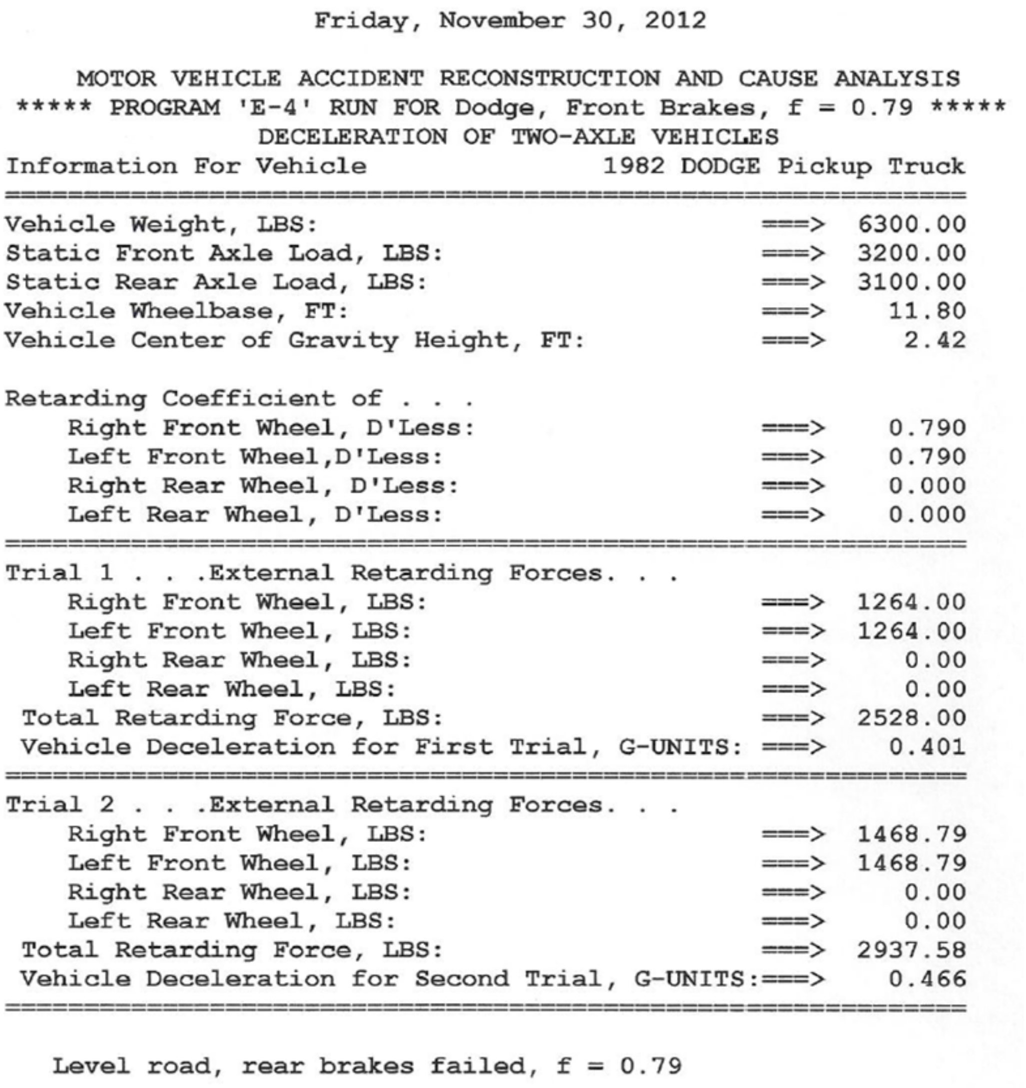
$$F_x = (F_z)(f_{site}) = (3200)(0.79) = 2528 \text{ lb.}$$

Consequently, the approximate deceleration based on the static front axle load is:

$$(a/g)_{\text{static}} = (2528)/6300 = 0.401\text{g}$$

Using a deceleration of 0.401g produces a load transfer upon the front axle to further increase the front braking force. MARC1-E4 was developed to make the first and second calculation.

We use MARC1- E4 to determine the probable deceleration. MARC1- E4 printout is shown below. Using the specific vehicle dimensions and a tire-road friction coeffi-



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                   Friday, November 30, 2012

    MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
 ***** PROGRAM 'E-4' RUN FOR Dodge, Front Brakes, f = 0.79 *****
                DECELERATION OF TWO-AXLE VEHICLES
Information For Vehicle             1982 DODGE Pickup Truck
==============================================================
Vehicle Weight, LBS:                                ===>  6300.00
Static Front Axle Load, LBS:                        ===>  3200.00
Static Rear Axle Load, LBS:                         ===>  3100.00
Vehicle Wheelbase, FT:                              ===>    11.80
Vehicle Center of Gravity Height, FT:               ===>     2.42

Retarding Coefficient of . . .
    Right Front Wheel, D'Less:                      ===>    0.790
    Left Front Wheel,D'Less:                        ===>    0.790
    Right Rear Wheel, D'Less:                       ===>    0.000
    Left Rear Wheel, D'Less:                        ===>    0.000
==============================================================
Trial 1 . . .External Retarding Forces. . .
    Right Front Wheel, LBS:                         ===>  1264.00
    Left Front Wheel, LBS:                          ===>  1264.00
    Right Rear Wheel, LBS:                          ===>     0.00
    Left Rear Wheel, LBS:                           ===>     0.00
 Total Retarding Force, LBS:                        ===>  2528.00
 Vehicle Deceleration for First Trial, G-UNITS:     ===>    0.401
==============================================================
Trial 2 . . .External Retarding Forces. . .
    Right Front Wheel, LBS:                         ===>  1468.79
    Left Front Wheel, LBS:                          ===>  1468.79
    Right Rear Wheel, LBS:                          ===>     0.00
    Left Rear Wheel, LBS:                           ===>     0.00
 Total Retarding Force, LBS:                        ===>  2937.58
 Vehicle Deceleration for Second Trial, G-UNITS:===>        0.466
==============================================================

   Level road, rear brakes failed, f = 0.79
```

MARC1 – E4 Data Printout for Front Brakes, Friction Coefficient f = 0.79, Level Roadway.

cient of 0.79 yields a deceleration of 0.466g or 15.00 ft/sec^2 with the only front brakes. Varying the center-of-gravity height by +/- 3 inches will only slightly affect deceleration. The deceleration of 0.466g includes the contribution of load transfer as shown in the MARC1=E5 printout. The front braking force without load transfer of (2)(1264) lb has increased to (2)(1468) lb.

Had the rear brakes been working properly and the front brakes failed, the drag factor would have been only 0.326g.

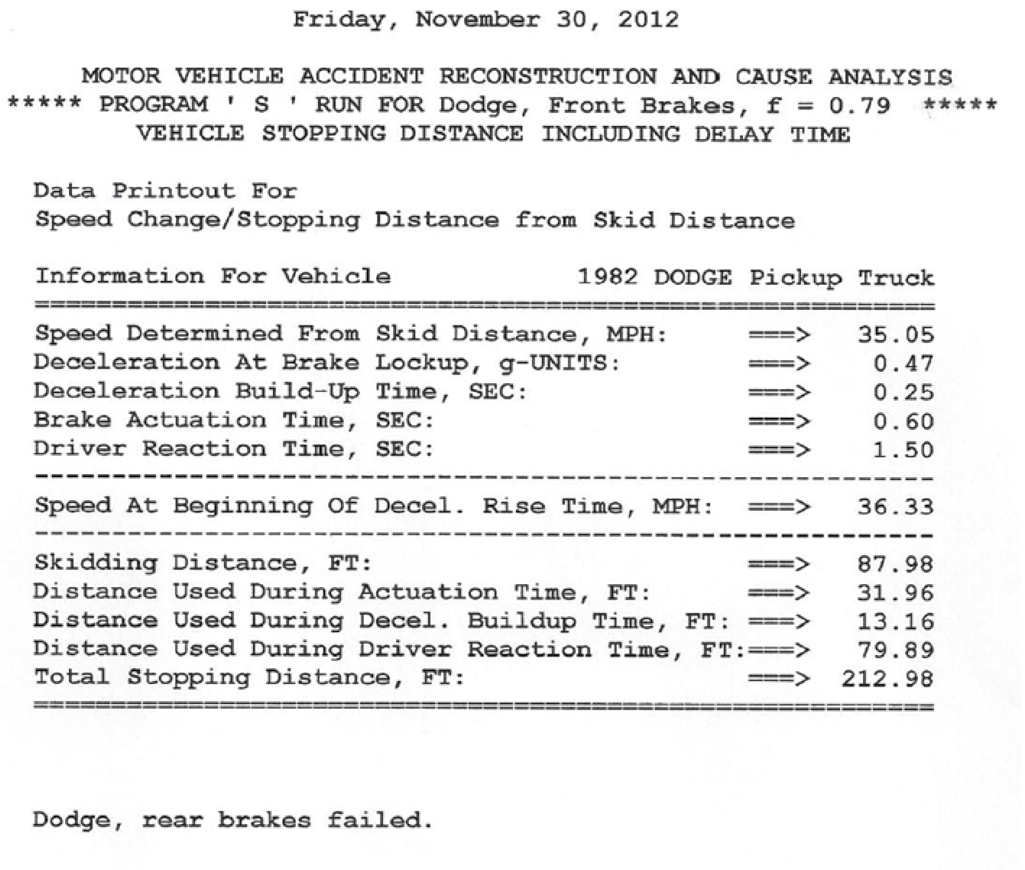
Had all brakes been functioning properly, the deceleration would have been 0.79g with all four brakes locked.

Case 1: Speed of the Dodge Truck when Brake Pedal Is Applied.

The probable speed of the Dodge at the moment of brake lockup would have been:

$V = [(2)(15.00)(88)]^{1/2} = 51.38$ ft/sec or 35.05 mph

The speed of the truck at the moment the brake pedal was first applied was approximately 36.33 mph as shown by MARC1-S. The increase in speed above the value at



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                  Friday, November 30, 2012

     MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
***** PROGRAM ' S ' RUN FOR Dodge, Front Brakes, f = 0.79  *****
        VEHICLE STOPPING DISTANCE INCLUDING DELAY TIME

  Data Printout For
  Speed Change/Stopping Distance from Skid Distance

  Information For Vehicle           1982 DODGE Pickup Truck
  ==========================================================
  Speed Determined From Skid Distance, MPH:      ===>   35.05
  Deceleration At Brake Lockup, g-UNITS:         ===>    0.47
  Deceleration Build-Up Time, SEC:               ===>    0.25
  Brake Actuation Time, SEC:                     ===>    0.60
  Driver Reaction Time, SEC:                     ===>    1.50
  ----------------------------------------------------------
  Speed At Beginning Of Decel. Rise Time, MPH:   ===>   36.33
  ----------------------------------------------------------
  Skidding Distance, FT:                         ===>   87.98
  Distance Used During Actuation Time, FT:       ===>   31.96
  Distance Used During Decel. Buildup Time, FT:  ===>   13.16
  Distance Used During Driver Reaction Time, FT:===>    79.89
  Total Stopping Distance, FT:                   ===>  212.98
  ==========================================================


  Dodge, rear brakes failed.
```

MARC1 – S: Dodge, Front Brakes, a = 0.466g.

brake lockup is caused by some deceleration that exists when the deceleration increases from zero value to the maximum deceleration at the moment of brake lockup.

Stated differently, the travel speed slows from a higher value to the level at brake lockup. In this case, deceleration build-up time is greater since the hydraulic rear brake failure causes a longer brake pedal travel.

The driver began to react to the bike approaching from his right side 212.98 feet or approximately 213 from the point of rest. Using the data from MARC1-S, for a driver reaction time of 1.5 sec, vehicle deceleration began to rise approximately 213 – (80 + 32) = 101 feet from the point of rest.

The speed of the truck at the moment of impact with the bike was:

$V = [(51.38)^2 - (2)(15.00)(88 - 9)]^{1/2} = 16.43$ ft/sec or 11.21 mph.

Case 1: Accident Causation Analysis

Travelling at the Speed Limit of 30 mph

When traveling at 30 mph or 44 ft/sec and locking the front brake the stopping distance would have been:

$$S = (44^2)/[(2)(15.00)] = 64.5\text{ft}$$

Consequently, had the driver driven at the speed limit of 30 mph and locked the front brakes at the same location as in the accident, the truck would have stopped approximately 88 – 9 – 64.5 = 14.5 ft from POI.

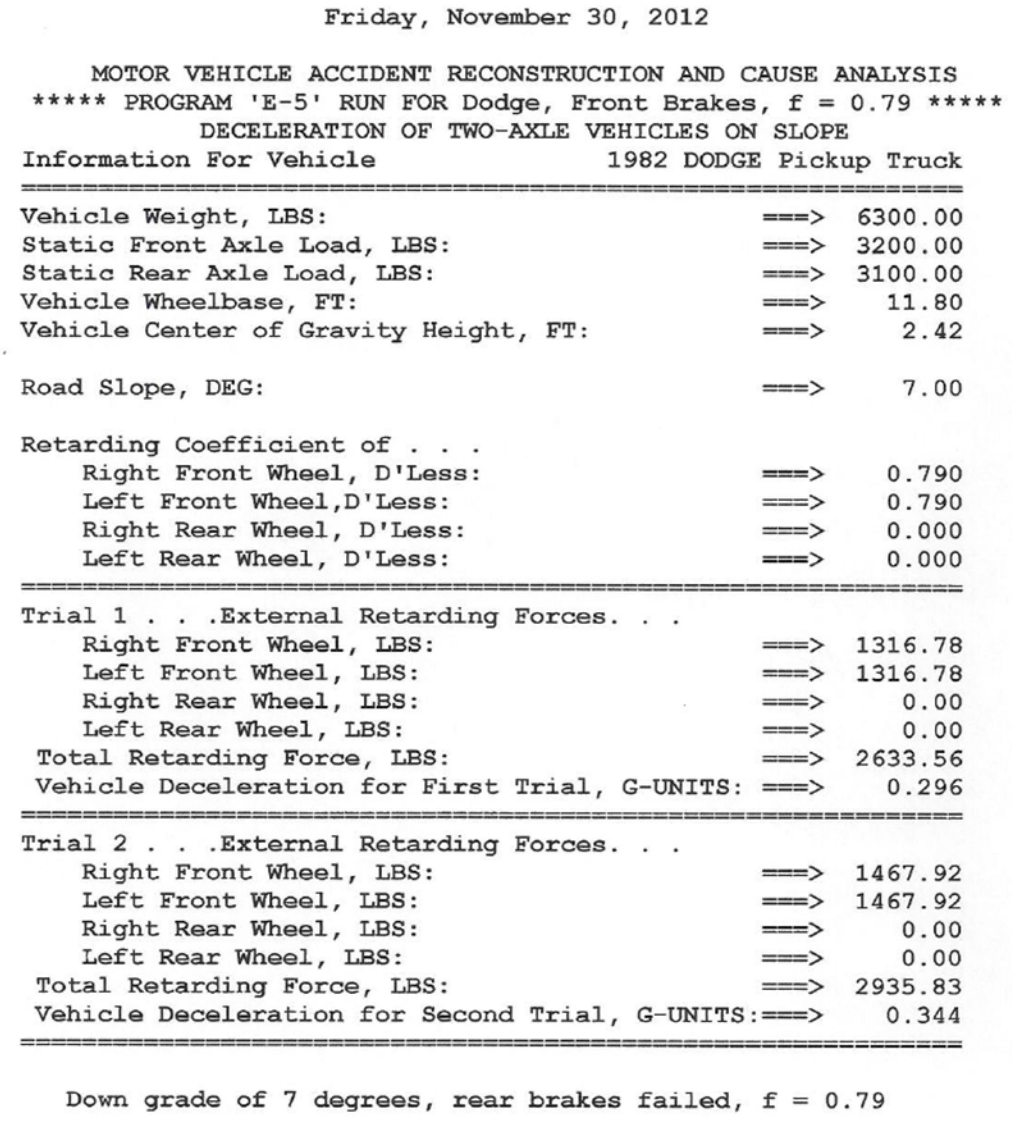
Traveling at 36.33 mph with Good Brakes

With good brakes and all brakes locked the deceleration would have been (0.79)(32.2) = 25.44 ft/sec^2. The drag factor is 0.79g. The speed is (36.33)(1.466) = 53.26 ft/sec. The stopping distance would have been:

$$S = (53.26^2)/[(2)(25.44))] = 55.75 \text{ ft.}$$

Consequently, the truck would have stopped 88 – 9 – 55.75 = 23.25 ft from POI.

The case settled due to excessive speed and defective safety inspection.



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                    Friday, November 30, 2012

     MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
 ***** PROGRAM 'E-5' RUN FOR Dodge, Front Brakes, f = 0.79 *****
           DECELERATION OF TWO-AXLE VEHICLES ON SLOPE
Information For Vehicle              1982 DODGE Pickup Truck
=============================================================
Vehicle Weight, LBS:                                ===>  6300.00
Static Front Axle Load, LBS:                        ===>  3200.00
Static Rear Axle Load, LBS:                         ===>  3100.00
Vehicle Wheelbase, FT:                              ===>    11.80
Vehicle Center of Gravity Height, FT:               ===>     2.42

Road Slope, DEG:                                    ===>     7.00

Retarding Coefficient of . . .
    Right Front Wheel, D'Less:                      ===>    0.790
    Left Front Wheel,D'Less:                        ===>    0.790
    Right Rear Wheel, D'Less:                       ===>    0.000
    Left Rear Wheel, D'Less:                        ===>    0.000
=============================================================
Trial 1 . . .External Retarding Forces. . .
    Right Front Wheel, LBS:                         ===>  1316.78
    Left Front Wheel, LBS:                          ===>  1316.78
    Right Rear Wheel, LBS:                          ===>     0.00
    Left Rear Wheel, LBS:                           ===>     0.00
 Total Retarding Force, LBS:                        ===>  2633.56
 Vehicle Deceleration for First Trial, G-UNITS:     ===>    0.296
=============================================================
Trial 2 . . .External Retarding Forces. . .
    Right Front Wheel, LBS:                         ===>  1467.92
    Left Front Wheel, LBS:                          ===>  1467.92
    Right Rear Wheel, LBS:                          ===>     0.00
    Left Rear Wheel, LBS:                           ===>     0.00
 Total Retarding Force, LBS:                        ===>  2935.83
 Vehicle Deceleration for Second Trial, G-UNITS:===>    0.344
=============================================================

   Down grade of 7 degrees, rear brakes failed, f = 0.79
```

MARC1 – E5 Data Printout for Front Brakes on Slope of 7 Degrees. Downhill Braking.

Case 1: Assume the Dodge Accident Site Had a 7-degree Down-slope

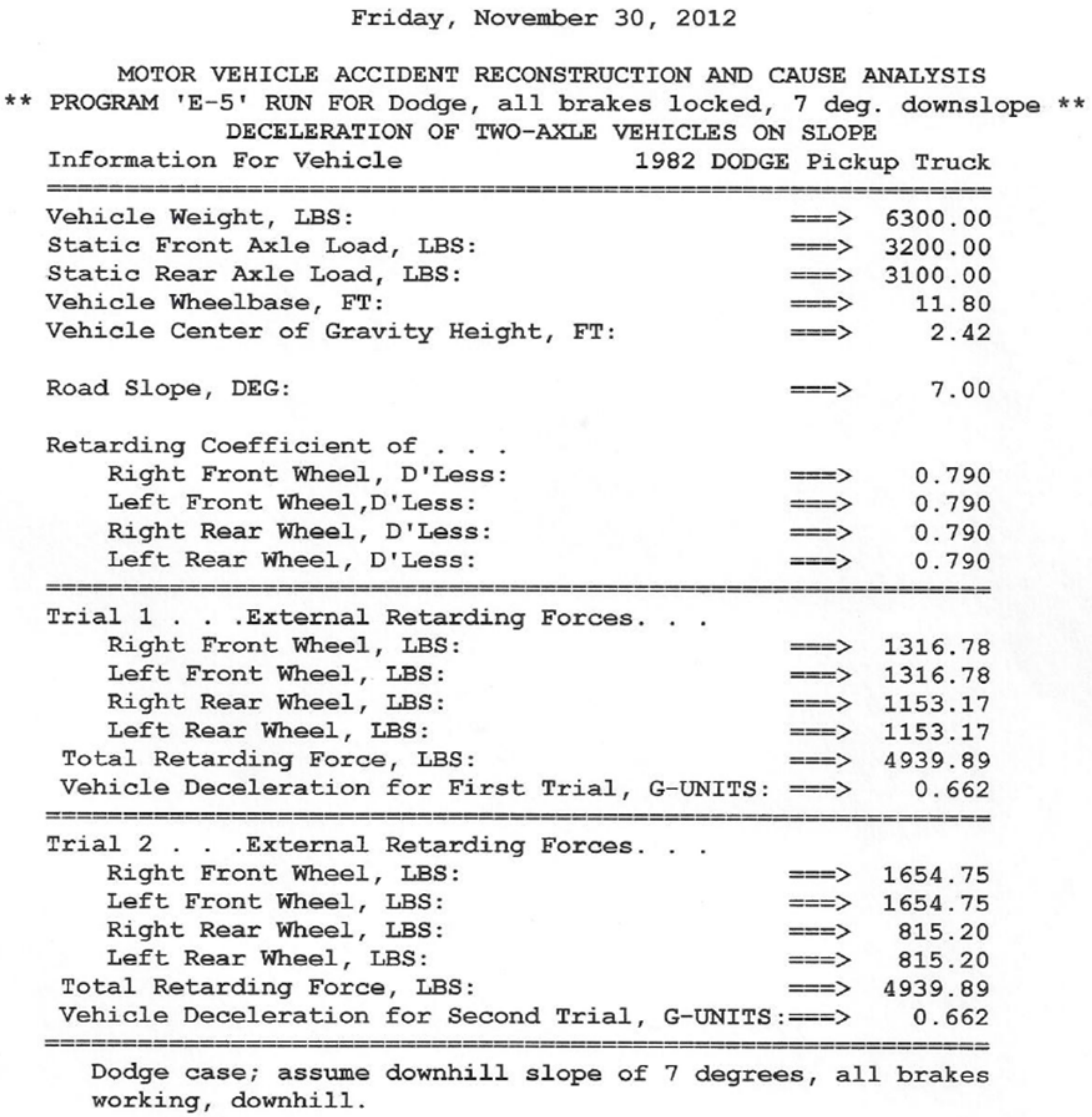
A slope angle α = 7 degrees equals a slope 12.2%, since tan7 = 0.122.

The tire forces between ground and Dodge change. *See* Case 3 for details. The vertical weight force becomes Wcosα, and the downhill gravity force becomes Wsinα. The downhill force will do two things, namely place more weight onto the front axle due to weight transfer similar to the regular load transfer due to braking as well as it forces the Dodge move downhill. The MARC1 – E5 is shown below. The deceleration now becomes 0.344g or 11.08 ft/sec^2. The probable speed at begin of skidding with a drag factor of 0.344 would have been 30 mph instead of 35.2 mph on the level road with a drag factor of 0.466g.

Using any simplified method of subtracting the slope from the level deceleration such as 0.47 – 0.12 = 0.35g, a slightly larger value than 0.344g.

If the rear brakes had been functioning properly and the front brakes failed, the drag factor would have been only 0.205g indicating that on a downhill slope the rear brakes are not as effective as the front brakes. On a seven-degree uphill grade the rear brakes-only drag factor would have been 0.442g

If the rear brakes had also been locked, then the deceleration would have been 0.662g as shown in the MARC1-E5 below. The approximate downhill drag factor would have been 0.79 – 0.12 = 0.67g.



```
                   Friday, November 30, 2012

      MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
** PROGRAM 'E-5' RUN FOR Dodge, all brakes locked, 7 deg. downslope **
            DECELERATION OF TWO-AXLE VEHICLES ON SLOPE
   Information For Vehicle               1982 DODGE Pickup Truck
   ==============================================================
   Vehicle Weight, LBS:                               ===>  6300.00
   Static Front Axle Load, LBS:                       ===>  3200.00
   Static Rear Axle Load, LBS:                        ===>  3100.00
   Vehicle Wheelbase, FT:                             ===>    11.80
   Vehicle Center of Gravity Height, FT:              ===>     2.42

   Road Slope, DEG:                                   ===>     7.00

   Retarding Coefficient of . . .
       Right Front Wheel, D'Less:                     ===>    0.790
       Left Front Wheel,D'Less:                       ===>    0.790
       Right Rear Wheel, D'Less:                      ===>    0.790
       Left Rear Wheel, D'Less:                       ===>    0.790
   ==============================================================
   Trial 1 . . .External Retarding Forces. . .
       Right Front Wheel, LBS:                        ===>  1316.78
       Left Front Wheel, LBS:                         ===>  1316.78
       Right Rear Wheel, LBS:                         ===>  1153.17
       Left Rear Wheel, LBS:                          ===>  1153.17
    Total Retarding Force, LBS:                       ===>  4939.89
    Vehicle Deceleration for First Trial, G-UNITS: ===>       0.662
   ==============================================================
   Trial 2 . . .External Retarding Forces. . .
       Right Front Wheel, LBS:                        ===>  1654.75
       Left Front Wheel, LBS:                         ===>  1654.75
       Right Rear Wheel, LBS:                         ===>   815.20
       Left Rear Wheel, LBS:                          ===>   815.20
    Total Retarding Force, LBS:                       ===>  4939.89
    Vehicle Deceleration for Second Trial, G-UNITS:===>       0.662
   ==============================================================
      Dodge case; assume downhill slope of 7 degrees, all brakes
      working, downhill.
```

MARC1 – E5 Data Printout; All Brakes on Downhill Slope of 7 Degrees.

Before we leave Case 1, view the next photograph . The tire marks were made by a Toyota Camry with the brakes applied at maximum pedal effort near 150 lb. The vehicle was decelerating at maximum wheels-unlocked effectiveness with the ABS system not noticeably modulating. The roadway was a stretch of highway not used for regular traffic. The tire marks are visible when viewed in the direction of travel as shown in the photo and are only faintly visible in the other direction. Without any additional information relative to pedal force, etc. what “stickiness” name can be assigned to the road? The tire marks appear to indicate front tire braking marks. Since the tire tread edges appear to be darkened, we can assume some above-moderate braking effort. Since the photograph indicates that both front brakes were working effectively, we can safely assume that the rear brakes were working also. This conclusion is based upon the Camry’s diagonal brake system where the individual front brakes are connected to the opposite rear brakes. However, without an inspection of the subject vehicle’s brake system, we cannot be entirely certain what the rear brakes did.

Assuming the inspection shows no brake system defect, and no drag boot or other skid test has been performed, the stickiness of the roadway would most likely

Front Tire Marks at Maximum Effectiveness; Toyota Camry – All Brakes Working.

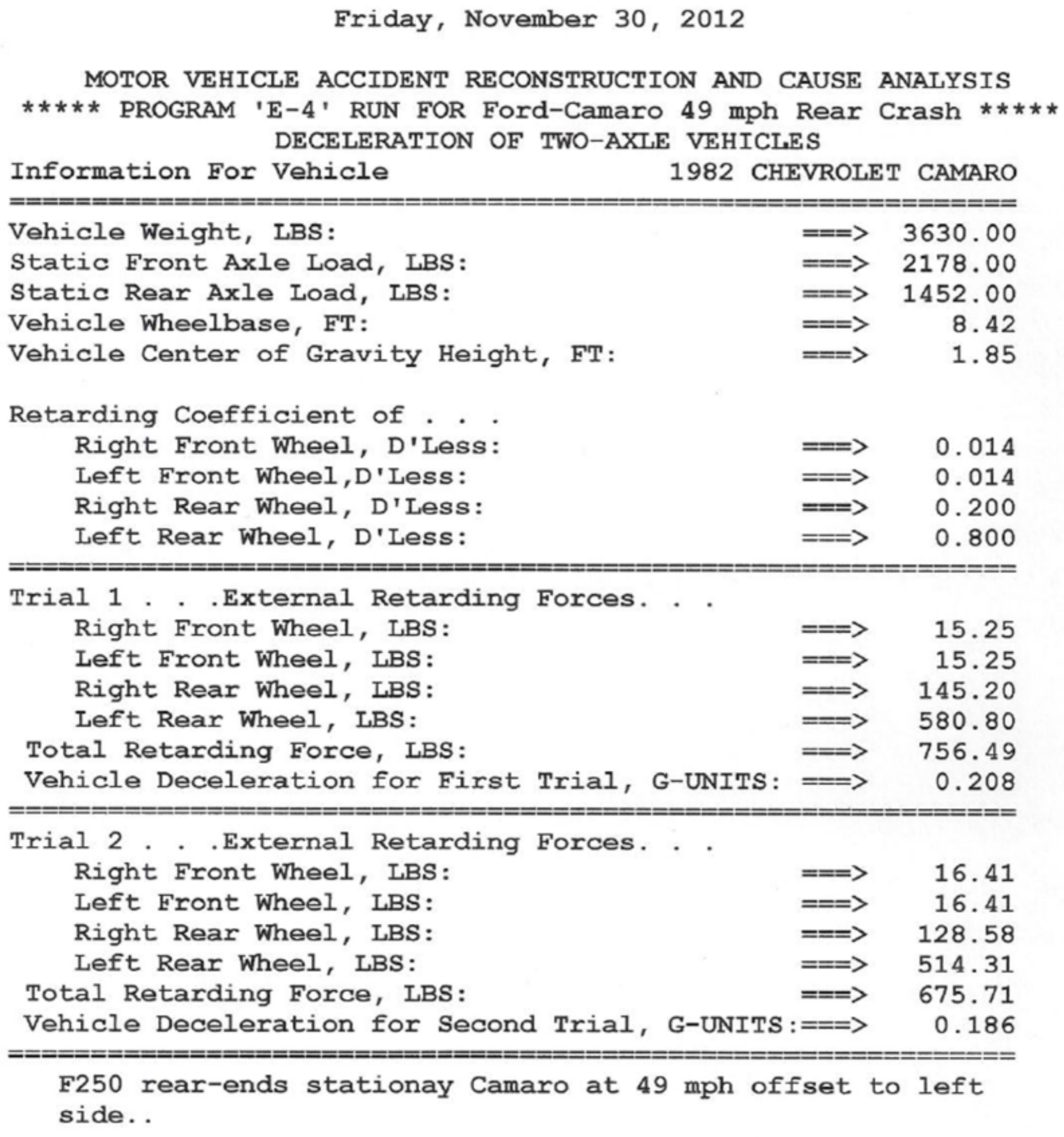
be 0.80 to 0.90 based solely on published data (Table 22-3 of 7th Edition).

Case 2: Ford Pickup Truck Rear-Ends Stationary Camaro

Two crash tests are described in Short Paper PCB 2-2006, IN-LINE COLLISIONS available from www.pcbraekinc.com. In the two off-set rear end tests a Ford F250 travelling at 49 mph and 39 mph, respectively impacted a stationary Camaro. We will only discuss the after-impact deceleration used in the reconstruction of impact speed. The left rear tire was “locked” by sheet metal crush in each test. A lesser retarding coefficient of 0.2 was assumed for the right rear tire in the 49 mph test. Normal rolling resistance was used for the front tires. MARC1- E4 printout shows a drag factor of 0.186g or 6 ft/sec^2. For more details and damage photographs see the short paper.

The reader should note, that with the rear wheel locked, the deceleration decreases when load transfer is included in the deceleration analysis. The retarding force of the left rear wheel decreases due to less normal force.

An impact speed of 39 mph was the probable impact speed at the time of the crash. Both the crush damage and distances traveled after impact of approximately 106 ft were consistent with actual accident scene measurements.

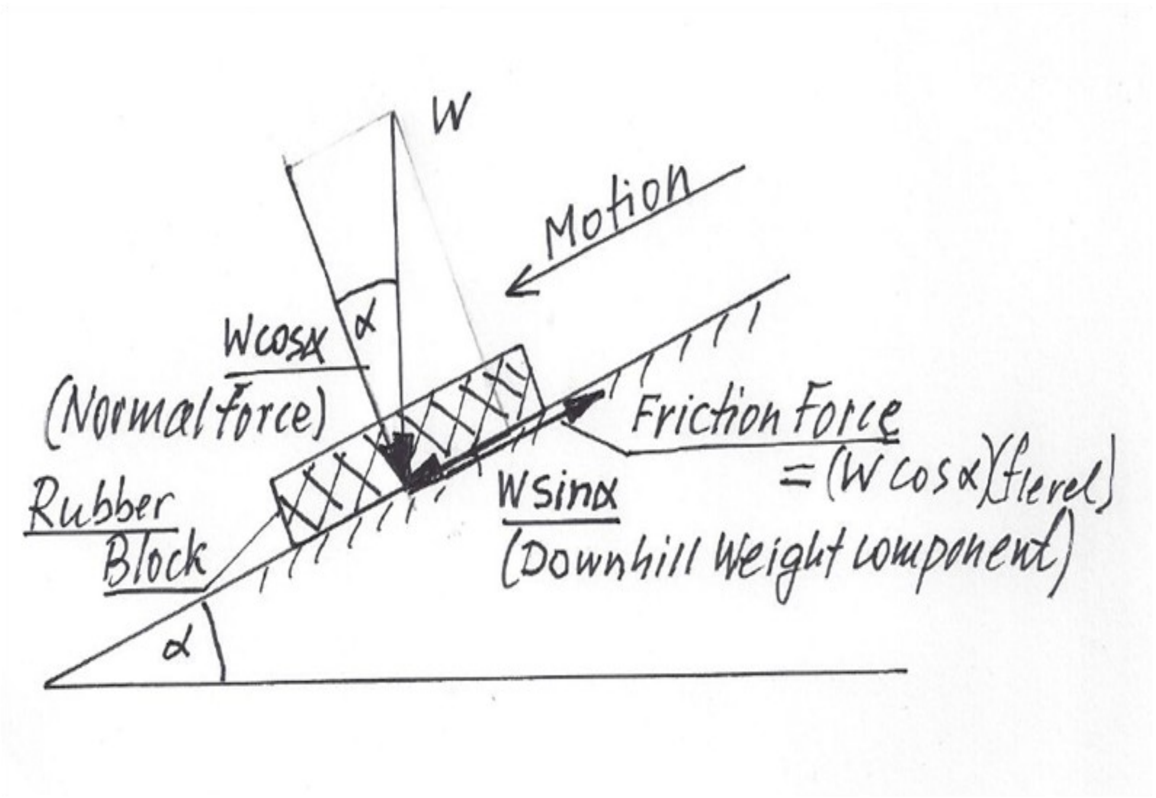


```
                 Friday, November 30, 2012

    MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
***** PROGRAM 'E-4' RUN FOR Ford-Camaro 49 mph Rear Crash *****
              DECELERATION OF TWO-AXLE VEHICLES
Information For Vehicle                1982 CHEVROLET CAMARO
==============================================================
Vehicle Weight, LBS:                               ===>  3630.00
Static Front Axle Load, LBS:                       ===>  2178.00
Static Rear Axle Load, LBS:                        ===>  1452.00
Vehicle Wheelbase, FT:                             ===>     8.42
Vehicle Center of Gravity Height, FT:              ===>     1.85

Retarding Coefficient of . . .
    Right Front Wheel, D'Less:                     ===>    0.014
    Left Front Wheel,D'Less:                       ===>    0.014
    Right Rear Wheel, D'Less:                      ===>    0.200
    Left Rear Wheel, D'Less:                       ===>    0.800
==============================================================
Trial 1 . . .External Retarding Forces. . .
    Right Front Wheel, LBS:                        ===>    15.25
    Left Front Wheel, LBS:                         ===>    15.25
    Right Rear Wheel, LBS:                         ===>   145.20
    Left Rear Wheel, LBS:                          ===>   580.80
 Total Retarding Force, LBS:                       ===>   756.49
 Vehicle Deceleration for First Trial, G-UNITS: ===>       0.208
==============================================================
Trial 2 . . .External Retarding Forces. . .
    Right Front Wheel, LBS:                        ===>    16.41
    Left Front Wheel, LBS:                         ===>    16.41
    Right Rear Wheel, LBS:                         ===>   128.58
    Left Rear Wheel, LBS:                          ===>   514.31
 Total Retarding Force, LBS:                       ===>   675.71
 Vehicle Deceleration for Second Trial, G-UNITS:===>       0.186
==============================================================
   F250 rear-ends stationay Camaro at 49 mph offset to left
   side..
```

MARC1 – E4 Data Printout Ford/Camaro 49 mph Test, a = 0.19g.



Rubber Block Sliding Down Grade.

Case 3: Sliding Up- or Downhill with all Brakes Locked

The prevailing wisdom in the accident reconstruction community is to simply add or subtract the grade from the level road tire-road friction coefficient. We must realize that this approach is only valid for small slope angles.

The two-axle vehicle can be simplified into a single rubber block sliding down the slope. The vertical weight W usually involved in producing tire friction becomes Wcosα. As slope increases, cosα becomes smaller, and hence, the friction-producing normal force. The forces acting on the block along the slope are slope force *W*sinα due to gravity down the slope and braking or friction force (f_{level})(*W*cosα) up the slope. If the braking forces are greater than the downhill force, the vehicle will slow down, if they are equal the speed does not change, and if they are smaller the vehicle will accelerate.

Newton's second law states that:

$$W(a/g) = (W\cos\alpha)(f_{level}) - W\sin\alpha \quad \text{or}$$

$$(a/g) = (\cos\alpha)(f_{level}) - \sin\alpha;\ \text{g-units}$$

The prevailing wisdom equation is:

$$(a/g) = (f_{level}) - \text{slope};\ \text{g-units}$$

For example, for α = 10 degrees and $f_{level} = 0.9$ the correct answer is:

$$(a/g) = (\cos 10)(0.9) - \sin 10 = (0.9848)(0.9) - 0.1736 = 0.7127\text{g}$$

The approximate answer is 0.9 - 0.1763 = 0.7237. The difference might be considered small in view of the uncertainties associated with tire-road friction coefficient measurements. However, as slope increases, so does the difference. For example, an accident site with a slope of 20 degrees and $f_{level} = 0.9$, yields $a/g = 0.50$ exact versus approximate of 0.54g. MARC1-E6 applies.

As slope increases a critical level will be reached when friction force and downhill gravity force balance. At that point the vehicle will neither accelerate nor decelerate down-hill.

The critical slope is reached when (f_{level})= tanα. Of course, this is the equation we implemented in high school physics many years ago when measuring the friction coefficient of different mating surfaces by raising a hinged slope with an angle measuring device. Once the body began to slide, we read the slope angle and taking tanα we knew the static friction coefficient.

Conclusions

1. Give the accident scene/site a “stickiness” name providing a place to start for the speed analysis. Doing this is of particular importance when dealing with non-typical surfaces such as median, gravel, wet, snow, oils or diesel fuel spills, muddy construction zones, oiled pavements, etc. Having measured some accident scene data points and analyzing them is better than to have measured nothing and trying “analyze” that.
2. As a minimum, use a drag boot for item 1 or similar device.
3. If possible, use subject vehicle or other vehicle for skid/ABS testing at accident scene.
4. Interpret accident scene tire marks correctly. If not certain, run both ABS and skid tests.
5. Inspect subject vehicle(s) for any brake system defects.
6. Determine if subject vehicle had ABS actuation from tire marks, and data recorder.
7. Inspect subject tires for any traction force affecting conditions. Measure inflation pressure. Note tread depths and unusual wear patterns.
8. Use proper method to determine, if possible, probable drag factor or deceleration of subject vehicle at time of accident from original “stickiness” data.
9. Check your drag factor results against published data generally accepted by reconstruction community.
10. For slope angles less than 10 degrees the “prevailing wisdom” equation may be used, meaning you can subtract the downhill slope as fraction (percent x 100) from the drag factor the subject vehicle would have experienced on a level road. Do the opposite for an uphill slope.
11. Compute probable vehicle speed(s) using a reasonable data range.
12. Use the **DIMS** or ***D***oes ***I***t ***M***ake ***S***ense check of your data against any other case specific data such as crush damage, witness statements, view analysis, etc.

Integrity in the Learning Environment

Bridget Reutter, GOHS Impaired Driver Program's Coordinator

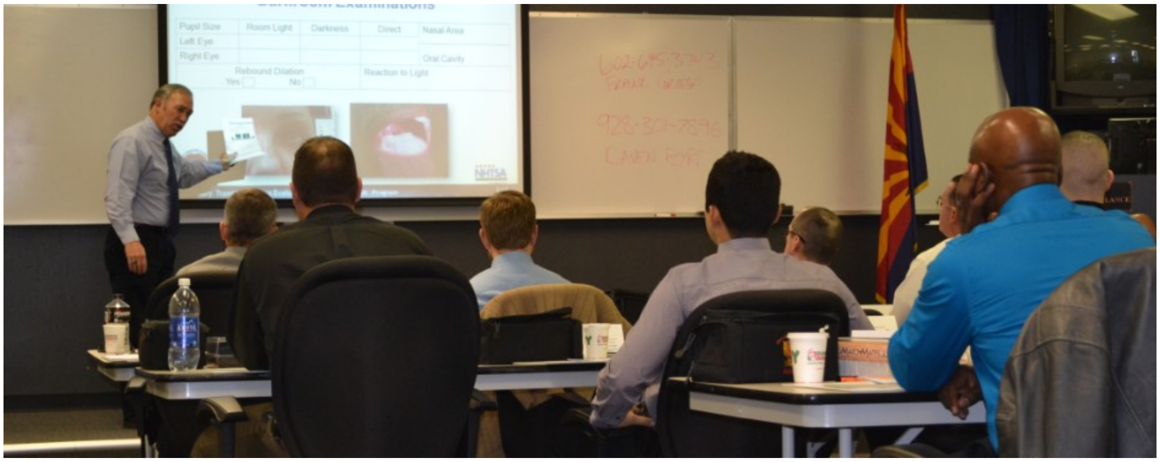
While attending the law enforcement academy as a recruit, we hear about the importance of integrity from every person teaching every class. All day, every day, from the quarters and pennies found on the ground to the number of bags of chips that come out of the vending machines and the avalanche of memos that follow, the expectation is for all officers to exhibit integrity. The presence of integrity in law enforcement is all encompassing, regardless of the subject matter. The reason we hear integrity preached so much is that without it, a law enforcement officer loses credibility. Without credibility, a law enforcement officer becomes ineffective. An officer without integrity is, well, not an officer…at least not a credible officer.

Back at the academy, we learned to listen to an instructor with rapt attention out of respect as well as a desire not to run the trails. Regardless, we did listen respectfully. The instructors teaching at the academy earned the title of instructor as well as the right to teach new officers. They shared knowledge and their experience in an effort to steer the recruit officers around some of the problems they would face in patrol… including some of the problems not listed in the index of any manuals. Interruptions in class did not happen unless an individual of higher rank entered the classroom and an appropriate greeting ensued.

How does the first paragraph relate to the second? A code of conduct governs every officer at every agency. The actions or inactions of an officer during training will reflect back on the agency. The officer is responsible for the material they receive when attending training whether initial or advanced officer training. The learning process continues regardless of the officer's presence in the classroom. So how does the officer testify that he or she attended all days and hours of training if they were repeatedly leaving the classroom to answer or make phone calls? How much information did the officer miss while carrying on a conversation during class? How much respect does the officer or the instructor have for the class or even other instructors if he or she is carrying on a conversation while others are teaching?

Integrity and respect for oneself are integral parts of being a sworn law enforcement officer. Having respect for yourself does not mean you are more important. Respect for yourself also does not mean you can or should treat other people including officers with less respect or become condescending because you hold a position, rank or title. Holding a position, rank or title should convey an expectation of respect for others.

All of this is stated to make a point about our expectations of law enforcement officers and instructors of all ranks and titles who are attending classes. Retain your integrity by exhibiting respect and providing a model for others to follow. You are not your position, rank or title. You are a person who is continuing to learn. Be sure to provide others around you the same opportunity while in a learning environment.



Miranda Warnings and FSTs

Beth Barnes, Arizona GOHS Traffic Safety Resource Prosecutor

Officers investigating DUI offenses are frequently faced with the question of whether *Miranda* applies to the field sobriety tests and the DRE investigation. Even if the defendant is in custody at the time they are administered, the Fifth Amendment's right against compelled self-incrimination does not apply to field sobriety tests or the majority of the DRE examination.

Arizona courts have repeatedly held field sobriety tests consist of physical, not testimonial evidence because they do not reveal an individual's subjective knowledge or thought process. *State v. Theriault,* 144 Ariz. 166, 167, 696 P.2d 718, 719 (App. 1984); *State v. Lee*, 184 Ariz. 230, 908 P.2d 44 (App. 1995). Accordingly, the Fifth Amendment protections against self incrimination do not apply to them. *Miranda* warnings, therefore, are not required prior to administering the FSTs even if the defendant is already under arrest. *Lee, supra.*

The US Supreme Court has come to the same conclusion. Initially in *Berkemer v. McCarty,* 468 U.S. 420 (1984), the High Court found that routine roadside questioning of drivers detained after a traffic stop did not constitute custodial interrogation under the Fifth Amendment. Later, in *Pennsylvania v. Muniz*, 496 U.S. 582 (1990), the Court specifically addressed the FSTs and held that physical observations made during the performance of the field sobriety tests, including speech characteristics, are not testimonial and do not require *Miranda* warnings. The Court noted that to be found testimonial, communication must "explicitly or implicitly, relate a factual assertion or disclose information." *Id*. The verbal portions of the field sobriety tests simply do not require the suspect to disclose information within the meaning of the Fifth Amendment.

Like the FSTs, the vast majority of the DRE examination is not going to be testimonial evidence or subject to *Miranda*. DRE officers are trained to ensure the suspect has been advised of the *Miranda* warnings prior to starting the DRE examination. This is good practice as it ensures any admissions which are the result of custodial interrogation will be admissible at trial. Other than the questioning/interrogation portion of the DRE protocol, however, none of the DRE examination should be testimonial. This is because blood pressure, pulse rate, body temperature, pupil size, and the other observations made during the DRE protocol do not reveal an individual's subjective knowledge or thought process. They are not factual assertions and are not subject to *Miranda*.

As to the specimen collection portion of the DRE examination, asking a defendant to provide a urine sample is not "interrogation." *United States v. Edmo,* 140 F.3d 1289 (9th Cir. 1998). Nor is asking a defendant to undergo a blood or breath test. *South Dakota v. Neville,* 459 U.S. 553, 554, n. 15, 130 S.Ct. 916, 74 L.Ed.2d 748 (1983) (blood); *Lee, supra.*(breath test and FSTs). *Miranda* does not apply. Additionally, booking questions going to biographical information have been held a specific exception to the *Miranda* rule. *State v. Jeney*, 163 Ariz. 293, 787 P.2d 1089 (App. 1990).

Of course, any time a suspect is subject to custodial questioning, the *Miranda* warnings do apply. Officers should not look for ways to avoid advising a suspect of the *Miranda* rights.

Article Submission Requirements and Protocols

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Any submissions should be made electronically to facilitate the rigorous review process and level of quality a publication such as this demands. Authors should submit their work in Microsoft Word in a easy to read and standard format, accompanied by any images or photographs, also in a standard format. The submitted work should include a title page with the author’s name, address, phone and email contact information. If the paper is of a highly specialized nature, the author may submit a list of at least three persons with the credentials and experience necessary to be qualified as peer-reviewers. The work must also include an abstract and a very short biography or “Author’s Note”.

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