

# FOURWHEELING ACADEMY

## CENTER OF GRAVITY

By Harry Lewellyn

### CAUTION

Read this article with safety and caution in mind. You are about to embark on an engineer's journey through center of gravity! Understand clearly the engineering world and the real world struggle to relate ... in words!

This is the first *FOURWHEELING ACADEMY* about keeping the rubber side down - rollovers. At some time or other, we have all been concerned with rolling. It's natural and it's to be expected. Your concern with level is your safety valve to survival. Learning your approximate rollover point is most crucial.

### APF

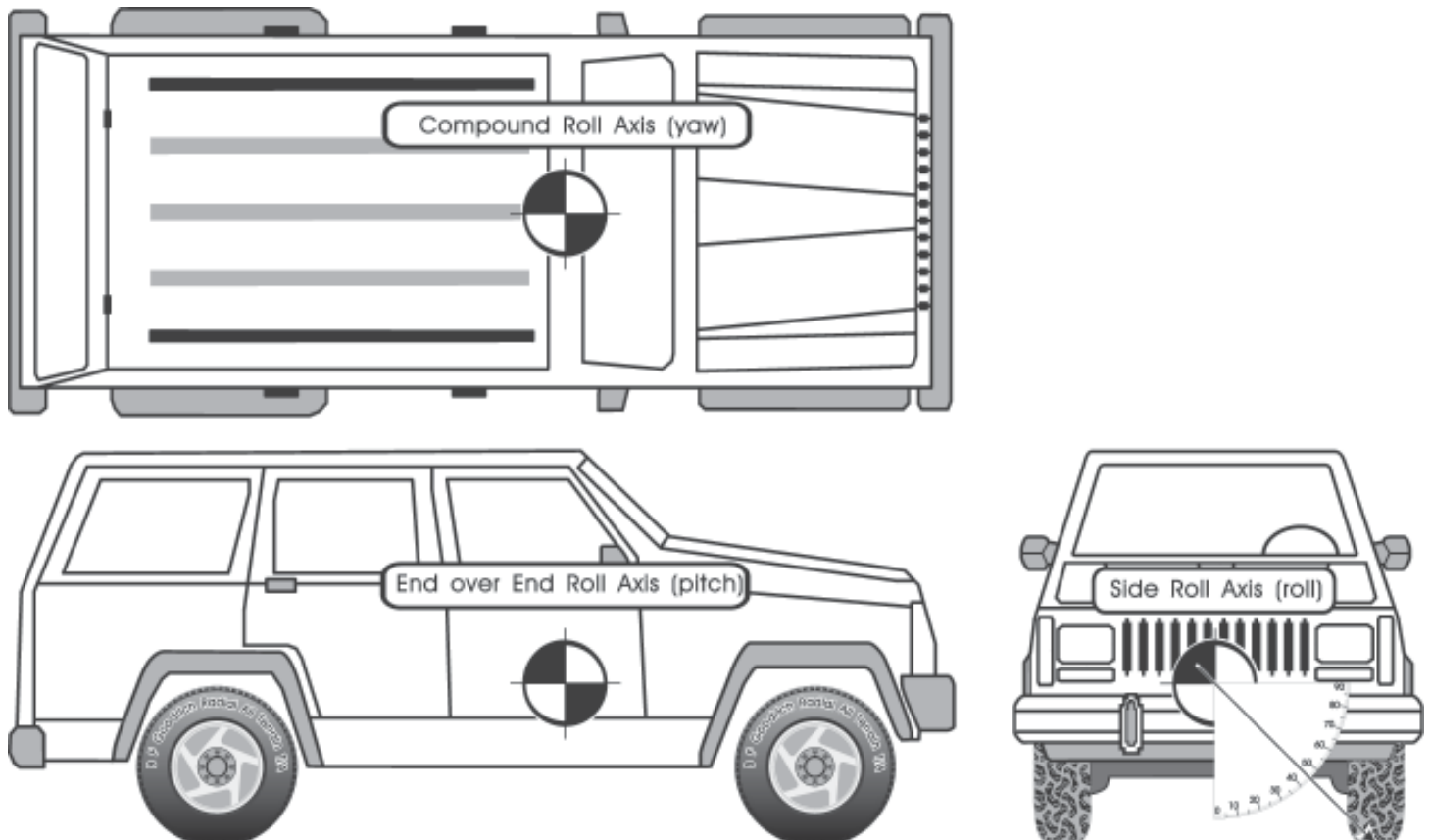
In my how-to-drive classes, I refer to your A P F: your A-(something nearest your seat cushion) Pucker Factor, that under normal driving conditions, goes off long before you are actually in danger of rolling. However, there are a numb-butted few who have no fear, or maybe, no sense of level. For them, the only way to learn, if ever, is the hard way.

With the experiment described below, you will learn about center of gravity and how to determine approximately where your static rollover danger point is. With enough interest, I will conduct a rollover seminar

where we actually use your vehicle, as we did with mine below. Write and let me know if you would be willing to pay ten or twenty bucks to "roll" your 4X.

### EVERYTHING HAS ONE

Dogs, sticks, stars, flowers, people and cars all have one. If it has mass (when gravity acts on it we call it weight), and whether it is living or inanimate, it is the basis of balance and stability. Center of gravity is a magical point that exists for all things. It typically can't be reached or touched, but it is the basis for predicting aircraft flight dynamics, how kangaroos jump or how far a 4X can lean. And for



About equal weight on left and right tires.

the critical technocrats out there, please cut me some slack regarding the precise interpretation of terms and concepts. But for all, be aware this article deals with static (non-moving), almost laboratory-like conditions.

## DYNAMICS DEFINED

The real world deals with dynamic (moving) conditions. Don't underestimate the effects of movement (dynamics). My intent is to give you a tangible basis for predicting when you are approaching rollover trouble. A future article will deal with what to do if you do roll.

## CENTER OF GRAVITY - DEFINED

Center of gravity defined: Picture barbecuing a chicken on a rotisserie. You'd like to run the skewer from head to rear and have the bird turn in perfect balance. Now picture two different approaches — a skewer that runs sideways from wing to wing, or another that runs up and down from the middle of the back and out between the feet. Each of these three skewers could lead to a clucker in perfect balance — not necessarily a practical approach, but nevertheless, a smoothly turning meal.

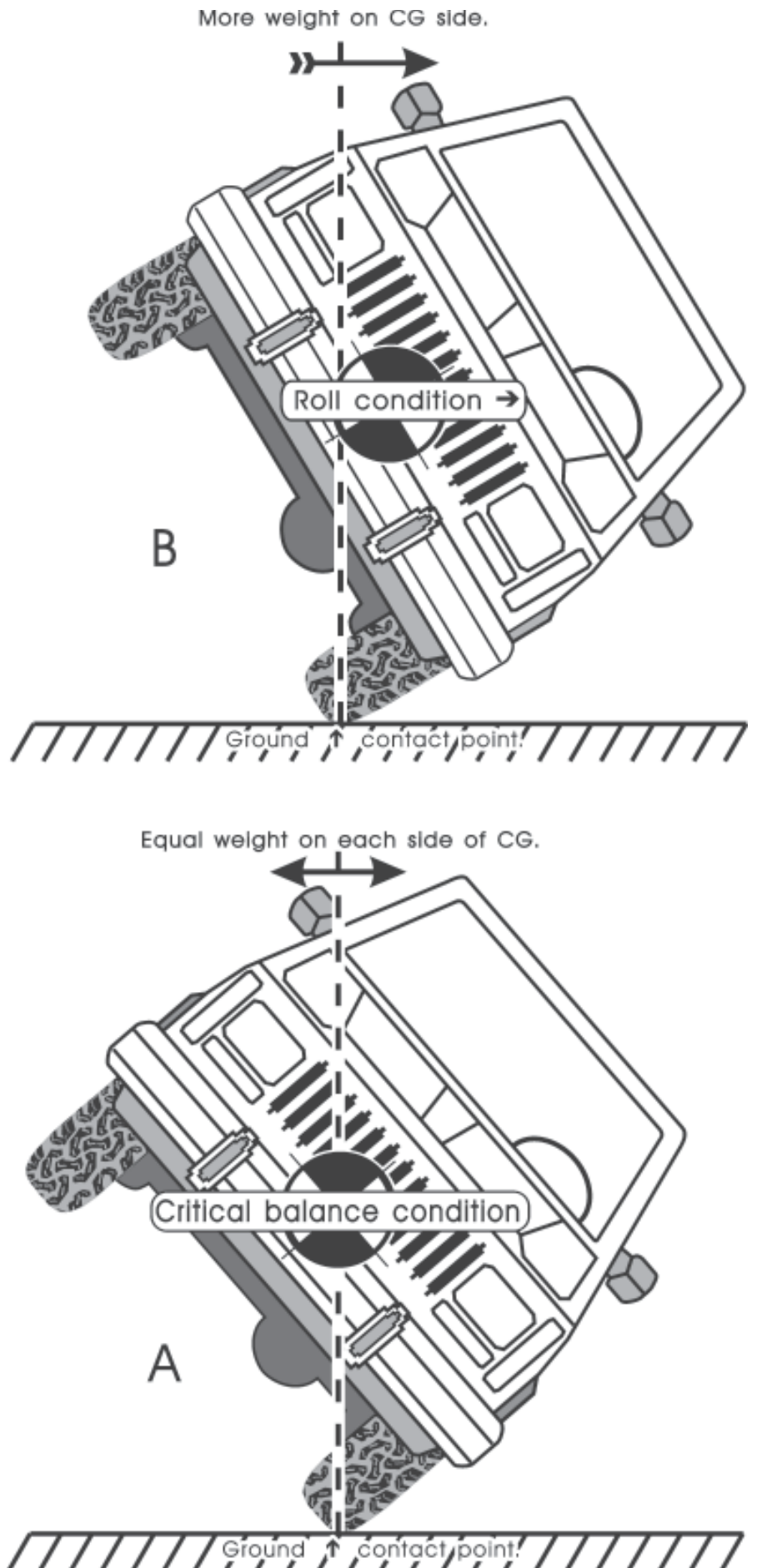
## THREE AXES

To the engineer, each skewer represents an axis of our three dimensional world. I hope it's easy to see that all three axes would intersect, cross each other, at a common point. This is because each view in the first figure has an axis in common with the other two. The intersection is the center of gravity (CG).

## PERFECT BALANCE

Take this a little further and connect a magical string to the CG. Now, given that the legs and wings don't flop around like they really do, you could move the chicken to any position - head level, feet up, tail at an angle and so on — and it would stay perfectly balanced. Suspended from the CG, anything and everything is stable in every and all positions. 4Xs have a center of gravity.

The figure on page 14 is a 4X in three straight-on views (an orthographic projection). The CG axis symbol,  $\oplus$ , in each view is like the end view of an arrow. This symbol,  $\oplus$ , represents the end view of each CG axis. We are most concerned with the head-on, vehicle, front view. Engineers please disregard traditional view designation. This view (axis) has to do with side rollover. The axis through the door has to do with steep-hill rollover — rear-end over front, or vice versa. We can disregard the



top view axis since it has to do with a compound roll where the 4X would be on its side and then roll rear-end over front. You can imagine that the actual CG (point), the three-axis intersection, is near your console.

## APPROXIMATING CG

Conservatively use this generalization for most sport-utility vehicles. To help find these axes in your 4X, visualize that your CG is where your right fist would hang when seated in the driver's seat. You probably cannot get your fist that low, but that is about where the CG is located. Working backwards from your fist, mentally project the three axes to the outside of your 4X. The axis that goes front-to-back is of most interest. You might solicit the help of a friend, outside the car, to determine a reference point at the grille. Lock this in your mind for future, field reference. We'll now learn how to use this point.

## USING THE CG

In the front view, with the 4X on level ground, the weight on the left tires is about equal to the weight on the right tires. As you lift the passenger side (right side) tires to higher (uneven) ground, the weight on the driver's side (left side) tires increases. Accordingly, the weight on the right tires now decreases. This is known as weight transfer. At some point, all of the weight is borne by the left tires and the right tires are just ready to come off the ground. This is the static, side-roll, balance point. For this explanation, the 4X is level, front to back — i.e., the chicken's head and tail are level, it's just balancing on one leg.

## BALANCE

The second figure (A) shows the 4X at the critical balance condition. Engineers call this equilibrium. Take note of the CG. It is directly and exactly vertically over the tire contact point. A vertical knife could cut the 4X in half, through the CG, and one piece would fall left and the other right. Each piece would be of exactly equal weight.

## ROLL

Picture the 4X going farther over (B). The CG is now beyond the tire contact point and therefore more weight is on one side than the other — the 4X would roll in the CG symbol direction.

To help understand this, picture another exactly vertical cut, only this time through the tire contact point only. It should be easy to see there is more weight on the CG-side than the other.

You don't have to roll your 4X to discover your approximate balance point and

angle. Using your right fist, front projection point, hang a plumb bob through the CG axis at the grille, then swing it over to the center of the tire at the ground contact point (see the first figure). Measure this angle and as I'll show below, I learned you have a pretty good approximation of your static balance or equilibrium point.

The above is what I have taught for years in class, but I truly did not know the reality of my "gestimated" CG. With the help of Mark Hinkley and Don Gilgan of the Off Road General Store in Laguna Hills, and others, we put the plumb bob to the metal.

## CAUTION

**The CAUTION:** First and foremost: all of the details are not presented in the following brief description of the experiment, so don't try this yourself. Secondly, if you must try it, muster up all the safety, caution and common sense available before proceeding. Again, this experiment is best left to those with some engineering sense and experience with vector resolution of forces. Also understand the results are less than perfect. Suspension travel, tire air pressure, load and many, many other factors were only briefly considered.

## THE EXPERIMENT

**The experiment:** Take a 4X and connect yank straps at one point near the top, (front-back) center of the vehicle like the B post. Now extend the straps in opposite directions, perpendicular to the side of the 4X. Connect two 4Xs with winches, to the straps, at right angles to the side of the first 4X.

You know what to do now — take in one winch and let out the other. At some point it will be obvious the 4X is falling in the pulled direction. Back off a bit until you determine the balance point, and then measure it. Actually, the hard core are probably rolling on the floor, because this is the way they change tires.

With much safety and apprehension, the photo shows the results. What surprised me was the fact that the 4X leaned a lot farther than expected and my right fist approximation was relatively conservative. What I also learned was the seat-of-the-pants feeling for my rollover point. My APF went berserk! I was actually sliding off the seat bottom before I would roll. I'm not going to give you the actual number, but it was in excess of 45°.

## TOUGH TIRES

I was also please and surprised to learn the tires did not deflect or collapse off the wheels. The BFG Baja TAs appeared as

though they were on level ground — virtually no side displacement.

We repeated the experiment with Don Gilgan's Wrangler and the recently rolled, Chuck Thompson 4Runner (see page 24). They too showed greater than 45° tilt angles and the slide-off-the-seat feeling.

We also tested my Explorer with driver, driver and two passengers, and a load on top in a couple of positions. I was amazed how little these load variables affected the CG.

## CONSERVATIVE CONCLUSION

These tests indicate when going very slowly, so the dynamics (movement) of the situation do not enter into the equation, and under ideal conditions, it is most likely your 4X would slip sideways on a sloped dirt or poor traction road before it would roll.

## NEVER UNDERESTIMATE THE EFFECTS OF MOVEMENT!

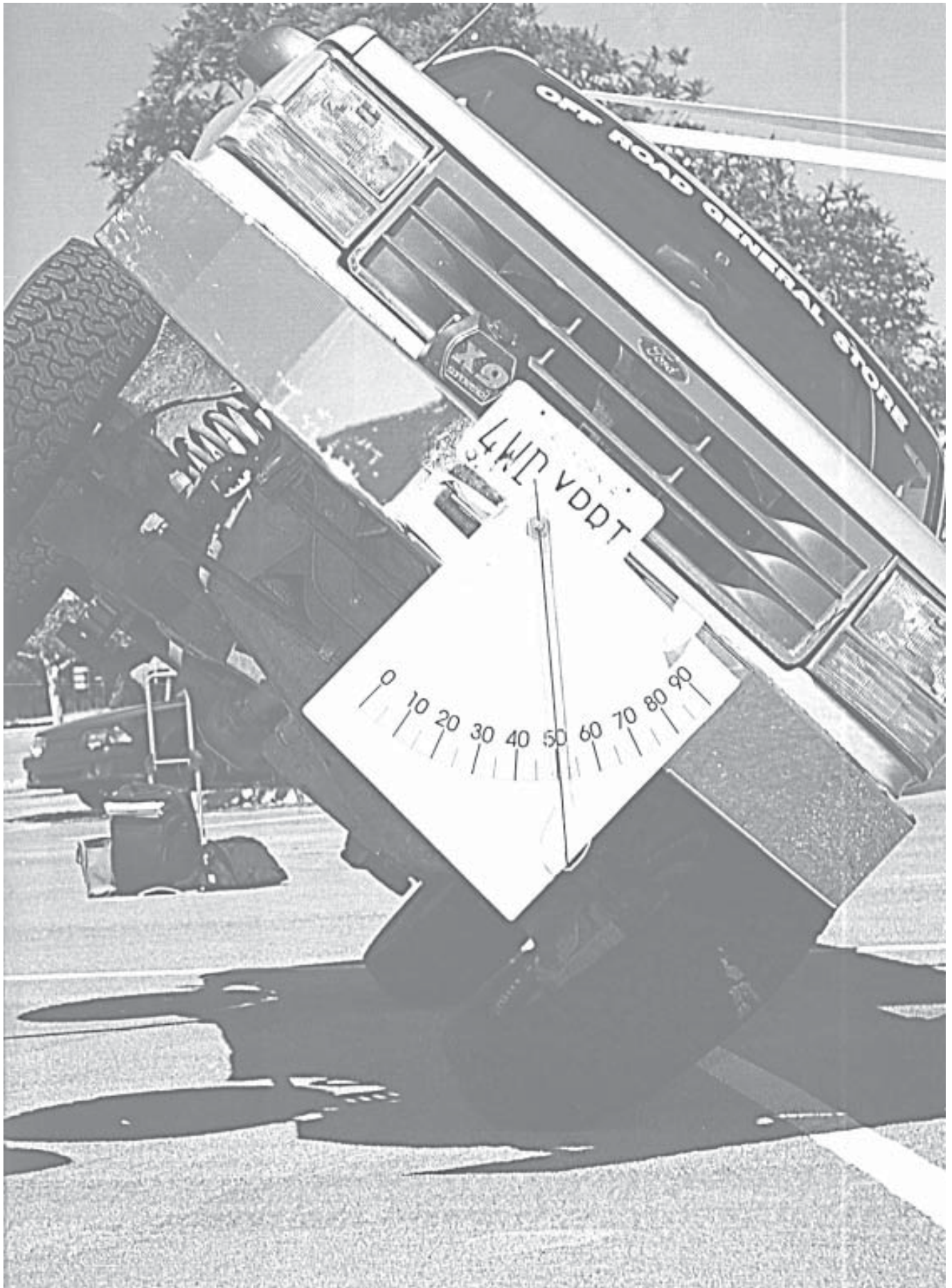
But it is obvious that 4Xs do roll, so never underestimate dynamic effects or what I call compound angles. Calculations, not presented here, indicate a combination of going down-hill and side-tilt are most dangerous. Chuck rolled in a compound, down-hill, side-tilt situation.

Further, picture you can drive in tight circles at a high rate of speed and roll any vehicle. You can also be moving on a less than critical tilt angle, hit a bump, and roll the vehicle. Repeating - NEVER UNDERESTIMATE THE DYNAMIC EFFECTS OF MOVEMENT!

The preceding is a disclaimer of a sort. What I would like are your personal experiences and insights about all the above to further improve the accuracy of this information. I want to present the most accurate and useful information possible. If I have erred, please write and tell me so I may pass along your knowledge. And in the same breath, I must ask for an engineering approach to new information. I shy away from chest pounding, suspender stretching, unsubstantiated claims.

The next article will have to do with after you are off the rubber and on the metal. To help with the spectacular side of rolling, I welcome your photos and experience on this too.





## FOURWHEELING ACADEMY

# ROLLING: Passenger Recovery

By Harry Lewellyn

### QUESTIONABLE EXPERIMENT

I didn't get enough takers on the roll your 4X offer last month to justify having a seminar. And I didn't get a barrage of inputs and corrections about center of gravity either. I don't know whether that's good or bad, but Jimmy Nyland of 4Wheeler magazine brings up the most important observation. The winch-over experiment does not have the high-side tires on the ground therefore the validity is in question. His prompting, and another pass at the experiment warrants a follow-up piece taking this into consideration. However, we both agree dynamics — movement - must be taken into account, and at best, winch-over test information should be used with a great deal of caution!

This no high-side tire touch business is worthy of the considerable discussion that follows. There may be some validity to the tire not being on the ground matter, but I reason as follows. At the exact point when the 4X is balanced (about to roll), the tires would literally be off the ground anyway.<sup>1</sup> Picture it like the old cigarette paper ignition-point test to determine exactly when your points are about to open. Kids ask dad what ignition points are! With the ultra thin paper (sensor) under the high-side tires, at exactly the moment just before roll, you would be able to start to gently drag the paper from under the tire. In essence, the wheels are off the ground at the balance point regardless of whether they started out touching the ground or not. This being the case, I conclude the test is reasonably valid. However, I suggest you consider what follows and I'd like to improve the experiment.

### READER REQUEST

An open request to all readers. What I am looking for is a section of concrete

or pavement which makes a gentle transition from flat (horizontal) to near vertical, with a flat (level) area on the high side. Picture a riverbed or irrigation channel with sides as described. Above the channel (transition area) is a road for an anchor vehicle. In essence, the upper vehicle can belay the roll vehicle. Anybody have any legal suggestions?

Short of this real world test channel, I will perform and report another approach. I will simply chain (fix) the suspension in the normal and various partially extended positions and measure the winch-over angle. I believe the weight of the suspension fixing mechanisms will not significantly change the actual center of gravity. Do any of you have other ideas or suggestions?

### HIGH PRESSURE GAS SHOCK CAUTION

Looking at another aspect of this tires on the ground business, consider the type of shocks involved. This is the kind of information I suspect high pressure gas shock manufacturers probably don't want you to hear. This variety of shock significantly distorts the above balance point reasoning, which I learned the hard way a few years ago.

Picture my experiment as described last month and above. With conventional shocks, the front/rear, high-side tire/axle combos hang to a specific position when tilted. Also understand high pressure gas shocks always want to fully extend themselves, or in effect, to a certain degree, provide spring-like lift. They try to extend their associated spring elements (leaf, coil or torsion bar) beyond their normal, quiescent, rest positions. And without going into the numbers, this is particularly accentuated in a tilt situation.

So let's take a tilting truck, with conventional shocks, to within a fraction of a degree of rolling. The unit is still

stable — its still on all four tires. Now, leaving it tilted, but stable, change the shocks to high pressure gas units. My guess is, with the high-side tires touching the ground, the lifting force, the extending action of the high pressure gas shocks on the high side would now push the truck past this previously stable point, beyond the balance point and over.<sup>1</sup> If you have high pressure gas shocks, in my opinion, you must reduce you static, winch-over roll test results.

You might say the shocks don't provide that much lifting force, but I argue near balance, it doesn't take much force to move the 4X in either direction — toward stability or roll! Throw multiple high pressure shocks into the experiment and you've really got a rollover kicker. I plan to calculate these forces, along with the follow-up experiment above and give you real numbers in a future issue. In the meantime, lets get on with rolling.

### FIVE PARTS TO ROLLING

Don Carter (and I agree) divides a roll scenario into five elements: 1) pre-roll, 2) the roll, 3) passenger recovery, 4) vehicle recovery and 5) damage assessment. One, two and three will be covered this month. We'll leave four and five for another issue.

### PRE-ROLL

Pre-roll starts before you leave the driveway. Secure everything! If it ain't tied down, it could be lethal in a roll! Your unsecured flashlight and fire extinguisher; the ice chest in back; the yank strap and clevis pin you just used, and even mans best friends of either variety can be a hazard when you roll.

Don also has a very graphic way of getting your attention regarding tying things down. Lay on your back face up. Now picture whatever you don't want to tie down being dropped in your face from

three or four feet above. Get the picture — tie down everything!

## CHECK UNDER THE HOOD

Now peek under your hood and make sure this compartment is roll checked. The drop in your face test may be a little foolish for these parts, but do take a serious look at everything. Your battery and aftermarket additions are particularly good candidates. These, and any loose parts can either do harm or be damaged in a roll.

Battery mounts are consistently weakened and eaten away by acid. The additional connections you have made for electrical accessories may put the hot wires closer to the hood or other electrical ground areas than expected. This means dangerous sparking when dislodged or bent during a roll. The racers try to preclude sparks by putting a nonconducting shield over the entire top of the battery.

How about fuel lines, auxiliary tanks and valves, and special filters that you've added outside the engine compartment? Gasoline and your electrical system combine to present your greatest potential hazard provided you survive the roll. As you inspect the underside and the balance of the 4X, think about fire.

I like to have a fire extinguisher accessible from the driver and passenger seats, without removing the seat belt. You can't always predict where you're going to end up, or how the interior will be arranged, but one thing for sure, seat belts definitely limit your movement both during and after a roll. Make your fire extinguisher accessible when you are seatbelted in the car.

Have you noticed that a rollbar seems to be way down on the discussion list? As mentioned below, I've been involved in quite a few rollovers and in all cases, they were relatively gentle, and almost slow motion affairs. Given reasonably rational behavior and judgment, the violent, high speed stunts you see in the movies are left to the silver screen or the race track. In summary, I won't ride in a car without a conventional metal top or rollbar, but I also depend on rational behavior for another degree of safety. Leave racing and chest pounding to those with specially equipped vehicles.

## IT CAN HAPPEN TO YOU

I'm not going to go into a lengthy

discussion about anti-roll driving skills, but be real clear, if you drive the rough long enough, it will most likely happen to you too. I've been close to 12 rolls and most were with reasonably experienced drivers including one Camel Trophy participant. Walt Wheelock was over 80 years old when he did his!

## MOST DO THE WRONG THING

Time and again I see people do the wrong thing. I believe I understand what two things go wrong. One has to do with our natural tendency to first resist virtually everything. The other thing is our misconception of what and where safety is!

On the Carrizo tour we go off the Diablo Dropoff. It's mild for the experienced and very intimidating for the beginner. Mother Nature wants to not only send us down the slope, but also slightly to the left, toward a big ditch! Beginners resist the left push with a right correction — up a steep side bank. Continued right correction will lead to a roll into the ditch. Turning in the direction of Mother Nature's gentle push leads to a successful trip down the dropoff. Like losing control in a turn, it is usually best to turn in the direction of the slide or Mother Nature's nudge.

We are on the road, we start to go off the shoulder and we immediately want back to (apparent) safety — the road. This is particularly true for Baja paved roads. The slopes off the side of the roads are quite steep and they are the last place you want to be sideways at 50 MPH! Our desire to get back to safety puts us sideways on the side-slope and hence we roll. Same goes for dirt roads. When we see the danger off the edge, want back to safety and create the roll.

## CHOOSE STUCK VS. ROLLING

In most situations the main objective is to keep the vehicle on all four tires, even if the vehicle ends up heading for hopelessly stuck. Less bodily injury and vehicle damage will occur if the rubber side stays down. Choose stuck versus rolled! With the greasy side up you have two tasks; one to right the vehicle and next, get unstuck.

## PLAN AHEAD

The best driving practice is to plan ahead. When facing a potential rollover situation, or for that matter, at all times, have a contingency plan for the "what ifs." For rolls, this is most often simply turning

straight downhill. Eventually these mental exercises will evolve into instinct. Instinctively knowing what to do is your best tool to handle a surprise roll.

My brother best describes what you do during the roll. Make love to the gear shift lever! Get down, cover your head and keep all body parts inside the 4X. If your roll is slow enough, get off the gas pedal and think about applying the brake.

I have actually rehearsed getting low; checking out how the center console interferes with my low profile; practicing how I will hold the shift lever and how the seat belt moves when approaching a dangerous situation.

## PASSENGER RECOVERY

Passenger recovery actually starts with those outside the vehicle. Our tendency is to blindly rush up to help. Wrong! I know you've all been taught God, motherhood and the pursuit of apple pie are foremost to helping others, but the first priority is always rescuer safety. Given an unstable 4X, you could end up with two disasters.

## RESCUER SAFETY MOST IMPORTANT

Rescuer safety is the first priority. The rescuer can be outside or within the vehicle, with special considerations for each.

## VEHICLE STABLE?

Is the vehicle stable? Has it stopped moving? If so, approach with all senses on alert. We are a visual animal, so our tendency is to only use our eyes. Look for all potential problems: instability; fire; leaking gasoline; electrical sparking.

## USE ALL OF YOUR SENSES

Also remember to use your other senses. Your nose can detect a gasoline leak long before your eyes find it. Same goes for your ears. They can hear electrical sparking and potential instability where vision fails. Use full sensual vigilance!

## APPROACH FROM THE HIGH SIDE

It should also make sense to only approach from the high side. The 4X could become unstable and roll on to you.

## ADVANCE WITH FIRE EXTINGUISHER IN HAND

Another not so obvious thing is to advance with fire extinguisher in hand.

## CHECK THE VEHICLE

From within, turn off the ignition and all electrical accessories. Then set the brake, put the car in park or in gear. As silly as it sounds, on two occasion, I have righted a car only to watch it roll off down hill.

## ASSESS PERSONAL AND PASSENGER INJURY

Next is personal injury. Assess you and your passengers' need for medical help. Without being too gory, think of the ABCs of first-aid - air, bleeding and cardio. If the vehicle is stable, attend to critical medical problems from within.

## BEWARE OF THE SEATBELT

Usually, you're a little shook up, but otherwise OK, so you want out immediately! Beware of the seatbelt hazard. You will find the buckle difficult to unlatch, so the obvious, but wrong thing to do is attack the stubborn critter with both hands. Consider your position and act accordingly. If you are up side down, you need to prevent falling on your head, and I've seen this simple mistake happen! The

driver can brace his legs under or around the steering wheel. The passengers have to use more creative means to keep from falling out of the seat.

If you are on your side, have the low-side person get out first. Unbuckling the high-side occupant first can lead to down-side personal injury.

## STAY ALERT

As you begin to move to get out, keep your senses on full alert. Is the vehicle remaining stable? Another natural tendency is to want to open the door. Forget it! Use the window. You'll find the doors hard to open and a potential hazard due to gravity pulling them in unexpected directions. And I suppose it goes without saying, with an up-side-down 4X, get out on the up side of the slope.

With a car on its side, you have no choice — the down-side door/window is on the ground, so the up-side is your exit path.

## UNFAMILIAR UNDERSIDE

Another consideration while on your side is exposure to unfamiliar undercar-

riage like hot exhaust system and sharp metal. I still own a pair of sandals which bear a scar in the sole from a hot muffler.

## MAKE THE FIRE EXTINGUISHER ACCESSIBLE

Before or as you exit, put the fire extinguisher outside. Either pass it to others or place it so it is accessible when you exit. Remember, you may still have another person to remove and vehicle recovery itself can cause a fire. I suppose, if you are really alert, and it's safe, you can also remove your recovery items like yank strap, chain, comealong and other items.

## VEHICLE RECOVERY

Vehicle recovery and damage assessment are for another issue, along with further experiments.

<sup>1</sup> Experiments since this article was written have proved this assumption to be wrong. In some cases, high pressure gas shock can push a vehicle over as described. In essence, the tires stay on the ground long after the vehicle is at equilibrium and rolling.



# ROLL RECOVERY TOOLS

- Fire Extinguisher
- Yank Strap (rope or chain)
- Comealong (hand winch)
- Winch
- Hammer (big)
- Tree Protector
- COYOTE CHAIN (a chain with a chain-hook and choker-hook on opposite ends) see newsletter to order
- Gloves
- Shovel
- D Shackles
- Pry Bar
- Duct Tape
- Snatch Block

## FOURWHEELING ACADEMY

# ROLLING: Vehicle Recovery and Damage Assessment

By Harry Lewellyn

In March, we treated the first three elements of rolling: 1) pre-roll, 2) roll, and 3) passenger recovery. This month, the *FOURWHEELING ACADEMY* picks up with the last two: 4) VEHICLE RECOVERY and 5) DAMAGE ASSESSMENT.

### CAUTION

As with this whole business of center of gravity and rolling, I must again add the cautions and conditions. It is impossible, or at least impractical, to address all of the circumstances, situations and solutions for all rolled vehicles. I start out with my and other's experience that most backcountry rolls are of a somewhat gentle nature. They are not of the race and silver screen variety. With these more drastic events, in a sentence, save the people and leave vehicle recovery to professionals!

### VEHICLE RECOVERY

Regardless of the final position, and repeating from March, first check vehicle stability, fire, gasoline leaks and electrical sparks. I also feel I left out another possibility in the March treatment of passenger recovery. Consider stabilizing or securing the 4X before attending to the passengers. Just because it has stopped moving, doesn't mean it is stable. It could still roll or slide. Check to see that the 4X is in gear or in park, the emergency brake is set and the ignition key is off.

On one occasion, I did a gentle quarter-turtle on to a small rock and came to rest on a rear fender near the tail light. Given unwise movement by the occupants, or the rock, the Cherokee could have ended up tumbling farther down the bank. What I chose to do was tether the high-side B post (the one between the back of the front door and the front of the back door windows) to a tree with a yank strap. I do not believe in trying to stabilize a vehicle by building up the downside with rocks or what have you, particularly when it involves earth and rock movement on the downside. All downside activity is dangerous.

If the passengers are safe and the vehicle came to a stable rest on its tires,

move on to DAMAGE ASSESSMENT below. If not, take time to look over the situation.

### ACCESS SAFETY

By now, you probably think it's an overkill, but reassess vehicle stability and fire potential. Make sure the onlookers are away from the downside, not smoking and keep the fire extinguishers handy.

### ACCESS THE SITUATION

Now, look for existing damage, the easiest way to right the vehicle and what additional damage could be caused while righting the roll. Keep your other senses on alert too: smell — gasoline or battery acid; sound — sparks or vehicle movement; vision — all the above.

### ABANDONMENT DETAILS

If you must go for assistance, remove all valuables, then go for the necessary parts or recovery help. If it is obvious the righted vehicle will be incapable of moving either under its own power or under tow, or it cannot be steered due to damaged or detached steering hardware, consider righting it anyway to protect Mother Nature. Virtually all vehicle fluids are a hazard to plants, animals and man. Also, the longer it's abnormally positioned, the more likely you will have abnormal problems. Maintenance-free batteries can eventually leak acid. Oil can slowly seep into the tops of the cylinders. Brake fluid can leak from the reservoir. Gear oils can leak out the vents and so on.

### PRE-RIGHTING FIXES

Provided the work can be performed in a safe, timely manner, and it's practical, considering fixing (some) things that are wrong before righting the 4X. It may be easier.

### RIGHTING DAMAGE

Righting damage is usually minimal, or at least of minor concern. Things to watch for are breaking additional glass, bending good sheet metal, causing suspen-

sion damage or damaging an otherwise good tire. Consider removing items like external spare tires, gas cans, roof racks or lowering the windshield before starting the flip operation.

### RIGHTING BASICS

Here's where the infinite variety comes in — righting the vehicle. Following are the basics. I find it typically more practical to use manpower versus machinery. It's easier to get her on her feet downhill versus uphill, however, you may be rolling over fresh metal or pushing into impossibly stuck. In addition, righting uphill means the work force must be on the dangerous, downhill side! Consider how stable the 4X will be after she's on her tires, too.

### MANPOWER CONSIDERATIONS

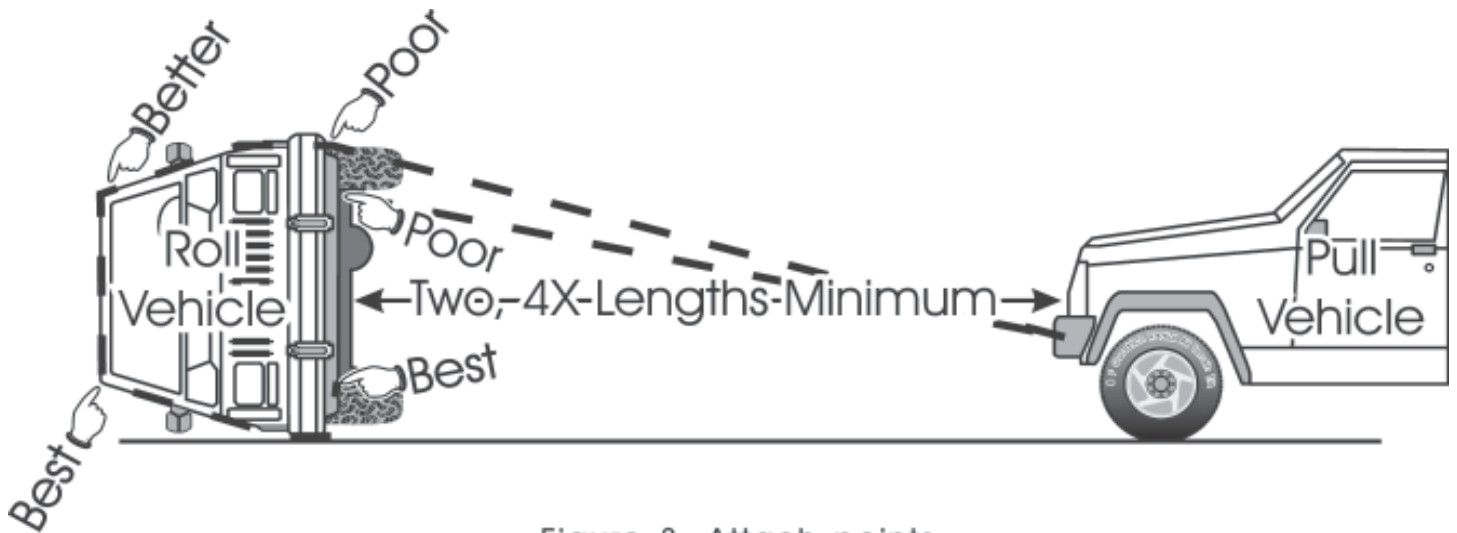
Using manpower has several considerations: 1) wear gloves; 2) a displayed underside exposes unfamiliar hot and sharp things; 3) the physical size and number in your workforce; 4) how many people can be positioned on the vehicle; 5) what hand grips are available on the vehicle for the righting crew; 6) who grips where; 7) the *tough spot*, and 8) backing off when balanced.

### WHO GRIPS WHERE

Who grips where means the shorter guys should be positioned at the hood and the taller guys at the roof.

### TOUGH SPOT

The *tough spot* is that point when everyone needs to transfer their grip from lifting to pushing. Work out a plan where this is accomplished one person at a time. Given everyone changing positions at the same time, you may find the 4X back on the metal and someone hurt! Become military like in your discipline. Have one (reasonable) chief and the rest braves. Discuss the plan before the operation, not during it! Listen to everyone's inputs before acting. I figure I'm lucky to be right half the time. Once the 4X is balanced, don't continue to push so hard you roll it over again or farther down the



**Figure 3, Attach points**

hill! Finally, use your legs and not your back muscles for it will take a little more extra effort than you probably anticipate. It always feels to me as if someone else is not doing their share, and I'm sure the others feel the same way about me.

**USING MACHINERY**

A complete description of using machinery is beyond the scope of this article, too, but again, a few pointers will help. Machinery is another vehicle, a winch, a come-a-long (hand winch) or something that gives you a mechanical advantage over simple manpower. In the last category falls improvised rope and pulley arrangements, or fulcrums and levers (lumber and logs). Consider all of your resources!

**ATTACH POINTS**

The common denominator for all cable/rope/chain/yank strap oriented work is attach points and pull angles. These figures graphically tell the story. These words attempt to tell why.

Attaching to the nearest, highest point will tend to drag the roll toward you and not right it. The figure above prioritizes the attach points.

Attaching over the 4X applies much needed down force and continues to yield maximum mechanical advantage throughout the entire righting process. The hard part is to find and get to a convenient attach point for this wrap-attach technique. The frame and window posts are best. Least desirable, and very likely dangerous, are mirrors, roof racks and sheet metal mounted light bars (roll bars).

Tow strap pull-direction is another critical factor (see the figure, right). At a right angle to the roll is best, but you have to adapt to the surroundings. Consider using your winch snatch block(s) and

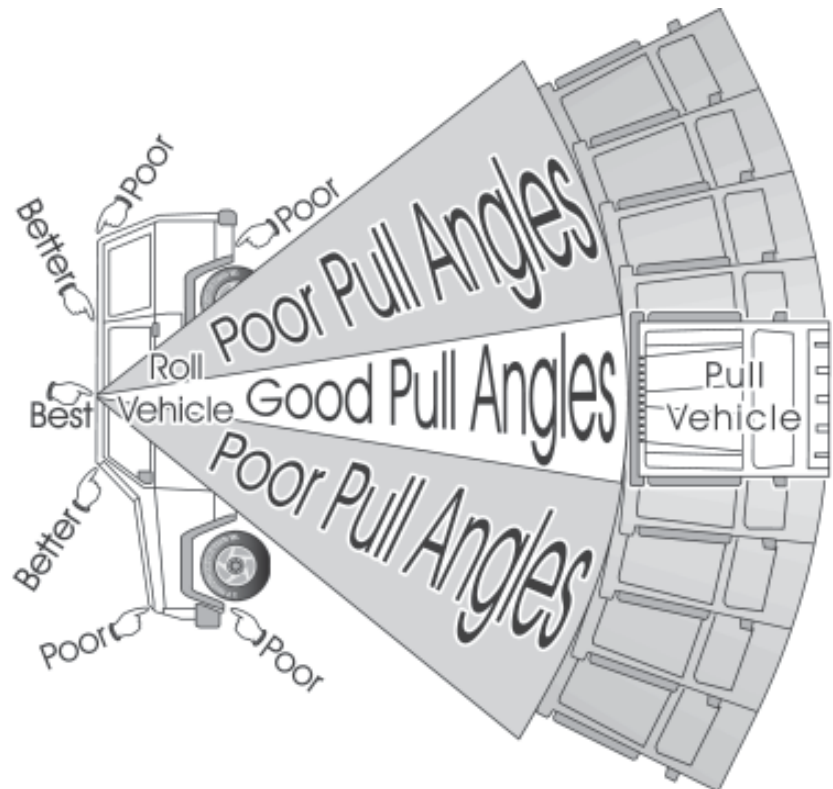
Mother Nature's resources (trees and rocks) to achieve optimum positioning for the line attached to the rolled vehicle. Remember to use tree protector straps, if you use plant life. Also, be sure you are far enough away from the roll to allow full rollback. It should be obvious too close is impractical from both the leverage and vehicle clearance standpoint.

Another pull scenario is to relocate in a series of vehicle-pull maneuvers. This requires you safely stabilize the roll while relocating the pull.

Finally, consider yank straps stretch under tension. A loaded nylon strap is potentially lethal. Use all winch cable-

related safety precautions, such as a blanket (what I call a parachute) on the pull strap, just as with getting unstuck. Also, yank straps do less paint and metal damage than do cables, chains and ropes.

Consider it fair, when safe and practical, to dig to maximize your righting advantage (see figure right). Five points on this digging thing: 1) be safe; 2) respect Mother Nature's sacred domain; 3) dig channels to the best attach points; 4) if the righted 4X could end up still unstable, dig a more level landing platform for stability (see figure to right); and 5) dig full body length, under the high-side, to lower the fulcrum, nearer mid-4X, to ease the right-

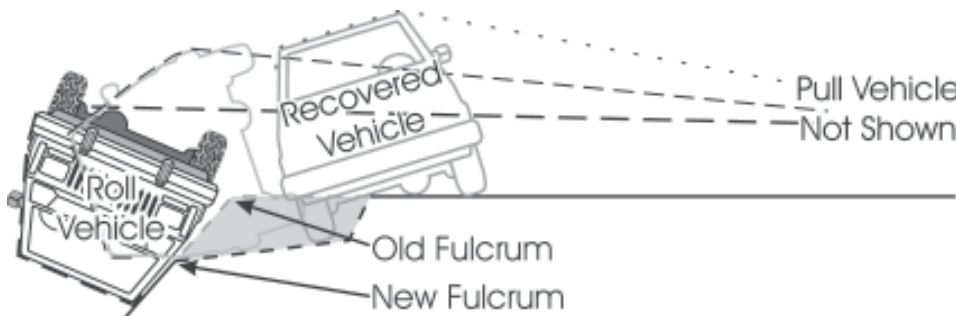


ing process. Items 4 and 5 apply to an uphill pull.

As with manpower, slow and easy at the last is important. Except in very few circumstances, time is an asset. I call it compounding and complicating the problem. You start out with a mechanical problem — a rolled vehicle — and in the righting rush, you end up with a medical problem — an injury. Take your time!

**DAMAGE ASSESSMENT**

If there are an infinite number of conditions to right a roll, then there are even more damage assessment conditions (mathematicians squirm). We'll again take a general approach and make no attempt



to tell you how to fix what's wrong.

With fire extinguisher in hand, and if practical, walk completely around the righted vehicle. You are looking on the top, sides and underneath to see if the car can be moved and whether or not it can be safely driven. Look for: 1) hazards —

termine if it can be latched down again. You don't want it popping up on the freeway trip home. Look and smell for gasoline. Check the battery for spilled acid and position integrity. Has it come loose? Neutralize spilled acid with baking soda and water, or simply rinse with water. Don't immediately fix electrical problems if you smell gasoline! Check all fluids. Check fan clearance.

**ASSIGN A DIRECTOR**

Someone other than the roll victims should be in charge considering the adrenaline could still be flowing! The person behind the wheel must be in full mental contact with reality for the next few tests!

That motionless, deep space stare of the roll driver and passengers is not a good choice for behind the wheel! Also, at some point before you plant your bottom in the drivers seat, broken glass should be removed from inside the 4X. Pay particular attention to glass that could continue

tions can suffer fatal damage by cranking with the coil wire simply removed and "floating" in the air. The coil must be grounded or allowed to spark the equivalent of the sparkplug gap, but not if you smell gasoline! Your objective is to cautiously determine if the motor turns freely and nothing is wrong versus revving a piece of broken fan into the radiator or onlookers. If the motor does not crank, pull all of the plugs and re-attempt to crank. Beware oil could come shooting out of the plug holes.

Given a trouble-less cranking motor, reconnect the coil, have everyone stand back and attempt to start. Loose parts could come flying! Flooding or fuel pump interlocks are the first things to check if it doesn't start. If she starts, immediately, check the engine gauges and lights, and look for leaks. Then look, listen and approach under the hood carefully for further inspection. A properly running motor leads to the running gear check.

**RUNNING GEAR CHECK**

Turn the steering wheel slowly lock-to-lock. Listen and check for front wheel turning clearance. Also check the power steering system for leaks. Push real hard on the brakes to see if the pedal sinks. A sinking pedal means bad brakes! And make sure they stop too! Fix them before going any further. Finally, see if the gear shift levers move OK.

**MOVEMENT CHECK**

Now is the moment of truth — it's time to see if she rolls — on the tires that is! Ease forward as outside observers help with how things sound and look. They are checking for tire clearance, bent wheels, bent drive shafts, dragging brakes and other mechanical malfunctions. Check reverse too.

**ADJUST MOVEMENT INTERFERENCE**

Remove, bend and adjust interfering body metal and other parts to accommodate vehicle movement. Don't worry about hurting already damaged parts, but do concern yourself with personal safety while realigning the offending pieces. Consider using winches and other mechanical advantage devices to assist with toughies.

Finally, drive cautiously back to camp and perform a more thorough inspection. The sidebar on page 20 lists some useful re-righting tools.



fire, gasoline leaks and electrical sparking; 2) flat tires or bent wheels; 3) wheel alignment; 4) loose body or mechanical parts; 5) bent drive shafts, stub axles or suspension elements; 6) disconnected exhaust system components; and 7) broken glass.

Raise the hood and immediately de-

to break while driving either on the dirt or freeway. Consider completely removing or taping broken panels.

**ENGINE CHECK**

If everything seems OK, disconnect and ground the ignition coil high voltage wire, and crank the motor a little at a time. Modern electronic components and igni-

# ROLLOVER REVELATIONS

*EDITOR'S NOTE: To put our ego aside and tell it how it is, is tough. I'm remembering a time racing around the hills on a motorcycle. I slide off the trail, hit a rock and blew a tire. By the time my friends arrived, the blown tire had caused the fall. Chuck Thompson takes a brave step in sharing how his Truckhaven roll really happened. My belief is he is better equipped for next time, by being honest with himself and us. Given our propensity to protect our egos with fabrications and exaggerations, we deprive ourselves of the real learning experience. Learn from Chuck's honesty!*

by Chuck Thompson

Now about the rollover. Although I'm certainly not proud of it, about the best job of ego recovery I can do at this point is to consider it's educational value and try to help out some others. I'll describe not only what and how it happened, but also how I could have prevented it.

There are a whole lot of reasons why it shouldn't have happened; the driver (me) was very experienced, this wasn't an area where any serious side tilt existed, the ground was dry, weather clear, etc. But it did happen...so why? Not surprisingly, it was several things going wrong.

First of all, I lost concentration. We had been traversing a series of steep overpitches, one after the other, and this had become routine enough that I had begun to think of other things and forgot to watch the truck ahead of me to get an indication of which way the trail went on the other side of the pitch. Second, about the time I cleared the top, I suddenly realized that I didn't know which way to go...to the right? To the left? Straight? And that's where I blew it.

At that point, realizing I wasn't sure of where I was on the trail, all I had to do was STOP! While stopped I could have done any number of things to decide what to do and taken all day to do it if I so desired. But I made the mistake of continuing, figuring I would sort it out as I went along. I began a right hand turn (something caused me to think the trail turned to the right; I don't know what it was and it's not important) and then,

almost as soon as I began the turn, I saw the trail straighten out in front of me so I turned back to the left to get back on it. What I didn't know at that instant was that my right front wheel had already begun to drop down into a steep gully. The very act of steering back onto the trail, at that point, created the roll. As soon as I realized what was happening, I steered into the roll, but by that time, it was way too late. We pitched over the right front corner of the Toyota, rolled over the passenger side and roof, and then came to rest on the driver's side of the vehicle. There were no injuries and help arrived immediately in the form of Steve Hollen and others.

What's the lesson? What can we learn? When I thought about what I could pass on to others, I wanted to get beyond the usual "pay more attention" kind of stuff. That's all important to be sure, but it isn't very specific. Of course we should be more aware, better prepared, etc. But what about when we're surprised, whether it's right that we should be or not? It goes like this:

**Rule Number One:** If at any time you don't for sure know where your vehicle is heading, STOP! Don't panic, just STOP! While stopped you can, at your leisure, do any or all of the following:

- (a) look around you and see if you can see anything;
- (b) ask your right seat passenger what is to the right...trail go that way?

Look to the left for yourself. If there isn't any trail to the right or left, then it's a pretty good bet it's going straight ahead...if there is a trail;

(c) get out and use your eyeballs.

**Rule Number Two:** Secure everything in your truck. In our case we had all our heavy stuff (shovel, hi-lift jack, tools, etc.) well-secured, except for the shackle which Steve Hollen found on the dash and which was responsible for shattering the windshield from the inside. Had we not, we could have turned a simple accident into serious injury. I can't overemphasize this point. Your gear should be stowed assuming there'll be a problem at some point. It's not only good off-road advice, but applies equally well to the freeway. You need to decide which objects you want flying around inside your car in an accident...and then strap the rest down.

Before the 4Runner was righted by hand, the passengers were warned to protect their heads from hitting the window when rolled back, the transmission was put in gear and the brake set.

Once righted, engine fluids were checked and other damage was assessed. Finding none, it was started, straightened out, and then driven on out. Lots of body damage but apparently little else. An experience and a lesson to be remembered.

