

2015 Webinar 3

Tire Behavior

There is no such thing as a free lunch!

4/6/2015

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In This Session

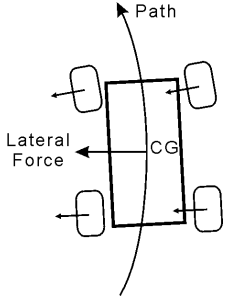
- Review: How a car turns a corner
- Slip angle creates lateral force
- Friction circle
- Induced drag
- Why wide tires give more grip
- Why tires are load sensitive
- Importance of balance, wedge
- Camber
- Questions

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Review: How a Car Turns a Corner

- Steering input creates a slip angle at the front tires resulting in a lateral force that starts to turn the car
- The rear tires stop the car from rotating with a slip angle and lateral force
- The combined lateral forces of the tires act at the CG accelerating the car toward the center of the arc of the path



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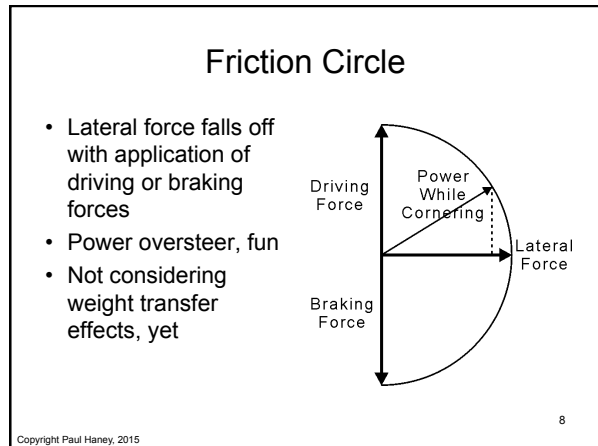
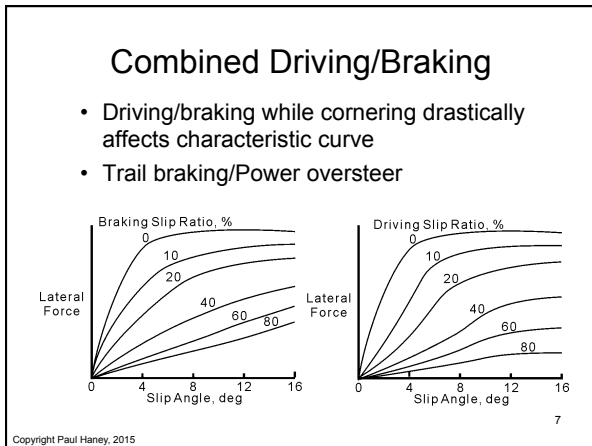
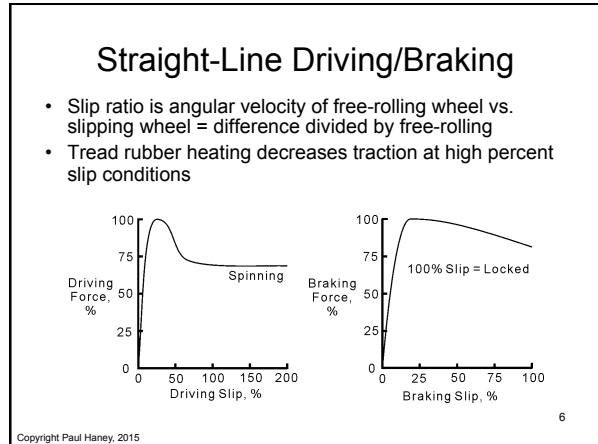
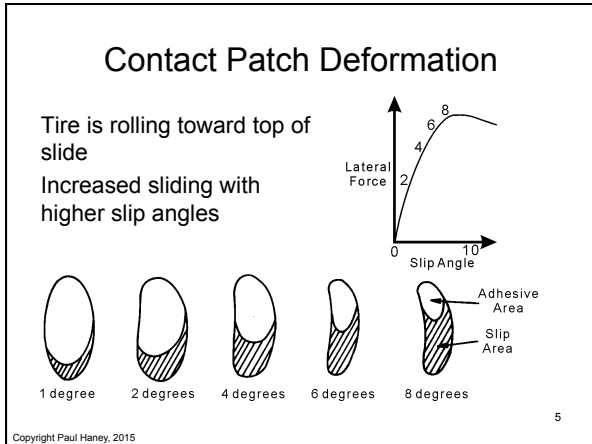
The Tires Are Turning the Car



The sidewall distortion you see is evidence of the lateral forces generated by each tire

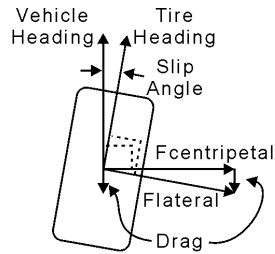
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Induced Drag

- Flateral=force of the tire, reacts 90 deg to the tire centerline
- Fcentripetal=force acting 90 deg to the car, has a drag component acting on the car
- Induced Drag gets bigger with slip angle and lateral force, racing radials

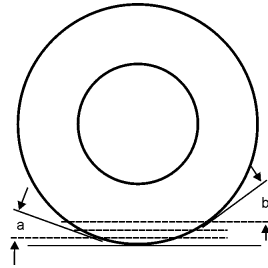


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Contact Patch Lengthens with Load

- CP area = Load lb / P psi
- Almost, maybe 95%
- Tread/sidewall bending stress increases CP force at edges of CP
- Longer CP means more distortion, more heat, higher fatigue stress
- Inflation pressure is critical to tire performance increases with tire temp

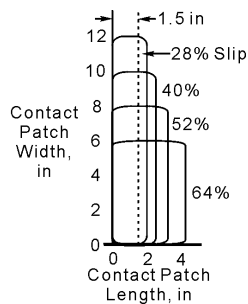


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Wide Tires Really Are Better

- Jim Hall story, 6 in wide to 12 in, 1966 Can-Am
- Assuming slip starts the same distance into CP for the same stiffness/inflation pressure/tread compound
- Same CP area but wider CP has less slip, more of the rubber is gripping
- Shorter CP means tread spends less time in the CP, lower peak surface temperatures

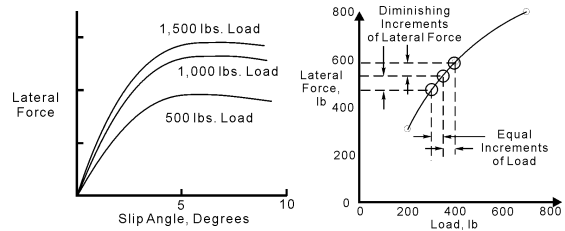


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The Load Sensitivity of Tires

- "The force vs. load curve is concave down" has been the explanation
- Actually, it's the same reason wide tires give more grip
- Increased load makes the CP longer, so higher percent slip in the CP



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WHY Are Tires Load Sensitive?

- Added Load on a tire forces an increase in CP area
- Tread can't get wider, has to get longer
- Slip starts same distance back of leading edge so more load means higher percent slip in the CP and more heating of the tread surface leading to loss of friction forces

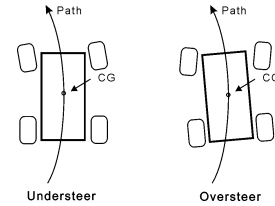


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Balance

- An unbalanced car entering a turn too fast loses grip at one end first, goes to larger radius path
- Oversteer less stable, rear tires gain slip angle in yaw, driver has to correct or car spins

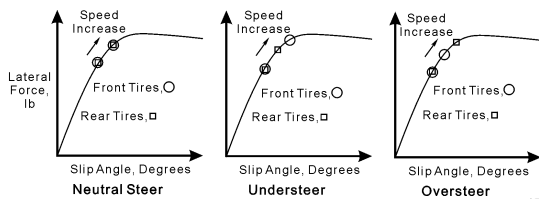


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Balance Leads to Speed

- **Lack of balance limits grip:** axle-pair of tires that reach the top of the curve first limits grip from the other pair
- At the top of the curve control is gone, more steer doesn't help but the driver still has the throttle

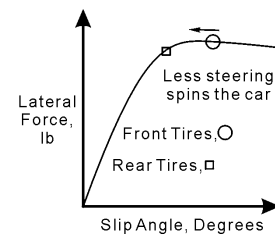


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So Tight It's Loose

- In a corner too fast, front tires over top of curve, rear tires gain grip
- At exit less steering moves front tires to more grip, rears to less, car spins
- Drivers need to be alert and skillful at the limit of the tires



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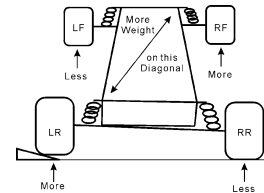
Command and Control

- Front tires are steered, **command** the car to rotate
- Rear tires **control** car rotation with a resisting slip angle and lateral force
- Weight distribution and roll stiffness distribution control balance
- Rotation momentum, driver style, driver comfort
- Rally car story

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Wedge: Diagonal Weight Adjustment



- Static adjustment changes balance in corner at speed
- More static weight on inside rear tire means less CP load difference at that end and less oversteer
- More weight on inside rear tire means more on the outside front, an adjustment toward understeer

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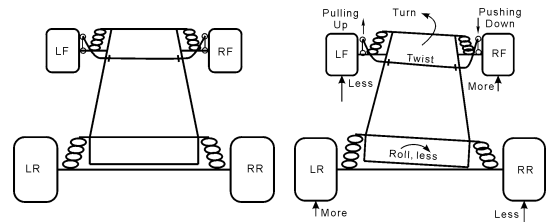
Wedge Summary

- Wedge is defined as more weight on the inside rear tire, a cure for oversteer, helps power down out of a corner
- Helps in one direction, hurts in the other
- Wedge results in more weight on outside front tire also, a doubly sensitive adjustment
- De-wedge is more weight on outside rear tire, a cure for understeer, berm example
- Faster speed in corner increases the effect, higher lateral acceleration and more weight transfer

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Anti-Roll Bar, Wedge Also



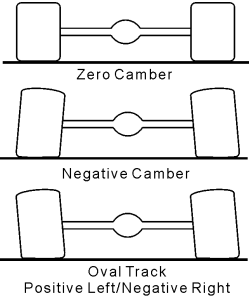
- Front ARB kills some grip at the front but puts more weight on inside rear tire-wedge, helps corner-exit (power) oversteer
- NASCAR trucks – 2 in front bar - lose some grip - gain aero

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Camber

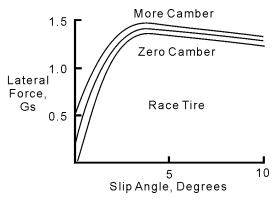
- Current suspension designs allow precise control of tire attitude
- Wider tires more affected by camber changes



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Lateral Force with Camber

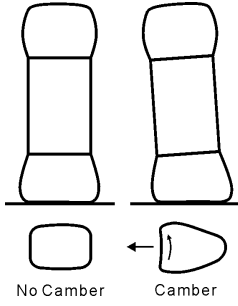
- Camber thrust adds to lateral force, even at zero slip angle
- Free grip, no extra heating
- Max lateral force at slightly smaller slip angle, so **less induced drag**



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Camber Thrust

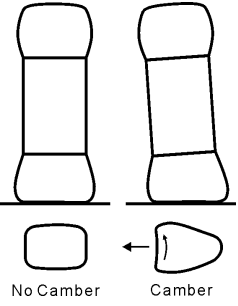
- Contact patch distortion creates angled leading edge where CP is loaded



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Camber Thrust

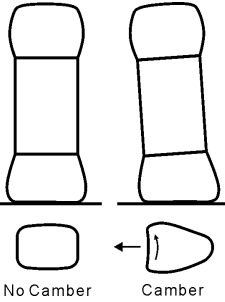
- Contact patch distortion creates angled leading edge where CP is loaded
- Lateral force increase with no steering angle
- No extra heating at high slip angles
- Less sidewall roll-under due to lateral force, more even load distribution in CP
- Trade-off: excess camber gain with roll or suspension travel can cause tire shoulder overload



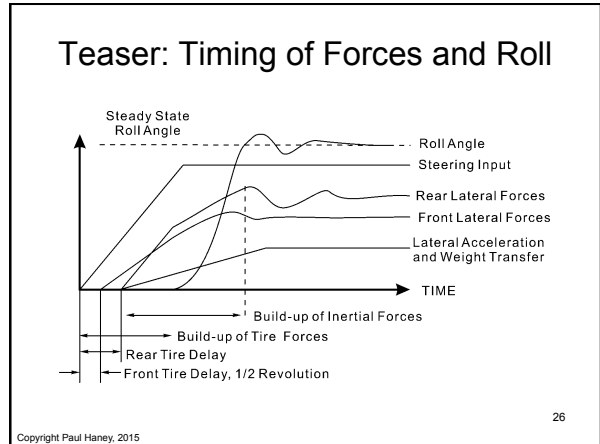
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Camber Thrust

- Contact patch distortion creates angled leading edge where CP is loaded
- Lateral force increase with no steering angle
- No extra heating at high slip angles
- Less sidewall roll-under due to lateral force, more even load distribution in CP
- Trade-off: excess camber gain with roll or suspension travel can cause tire shoulder overload
- CP area loss in front tire during braking is the usual upper limit



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The Racing & High-Performance Tire

Subtitled: Using the Tires to Tune for Grip & Balance

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