

BSc /HND Automotive and Motorsport Engineering

Data Acquisition and Dynamics

Session 3

Load Splits

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Wheel Load Split

The difference between two vertical wheel loads can be called a Wheel Load Split

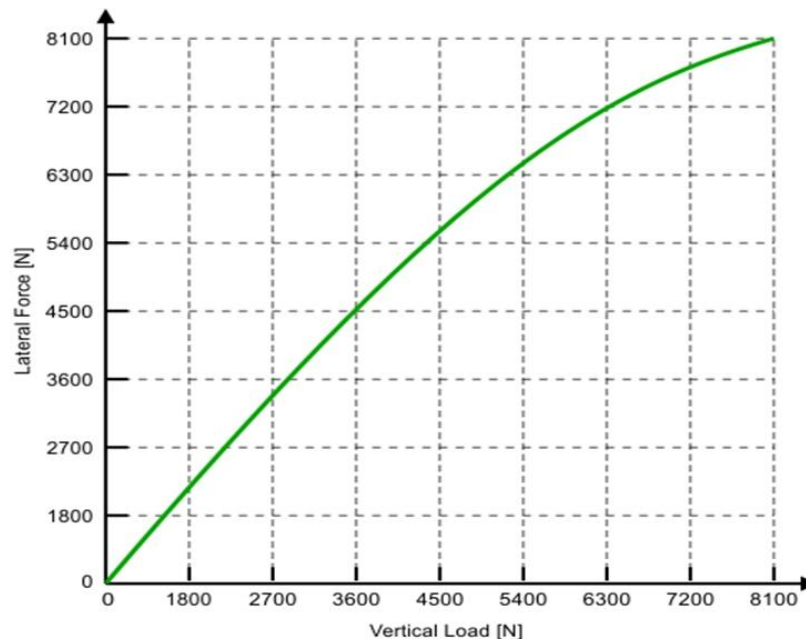
If the individual wheel loads can be calculated or measured then a simple calculation can be used to find the Wheel Load Splits between inner and outer wheels on an axle or between front and rear wheels and so on.

Tyre Grip

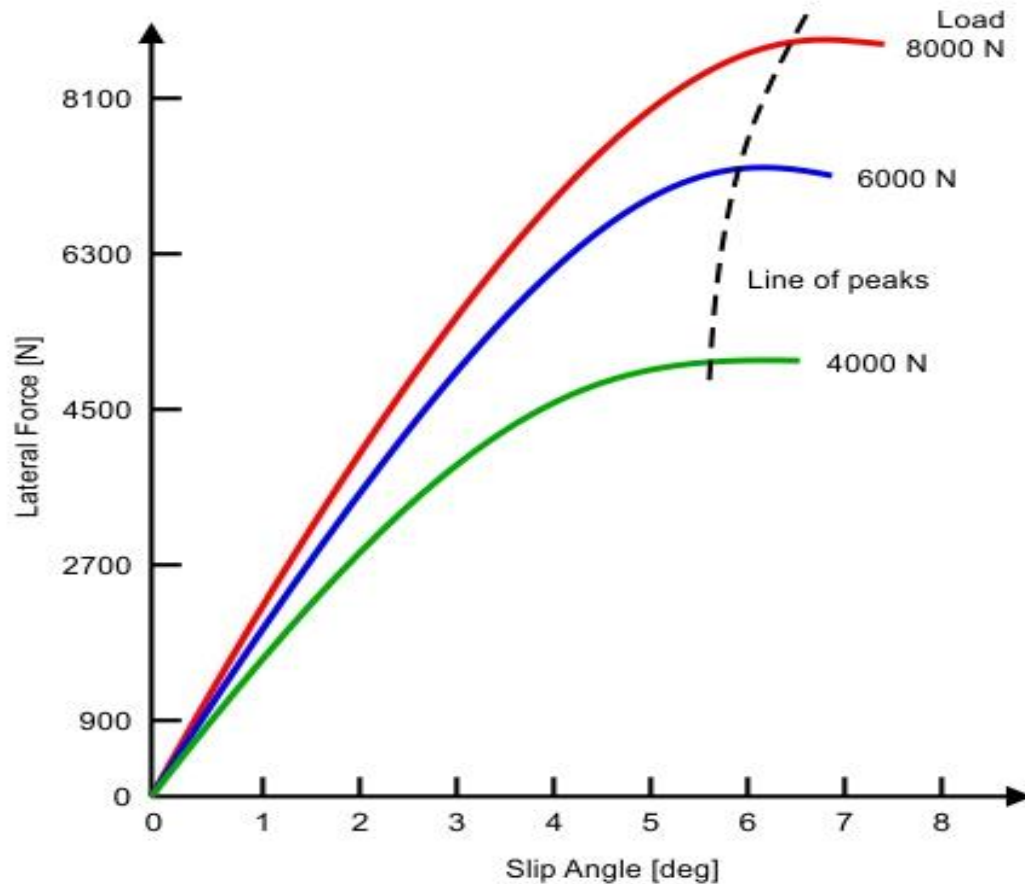
The tyre performance characteristics of the tyres at each end of the car provide the lateral force or grip needed to achieve the required lateral acceleration of the masses at each end.

Load /Slip Angle Characteristics

One of the most important relationships is that between tyre load and lateral force generated

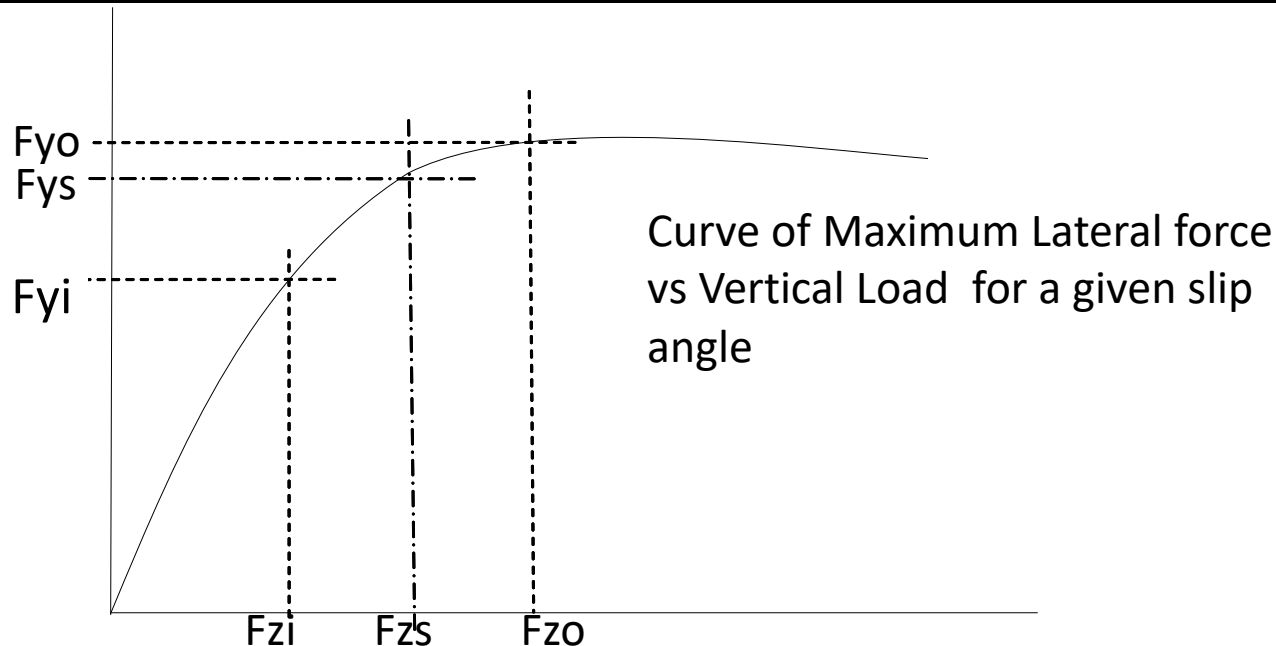


Slip Angle Characteristics for Different Loads



MILLIKEN & MILLIKEN, Race Car Vehicle Dynamics

How weight transfer reduces total axle grip



When travelling in a straight line

F_{zs} = Vertical load on each wheel $2 \times F_{ys}$ = Lateral force potential for the two tyres

When Cornering

F_{zi} = Vertical load Inner wheel F_{yi} = Lateral force created by the inner wheel

F_{zo} = Vertical load outer wheel F_{yo} = Lateral force created by the outer wheel

Lateral Force Generated

- The lateral force that can be generated by the pair of tyres on an axle is the sum of the lateral force generated by inner and outer tyres .
- The maximum lateral force available is when there is no weight transfer is equal to

$$2 \times F_{ys}$$

Change in axle grip with WT

- If there is any weight transfer F_{zo} moves to the right and F_{zi} moves to the left
- As they separate F_{yo} becomes greater and F_{yi} becomes less

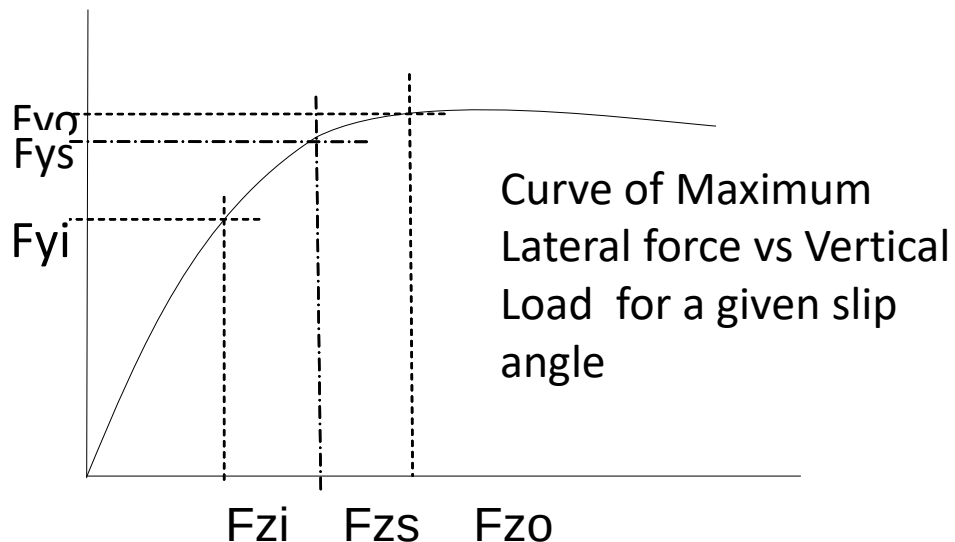
BUT

- The increase in F_{yo} is not as great as the reduction in F_{yi}
- So the result is that:

weight transfer reduces axle grip

Change in axle grip with WT

The greater the weight transfer, the greater the difference in vertical loads between inner and outer wheels (greater load split) and hence the less grip the axle will produce.



Effect of different load splits

If the load split is increased at the front of an understeering car it will understeer more

If the load split is increased at the rear of an understeering car it will understeer less

How can load splits predict handling behaviour ?

Consider three load splits

1. Front Load Split (FLS) $F_{zfl} - F_{zfr}$

2. Rear Load Split (RLS) $F_{zrl} - F_{zrr}$

3. Front Rear Load Split Difference (FRLSD) $FLS - RLS$

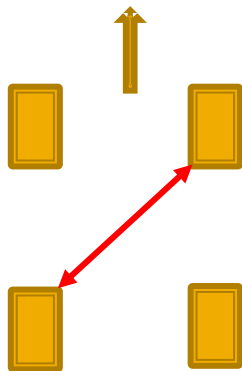
Additional relationships

- As well as the most important Load splits
- FLS, RLS and FRLSD we can also look at 'Wedge' and L-R Split

Wedge

'Wedge' is a term used in US oval racing to indicate the diagonal wheel load distribution or bias and is found from:

$$\frac{\text{Front Right Wheel Load} + \text{Rear Left Wheel Load}}{\text{Total Wheel Load}}$$



Why Wedge?

A great deal of US motorsport runs anticlockwise on oval circuits and so only left turns are required. Cars are optimised for this. The effect it has on car balance is turn direction dependent. Although it would be just as relevant to use the opposite bias when describing load distribution it reduces confusion to use one definition.

Sid Weight Totals

Left side total %

$$(LF+LR/ \text{Total Weight}) \times 100$$

Right side total %

$$(RF + RR / \text{Total Weight}) \times 100$$

These will indicate how a car will behave in terms of maximum cornering ability. If they are the same for left and right turns the car will have the same balance. If not then the car will have different levels of total grip in left and right turns

Class Activity

Looking at the effect of Load Splits

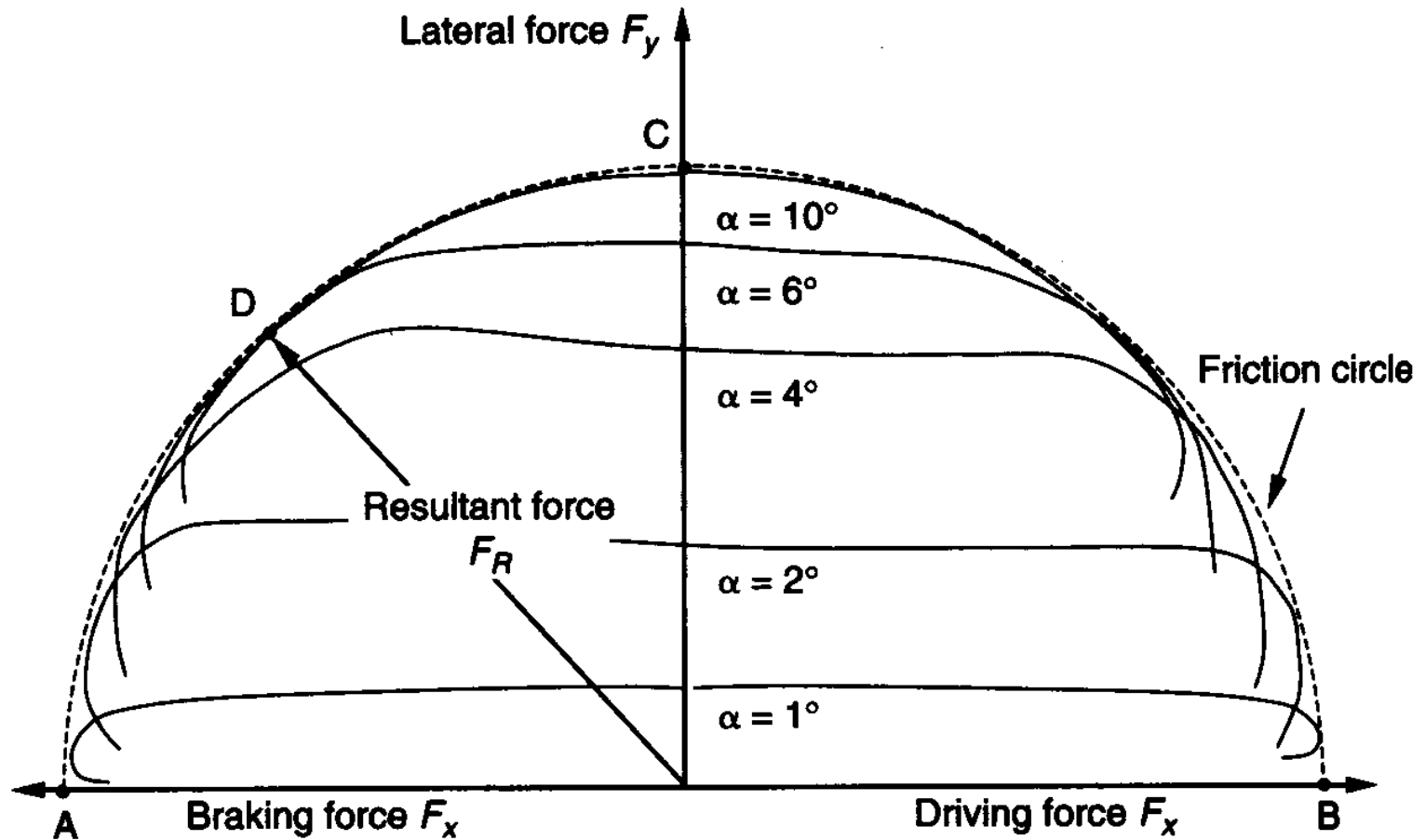
Look at the values for load splits, produced for each configuration.

Decide how you would describe the handling characteristic of each of the three configurations

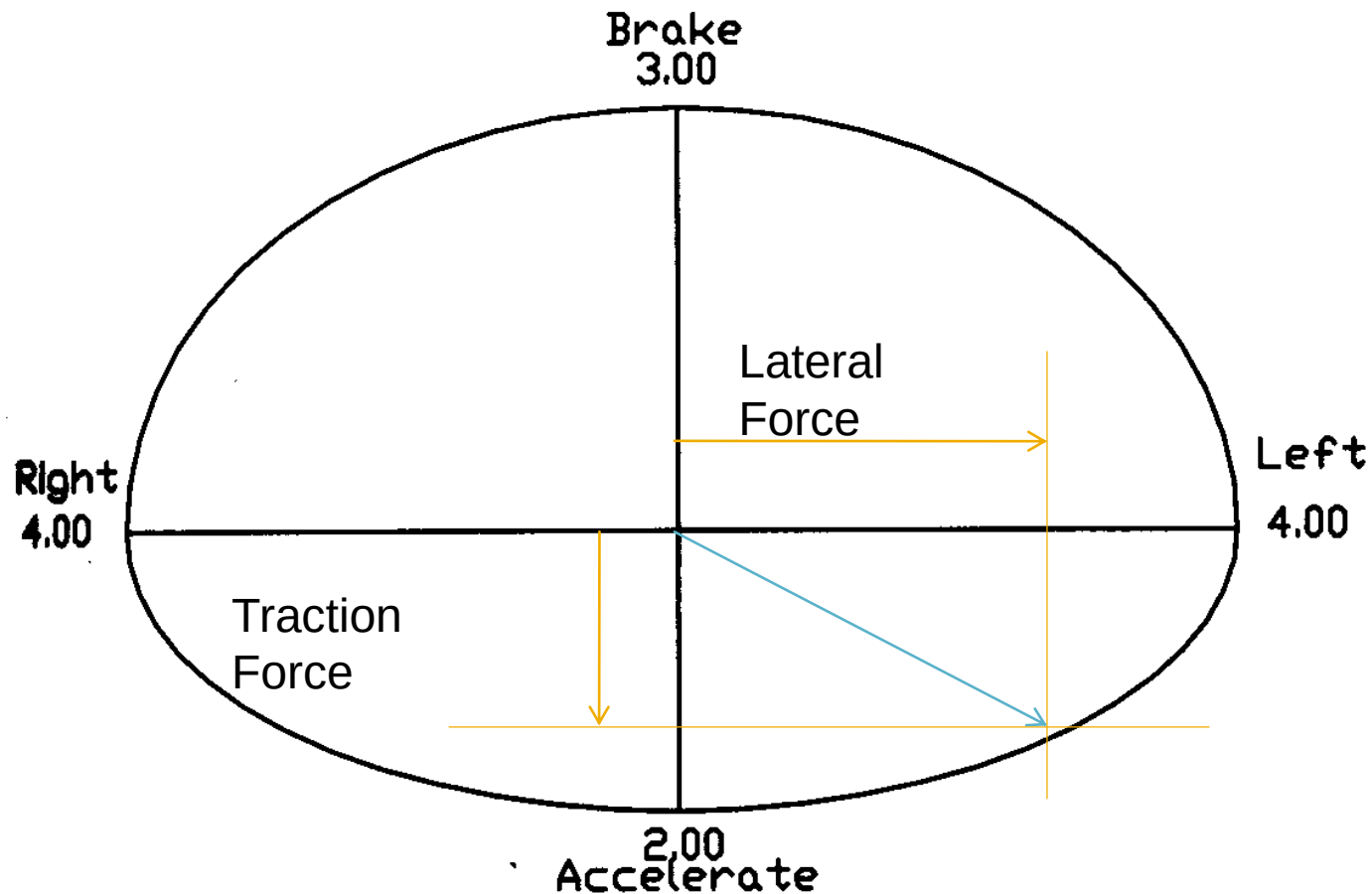
Effect of traction and braking on the lateral force capability of a tyre

Traction and braking forces will further reduce the lateral force available for cornering and influence the handling balance.

Traction Circle

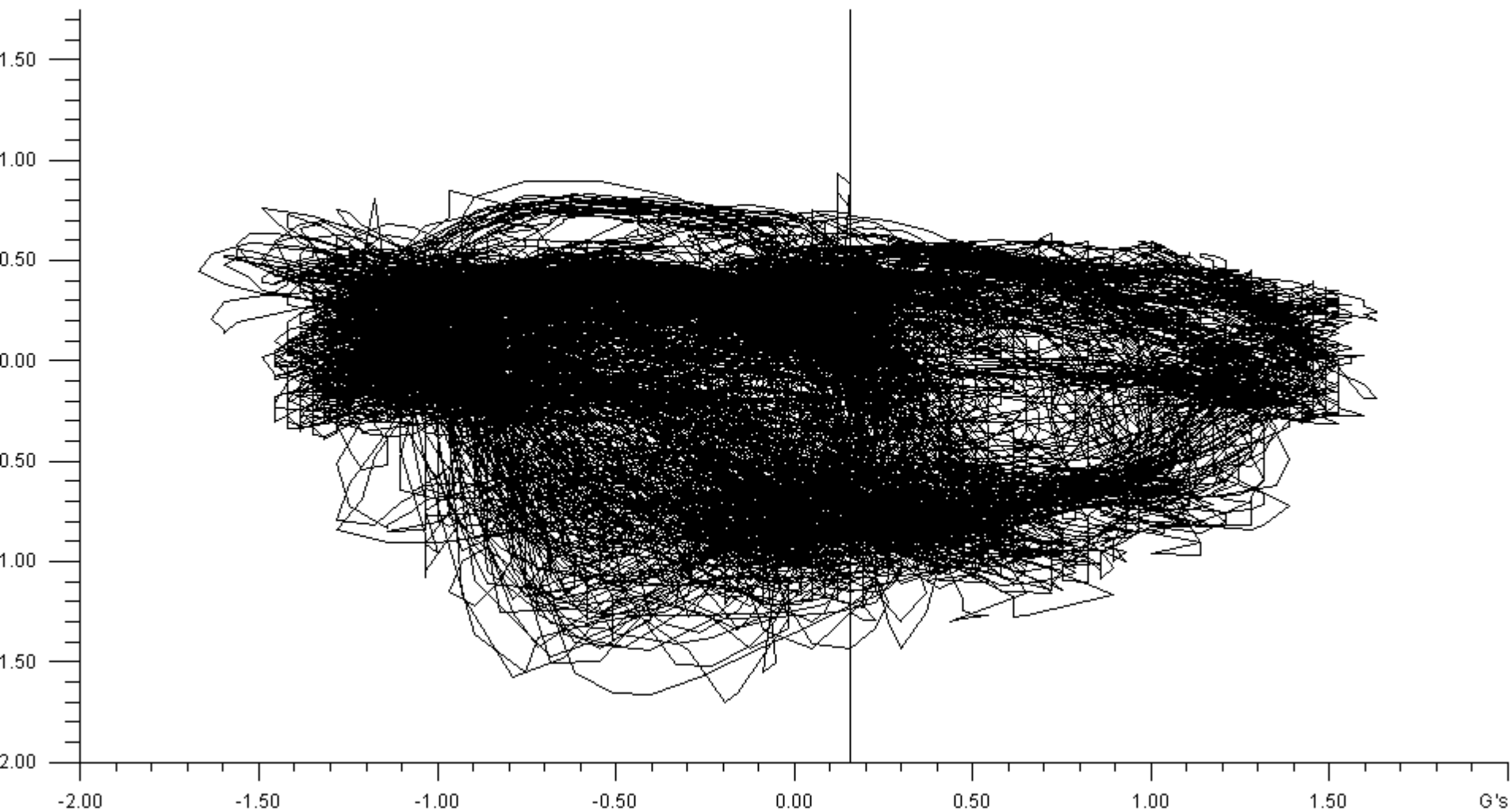


Traction Circle (another version)





G's



0.000 (secs) Lateral Accel -0.23 (G's) Inline Accel 0.00 (G's)