

Vehicle Technology

Introduction to Vehicle Dynamics

- Tyres
- Suspension
 - Springs
 - Dampers
 - Steering
- Cornering

Module Content

- Two Parts

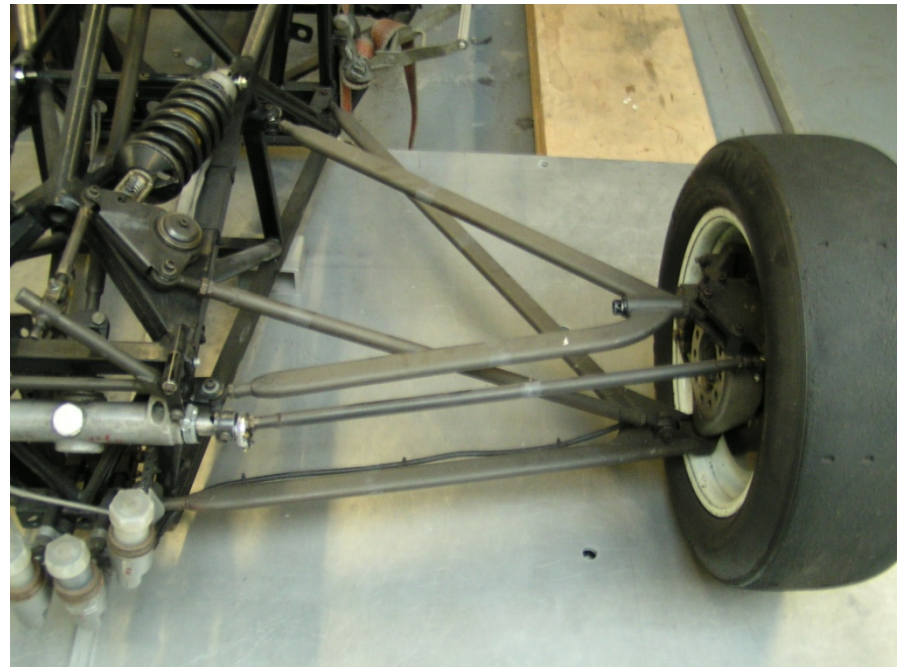
- 1. Suspension measurement and recording
- 2. Suspension geometry and frequency analysis

Assessment
25% coursework

- Attendance
- Team working, sharing.
- Accuracy
- Equipment
- Recording
 - Notes
 - Photos
- Relation to second part

Assignment 2 - measurement

Formula Ford Van Diemen



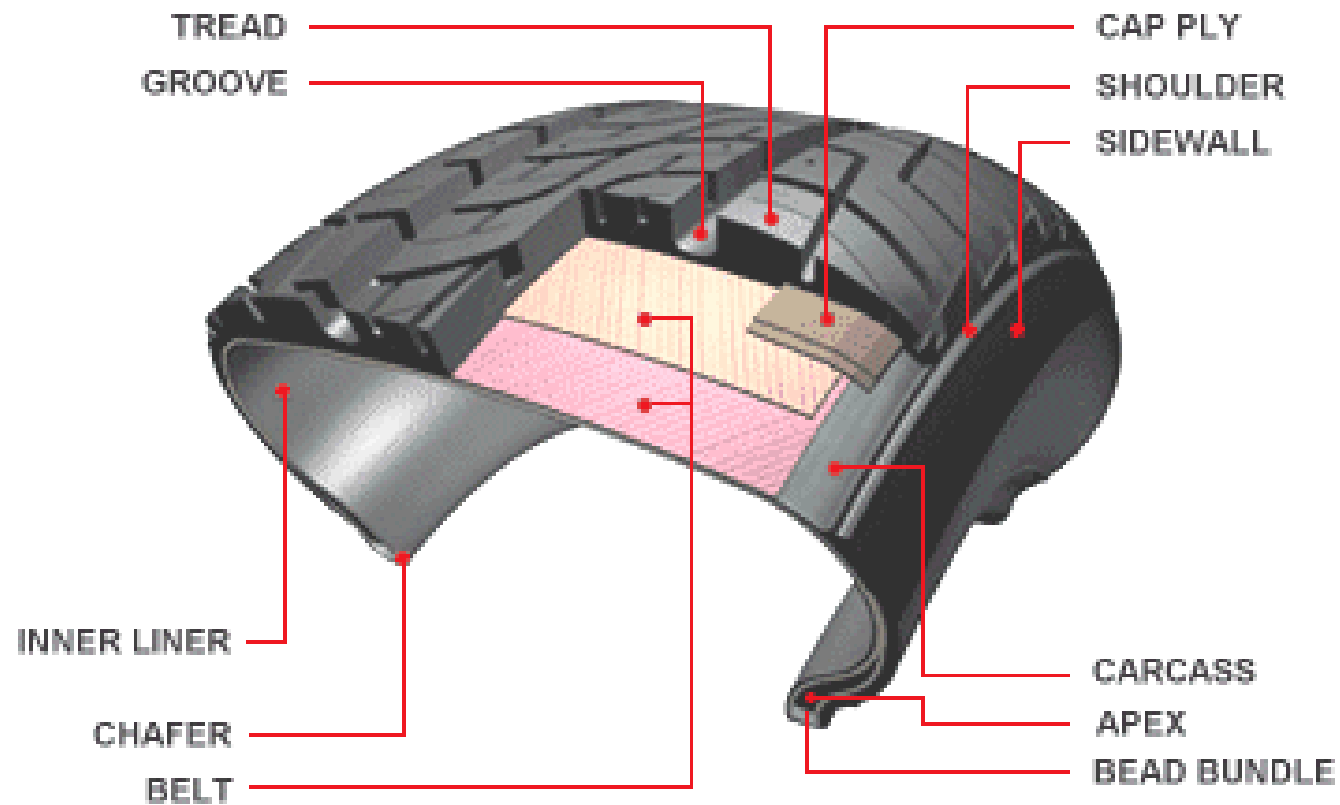
Most important vehicle component?

- Whatever you do to improve the vehicle performance the forces go through the tyres
 - Acceleration
 - Braking
 - Cornering
- Tyre selection is critical
 - Performance verses wear
 - Handling feel - feedback
 - Comfort – ride and noise
 - Economy – fuel consumption
- Tyre properties and dynamics are an important area of study

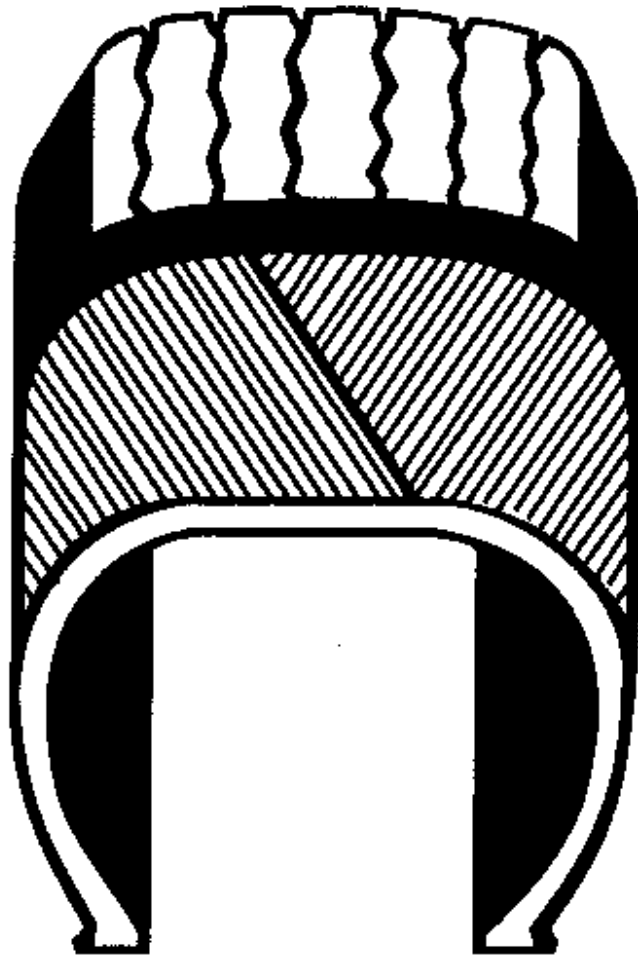
The Contact Patch

- The area of the tyre in physical contact with the ground.
- The contact patch changes shape and size depending on various factors, such as:
 - Tyre dimensions
 - Pressure – internal air (gas) pressure.
 - Vertical loading
 - Tractive effort
 - Lateral loading
 - Wheel attitude

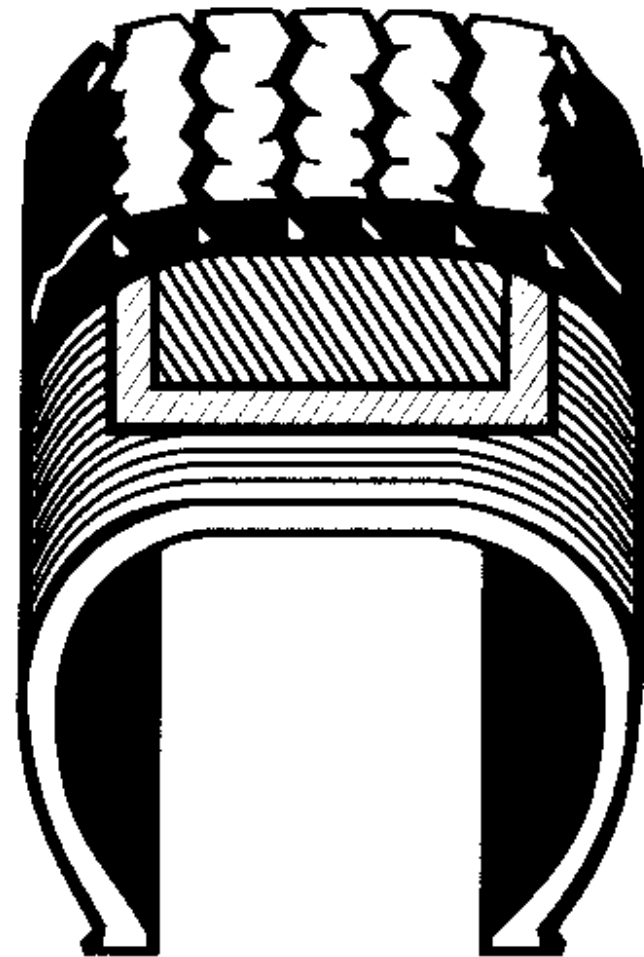
Tyre construction



Tyre construction

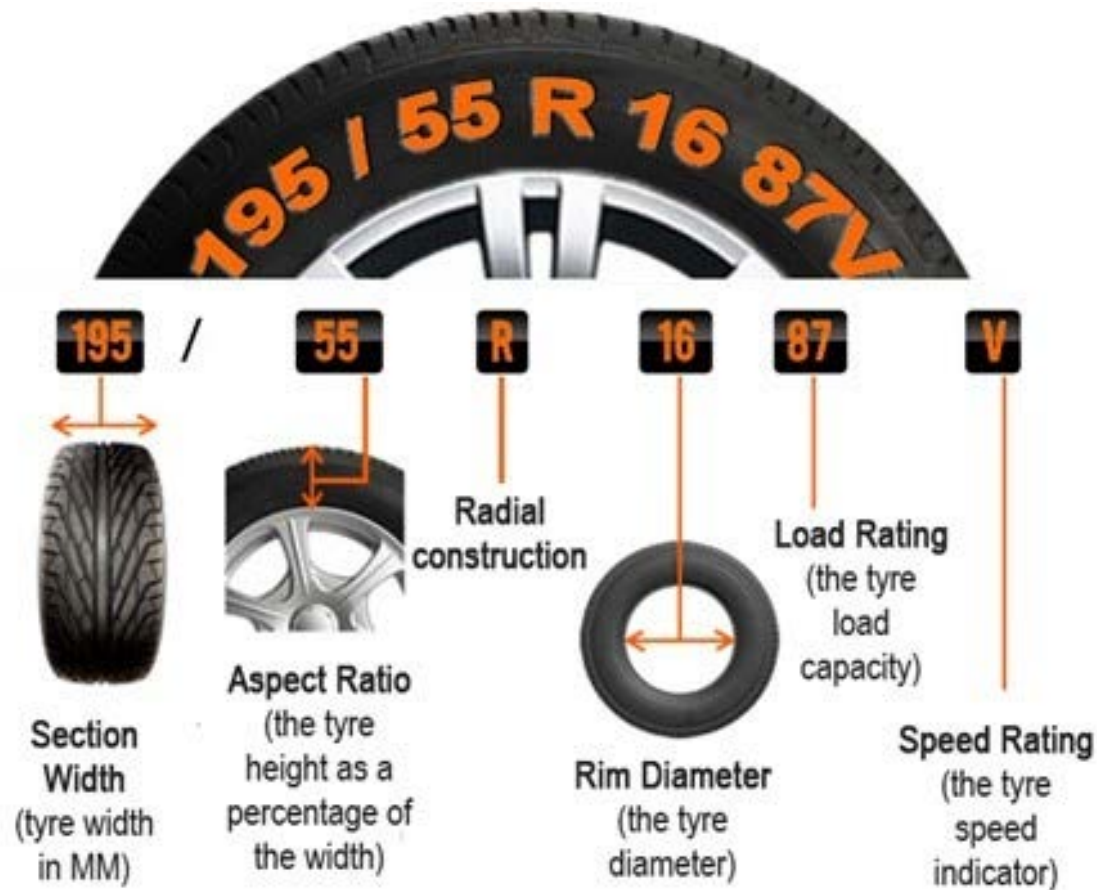


Bias-ply Tire



Radial-ply Tire

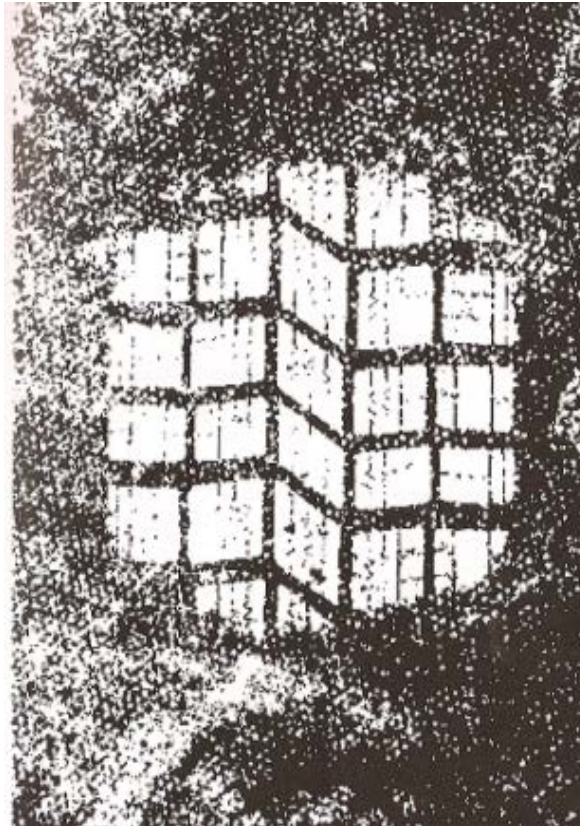
Tyre size and ratings



Tyre size and ratings

Speed Rating													
code	km/h	code	km/h	code	km/h	code	km/h	code	km/h	code	km/h	code	km/h
B	50	E	70	J	100	M	130	Q	160	T	190	V	240
C	60	F	80	K	110	N	140	R	170	U	200	Z	>240
D	65	G	90	L	120	P	150	S	180	H	210	W	270
												(W)	>270
Load Index													
Index	kg	Index	kg	Index	kg	Index	kg	Index	kg	Index	kg	Index	kg
30	106	40	140	50	190	60	250	70	335	80	450	90	600
31	109	41	145	51	195	61	257	71	345	81	462	91	615
32	112	42	150	52	200	62	265	72	355	82	475	92	630
33	115	43	155	53	206	63	272	73	365	83	487	93	650
34	118	44	160	54	212	64	280	74	375	84	500	94	670
35	121	45	165	55	218	65	290	75	387	85	515	95	690
36	125	46	170	56	224	66	300	76	400	86	530	96	710
37	128	47	175	57	230	67	307	77	412	87	545	97	730
38	132	48	180	58	236	68	315	78	425	88	560	98	750
39	136	49	185	59	243	69	325	79	437	89	580	99	775
												100	800

The Contact Patch – the bit doing
(*most of*) the work!



The Contact Patch

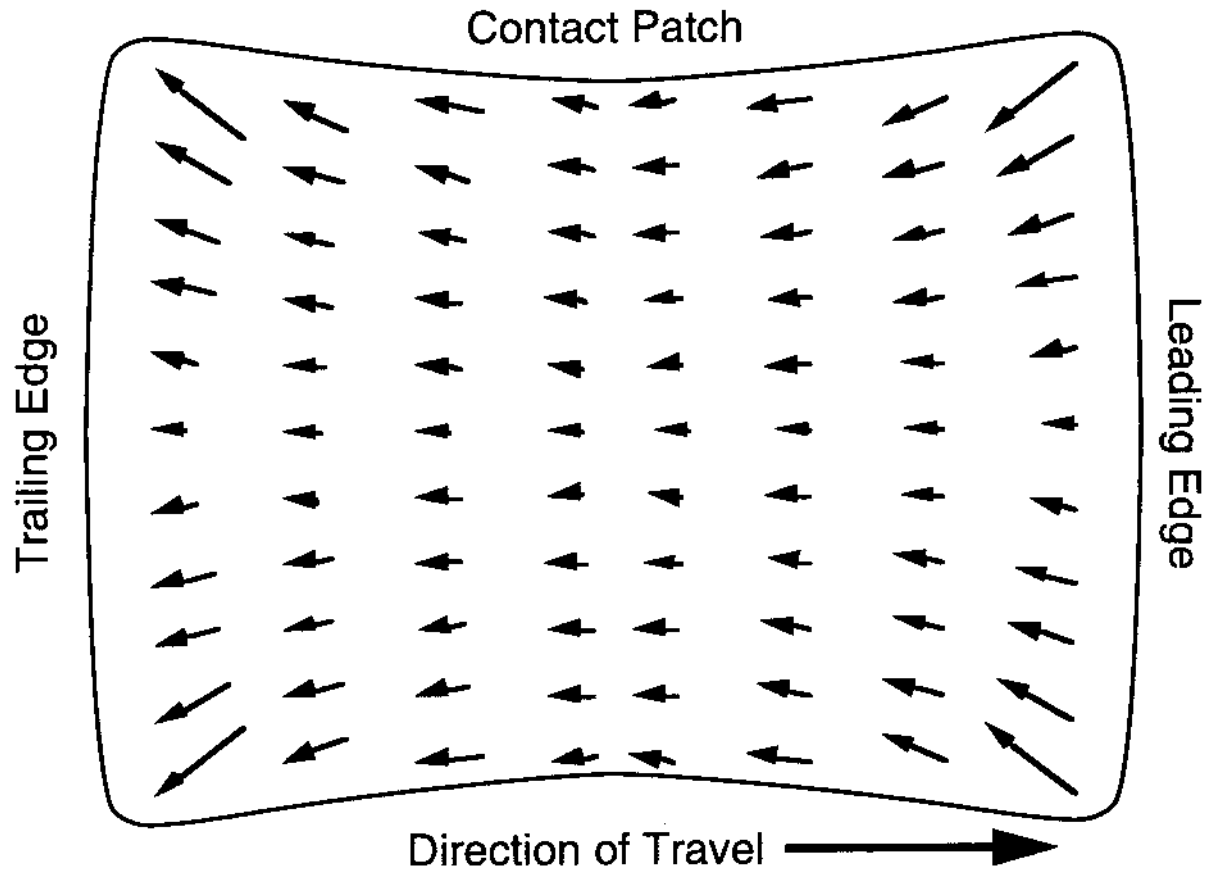
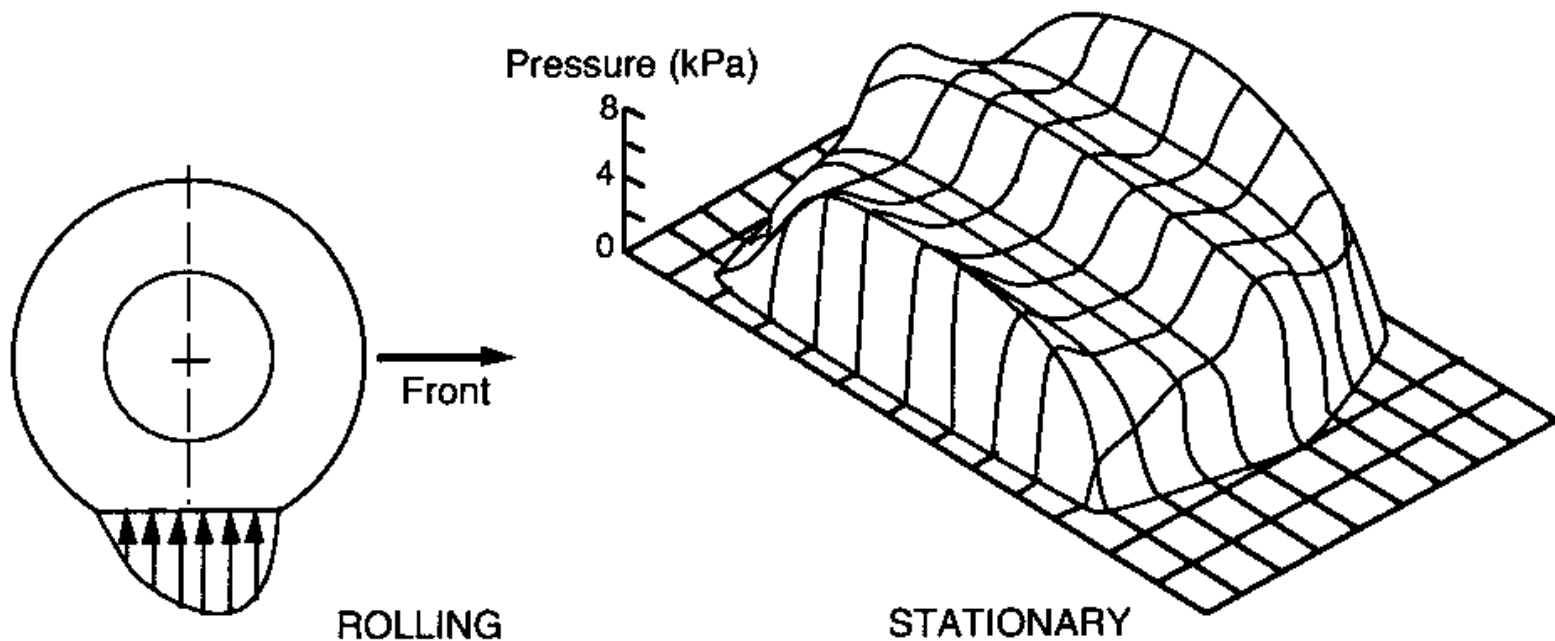


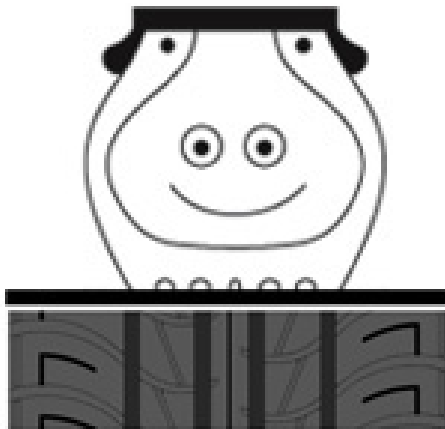
Fig. 10.2 Squirm in the contact patch of a bias-ply tire.

Basic tyre forces – Rolling resistance

- Not to be confused with tyre friction.
- Is a result of visco-elastic deformation of the leading edge of the tyre that shifts the vertical pressure forward.
- The vertical resultant force is offset from the centre of the wheel causing a resultant resistant force

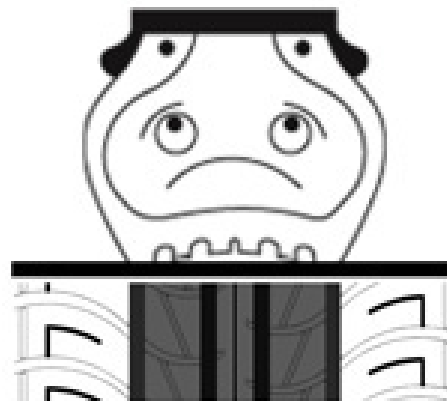


Basic tyre forces - RR and Pressure



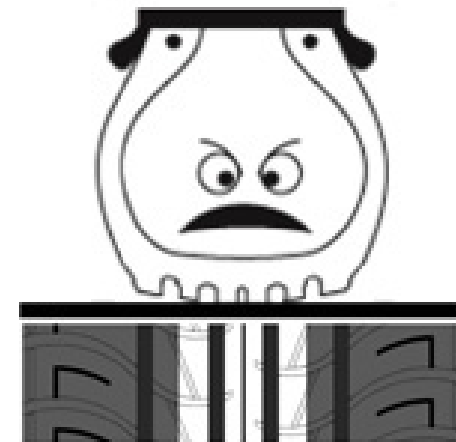
Proper Tire Pressure

Normal wear and tear
with extended tire life



Low Tire Pressure

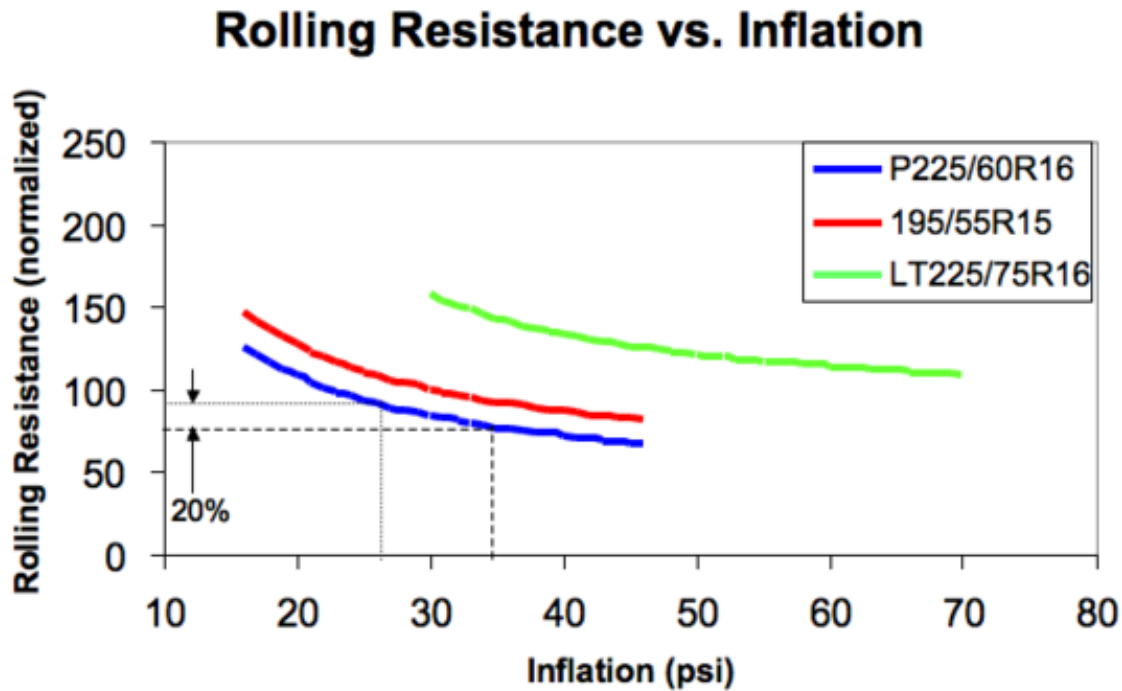
Causes uneven wear and
excessive wear on tire
shoulders



High Tire Pressure

Causes uneven wear and
excessive wear in tread
center

Basic tyre forces - RR and Pressure

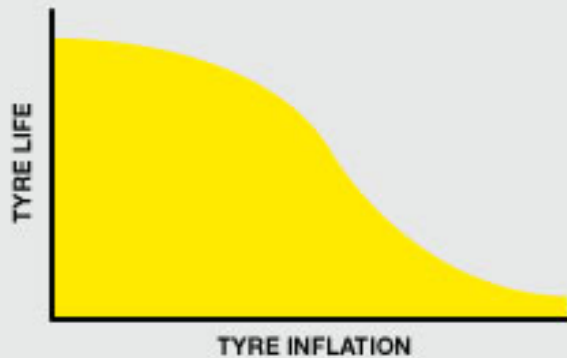


Basic tyre forces - RR and Fuel Consumption

TYRE LIFE vs. INFLATION



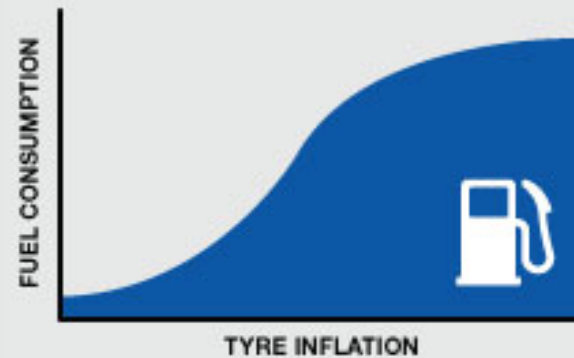
Tyre life is reduced as inflation decreases



FUEL CONSUMPTION vs. INFLATION

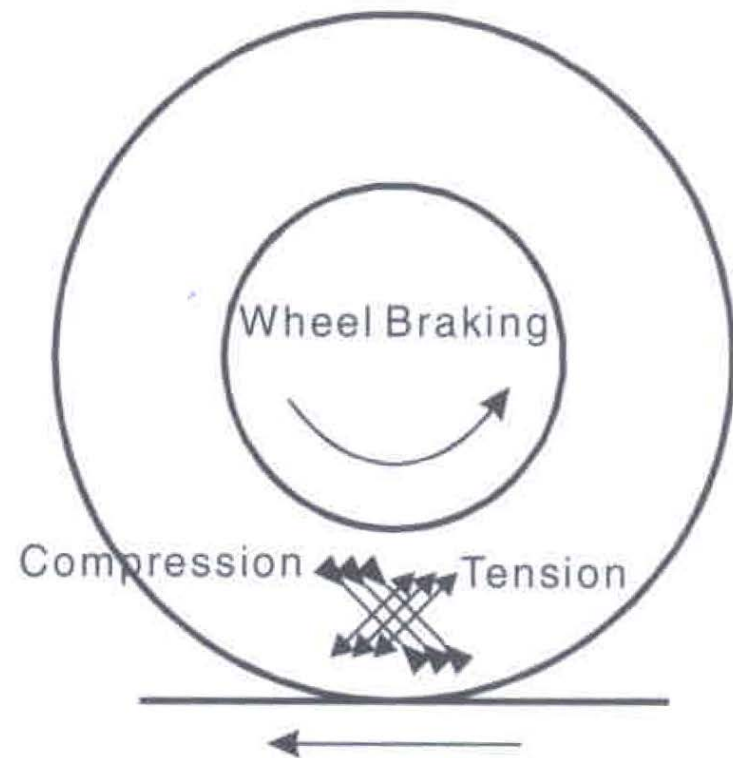
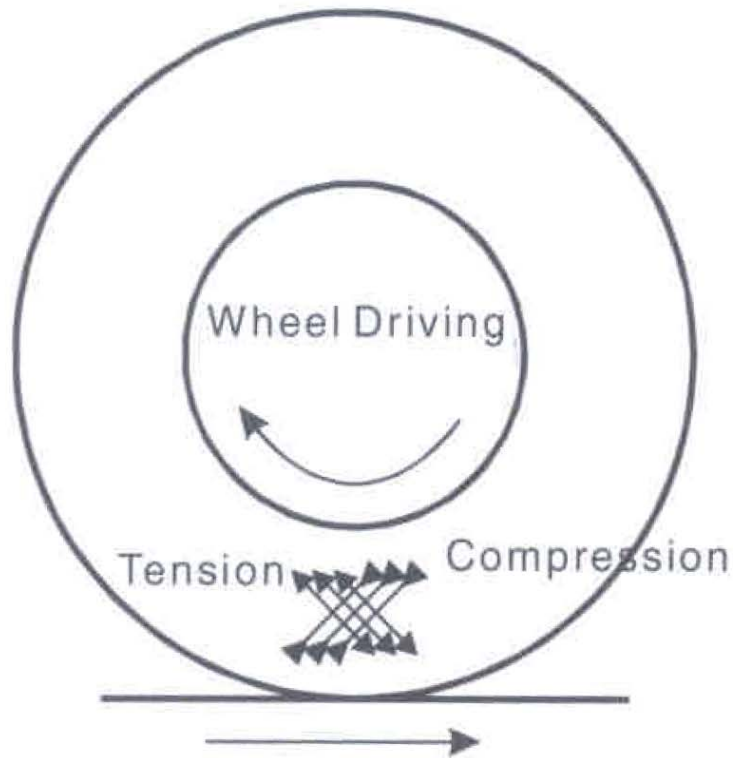


Fuel consumption increases as inflation decreases



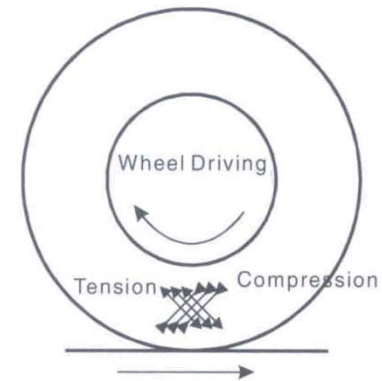
Basic tyre forces - traction

- Sidewalls in shear due to traction / drive forces



Basic tyre forces - traction

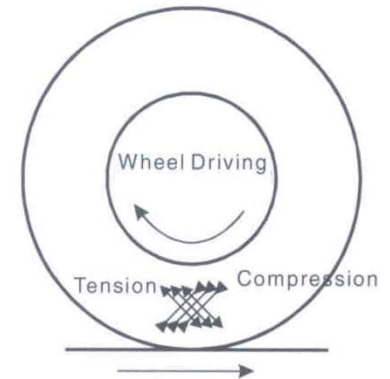
- Sidewalls in shear due to traction / drive forces



Basic tyre forces - traction

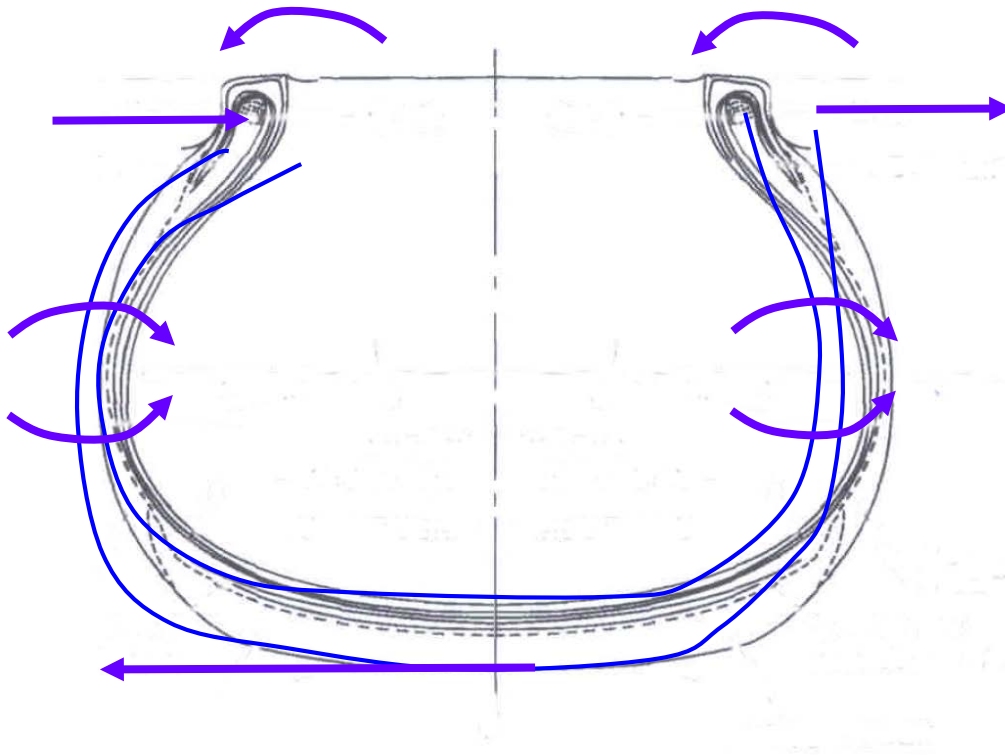
- Sidewalls in shear due to traction / drive forces

<https://www.youtube.com/watch?v=HldiiDmvTxI>



Basic tyre forces – Lateral force

- Sidewalls in bending due to lateral forces
- Beads react moments as well as forces



Carcass Distortion



Carcass Distortion

- <https://www.youtube.com/watch?v=uLEAlvRJ1Rs>

Carcass Distortion

- The tyre does distort and deform when reacting the forces we demand of it.
- In a performance event the continual stretching and relaxing of the rubber can lead to heat build up. In extreme causing a blow out.
- However there is an 'optimal' temp for the tyre to work at.
 - Summer tyres/winter tyres
 - Race tyre warm up and monitoring

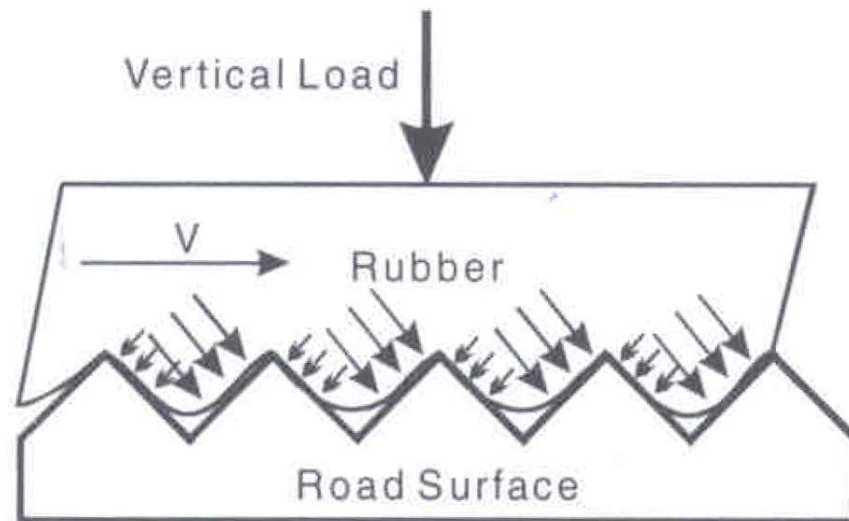
Frictional forces – what makes it stick!

- Several mechanisms for generating ‘frictional’ forces – lateral and longitudinal
 - hysteresis
 - adhesion
 - tearing

Frictional forces

- Several mechanisms for generating 'frictional' forces

- hysteresis



- adhesion
 - tearing

Frictional forces

- Several mechanisms for generating ‘frictional’ forces
 - hysteresis
 - dominates “real world” tyre grip on uneven (textured) surfaces
 - generates pressure differential between loading and unloading faces of rubber
 - also known as “mechanical keying”
 - high level of damping (hysteresis) in compound promotes grip on textured surfaces
 - sensitive to sliding velocity and road texture
 - insensitive to lubrication (liquid, powder)
 - adhesion
 - tearing

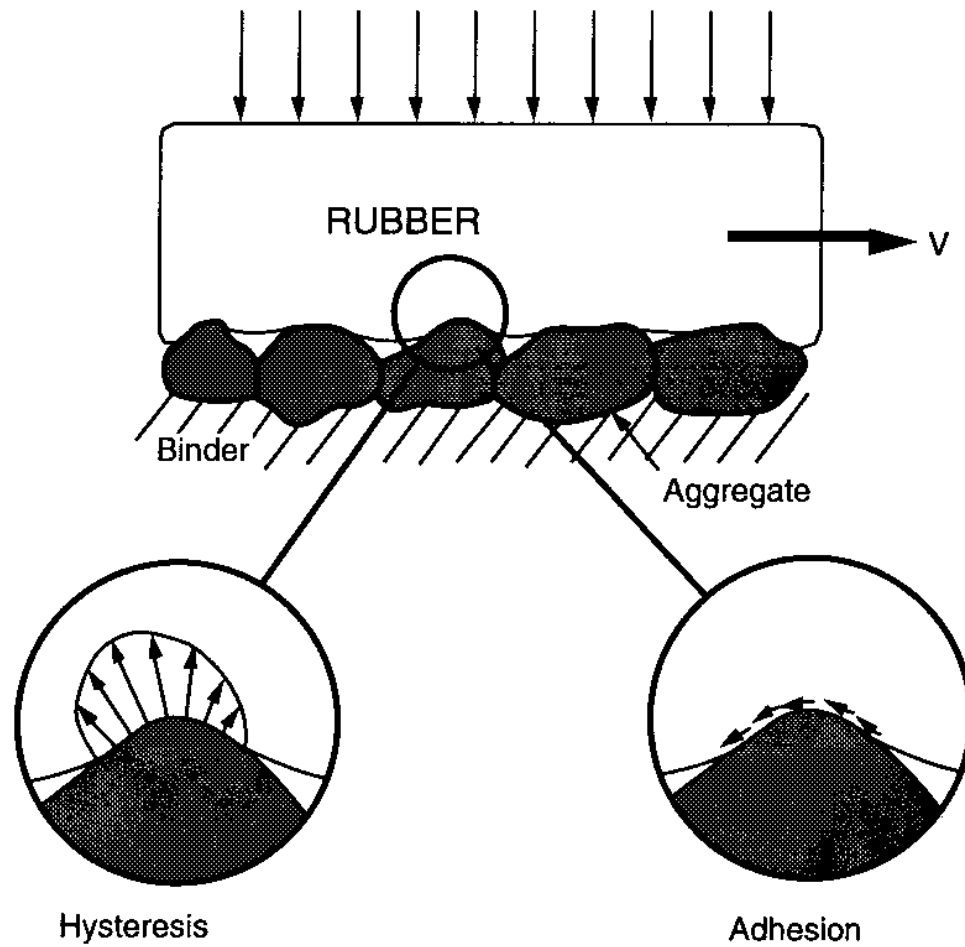
Frictional forces

- Several mechanisms for generating ‘frictional’ forces
 - Hysteresis
 - adhesion
 - “momentary molecular bonding” between tyre and road
 - uses “residual electrostatic forces”
 - primary mechanism for “rubber on glass” friction
 - “tops up” grip for dry, non lubricated surfaces
 - highest at very low sliding velocities
 - tearing

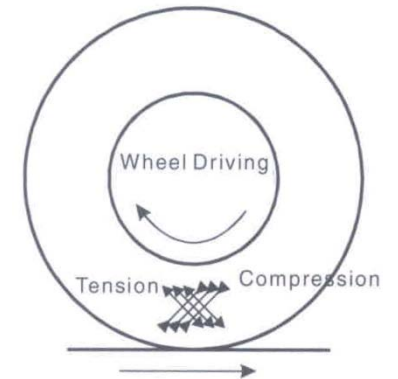
Frictional forces

- Several mechanisms for generating ‘frictional’ forces
 - hysteresis
 - adhesion
 - tearing
 - physical limit of rubber cohesion
 - surface of rubber dragged away from body
 - deposits on road (“skid marks”), rubber dust on bodywork, tyre graining
 - responsible for tread wear, always occurring to some extent

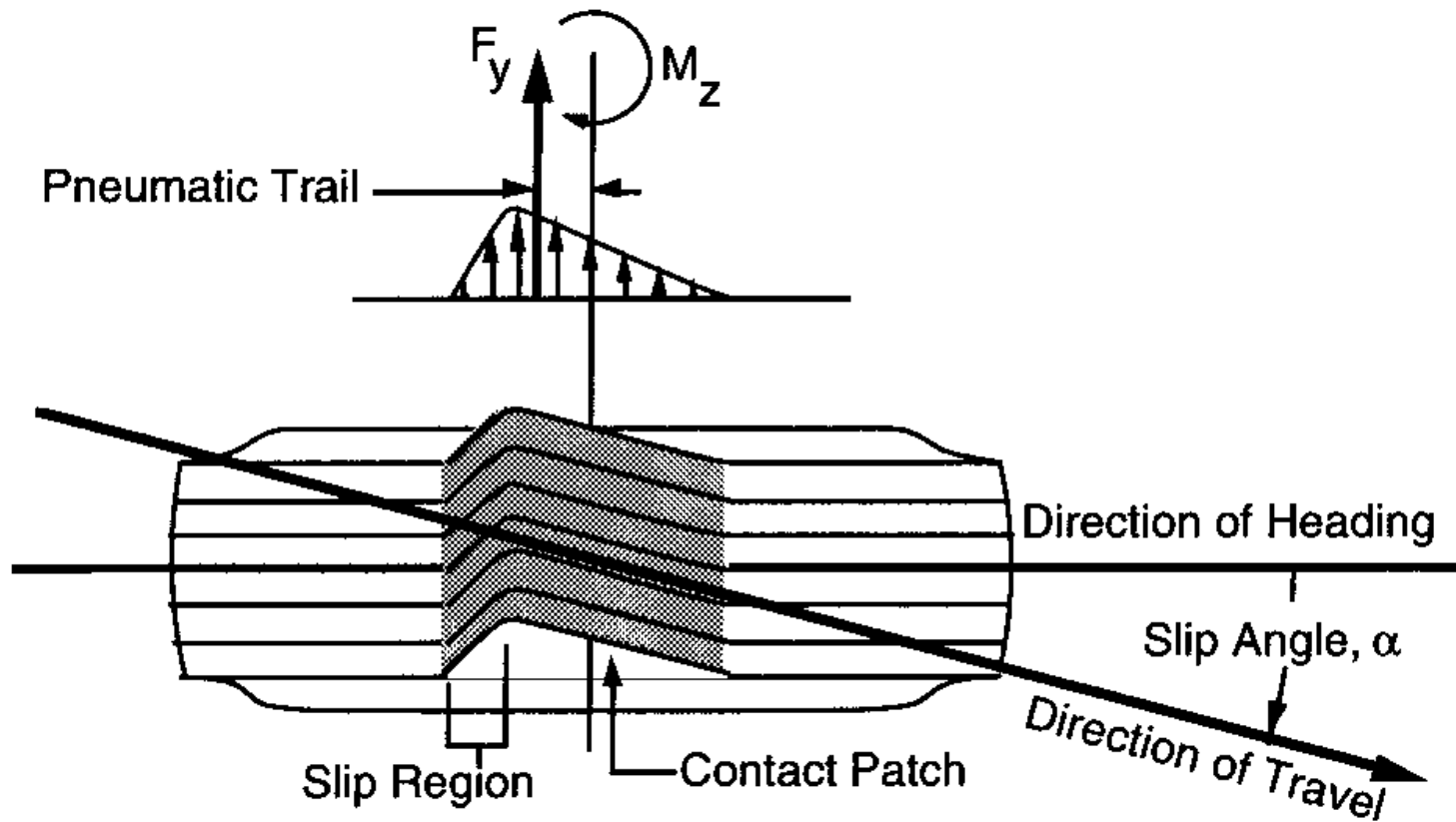
Frictional forces



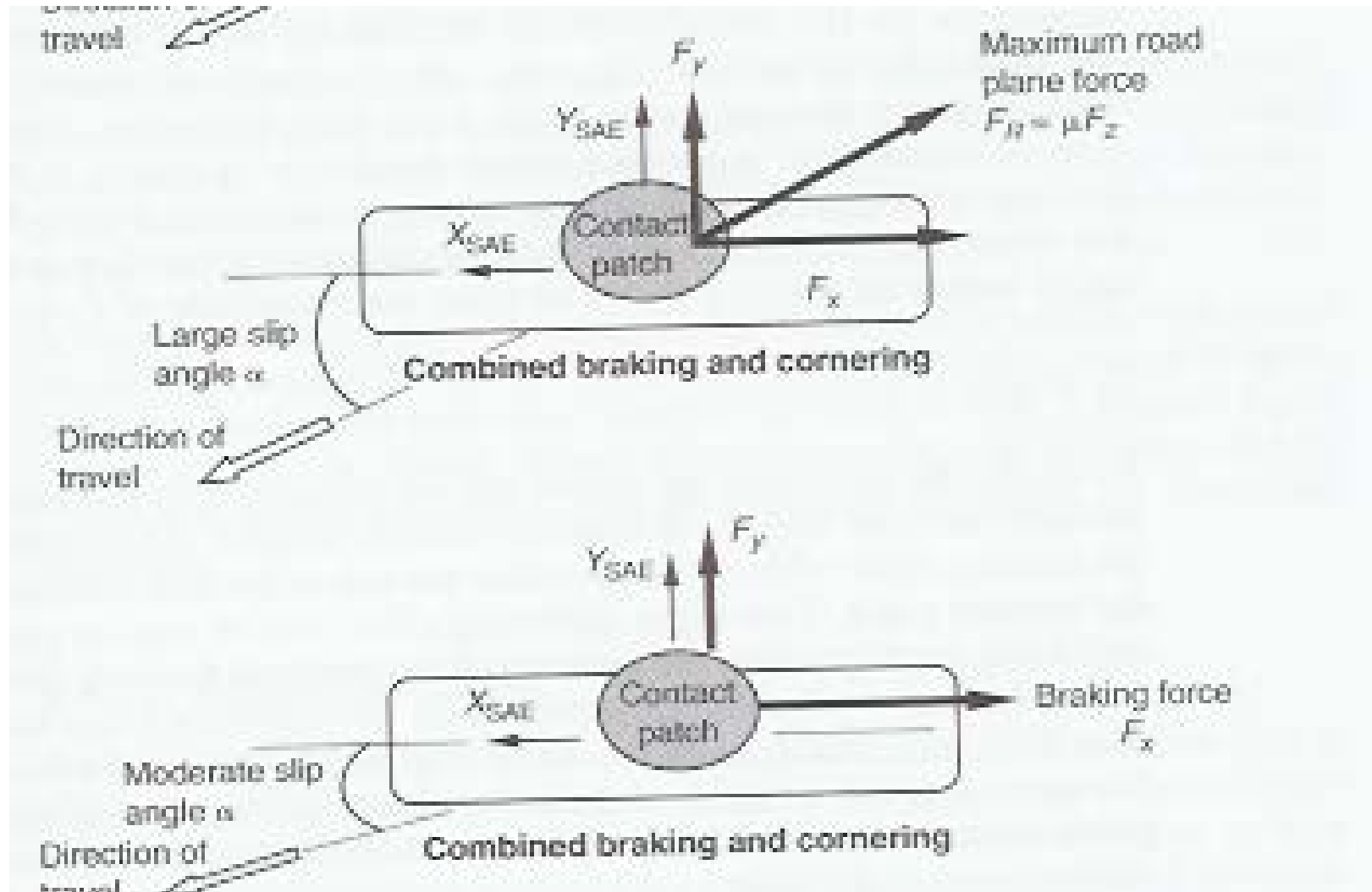
Basic tyre forces - traction

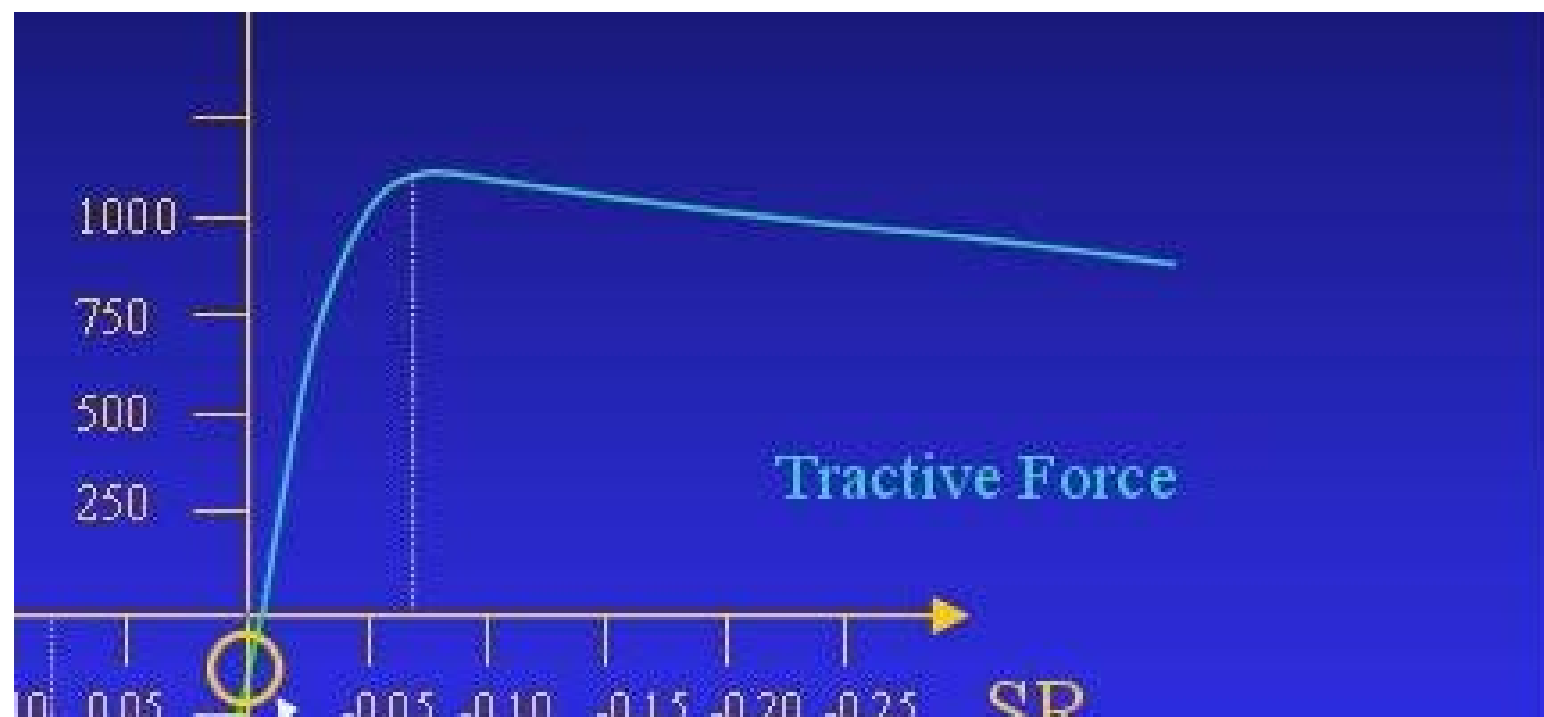


Slip angle



Tyre characteristics

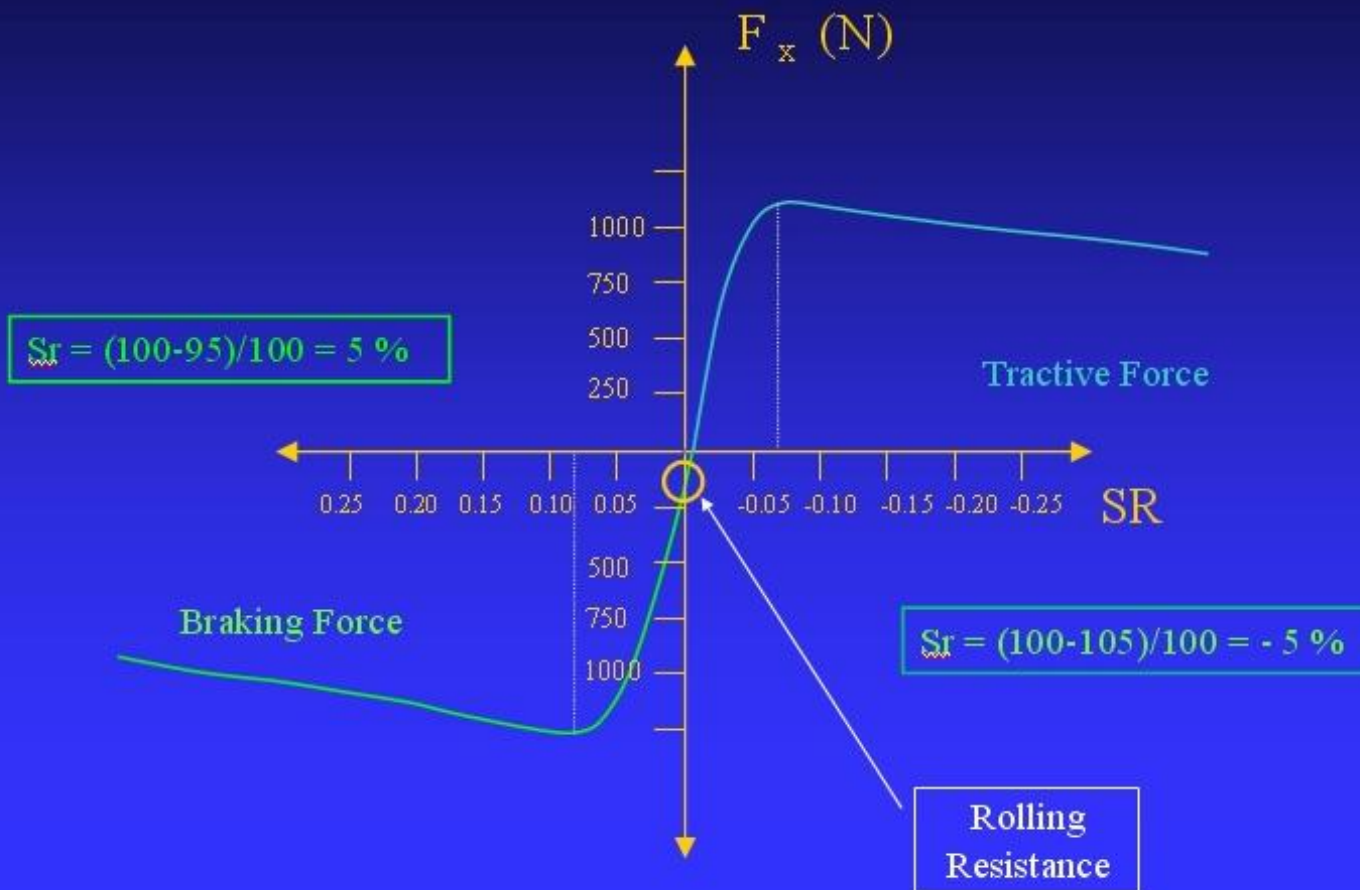




Tyre characteristics

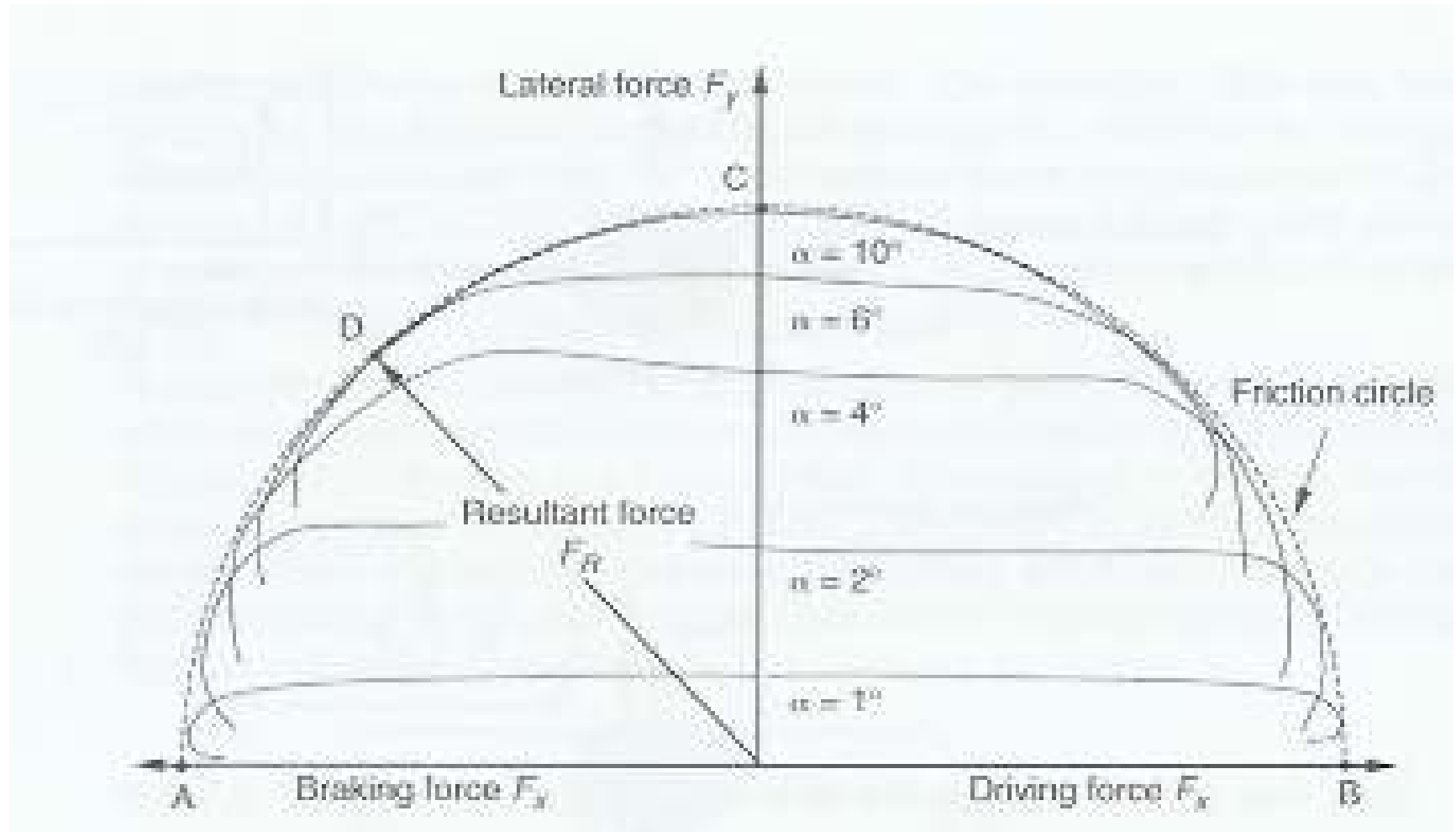
Tyre Longitudinal Friction Coefficient Variation

$$F_x = \text{fn} (\text{Slip ratio, Rubber, Temperature, Pressure, Ground, ...})$$



Tyre characteristics

Friction circle (ellipse)



Grip videos

<https://www.youtube.com/watch?v=3kWbprsnOAI>

https://www.youtube.com/watch?v=ePR2jO8_i7g

<https://www.youtube.com/watch?v=yJpj6VuETf4>

Tyre testing



- **Measurement of rolling resistance**

- The measurement of rolling resistance to ISO 8767

- **Durability**

- Testing gives information on effects on tyre from many cycles

- **Overload**

- Assess overload conditions and the ability of the tyre to cope

- https://www.youtube.com/watch?v=nmo_dkNZIHM

- <https://www.youtube.com/watch?v=1o9mVZxoayA>