



Motorcycle Dynamics

Cornering

Cornering



2 things allow a bike to corner –

- Gyroscopic effect
- Centrifugal force

The intensity of the centrifugal force is –

$$F = \frac{mv^2}{r}$$

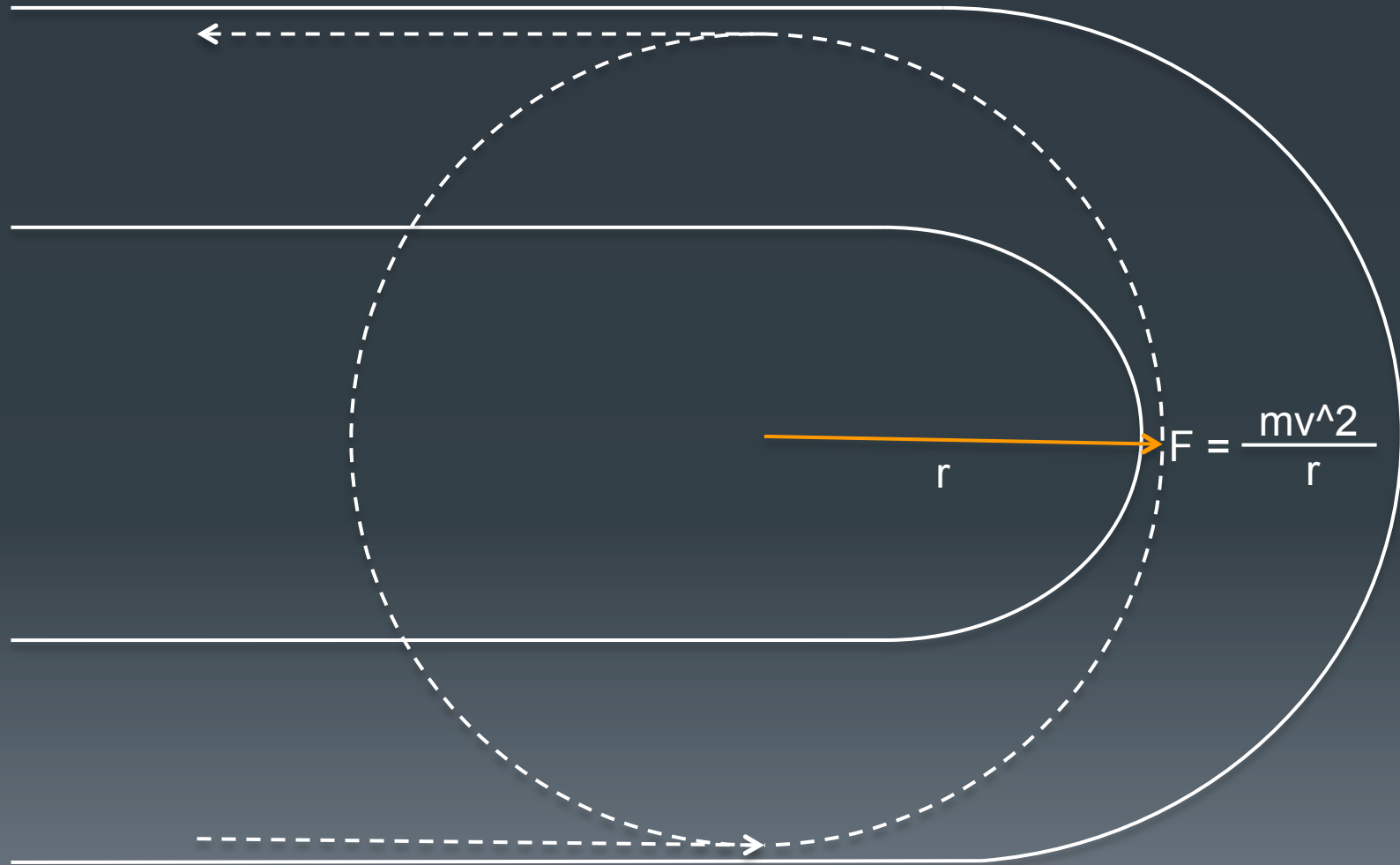
Where –

m = Mass

v = Velocity

r = Corner Radius

Cornering



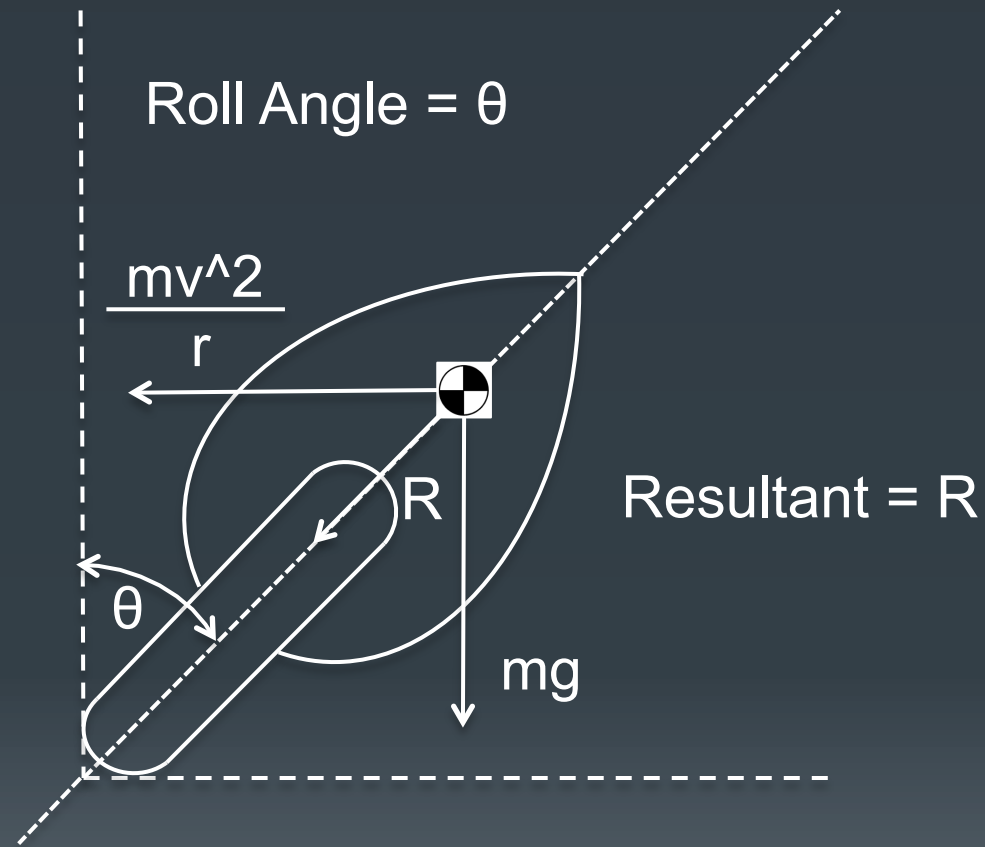
Cornering



Consider the left turn on the previous slide. Ride at a decent speed, perform a brief, rapid turn of the handlebars to the right. A centrifugal and gyroscopic force are created.

- The Centrifugal force acts on the CoG and tends to overturn the bike to the left.
- The Gyroscopic Moment created from the turn of the bars causes a lean to the left.
- We need an act to cause a state of equilibrium otherwise we would fall off. Turn the bars to the left to put the bike on a circular path. This gives a new centrifugal force and a state of equilibrium/balance.

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The resultant of the centrifugal force and mg lie on a limit through the contact patch and the CoG.

Cornering



Ideal Roll Angle

There is only one angle of inclination that allows you to maintain balance at a particular speed and a constant radius –

$$\tan\theta = \frac{\cancel{m} v^2}{r \cancel{m} g} = \frac{v^2}{r g}$$

$$\theta = \tan^{-1}\left(\frac{v^2}{r g}\right)$$

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Example –



Qatar 2010 Moto 2 race Kenny Noyes

Cornering

On the previous slide was an Ariel shot of Qatar, the multi coloured line is the GPS speed & this shows the racing line the rider has taken through the various turns and the change in colour indicates a change in speed. We are going to focus on Turn 2, shown below –

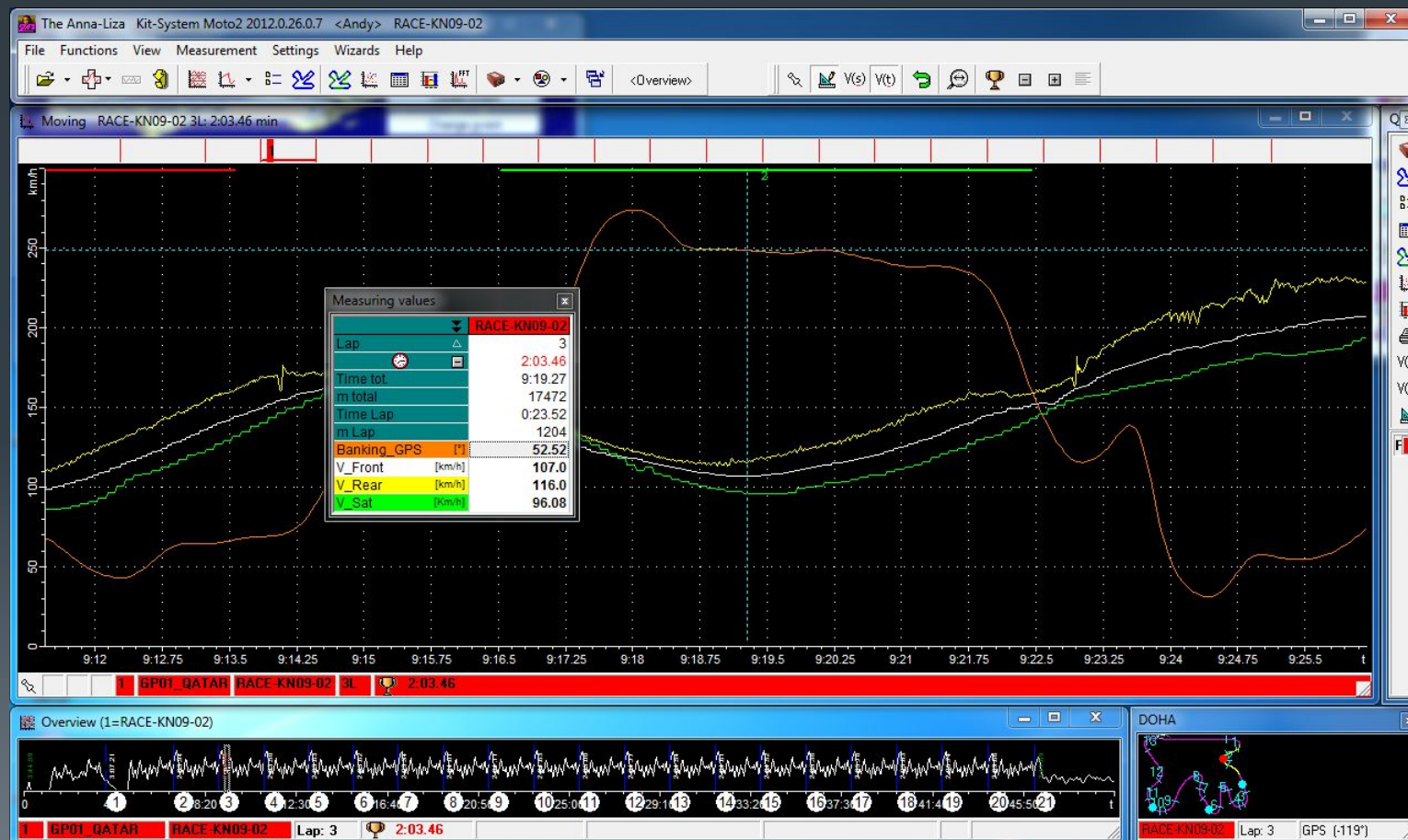
The red lines have been used to calculate the radius of the turn as follows.

$$r = \frac{S^2 + l^2}{2*s}$$



Cornering

Below is the data from turn 2 on Kenny Noyes fastest lap from the race –



Cornering



Example –

From creating a scale for the turn 2 photo the following corner radius was found –

$$\text{Corner Radius} = \frac{17^2 + 45^2}{2 \cdot 17} = 68.06\text{m}$$

Where –

$$s = 17\text{m}$$

$$l = 45\text{m}$$

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Example –

From the data the following parameters were found -

$V_{\text{Rear}} = 116 \text{ km/h} = 32.22 \text{ m/s}$

$V_{\text{Front}} = 107 \text{ km/h} = 29.72 \text{ m/s}$

$V_{\text{Sat}} = 96.08 \text{ km/h} = 26.69 \text{ m/s}$

Lean Angle (Banking) = 52.52°

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Using V Rear –

$$\theta = \tan^{-1}\left(\frac{32.22^2}{68.06 \times 9.81}\right) = 57.25^\circ$$

Using this value for velocity gives an incorrect lean angle.

Using V Front –

$$\theta = \tan^{-1}\left(\frac{29.27^2}{68.06 \times 9.81}\right) = 52.07^\circ$$

Using this value gives a lean angle very close to what we are after, but we will see later why this is still incorrect.

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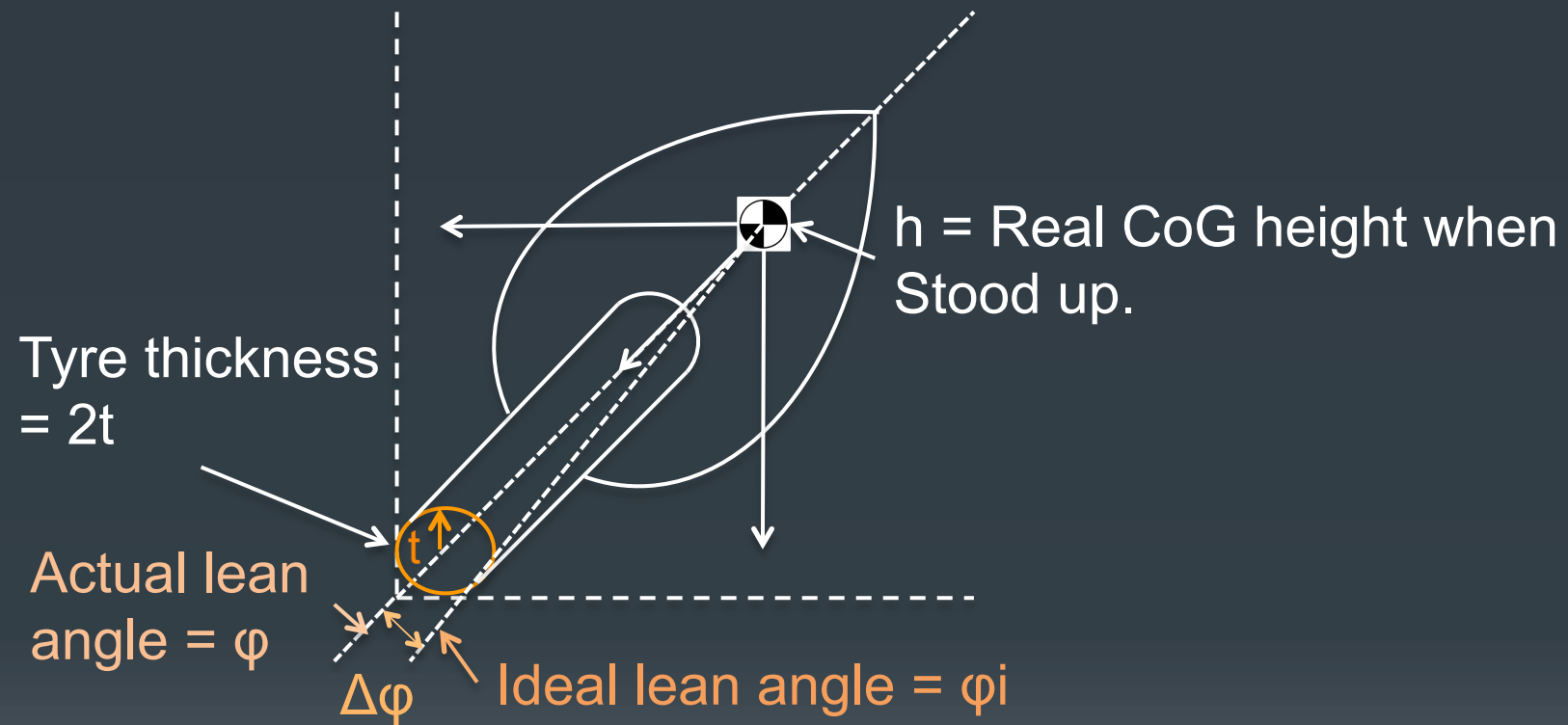
The last two examples are incorrect because at a lean angle on this data there is no correction for wheel speed, therefore the tyre profile increases the velocity with lean angle and this is not the true velocity of the motorcycle, for that we need V_{Sat} .

Using V_{Sat} –

$$\theta = \tan^{-1}\left(\frac{26.69^2}{68.06 \times 9.81}\right) = 46.85^\circ$$

So even though this is the correct speed the angle is still not the same as the data, but this equation does not include tyre thickness.

Cornering



$$\varphi = \varphi_i + \Delta\varphi$$

Cornering

What is $\Delta\phi$?

$\Delta\phi$ is the increase in lean angle.

$$\frac{\sin \Delta\phi}{t} = \frac{\sin \phi_i}{h - t}$$

Take the V_{Sat} example from before, $\phi_i = 46.85^\circ$

Real lean angles > Ideal lean angles.

$$\phi = \phi_i + \Delta\phi$$

Cornering

$$\frac{\sin \Delta\varphi}{t} = \frac{\sin \varphi_i}{h - t}$$

$$\begin{aligned}\sin \Delta\varphi &= t \left(\frac{\sin \varphi_i}{h - t} \right) \\ &= 0.075 \left(\frac{\sin 46.85}{0.6 - 0.075} \right) \\ &= 0.104\end{aligned}$$

$$\Delta\varphi = \sin^{-1}(0.104)$$

$$\Delta\varphi = 5.97^\circ$$

$$\varphi = \varphi_i + \Delta\varphi$$

$$\varphi = 46.85 + 5.97 = 52.82^\circ$$