# Rail Wheel Interaction & Nadal’s Formula

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# TYPES OF DERAILMENTS

1.Sudden derailments:

These may be due to various reasons like

Sudden shifting of load, Excessive speed on curve or turn out, Broken wheels/springs, Failure of track or vehicle component, Obstruction on track.

2.Gradual derailments:

The cause of accident may be singly or jointly any of the following: (i) Track defects (ii) Vehicle defects (iii) Unfavourable operating features.

In this the theory of Rail wheel Interaction and Nadal's formula applicable.

# WHY STUDY THIS?

- To increase train speeds
- For heavy haul
- Prevent undue wear – reduce costs
- Safety, guidance and stability of vehicle
- Passenger comfort
- Energy efficiency.
- Environment: emissions, noise, particulates

# DIFFICULTIES

- A highly empirical subject
- Contact area cannot be directly observed
- Every passage is unique, has an effect
- Continuously changing environment
- Continuously changing geometries
- Several factors out of control.
- Requires high-level of computing
- Many degrees of freedom.

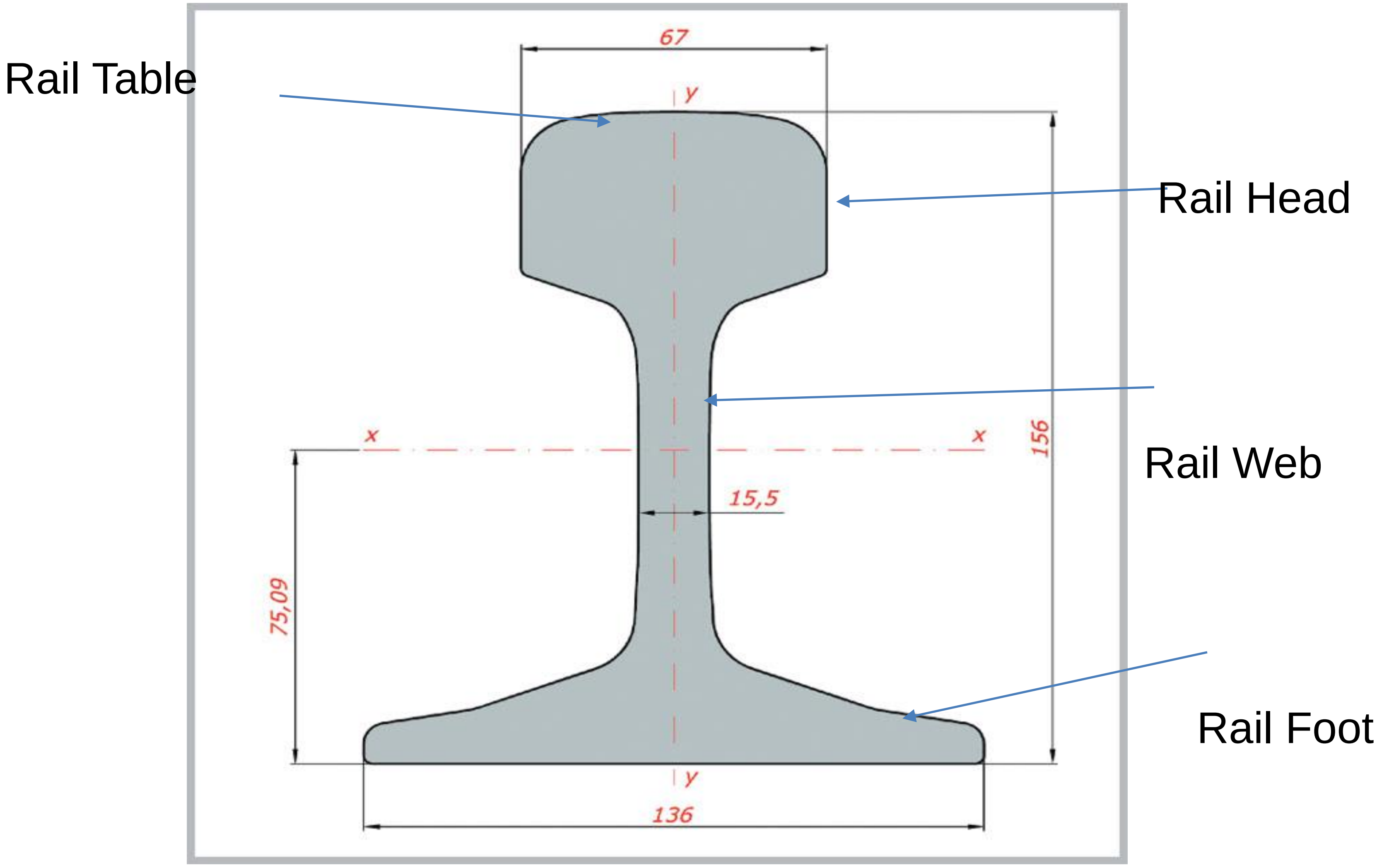
# TRACK GAUGE:

The distance between two running edges(gauge faces) of right and left rails approximately 13mm below the rail table is called a Gauge. The standard Rail Gauge is 1676mm.

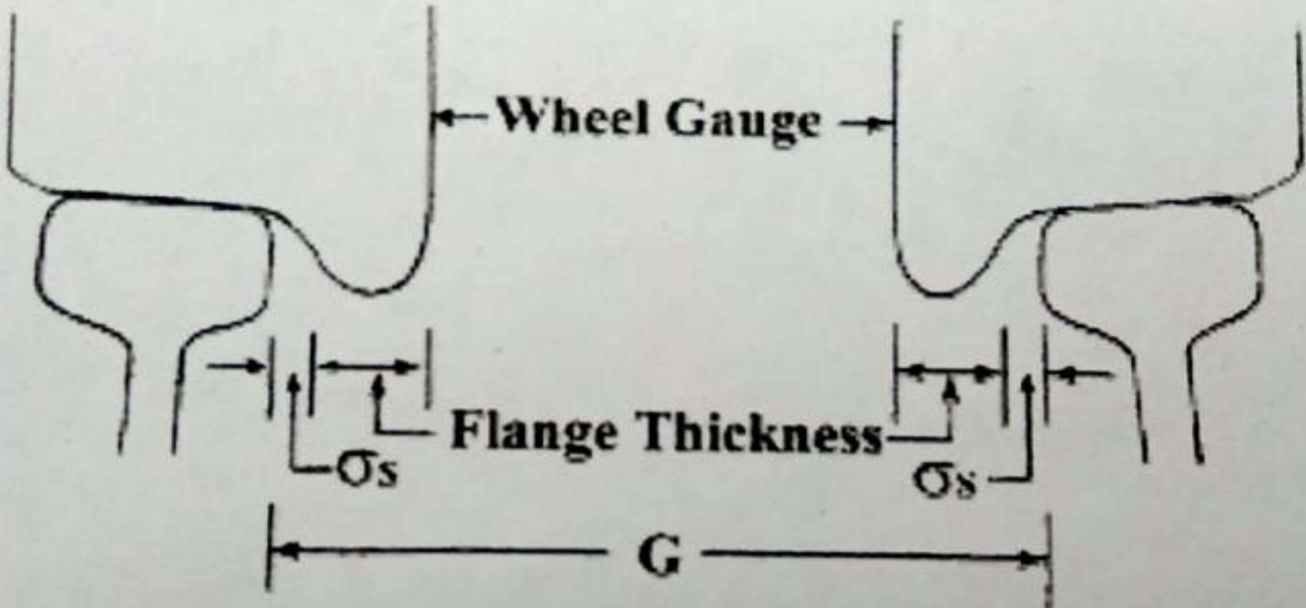

Right Rail on Track

**Left Rail on Track**

# 52KG RAIL PROFILE



# PLAY BETWEEN WHEEL SET AND TRACK




Modified and re-de

**Fig. 20.1: Play between Wheel-Set and Track**

# PLAY CALCULATION

- $\sigma s$ for BG=1676-(Wheel Gauge+2xflange thickness)

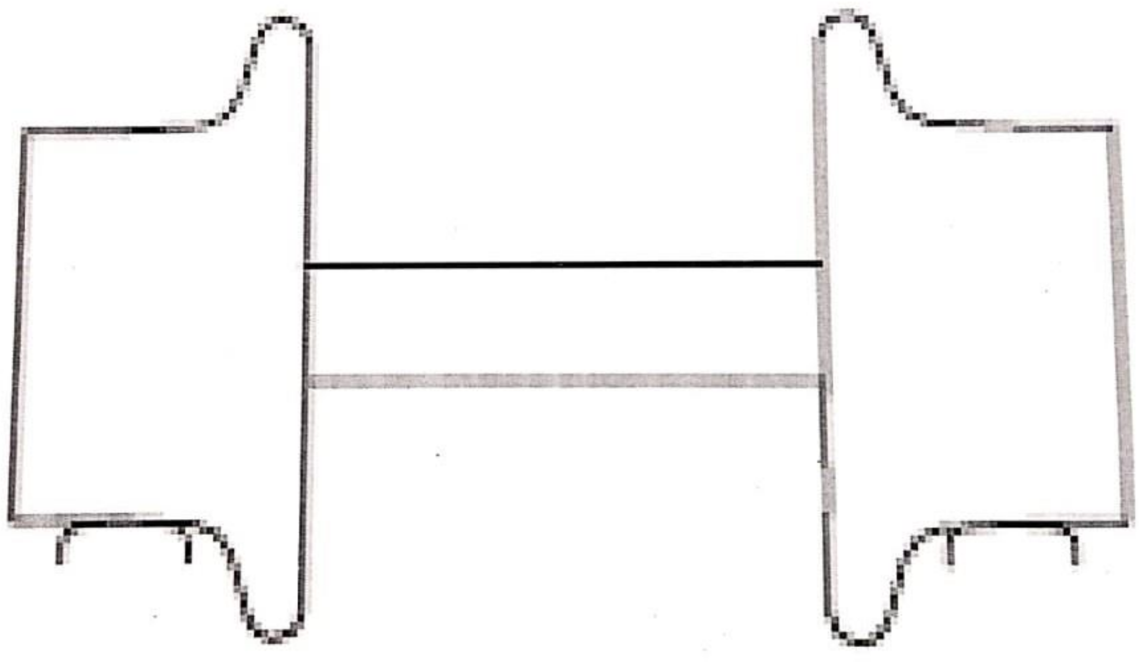
  $\sigma s$ =1676-(1600+2x28.5)=19mm

  The actual play can be different from the standard play owing to tolerances and wear.

# Motion of Wheels on the Track

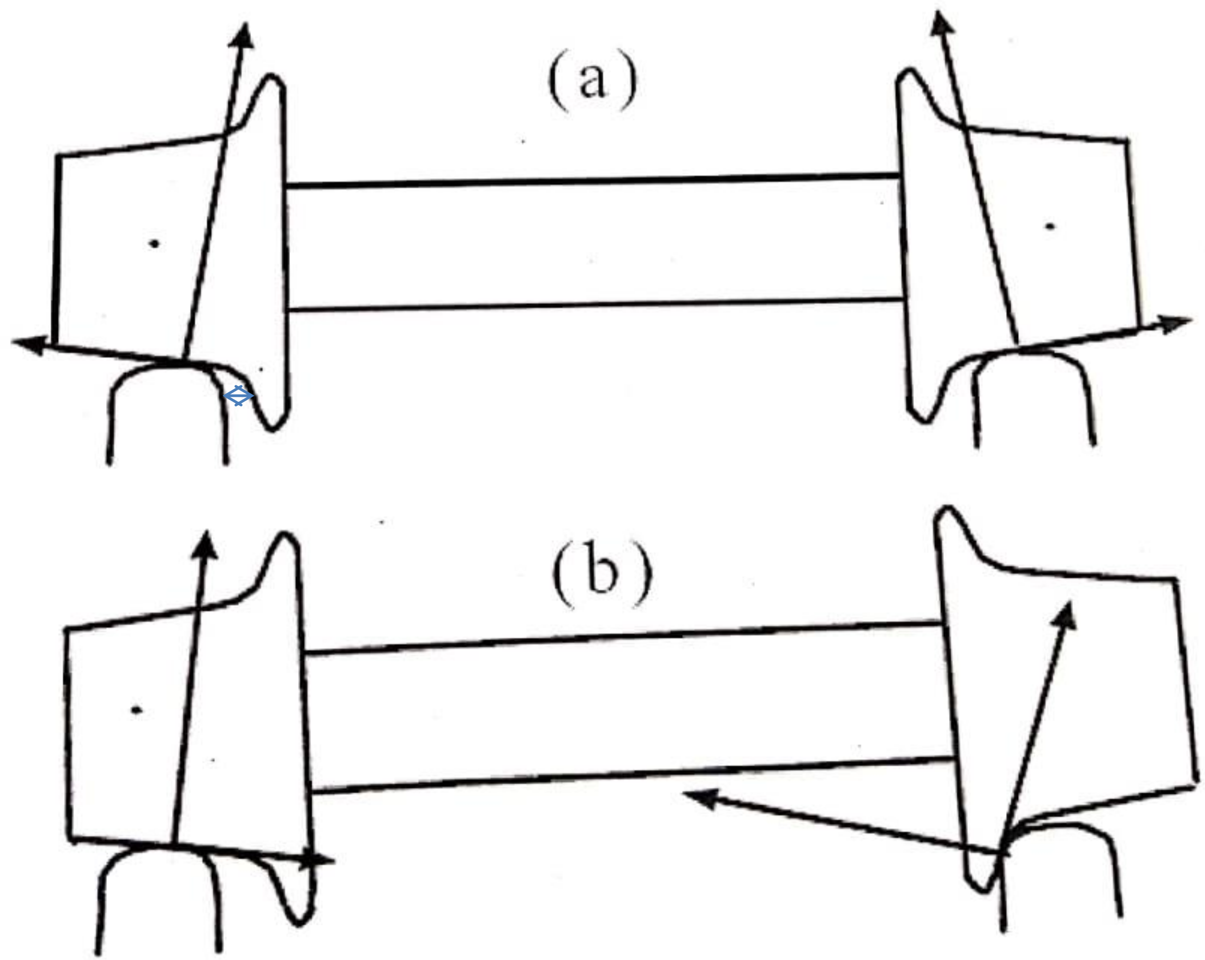
- Motion of wheels on the track will be always sinusoidal path.

# The most basic wheel:

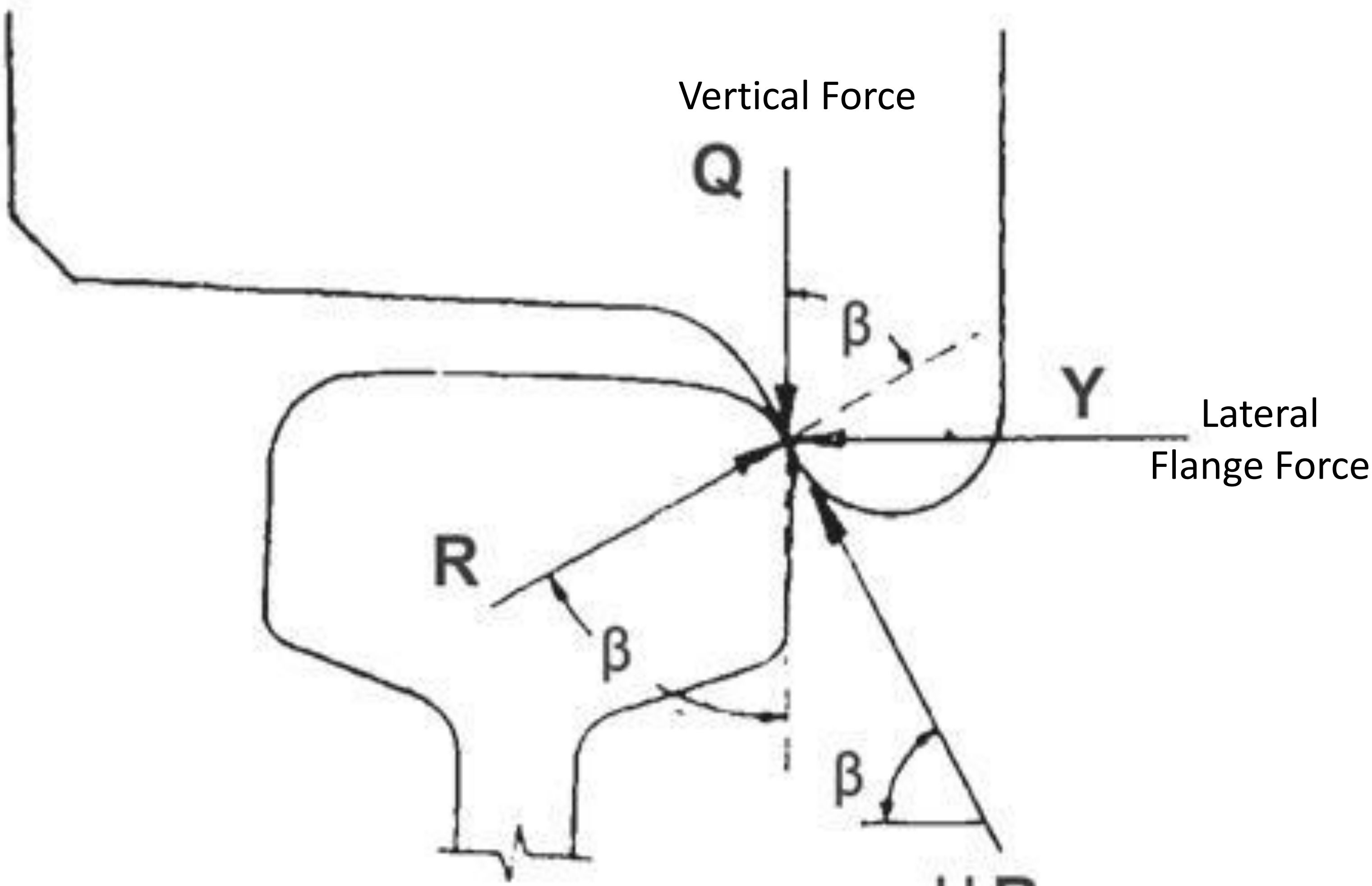


# Wheel in Derailed condition

# Gravitational Stiffness



# FORCES AT RAIL-WHEEL CONTACT AT THE MOMENT OF INCIPIENT DERAILMENT




$F = \mu R$

# Definition of Terms

- Q=Wheel load
- Y=Lateral Flange Force
- R=Normal Reaction
- F=Frictional Force
- $F=\mu R$
- $\mu$=Co-efficient of friction

Lateral Flange Force, $Y = R\sin\beta - F\cos\beta$

Vertical Force, $Q = R\cos\beta + F\sin\beta$

$$\frac{Y}{Q} = \frac{R\sin\beta - F\cos\beta}{R\cos\beta + F\sin\beta}$$

$$\frac{Y}{Q} = \frac{R\,Sin\beta - F\cos\beta}{R\cos\beta + F\,Sin\beta}$$

Dividing both Numerator and Denominator with Cosβ and $F=\mu R$

$$\frac{Y}{Q} = \frac{Tan\beta - \mu}{1 + \mu\,Tan\beta}$$

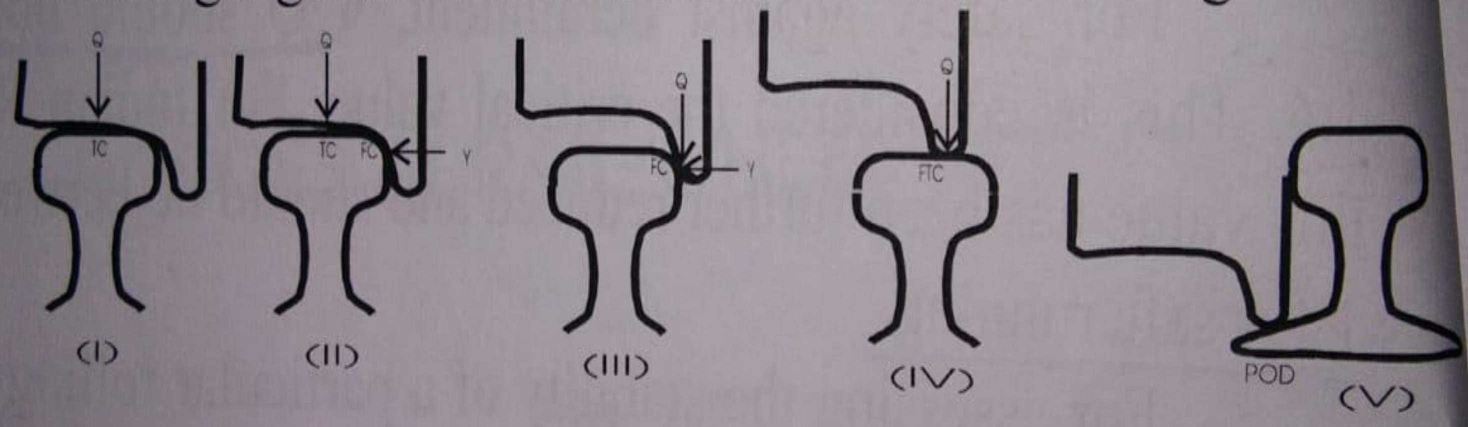
$$\frac{Y}{Q} \leq \frac{\tan\beta - \mu}{1 + \mu \tan\beta}$$

This is enunciated by Nadal's in the year 1908.

Y/Q is called as derailment coefficient

# Various stages of Wheel Flange Climbing

The various stages of wheel flange climbing on the r
table during a gradual derailment are shown in the fig. 1.3.



For majority of wheels, $\beta=68^{o}$ degrees

$\mu=.25$

Nadal’s Formula True when

- Angle of attack is large
- Large lateral force
- Reduced vertical load on wheel
- Track with significant vertical irregularity
- Or high degree of track twist

For Safety against derailment, Y/Q should not exceed 1.4

For safe running this value must lie between 0.8 to 1

End