

Rolling Friction Summary

ChatGPT said:



Banking of a Curve (from Laws of Motion)

Introduction: When a vehicle moves around a curved path, a centripetal force is required to keep it in circular motion. On a flat road, this force is provided by friction. However, if the road is banked at an angle, the normal force exerted by the road on the vehicle also provides a component that contributes to this centripetal force.

Banking of Roads:

- **Centripetal Force on a Banked Road:** On a banked curve, the normal reaction force from the road and the friction force provide the required centripetal force to keep the vehicle moving in a circular path. The angle of banking reduces the reliance on friction, allowing higher speeds even in poor friction conditions.
- **Equations of Motion for a Banked Road:**
 - The vertical forces balance out: $N \cos \theta = mg + f \sin \theta$
 - The horizontal forces provide the necessary centripetal force: $N \sin \theta + f \cos \theta = \frac{mv^2}{R}$

Where:

- N is the normal reaction,
 - f is the frictional force,
 - m is the mass of the vehicle,
 - v is the speed of the vehicle,
 - R is the radius of the curve,
 - θ is the banking angle.
- **Optimum Speed on a Banked Road:** If friction is neglected, the optimum speed at which a vehicle can safely negotiate a banked curve without relying on friction is given by:

$$v_0 = \sqrt{Rg \tan \theta}$$

At this speed, the frictional force is zero, and the vehicle relies entirely on the banking angle to provide the necessary centripetal force.

- **Maximum Speed with Friction:** The maximum permissible speed on a banked road, considering the friction force, can be expressed as:

$$v_{\max} = \sqrt{\frac{Rg(\tan \theta + \mu_s)}{1 - \mu_s \tan \theta}}$$

where μ_s is the coefficient of static friction. This formula shows that as the angle of banking increases or the friction between the tires and the road improves, the maximum possible speed increases.