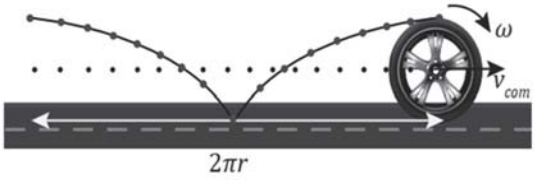
PURE ROLLING MOTION

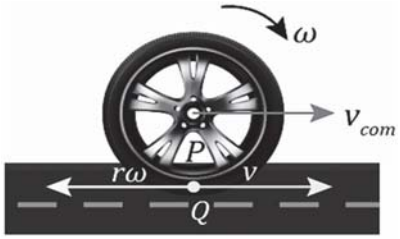
A rolling motion occurs when an object moves by combining rotational and translational motions. To illustrate, consider a wheel in motion. The red trajectory depicts the rotational movement of a point along the edge of the wheel, tracing its circular path as the wheel rotates. Concurrently, the blue dotted trajectory illustrates the translational motion of the wheel's center of mass, depicting how the wheel moves as a whole through space. It's important to note that during the rolling motion of the wheel, the points along its edge don't strictly adhere to circular paths; rather, they contribute to the overall rolling movement of the wheel.



The trajectory followed by a particle situated on the outer edge of a wheel is termed a cycloid. As the wheel completes one full rotation, its center of mass travels a distance equivalent to the circumference of the wheel, which is 2πr, over the time period from t = 0 to t = T. During the rolling motion, the contact between the wheel and the surface occurs at a single point, emphasizing the concentrated nature of the interaction between the two surfaces.

Concept of Pure Rolling Motion:

When a wheel moves without slipping, it's referred to as pure rolling motion. In this state, there's no relative motion between the contact point on the wheel (designated as point P in the provided illustration) and the corresponding point on the road (labeled as point Q in the figure). Consequently, the velocities at point P and point Q are equal, denoted as v_P and v_Q respectively. This equivalence of velocities between the two points is the defining condition for pure rolling motion.



$$\vec{v}_P = \vec{v}_Q$$

$$v - r\omega = 0$$

$$\Rightarrow \quad v = r\omega$$

Each particle located on the wheel experiences an acceleration, which is commonly referred to as centripetal acceleration. As the wheel undergoes rolling motion, every point on its circumference reaches a momentary state of rest relative to the ground when it descends to its lowest position.