

ANTI-LOCK BRAKING SYSTEM

TATA SIERRA SUV – MATLAB SCRIPT

1. Command Window Input & Results:

The screenshot shows the MATLAB interface with the following details:

- Editor:** The file `ABS_SCRIPT.m` is open, containing MATLAB code for calculating constants and theoretical values for an Anti-Lock Braking System.
- Command Window:**

```

Enter vehicle speed in km/h: 80
Initial Vehicle Speed = 22.22 m/s
Initial Wheel Speed = 67.34 rad/s
Estimated Stopping Time ≈ 2.52 sec
Estimated Stopping Distance ≈ 27.97 meters

```
- Workspace:** A table showing variables and their values, including `a_theory`, `base_w`, `dt`, `g`, `i`, `I`, `m`, `M`, `mu_peak`, `R`, `s_stop`, `t`, `t_stop`, `v`, `v0`, `v_kmh`, `w`, `zig`, `zig_amp`, and `zig_freq`.

FIG.1.1: Displays user-entered vehicle speed and the computed theoretical values such as initial speeds, stopping time, and stopping distance using ABS braking equations.

2. WHEEL SPEED AND VEHICLE SPEED :

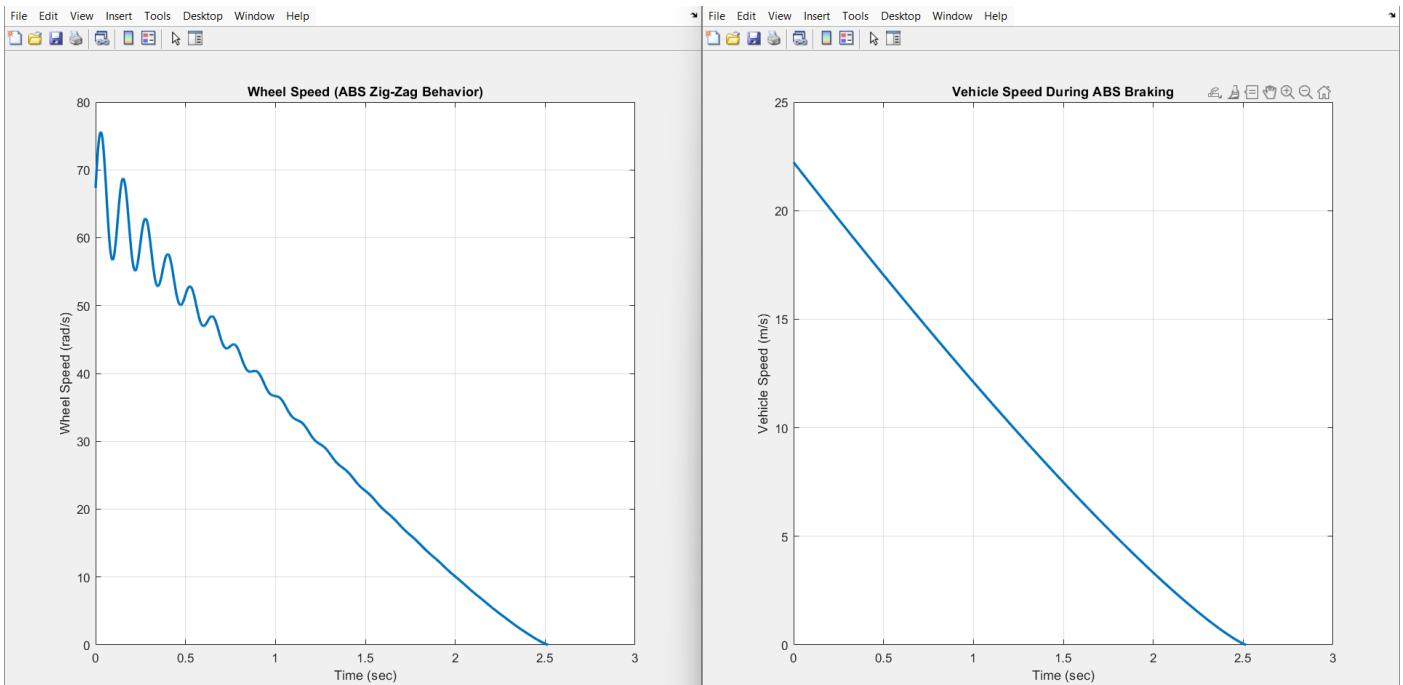


FIG1.2: WHEEL SPEED: Illustrates oscillatory wheel speed caused by ABS modulation, gradually decreasing to zero while preventing wheel lock.

VEHICLE SPEED: Represents smooth nonlinear reduction of vehicle speed from initial velocity to zero within the estimated stopping time.

DESIGN AND CALCULATIONS - ABS

* STEP 1: Convert Vehicle Speed

$$V_0 = \frac{80 \times 1000}{3600}$$

$$\boxed{V_0 = 22.22 \text{ m/s}}$$

* STEP 2: Wheel Angular Speed

Given, $R = 0.33 \text{ m}$

$$\omega_0 = \frac{V_0}{R} = \frac{22.22}{0.33}$$

$$\boxed{\omega_0 = 67.34 \text{ rad/s}}$$

* STEP 3: Vehicle Mass Data

Total Vehicle Mass : $M = 1700 \text{ kg}$

$$m = \frac{1700}{4} = \boxed{425 \text{ kg (one wheel)}}$$

* STEP 4: Normal Force on One Wheel

$$N = \frac{Mg}{4} = \frac{1700 \times 9.81}{4} = \boxed{4169.25 \text{ N}}$$

* STEP 5: Friction Force (Dry Asphalt)

For Dry road, $\mu \approx 0.9$

$$F = \mu N$$

$$F = 0.9 \times 4169.25 = \boxed{3752.3 \text{ N}}$$

* STEP 6: Vehicle Deceleration

$$a = \frac{F_{\text{total}}}{M} \quad (\text{Total Force from 4 wheel})$$

$$F_{\text{total}} = 4F = 4 \times 3752.3$$

$$F_{\text{total}} = 15009.2 \text{ N}$$

$$\rightarrow a = \frac{F_{\text{total}}}{M} = \frac{15009.2}{1700}$$

$$\boxed{a = 8.83 \text{ m/s}^2}$$

* STEP 7: Stopping Time

$$t = \frac{V_0}{a} = \frac{22.22}{8.83}$$

$$\boxed{t = 2.52 \text{ sec}}$$

* STEP 8: Stopping Distance

$$S = \frac{V_0^2}{2a} = \frac{(22.22)^2}{2 \times 8.83}$$

$$S = \frac{493.8}{17.66} = \boxed{27.97 \text{ meters}}$$

* STEP 9: Wheel Rotational Inertia

$$I = 0.5 \times M_{\text{wheel}} \times R^2$$

$$I = 0.5 \times 20 \times (0.33)^2 = 1.089 \text{ kg.m}^2$$

$\rightarrow I = 1.5 \text{ kg.m}^2$ is reasonable including
tire + brake disc.

* STEP 10: ABS Theory

$$\text{Slip ratio: } \lambda = \frac{v - \omega R}{v}$$

ABS keeps slip near 0.15 - 0.2

This produces:
 * zig-zag oscillation
 * Average deceleration $\approx 8.8 \text{ m/s}^2$
 * Stopping time $\approx 2.5 \text{ sec}$