

# Measurements

*Autocorrelation and Time averaging*

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Course website

- ✓ Measurements on Beep

# Measurements to investigate the dynamics of the tires

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Dynamical analysis of a road vehicle tire:

- Measure of the acceleration on the tire
- Accelerometers inside the tire, close to the contact area



Extract information about the contact with the road surface

The **tire** is subjected to **accelerations** that depend on:

- Type of steer
- Type of asphalt
- Vehicle configuration (camber angle, angular velocity, possible skidding slip, ...)



The measurement of these accelerations can give important **information on the tire dynamics** and therefore on the one of the **vehicle**

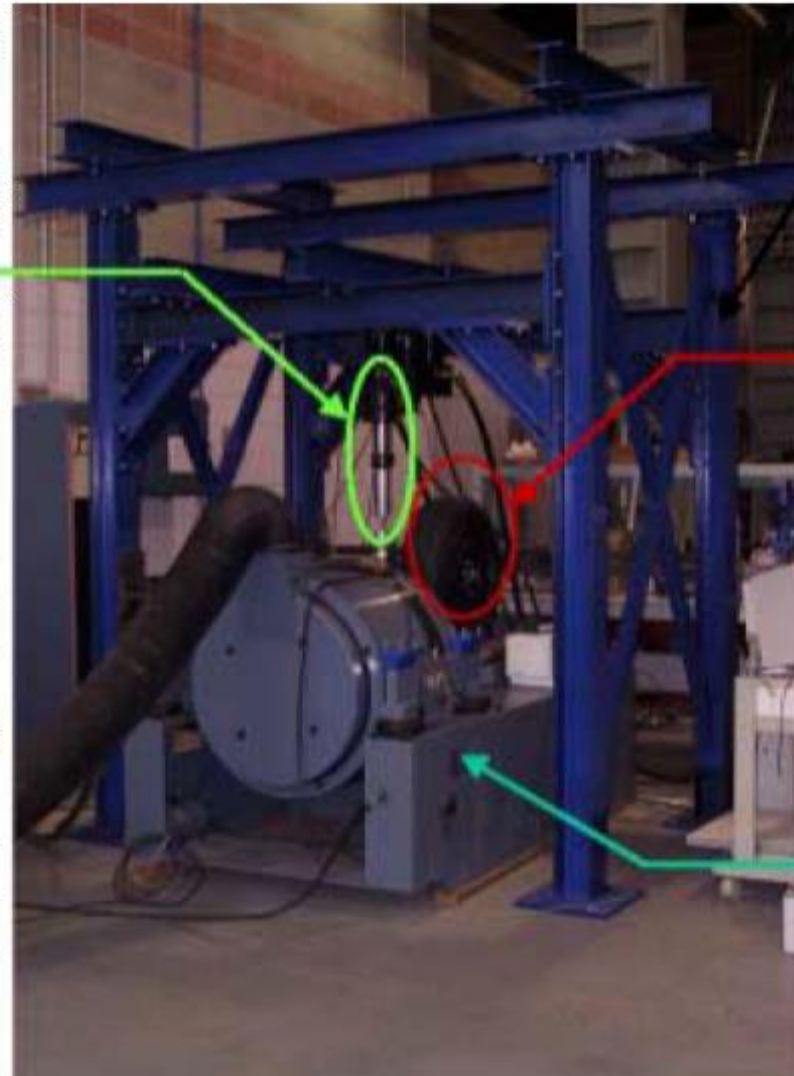
# Acceleration measurements on a vehicle tire by means of MEMS sensors

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## First step

Study of the system dynamics

Hydraulic actuator



Portal

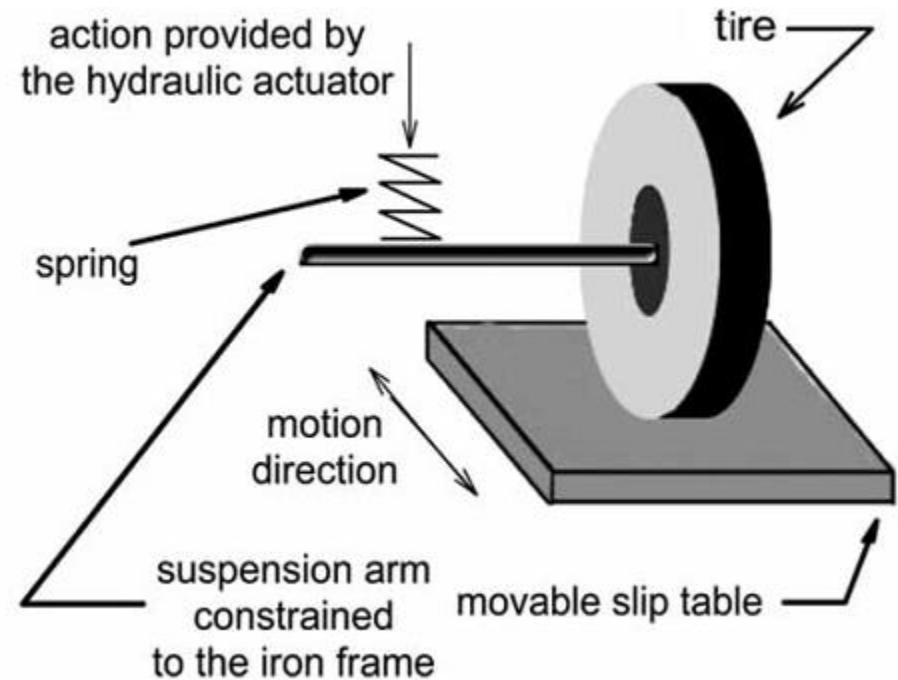
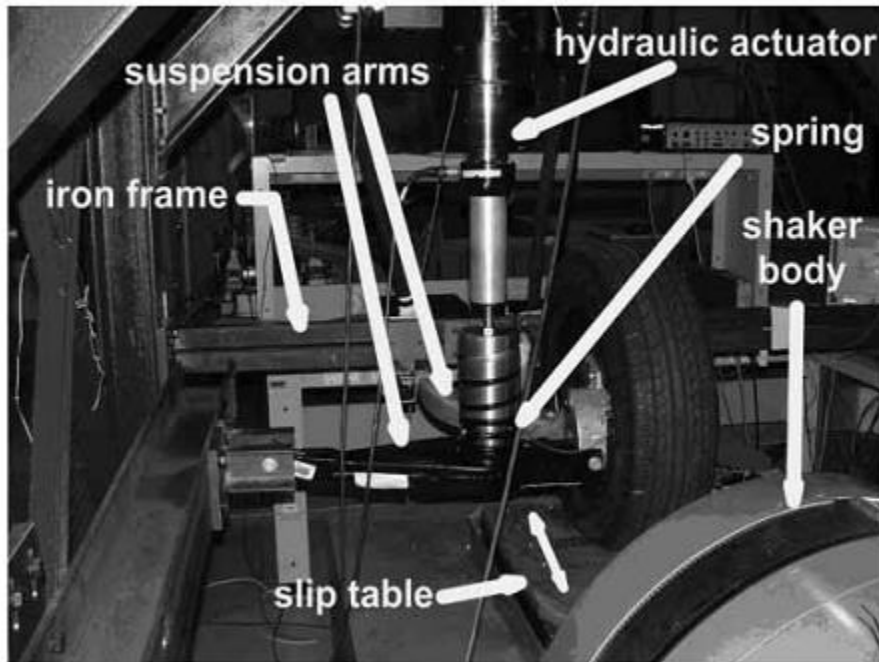
Tire

Slip Table



## First step

Study of the system dynamics



## Second step

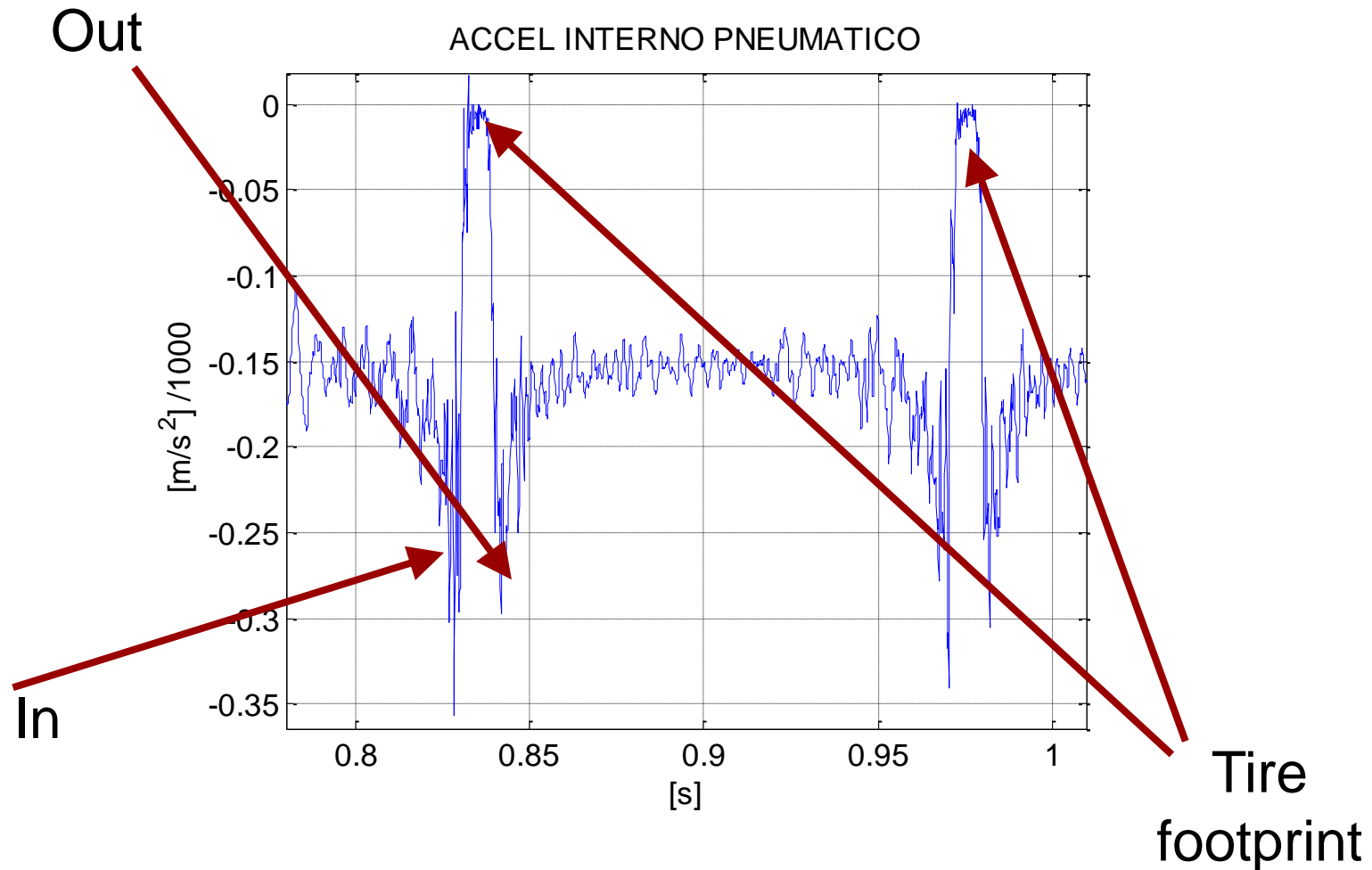
Road tests



# Acceleration measurements on a vehicle tire by means of MEMS sensors

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## Signal of the radial acceleration



Calculate the **vehicle velocity** knowing that the tire diameter is 16 in (1 in = 0.0254 m)

This problem can be solved by deriving the **rotation period** by means of the **autocorrelation**.

$$R_{XX}(\tau) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_0^T x(t) \cdot x(t + \tau) \cdot dt$$

- Can this formula be applied as it is? Or should I take into account that the recorded signal is not infinite?
- How should be modified the autocorrelation formula?



$$R_{XX}(k \cdot \Delta t) = \frac{1}{(N - k) \cdot \Delta t} \cdot \sum_{i=1}^{N-k} (x(i) \cdot x(i + k) \cdot \Delta t)$$

$$k = 1:N$$

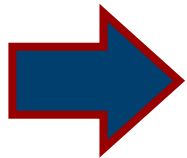
$$R_{XX}(k \cdot \Delta t) = \frac{1}{(N - k) \cdot \cancel{\Delta t}} \cdot \sum_{i=1}^{N-k} (x(i) \cdot x(i + k) \cdot \cancel{\Delta t})$$

$$R_{XX}(k \cdot \Delta t) = \frac{1}{N - k} \cdot \sum_{i=1}^{N-k} (x(i) \cdot x(i + k))$$

1. Load the data and plot the time signal
2. Implement the autocorrelation function in order to find the revolution period of the tire.
3. Calculate the vehicle velocity using the first two peaks of the autocorrelation (the tire diameter is known).
4. Find the distance between the first 10 peaks and see if the vehicle velocity is constant.

USE THE FUNCTIONS **DIFF** and **findpeaks**

5. Compare the autocorrelation obtained at point 2 with the one obtained using the Matlab function
  - Use the Matlab function `XCORR`
  - Compare graphically the results



The autocorrelation function allowed to  
**estimate the period** of the signal

An average process in the time domain allows to highlight the deterministic part of a signal

Once understood which is the right method to calculate the autocorrelation function:

6. Find the period of the signal and split the time history in the single periods (use the estimate of the period on the first two peaks)
7. Average the signals (time averaging)
8. Compare graphically the result with the original signal.