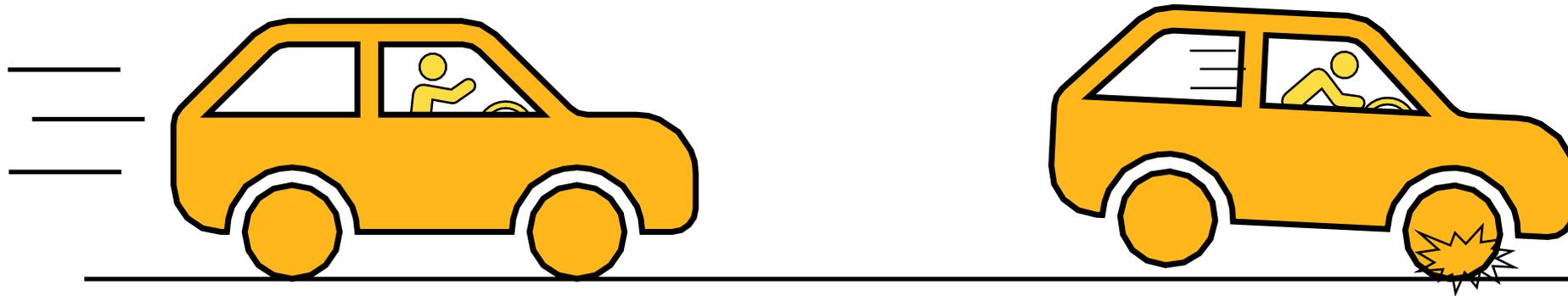# Inertial Effects

Time Domain Dynamic Problems

Intro to Inertial Forces

- Inertial forces are fictitious forces that act due to inertia of objects moving with respect to a reference frame.

- A passenger moving forward when a car is brought to sudden rest is due to inertial forces.

- These forces are not applied on bodies, rather they act on them due to their inertia.

Intro to Inertial Forces (cont.)

- In terms of energy, the kinetic energy of passengers did not transform into a different form of energy and hence they continue their motion.

- If the passenger is wearing a seatbelt, the seatbelt will provide support and stop the passenger and, in the process, the seatbelt deforms. So the kinetic energy of the passenger is converted into internal (or potential) energy of the seatbelt.

Inertial Effects

- Inertial effects are introduced by the mass term in the governing equations.

$$\underbrace{M\{\ddot{u}\}}_{\text{Inertial forces}} + C\{\dot{u}\} + K\{u\} = \{F\}$$

- Body forces such as gravitational and centrifugal forces are considered inertial forces.

- However, the presence of these forces alone does not make the analysis time-dependent.

Body Forces on Wind Turbine

- Let's take example of this wind turbine.

- Look at the blades to study centrifugal forces.

- When the blades are rotating at a constant angular velocity, the centrifugal force remains constant.

- Look at the blades to study gravitational forces.

- The gravitational force does not change with time so it may be added to the force vector.

- In both the cases, the force vector is added to the reaction force vector and the analysis can be treated as static without losing context.

Body Forces on Wind Turbine (cont.)

- In the absence of damping, the inertial force vector, F_I, may be added to the reaction force vector, F.

$$[K]\{u\} = \{F\} + \{F_I\}$$

- This equation is similar to a static analysis.

- So when do inertial forces introduce time dependency?

When inertial force are not constant over time, the system becomes time-dependent.