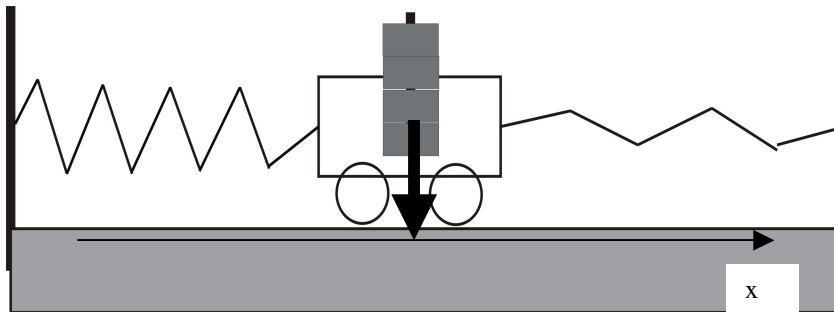


Given is a horizontal oscillating system like shown in FIG. 1).  
In order to determine the spring constant of the total system, we displace the car at  $x = 10\text{cm}$  from rest position.  
For this displacement we need a (horizontal) force of  $F=5,0\text{N}$ .

- Calculate the spring constant  $D$  of the total system
- Assuming that both springs (left and right) have the same individual spring constant, what would be the individual spring constant of just one spring ?



**FIG. 1)**  
**horizontal oscillating system**

- Write down the force law  $F(x)$  where  $x$  is the displacement from rest position ( $x=0$ )
- Write down the differential equation for the oscillation

**At  $t=0$ , the car is moved 10cm to the right (positive  $x$ -direction), so  $x(0) = 0,1\text{ m}$ .**

- Give the solution  $x(t)$  of the differential equation for this initial condition
- Give the solution for  $v(t)$  - hint:  $v(t)$  is the first time-derivative of  $x(t)$
- Calculate the maximum velocity
- Calculate the period  $T$  of our given system

### Further questions

- How much is the maximum potential energy of the system ? At what time  $t_1$  during the first period does the system reach its maximum potential energy ?
- How much is the maximum kinetic energy of the system ? At what time  $t_2$  during the first period does the system reach its maximum kinetic energy ?
- At what time  $t_3$  does the system pass the rest position for the first time ?
- At what time  $t_4$  does the system pass the position  $x = 0,05\text{m}$ ? At what time  $t_5$  does it pass this position next time ?

### Damping

In our calculation we always neglected the damping of the system. The damping is unavoidable because of mechanical friction.

- Sketch a diagram over some periods of an oscillation including damping.

Information: the damping has **n o** significant influence on the period  $T$  .

### For advanced learners

The law of conservation of energy is one of the most important facts in nature. In our oscillating system we have a continuous energy transformation between two! kinds of energy ; which ones ?

If the law of conservation of energy is true, the sum of these two kinds of energy must be constant with time (without damping of course). You can prove this fact by calculation!

- Prove, that  $W_{\text{pot}}(t) + W_{\text{kin}}(t) = \text{constant}$