University of Badji Mokhtar-Annaba
Faculty of Engineering Sciences
Department of Science and Technology, 2nd Year
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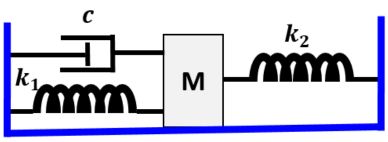
Module: Physics 3

2024-2025

TD2

<u>Exercise 1:</u>

Consider the following mechanical system:



a) Write the equation of motion for the mass M along the x -axis.
b) For what values of c is the system's motion damped oscillatory?
c) Determine the general expression for $x(t)$ for $c = 0{,}1Nm^{-1}s$, the logarithmic decrement δ and the quality factor Q of the system.
$M = 1kg$, $k_1 = 20\text{N/m}$, $k_2 = 5\text{N/m}$

<u>Exercise 2:</u>

A body of mass $m = 1kg$ is suspended from a fixed point by a spring with a stiffness constant k, immersed in a liquid. The liquid exerts a frictional force on the body equal to $-c\vec{v}$ where $\vec{v}$, is the velocity of the body and c is a constant equal to 0,4 Nm^{-1}s.

a) Determine the values of k for which the motion of the body in the liquid is damped oscillatory.

b) If the motion of the body is damped oscillatory with a logarithmic decrement $\delta = 10^{-2}$, determine the pseudo-period and the stiffness constant of the spring.

<u>Exercise 3:</u>

A block of mass $m = 7kg$ is suspended from a spring with a stiffness $k = 600$ N/m. If the block receives an upward velocity $v = 0.6\text{m}/s$ from its equilibrium position at $t = 0$, determine its position as a function of time $x(t)$. Assume that its positive displacement is downward, and its motion occurs in a medium that provides a damping force $F = (50\,|v|\,)$N, where v is in m/s.

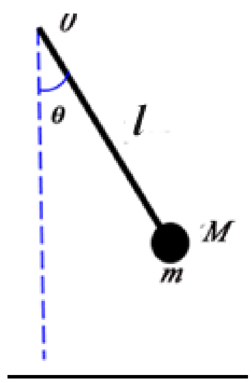
<u>Exercise 4:</u>

A rod OM, of length l, negligible mass, carries a mass m considered as a point mass at its end. It is movable in the vertical plane, and the articulation at O is perfect.

a) Write the equation of motion for m for small amplitude oscillations. Write the general expression for $\theta(t)$

b) What happens to this equation if the rod is subjected to an external force perpendicular to the rod and of magnitude F at a point A located at a distance $OA = a$ from the suspension point O.

c) What happens to this equation if the mass is subjected to viscous frictional force given by the equation $\vec{F}_f = -c\vec{v}$, where c is a positive constant and $\vec{v}$ is the velocity of the mass. Determine the frequency of damped oscillations in the case of weak damping

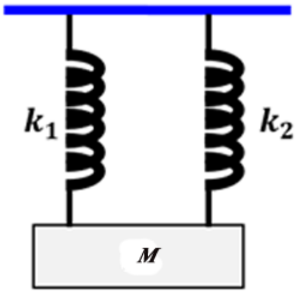


Exercise 5:

A mass $m = 10kg$ is suspended from a ceiling via two springs with stiffness $k_1 = 30\text{N/m}$, $k_2 = 70\text{N/m}$ as shown in the figure. The mass m is subjected to a force $F(t)$ directed along x with expression $F(t) = 0{,}2\sin 3t$.

a)Write the equation of motion for the mass.

b)Determine the displacement x of the mass as a function of time t if at $t = 0$, $x = 5cm$ and $\dot{x} = 0$



Exercise 6:

A body of mass $m = 1\text{kg}$ is connected to a fixed point A by a spring with a stiffness constant $\text{k} = 9\text{x}10^2\text{N/m}$. The body can slide without friction on the horizontal plane.

a) Determine the natural frequency of the system's oscillations.

b) Determine $x(t)$ knowing that at $t = 0s$, $x = 4cm$ and $\dot{x} = 0m/s$.

In a viscous fluid where the frictional force is of the form $\vec{F_f} = -c\vec{v}$, the system undergoes damped oscillations with a pseudo-frequency $\omega_a = 5{,}45rad/s$.

c) Deduce the friction coefficient c.

d) Calculate the logarithmic decrement.

e) Calculate the quality factor Q of the system.

Calculate $x(t)$ at $t = 100T_a$ if at $t = 0s$, $x = 2cm$, where T_a is the pseudo-period of the motion.

Exercise 7:

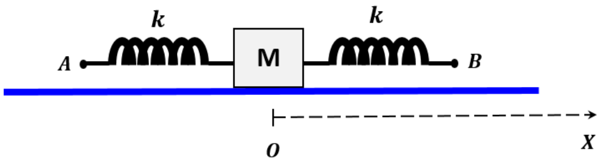
The ratio of successive amplitudes of a single-degree-of-freedom damped system is $18/1$. Determine the ratio of successive amplitudes if the damping ratio ζ is:

(a) doubled

(b) halved.

Exercise 8:

Consider the system shown in the figure below:



Determine the natural frequency of the oscillations of the mass m if points A and B are fixed.

If points A and B undergo vibrations in the x direction of the form $-Ccos\omega_1 t$ et $Ccos\omega_2 t$, respectively:

a) Determine $x(t)$.

b) What are the values of the resonance frequencies?