Since ancient times pendulums have been used by people for various purposes, such as the element that triggers the clock mechanism, seismic vibration sensors, vibration dampers in high buildings, the earth rotation indicator (Foucault pendulum) or a device harvesting energy from vibrations of the ground. Pendulums are also commonly used as toys, e.g. swings. Purely mechanical pendulum systems have already been studied many times by scientists until technological progress has allowed for the introduction of new interactions, e.g., magnetic forces. Due to the presence of these forces, the dynamics of such systems can be significantly changed. History of technology shows that combining different fields of physics can give much better results (synergy) in technological progress than being limited to only one of the fields, an example may be the revolutionization of the industry by an electric motor. For scientists, pendulums are a very important research object not only because of their simple structure but also rich nonlinear dynamics analogous to other vibrating systems such as machines or molecules. The presented project includes the research of the dynamics of mechatronic systems based on a pendulum or coupled pendulums exposed to a magnetic field. The internal non-linearity of such systems is amplified by introducing a strong non-linearity of the magnetic interaction, that gives the possibility of the appearance of previously unobserved dynamic behaviours. During this project, two experimental rigs composed of magnetic pendulums will be studied numerically, analytically and experimentally. The first experimental rig comprises a single magnetic pendulum (see Fig. 1a), i.e., a pendulum whose arm is equipped with a magnet and an electric coil is located under the pendulum. When an electric current flows through the coil, the pendulum is stimulated to move. The second experimental rig consists of two pendulums whose axes are joined by a mechanical spring (see Fig. 1b). One of the pendulums is forced by a magnetic field while the other pendulum is excited via a mechanical coupling. The main difference between the magnetic excitation and the typical harmonic mechanical excitation (which has been studied by scientists, numerously) is that the magnetic force depends not only on the independent time variable but also on the distance between the pendulum's magnet and the coil. This fact indirectly leads to the reason for undertaking research on this type of systems and filling the scientific gap in the knowledge of their nonlinear dynamics. Moreover, it is possible to find practical applications of such systems in relation to their behaviours observed during the conducted research.

(a) (b)

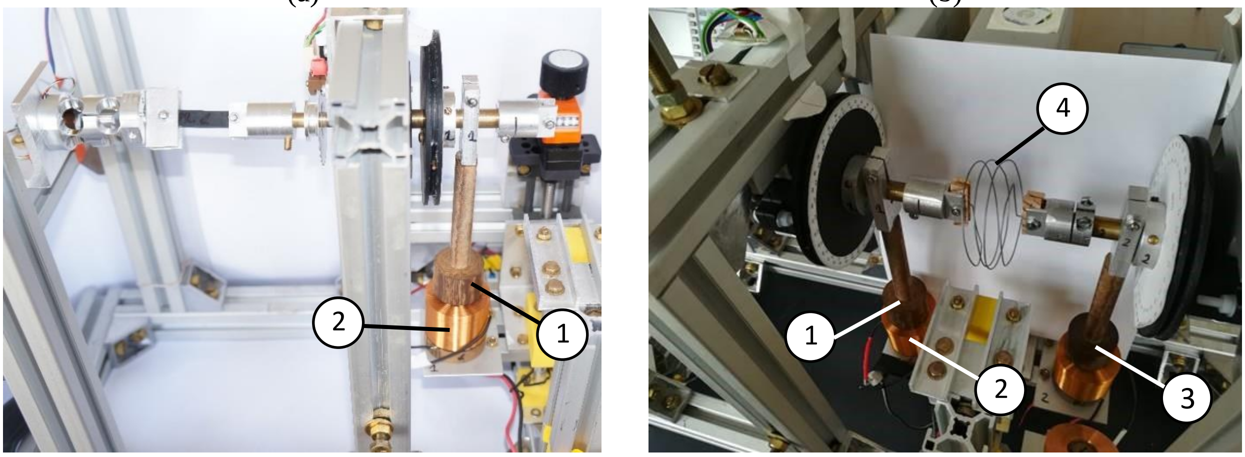

Fig. 1. Experimental rig of a single magnetic pendulum (a) and two coupled magnetically forced pendulums (b). Pendulum with a magnet – (1); an electric coil – (2); a pendulum without a magnet – (3); a mechanical spring – (4).

The aim of the project is to investigate the influence of the current signal's parameters (frequency and phase shift) on the dynamics of a single magnetic pendulum system. The frequency and phase shift are dependent on a dynamic variable which is the angular position of the pendulum. These studies can lead to a better understanding of the influence of magnetic forces on the behaviour of nonlinear pendulum systems. Probably, the magnetic field due to its nonlinear nature will lead to a significant increase in the sensitivity of these systems to motion conditions. In effect, that will expand the diversity of their behaviour. It is also planned to study the control of the energy flow between the coupled pendulums by induced magnetic forces. Thanks to such control, it will be possible to control the vibration amplitude of each pendulum. The results of that investigations can be directly used in technical applications for vibrating systems, e.g., harvesting energy from vibrating buildings or machines.