

# “Tuneable” levitating pencil

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**Abstract.** Participants of the workshop will build a simple device in which a pencil levitates due to the repulsion of permanent magnets. The advantage of this construction over those described on various websites is that some parameters can be set, namely the distance of magnets under the pencil and the number of these magnets. This enables to investigate how the behaviour of the pencil (the height in which it levitates, its stability, oscillations etc.) depends on the parameters. Both the theory behind the tool and the possibilities of its use in physics teaching and learning will be discussed in the workshop.

## Introduction

The pencil levitating due to the repulsion of permanent magnets is described on various websites ([1] and others) and there are also a few papers dealing with it (e.g. [2]). However, different instructions on how to orient the magnets can be found on the websites; sometimes it is written that the magnet near the tip of the pencil should be attracted to the magnets below it. Also, to make the pencil levitate is something described as quite a difficult task. For example, in [3] the author (identified just by a nickname) writes “YOU CAN MAKE A PENCIL FLOAT IN MIDAIR! I didn't, but that doesn't mean you can't! You just need a LOT of patience!”.

This (and the interest of Czech physics teachers in this device) motivated the development of a version of the levitating pencil that would allow changing its parameters, investigating its behaviour and making some simple measurements. The main aim was to understand the behaviour of this gadget – partly out of curiosity and also to know how to make the levitating pencil reliable and stable enough.

Some interesting questions we can investigate include:

- How to orient the poles of the magnets on and under the pencil?
- Where should the magnets on the pencil be relative to the magnets below?
- How does the distance of the magnets under the pencil influence its behaviour?
- How high can the pencil levitate?
- What is the lowest position in which the pencil can be?
- At what position of the magnets is the levitating pencil most stable?

## “Tuneable” levitating pencil construction

The original version of the levitating pencil used for experimenting is shown in Fig.1. (A slightly updated version will be used in the proposed workshop.)



Fig. 1. A simple version of a tuneable levitating pencil.

## Some results and possibilities for further investigations

For ferrite magnets with an outer diameter of about 18 mm, the height at which the pencil levitates ranges from about 1.2 cm to 2.6 cm above the centres of magnets below; the most stable position is at a height of about 2 cm.

Workshops for Czech physics teachers and future teachers proved that participants can easily build the “tuneable” levitating pencil in about one hour.

The tool described here can be used in physics teaching and learning at various school levels, from lower and upper secondary to undergraduate. It can serve from a simple but a bit surprising demonstration of magnet repulsion to an illustration of Earnshaw’s theorem, to motivate applying the formula for the force between elementary dipoles (and to investigate, how the force between magnets of finite dimensions differs from that simple formula), to investigate the stability of the pencil (using the formula for the potential energy of the dipole in an external magnetic field), to investigate oscillations of the pencil etc.

## Conclusions

During the workshop, participants will build their own levitating pencil and perform some simple experiments with it; further possibilities of its use will be discussed.

## References

- [1] A. Gupta, *It levitates, it spins, it writes*. Available online:  
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- [2] D. Kagan, Building a magnetic levitation toy. *The Physics Teacher* **31** (1993) 432-433.
- [3] CharlieA11: *How to make a pencil levitate*. Available online:  
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