

Investigations for the whole body and a smartphone in playgrounds and amusement parks

Teaching force and motion is a well-known challenge. The traditional mathematical descriptions of bodies in motion rarely connect to human bodies and acceleration often remains an abstract concept. However, the forces experienced by an accelerating body can also be measured with smartphone sensors, and the data recorded can be saved and brought back to the classroom for analysis. In this way, the motions studied need no longer be restricted to constant velocity or uniform acceleration, but can include more general motions of everyday life. Playgrounds and amusement parks offer many types of motion that are well suited for investigations using smartphones, although the interpretation of the results is not always straightforward.

Bringing a class to an amusement park can be very rewarding, but bringing the class outside the school placed special demands on the teacher role, as discussed in [1]. Teachers may also need personal support to overcome initial thresholds to using phones in STEM teaching, and are often surprised when they discover the possibilities, e.g. seeing the inspiring lesson plans, e.g. in [2], covering many sensors in addition to accelerometers, gyros and barometers.

In physics teaching, motion is usually described mathematically, and viewed from outside. In interviews with students close to amusement rides, we find that many of them are not used to thinking about when you feel light or heavy and connect it to the motion [3,4]. The inside perspective of experiencing the changing forces can also be recorded using the accelerometer of the phone. Integrating the extracted acceleration data for a part of a one-dimensional ride gives the corresponding velocity. The graphs can be used to discuss the general relation between integrals and derivatives for more general motions than constant velocity or uniformly accelerated motion [3].

Amusement rides are full of examples to illustrate central concepts in mathematics and physics, including force and motion in 1, 2 and 3 dimensions. Roller coaster lifthills are inclined planes. Carousels give opportunities to observe what happens in slowly rotating systems. Giant swings let you experience the forces in a pendulum. Drop towers and roller coasters hills may let you experience 2-3 seconds of free fall, whereas in the valleys you may feel 3-5 times as heavy as usual. The experience of the body is related to the fundamental principle of equivalence between inertial and gravitational mass which can be investigated already on the playground [5]. Calculated values can be compared to observations or to data collected using smartphone sensors for acceleration, rotation and air pressure. The www site Tivoli.fysik.org includes many examples and resources to be used by teachers in the classroom or in connection with an amusement park visit.

Working out forces for the different situations can be challenging, and during the discussion following students initial work, many incomplete force conceptions can be exposed and clarified.

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