Energy conversion in a switchback (Item No.: P1296400)

Curricular Relevance

Area of Expertise: Physik
Education Level: Klasse 7-10
Topic: Energie
Subtopic: Energieformen, Energieumwandlung und Energieerhaltung
Experiment: Energieumwandlungen bei der Berg- und Talfahrt

Difficulty
Intermediate

Preparation Time
10 Minutes

Execution Time
20 Minutes

Recommended Group Size
1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Principle and Equipment

Principle

The switchback is to be used to demonstrate that mechanical forms of energy can be converted into one another.

Equipment

Position No.	Material	Order No.	Quantity
1	Demo Physics board with stand	02150-00	1
2	Scale for demonstration board	02153-00	1
3	Rollercoaster track, fix.magnet	02159-00	1
4	Marker, black	46402-01	1

Set-up and procedure

- Use the pen and the rule to draw a line on the demoboard parallel to the upper edge (distance from it, e.g.,about 10 cm).
- Fit the switchback on the demo-board and first adjust it to an almest symmetrical form, take care in doing this that both ends of it lie on the drawn line, and so are at the same height.
- Place the car standardly supplied with it on the switchback (Fig. 1) and let go of the car.

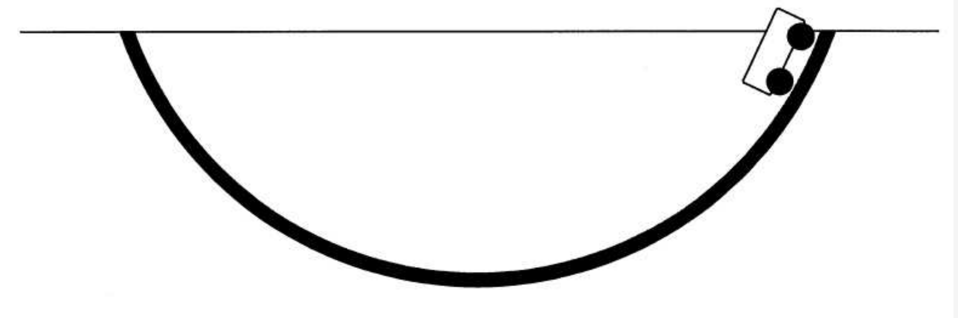

Fig. 1

- Observe the movement of the car.
- Repeat the procedure.
- Describe your Observations (1).
- Change the shape of the track, but ensure that the ends of it are always at the same height (see Fig. 2).
- Observe the movement and describe what you observe (2).

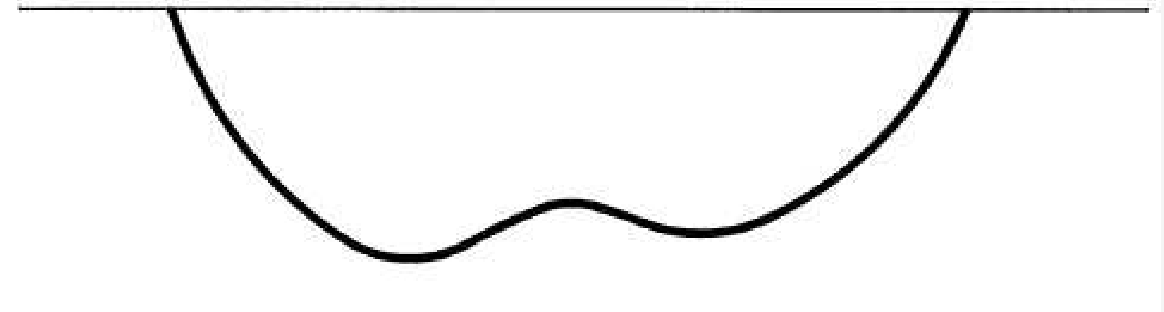

Fig. 2

Observations and evaluation

Observations

1. The car moves downwards and accelerates to the lowest point of the track, then decelerates while moving upwards to a point which is lower than the starting point.
   Now the same movement occurs in the reverse direction, and this whole procedure is repeated until the car comes to rest at the lowest point of the track.
2. In principle, the movement of the car after letting go of it is the same. It rolls down and up with decreasing height of the point of reversal. When the track has 2 minimums, as shown in Fig. 2, the car finally comes to rest in the one or the other of these.

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Evaluation

The potential energy Wpot which the car possesses at the start of its movement, is converted into kinetic energy W_{pot} until the lowest part of the track is reached and W_{kin} is at its maximum.

Now W_{kin} is converted back into W_{pot} but this does not again reach the initial value, because part of the energy has been converted into heat (thermal energy) by frictional work.

In end effect, friction is the cause of the car coming to rest at the lowest part of the track after a number of conversion processes $W_{pot} \leftrightarrow W_{kin}$ have occurred.

Remarks

We recommend that, before the car is released, you ask the students to make predictions on which movement will result. This contributes both to motivation and to careful observation.

The following question could be interesting, for example: Assuming the track is symmetrical, should the flanks of it be more steeply or less steeply curved for the most possible conversion processes to occur?

Answer: They must be steeply curved. Reason: 1. W_{pot} is then as large as possible. 2. The frictional force is then particularly low over long stretches of the track because $F_R = \mu * F_N = \mu * F_G * cos\alpha$. With steep flanks, therefore, relatively much potential energy is available, from which only a relatively small amount is converted into heat during each completed movement.

The correct answer can be confirmed experimentally. When the flanks are steep, 6 to 8 back and forth movements can be observed, with a very flat track only 2, for example.

The switchback could also be used in Atomic Physics or in Chemistry to replicate the potential for an electron circulating around an atomic nucleus. A wooden ball (*d* = 25 mm, order no. 02470-00) would come to rest at the energetically most favourable point of the curve (see Fig. 3).

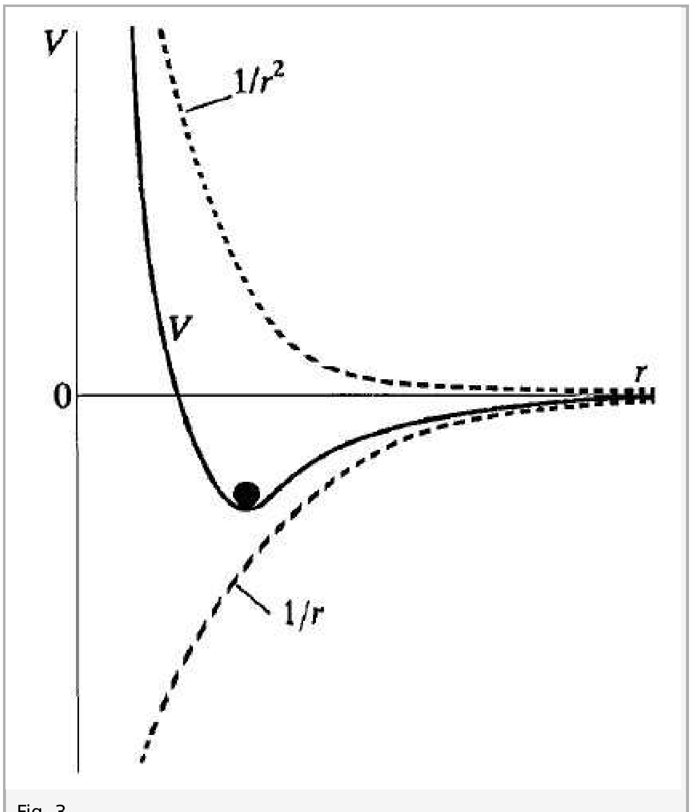

Fig. 3

Fig. 3: The potential energy of an electron in a hydrogen atom consists of two parts: Coulomb energy, proportional to $-\left[\frac{1}{r}\right]$, and energy of the orbital movement of the electron around the nucleus, proportional to $\frac{1}{r^2}$.