Waltenhofen's pendulum

DEMONSTRATE AND INVESTIGATE HOW AN EDDY-CURRENT BRAKE WORKS

- Investigate the braking of a Waltenhofen pendulum due to eddy currents in a non-uniform magnetic field
- Demonstrate the suppression of eddy currents in a metal disc with slots

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BASIC PRINCIPLES

When a metal disc moves through a non-uniform magnetic field, any arbitrary section of the disc experiences constantly changing magnetic flux and an eddy voltage is induced therein. This causes electrical eddy currents to flow all over the disc. These undergo Lorentz forces within the magnetic field that act to slow down the motion of the disc. Such eddy currents are drastically reduced if the metal disc has slots in it, since this means that the current has to flow from one segment to the next by a more circuitous route. Such a disc is slowed down only slightly.

The emergence and suppression of eddy currents can be clearly demonstrated using a Waltenhofen pendulum. This includes a partially slotted metal disc that oscillates inside a non-uniform magnetic field.

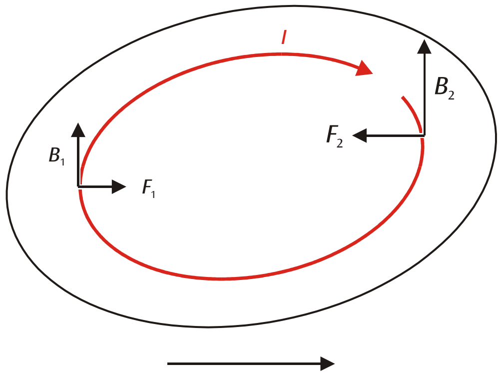

Fig. 1: Eddy current I in a metal disc moving at speed v through a non-uniform magnetic field B_1, B_2 with Lorentz forces F_1 and F_2 acting on both limbs of the eddy. The force acting against the motion is greater than that operating in the same direction.

Fig. 2 Set-up Waltenhofen's pendulum

LIST OF APPARATUS

1	Waltenhofen's pendulum	U8497500
1	Stand base, 150mm	U13270
1	Stand rod, 750mm	U15003
1	Universal clamp	U13255
1	Horseshoe magnet, 150 x 130 x 40mm	U8497210
1	Pair of pole pieces, drilled	U8497200
1	Clamp, 1 pair, 40 x 40mm	U8497181
2	Coils, number of turns – 1200 each	U8497440
1	DC power supply unit 16V, 0-2.5A, e.g.	U8521145
1	Set of 15 safety connecting leads	U13802

SET-UP

- Set up an electromagnet consisting of a horseshoe magnet, two coils with 1200 windings each and two pole pieces.
- Connect the coils in series to the DC power supply unit.
- Firmly attach the aluminium disc to the slotted area inside the pendulum rod.
- Mount the stand rod in the stand base. Use the universal clamp to attach the magnetised rod to the stand rod and suspend the Waltenhofen pendulum from it.
- Arrange the apparatus in such a way that the section of the aluminium disc without any slots can oscillate freely between the tips of the pole pieces and the pendulum can come to a state of rest between these pole pieces.
- Select the smallest possible distance between the pole pieces before attaching them, making sure that this does not obstruct the motion of the pendulum.

EXPERIMENT PROCEDURE

- Gradually increase the current passing through the electromagnet in stages.
- Displace the pendulum from its state of rest and observe its oscillations.
- Firmly attach the aluminium disc to the area without slots and repeat the procedure.

SAMPLE MEASUREMENTS

Table 1: Number of oscillations of the aluminium disc in the magnetic field after being deflected from its state of rest. The pole pieces are at a distance of 8mm and the deflection is approx. 7cm.

	Number of oscillations	
I (A)	side without slots	side with slots
0.25	21	90
0.5	6	59
0.75	3	46
1	2	37
1.25	1	30

EVALUATION

When the side of the metal disc without slots moves through the non-uniform magnetic field, its oscillation is damped. The damping increases with the magnitude of the magnetic field. Eddy currents are induced within the disc and the non-uniform magnetic field exerts a force on the eddy currents that opposes their motion (c.f. Lenz's Law).

If the slotted side of the metal disc moves through the non-uniform magnetic field, the damping of the motion is only slight since it is much more difficult for the eddy currents to form.

RESULTS

Eddy currents are induced in a metal disc which moves within a non-uniform magnetic field. This non-uniform magnetic field exerts a force on the eddy currents that opposes their motion (c.f. Lenz's Law).

In the slotted aluminium disc, it is difficult for eddy currents to form.