# METHODOLOGICAL NOTES

## SOME LECTURE DEMONSTRATIONS FOR A PHYSICS COURSE*

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**1. Foucault's Experiment.** The usual method of demonstrating the experiment (observation of the shadow of a thread) requires a considerable time interval (up to several minutes) and has the additional disadvantage of dividing the observer's attention between the thread and its shadow.

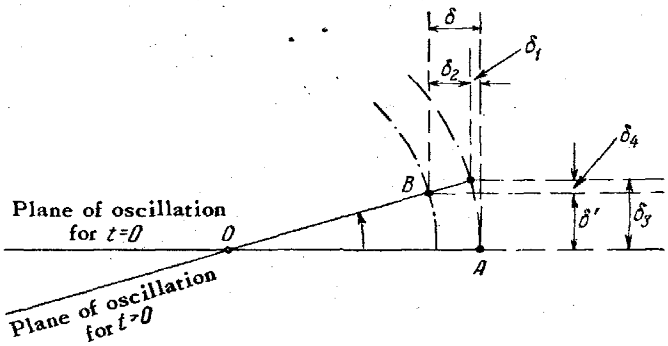


Figure 1

In R. W. Pohl's book "Introduction to Mechanics and Acoustics" (Russian edition of 1957, Fig. 180) it is suggested that the pendulum be projected with the help of a lens that magnifies the visible linear displacement and prevents the division of the observer's attention. However, judging from the figure, the projection is in the direction normal to the initial plane of oscillation. As can be seen from Fig. 1, the projection of the pendulum displacement (in the position of maximum deviation) is in this case the sum of the displacement projections due to the rotation of the earth $\delta_1$ and the displacement due to the unavoidable damping $\delta_2$. Consequently, even in the absence of the rotation of the earth some displacement would be obtained, and the experiment thus is not sufficiently convincing. We project onto the direction of the initial pendulum oscillations, and therefore the displacement due to the damping $\delta_4$ is subtracted from the displacement due to the rotation of the earth $\delta_3$; the experiment becomes thereby methodologically irreproachable. With sufficient magnification, a noticeable displacement is obtained in a large lecture hall (pendulum length 10 – 12 m) within four or five oscillations.

**2. Newton's Third Law.** A vertical coil K and a rod magnet M (or an iron rod) are placed on the pan of a balanced scale. The upper end of the rod enters a glass tube T, held by a stand not connected with the balance (Fig. 2). A voltage is supplied to the coil; a current results which creates a force tending to pull the magnet into the coil. As long as this force is smaller than the weight of the magnet, the equilibrium of the balance is not disturbed. However, when the current becomes sufficiently large, the magnet is quickly pulled into the coil, whereby *the instantaneous load on the scale of the balance is increased.*

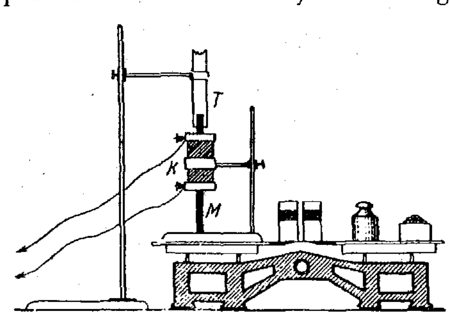


Figure 2

**3. Conservation of Angular Momentum.** A small electric motor is suspended with the aid of long and thin conducting wires, so that the rotor axis is vertical. When a voltage is supplied to the motor the following can be observed:

a) when the stator is held in the hand, the rotor rotates in the direction determined by the construction of the motor;

b) when the rotor is held, the stator rotates in the direction opposite to that in the above experiment (as far as the wires allow);

c) when the motor is left alone, both the rotor and the stator rotate in opposite directions;

d) when the rotor and stator are rigidly connected to each other by means of screws, no rotation results, proving the numerical equality of both momenta.

The experiment can be used not only in the study of rotary motion, but also in presenting the theory of dia- and paramagnetism.

**4. Comparison of Electric Oscillation Frequencies.** Along with Lissajous figures, the analysis of which becomes difficult for large whole-number frequency ratios, the following method also finds application in technology.

The circuit of Fig. 3 (its functioning is explained by the vector diagram) produces two voltages of equal amplitude and unknown frequency $f_x$, whose phases are

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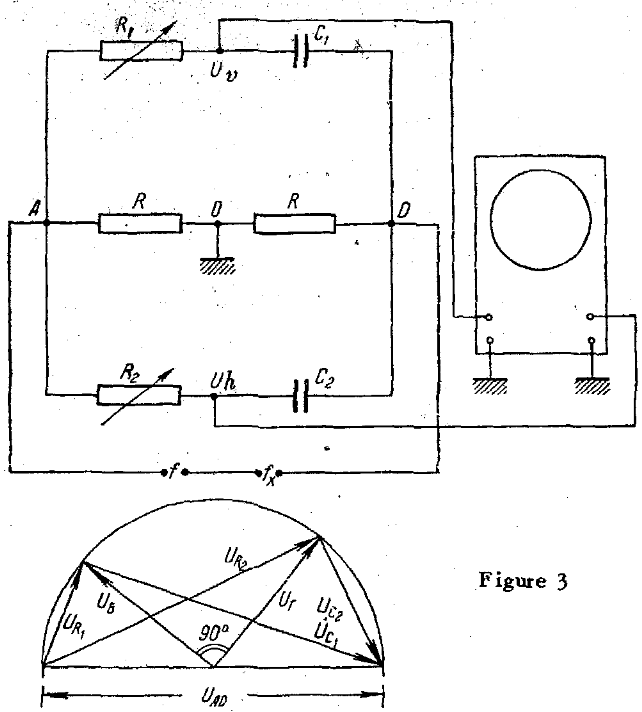


Figure 3

shifted by 90°. These voltages are fed to a cathode-ray oscilloscope, causing its electron beam to describe a circle. Simultaneously, the oscilloscope receives similar (but of different amplitude) voltages of a known frequency $f$; under their action the beam also describes a circle, albeit of different radius and of different angular frequency. Under simultaneous action of both frequencies, the beam describes an epitrochoid (Fig. 4). The figure is stationary and simplest for whole-number frequency ratios, the latter being equal to the number of turns in the epitrochoid plus one.

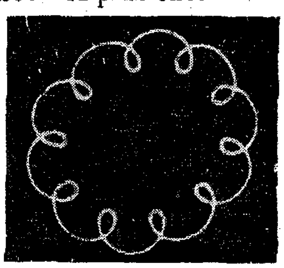

Figure 4

**5. The Penetrative Ability of X Rays.** It is often thought that the penetration of x-rays is always greater than that of visible and other rays. To dispel this fallacy, first a crown-glass lens and then one of flint glass is placed in the path of the beam (between the tube and the fluorescent screen). It is then observed that crown glass (containing lead salts) is practically opaque to x-rays, although visible light passes through the lens without noticeable absorption.

**6. The Magnetic Field Inside a Hollow Conductor.** We know from electrodynamics that inside a long hollow circular cylinder the magnetic field due to a current which is uniformly distributed over the cross section and flows along the generatrices of the cylinder is zero. To demonstrate this fact, an alternating current is passed through a long (not less than 20 – 30 diameters) pipe of circular cross section. Its magnetic field is checked with the aid of a small multiturn coil (like that of a telephone) connected to an oscilloscope. The coil detects a considerable magnetic field outside the pipe; its amplitude decreases as the coil is moved away from the pipe. However, everywhere inside the pipe the field observed is very much weaker (this field is due to the finite length of the pipe and to the slight asymmetry of the current distribution); this field becomes stronger near the ends of the pipe.

The success of this experiment depends greatly on the symmetry of the current supply to the pipe; the conductors that supplied the current were divided into 6 – 8 leads; these were attached to the pipe by means of screws symmetrically distributed over the edge of the pipe.

**7. A Model of Stern's Experiment.** To set up a model of Stern's experiment with a molecular beam, cylinders $Z_1$ and $Z_2$ with axes parallel to the vertical axis of rotation of a dc motor are used. The inner

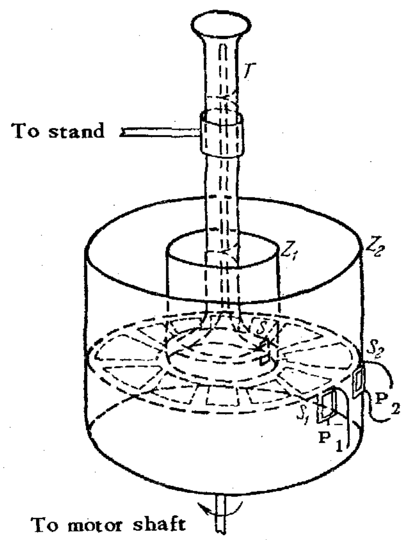


Figure 5

cylinder has a narrow slit $S$; in the outer cylinder there are two slits $S_1$ and $S_2$, covered on the outside by glass containers $P_1$ and $P_2$. The slits S and $S_1$ are placed along the same radius; the outer slits are slightly lower with respect to $S$ along the vertical. A double (glass) tube $T$ with funnel-like ends is placed inside the cylinders, along an extension of the motor shaft. The lower funnel-like end is at the same height as the slit $S$. Small hard particles (millet) are poured in a continuous stream into tube $T$. When the cylinders are not in motion the particles are observed to collect overwhelmingly in $P_1$, during motion in the direction of the arrow -- in $P_2$. As the number of particles caught is not large, it is possible to compare the contents of the containers after each part of the experiment by pouring out the seeds onto a pharmaceutical balance.

Translated by Z. Barnea