$2 \qquad \mu_0 \quad]$

Experiment 23.1: To determine the magnetic susceptibility of a solid. (Gouy's method).

Apparatus: An electromagnet with power supply, a sensitive balance (preferably a digital weighing machine), solid object in the shape of a long cylinder, a gauss-meter (or a flux-meter) and fractional weights.

Theory: This method depends on the force exerted on a body placed in a non-homogenous magnetic field. The variable magnetic field is provided by an electromagnet with wedge shaped pole pieces.

Fig. 23.1 illustrates the experimental set-up. The field of the magnet varies rapidly along the vertical direction, due to the wedging of the pole pieces. Thus, the force on the specimen is vertical. In this experiment the influence of the earth's field is neglected. The specimen whose magnetic susceptibility is to be determined is connected to one arm of a sensitive balance or a digital weighing machine. The balance is enclosed in a box so that the air does not affect the weighing.

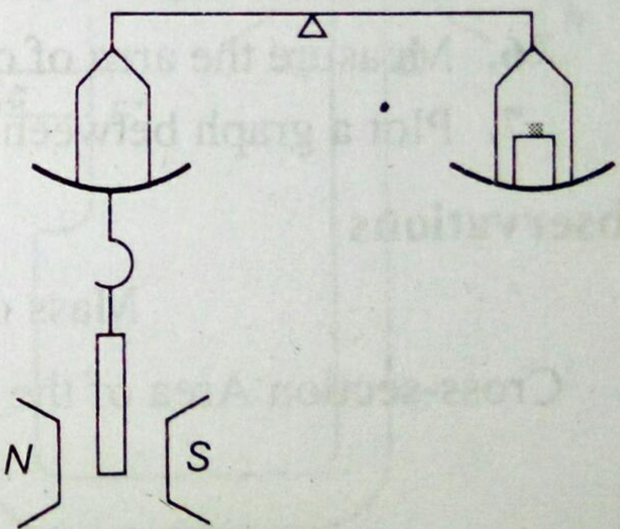

Fig. 23.1

There is a hole in the box through which the specimen hangs out. It is hung in field between the pole pieces of the magnet in such a way that its lower end is i homogeneous magnetic field B and the upper end is in a much weaker field. T force resulting from the field is counter-balanced by altering the weights in the oth pan of the balance. If the difference is denoted by mg, this is equal to the force arisi from the magnetic field.

$$\therefore \qquad mg = \frac{1}{2}\frac{\chi AB^2}{\mu_0}$$

or the magnetic susceptibility,
$$\chi = \mu_0 \frac{2\,mg}{AB^2} \qquad (23.8$$

where A is the area of cross section of the substance in metre^2, g is the acceleration due to gravity ($= 9.8$ m/s^2) and $\mu_0 = 4\pi \times 10^{-7}$ Wb/A.m.

Thus by measuring m, A and B, the susceptibility χ of the sample can be determined.

Procedure

1. Connect the electromagnet with power supply.
2. The specimen in the shape of a rod is connected to one arm of a sensitive balance and hung vertically such that its lower end is in between the two pole pieces and the upper end is outside the pole pieces.
3. Put the weight in the other arm of the balance so as to bring its needle in the centre. In case of a digital weighing machine a knob is provided for the purpose and the mass is directly given by the machine. Note down the mass M of the rod.
4. Switch on the field B and add weights in the pan to bring the balance needle at the centre. Note down the mass M' of the rod in the presence of the magnetic field. Then $(M'-M)$ gives the mass m required to counter balance the effect of the magnetic field. Measure the field using a gauss-meter. Convert it to tesla by multiplying with 10^{-4}.
5. Change the field by varying the current in the power-supply of the electro-magnet. Note down the magnetic field B and the corresponding mass M' of the rod. Take 5–6 such readings.
6. Measure the area of cross-section of the sample with a suitable instrument.
7. Plot a graph between B^2 along x-axis and m $(= M' - M)$ along y-axis.

Observations

Mass of the rod, $M = \ldots$ gm $= \ldots$ kg

Cross-section Area of the specimen, $A = \ldots$ cm$^2 = \ldots$ m^2

$$\mu_0 = 4\pi \times 10^{-7} \text{ Wb/A.m}$$

$$g = 9.8 \text{ m/s}^2$$

S. No.	*Magnetic field B (Tesla)**	B^2 *(Tesla)*^{2}	*Mass of the rod in mag. field M′ (kg)*	*Mass to counter balance the field m = M′ − M (kg)*
1.				
2.				
3.				
.				
.				
.				

Calculations

$$\chi = \ldots \mu_0 \frac{2mg}{AB^2}$$

$$= \frac{2\mu_0 g}{A} \times \text{slope}$$

$$= \ldots$$

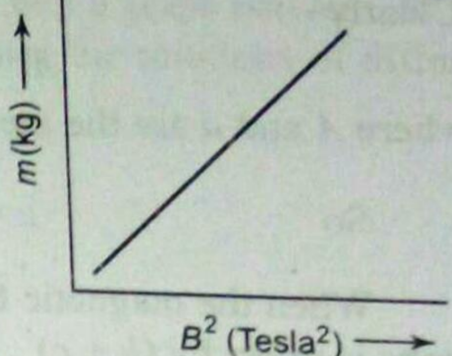

Fig. 23.2

Result

The magnetic susceptibility of the specimen = ...

Precautions and Sources of Error

1. The pole pieces of the electromagnetic should be wedge shaped with enough spacing so that the field may be uniform.
2. The current in the electromagnet should not be passed for long time.
3. The balance should be very sensitive preferably a digital balance and should be enclosed in a box so that the weighing is not affected by the air.
4. The specimen should be freely suspended with no mechanical restraint from the balance.

Weak Points

Gouy's method is a simple but not a sufficiently accurate one. This is because the force is weak even in strong fields because of the low values of susceptibilities of dia and paramagnetic substances. To produce a force equivalent to 1 gwt, the field required will be of the order of 10^5 gauss.