Experiment 7
Lee's Method

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Synopsis

In this experiment the thermal conductivity of a bad conductor is measured.

I. THEORY AND PROCEDURE

A. Apparatus

- Lee's Apparatus
- Bad conductor discs
- Two thermometers
- Boiler and Induction
- Stop watch
- Weighing balance
- Vernier Caliper
- Screw gauge

B. Theory

Fourier's Law of heat conductance gives the rate of transfer of heat between two objects at temperatures T_1 and T_2 connected by a conductor with conductivity k and cross-sectional areas A (assumed uniform) and length l as

$$\frac{\Delta Q}{\Delta t} = k\frac{A}{l}(T_2 - T_1)$$

This equation governs the rate of heat transfer from disc D_2 to D_1in the first half of the experiment; where D_1 and D_2 are bottom and top discs of Lee's apparatus respectively.

The instantaneous rate at which a warm body loses heat to surroundings is given by Newton's law of cooling (which is a special case of Stefan's law, when the temperature differences are small, and there are losses other than radiative losses).

$$\frac{\mathrm{d}T}{\mathrm{d}t} = -b(T - T_a)$$

,where T_a is the ambient temperature. This law governs the rate at which the disc D_1 cools in the second half of the experiment.

If m is the mass of the disk and s is the specific heat of the material of D_1, then the rate at which heat is lost by the disc D_1

$$\frac{\Delta Q_1}{\Delta t} = ms\frac{\mathrm{d}t_1}{\mathrm{d}t}$$

In the steady state achieved in the first half of the experiment, the heat supplied by the steam is lost by cooling of disc D_1. Hence the heat balance in the experiment is given by combining equations two heat transfer equations.

$$ms\frac{\mathrm{d}T}{\mathrm{d}t} = k\frac{A}{l}(T_2 - T_1) \tag{1}$$

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$\mathrm{d}T/\mathrm{d}t$ for D_1 can be determined from the cooling curve obtained in the second part of the experiment. As an approximation a single value of $\mathrm{d}T/dt$ can be used for this calculation. It is calculated at the value T_1 during the cooling of the disc D_1 from $T_1 + 10$ °C to $T_1 - 7$ °C. From the known value of $s = 0.380\ \mathrm{J\,g^{-1}\,K^{-1}}$ for brass, k can be determined.

Note that if the two thermometers do not initially show the same reading, the difference $T_2 - T_1$ will have to be corrected by the quantity T' determined at the beginning of the experiment.

C. Procedure

1. Fill the boiler with water to nearly half and heat it to produce steam. In the mean time, weigh the disc D_1 on which the apparatus rests.
2. Further, measure the diameter of specimen disc d with a vernier calliper and its thickness using a screw gauge at several spaces and determine the mean thickness.
3. Clamp the glass specimen between the base disk D_2 of the steam jacket and the auxiliary brass disc D_1. Insert the thermometers (either mercury thermometer or thermocouples) in the two brass disks D_1, D_2.
4. Check if they show the same readings at room temperature. If not, note the difference T'.
5. Connect the boiler outlet with the inlet of the steam chamber by a rubber tube. Continue passing steam until the two brass disks reach a steady temperature. Note down the temperatures T_1 and T_2 of the two discs.
6. The second part of the experiment involves the determination of the cooling rate of disc D_1 alone. Remove the sample disc. Heat the disc D_1 directly by the steam chamber till its temperature is about $T_1 + 10$ °C.
7. Remove the steam chamber and place the insulating disk on it. Record the temperature of the brass disc at half minute intervals. Continue till the temperature falls to about $T_1 - 7$ °C.

D. Precautions

- PRECAUTIONS

II. OBSERVATIONS

Mass of D1 = in all variables add a underline

ENTER A Actual data HERE

Material	T_i (°C)	Length (cm)	ΔL (10^{-5} m)
Copper	24.0	59.8	75
Copper	25.5-24.5-25.5	59.7	74
Aluminium	24.0-23.0-24.7	59.9	105
Brass	24.1-23.2-24.3	59.7	85
Steel	22.1-24.8-20.5	-	74
Aluminium	24.3-23.7-24.3	59.8	104
Brass	23.7-22.4-24.3	60.0	85
Steel	24.6-25.3	59.9	76
Brass	24.8-25.3	60.1	86
Steel	23.3-23.5	59.7	76

TABLE I. Data taken on 11 Mar 2025, the variables represents the property as described in the theory.

Least count of scale: 0.1 cm
Least count of thermometer: 0.1 °C
Least count of spherometer: 10^{-5} m

III. UNCERTAINTIES AND ERROR SOURCES

A. Measurement Uncertainties

- **Weight Measurements:**
- **Length Measurements:**
- **Temperature Measurements:** Uncertainty of ± 0.05 K due to instrument resolution.

B. Random Errors

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C. Systematic Errors

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IV. CALCULATION AND ERROR ANALYSIS

A. Error Propagation

Using Equation-1 we get:

$$k = ms\frac{l}{A}\frac{\dot{T}}{T_2 - T_1}$$

From the length, temperature and mass uncertainty, the error to k will travel using the formula for error propagation as: **ENTER A BOOK ERROR PROPER HERE**

(2)

REFRENCE THE BOOOkThe uncertainty in α is given by the basic formula for error propagation.:

$$\sigma_\alpha = \alpha\sqrt{\left(\frac{\sigma_{\Delta L}}{\Delta L}\right)^2 + \left(\frac{\sigma_L}{L}\right)^2 + \left(\frac{\sigma_{\Delta T}}{\Delta T}\right)^2}$$

where $\sigma_{\Delta L}, \sigma_L, \sigma_{\Delta T}$ are the uncertainties in expansion length, initial length, and temperature difference, respectively.

B. Calculation

We calculate the value of α of all data points and their uncertainity from hte above formul, we get:[1]

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[1] Refer to **?** for calculations

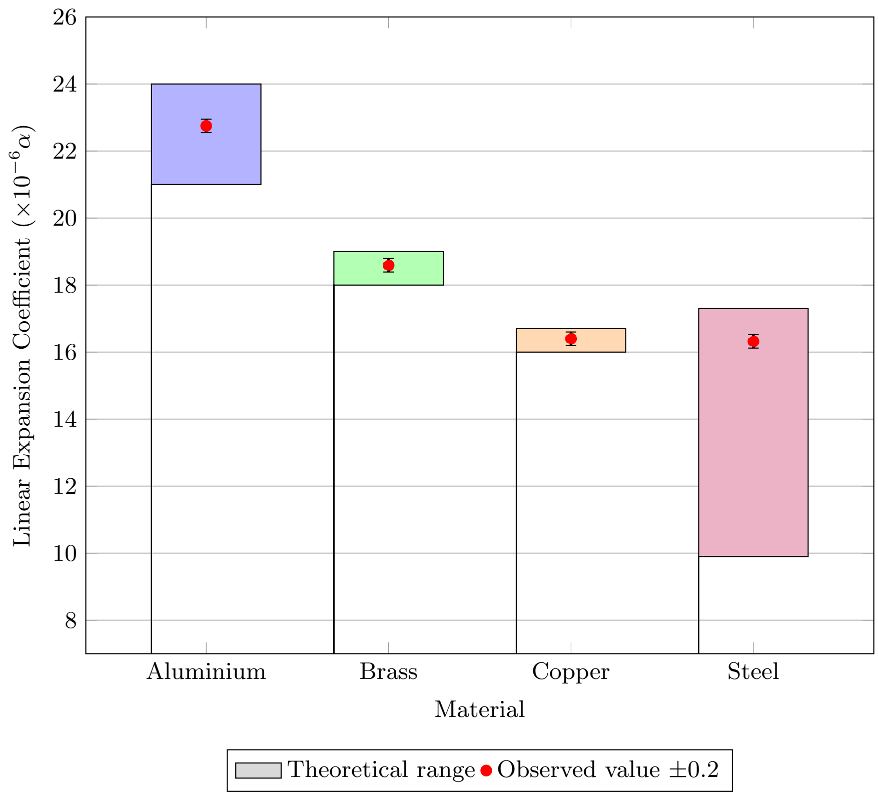
Material	α (1/°C)
Aluminium	$(2.303 \pm 0.005) \times 10^{-5}$
Aluminium	$(2.291 \pm 0.005) \times 10^{-5}$
Brass	$(1.870 \pm 0.004) \times 10^{-5}$
Brass	$(1.851 \pm 0.004) \times 10^{-5}$
Brass	$(1.909 \pm 0.004) \times 10^{-5}$
Copper	$(1.650 \pm 0.003) \times 10^{-5}$
Copper	$(1.656 \pm 0.003) \times 10^{-5}$
Steel	$(1.591 \pm 0.003) \times 10^{-5}$
Steel	$(1.691 \pm 0.003) \times 10^{-5}$
Steel	$(1.662 \pm 0.003) \times 10^{-5}$

TABLE II. Calculated expansion coefficients

V. RESULT

The calculated values of α show high precision but large variations from expected values. The inconsistencies suggest experimental errors, leading to unreliable results.

ENTER A ACTUAL LAB VALUES HERE DONT DELTE



Lets fucking go

Appendix A: Theoretical Values

The expected values of α in $^{\circ}\mathrm{C}^{-1}$ are:[2]

$$\begin{aligned} \alpha_{\text{Steel}} &\approx (1.08 - 1.25) \times 10^{-5} \\ \alpha_{\text{Brass}} &\approx (1.8 - 1.9) \times 10^{-5} \\ \alpha_{\text{Aluminium}} &\approx (2.1 - 2.4) \times 10^{-5} \\ \alpha_{\text{Copper}} &\approx 1.78 \times 10^{-5} \end{aligned}$$

REFERENCES

[2] **?**