Experimental Competition

I. Determination of Capacitance

Background

It is known that capacitors play a significant role in the electrical circuits. There are several methods of measurements of the capacitance of a capacitor. In this experiment you are required to perform the experiment in order to determine the capacitance of an AC capacitor using a simple electrical circuitry.

In Fig. 1.1 (a), a capacitor of capacitance C and a resistor of resistance R are connected in series to the alternating voltage source of mains frequency. The electrical power which is dissipated at the resistor R depends on the values of $\mathcal{E}_0$, C, R and frequency of the mains f. Graphical analysis of this relationship can be used to determine C.

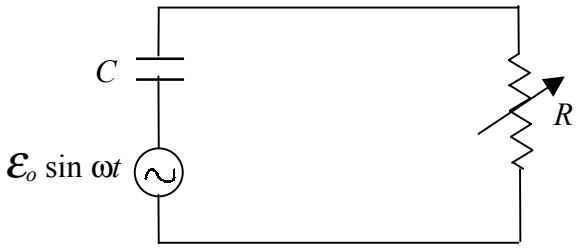


Fig. 1.1 (a): AC Circuit for determination of capacitance C

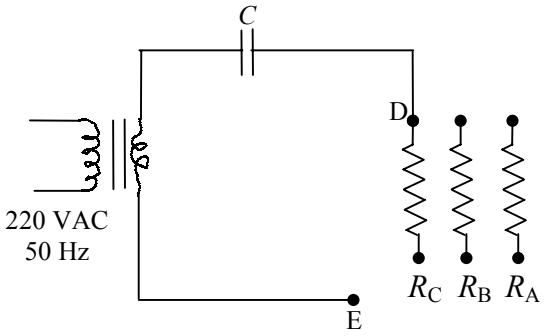


Fig. 1.1 (b): A schematic diagram of the equipment used

Materials and apparatus

1. capacitor
2. three resistors of known values with ±5% errors ($R_A = 680\Omega$, $R_B = 1500\Omega$ and $R_C = 3300\Omega$) as shown in figure 1.1 (b).
3. step-down isolation transformer for alternating voltage source of f = 50 Hz
4. digital voltmeter
5. electrical connectors
6. linear graph papers

Warning: **The digital multimeter in this experiment will be used for measuring the rms voltage ($\tilde{V}$) <u>across *R*</u> only. <u>Do not use it to measure in other modes.</u>**

Instructions

a) Derive the expression for the average power dissipation $\overline{P}$ in resistor R in terms of $\mathcal{E}_o$, R, C and ω. (1 point)

b) Deduce the condition for which $\overline{P}$ is a maximum. (1 point)

c) Convert the dependence found in a) into a linear dependence of certain quantities α and β. (1 point)

d) Measure the root mean square (effective) voltage V across R for each of all possible combinations of R_A, R_B and R_C. (2.5 points)

e) Plot $\overline{P}$ versus R and from this graph compute the value of capacitance C. (2 points)

f) From c), draw the graph of α versus β and determine capacitance C. (2 points)

g) Estimate the uncertainties in the values of C obtained in e) and f). (0.5 point)

Experimental Competition

II. Cylindrical Bore

Background

There are many techniques to study the object with a bore inside. Mechanical oscillation method is one of the non-destructive techniques. In this problem, you are given a brass cube of uniform density with cylindrical bore inside. You are required to perform non-destructive mechanical measurements and use these data to plot the appropriate graph to find the ratio of the radius of the bore to the side of the cube.

The cube of sides a has a cylindrical bore of radius b along the axis of symmetry as shown in Fig. 2.1. This bore is covered by very thin discs of the same material. A, B and C represent small holes at the corners of the cube. These holes can be used for suspending the cube in two configurations. Fig. 2.2(a) shows the suspension using B and C; the other suspension is by using A and B as shown in Fig 2.2(b).

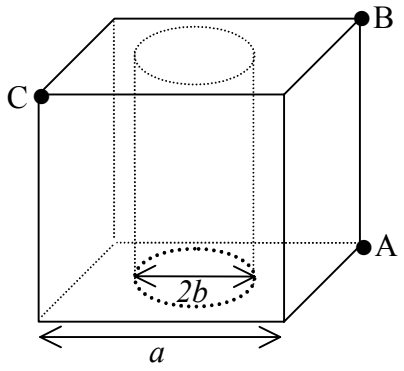
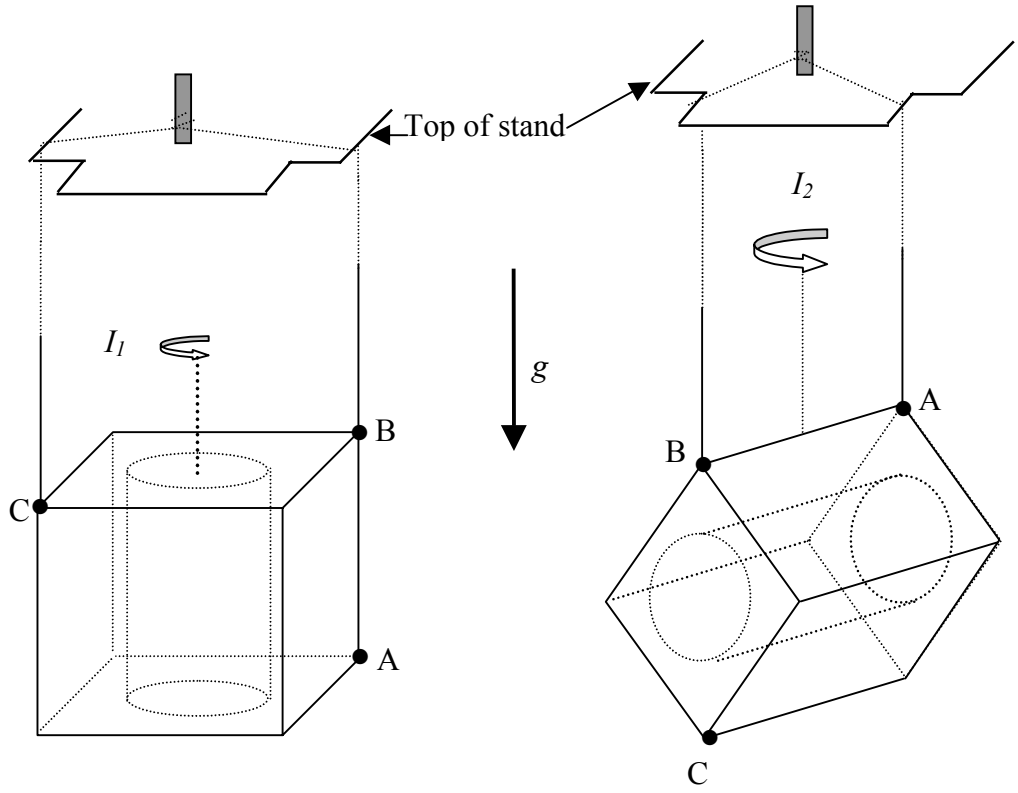


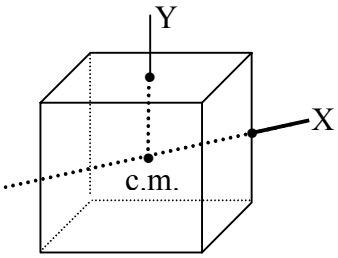
Fig. 2.1 Geometry of cube with cylindrical bore



2.2(a) 2.2(b)

Fig. 2.2 Two configurations of cube's suspension

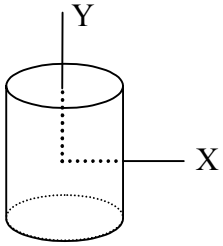
Students may use the following in their derivation of necessary formulae:



For a solid cube of side a

$I = \frac{1}{6}Ma^2$ about both axes

c.m. = centre of mass



For a solid cylinder of radius b length a

$I_Y = \frac{1}{2}mb^2$

$I_X = \frac{1}{12}ma^2 + \frac{1}{4}mb^2$

Materials and apparatus

1. brass cube
2. stop watch
3. stand
4. thread
5. ruler/ centimeter stick
6. linear graph papers

Experiment

a) Choose only one of the two bifilar suspensions as shown in Fig. 2.2, and derive the expressions for the moment of inertia and the period of oscillation about the vertical axis through the centre of mass in terms of ℓ, d, b, a and g where ℓ is the length of each thread and d is the separation between threads. (2 points)

b) Perform necessary non-destructive mechanical measurements and use these data to plot an appropriate graph and then find the value of $\frac{b}{a}$. (8 points)

The value of g for Bangkok = 9.78 m/s^2.
