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IMPROVISING TECHNIQUES IN EXPERIMENTAL PHYSICS FOR NIGERIAN SCHOOLS: A COMPOUND MICROSCOPE.

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Abstract

In the course of formal education, Nigeria faces some major problems, one of these is the lack of teaching material which should go a long way to stimulate learning. It is for this purpose that a compound microscope has been designed and constructed for use in Nigerian secondary schools where such equipment is either completely lacking or available in limited quantity. A compound microscope consists essentially of a base, a stage, an arm and two tubes which support the objective and the eye-piece lenses. The magnifying power of the constructed microscope was determined and found to be 10. The experimental and the theoretical magnifying powers differed by 8%. The constructed microscope can be used in physical and biological lessons.

Introduction

Physics as a teaching subject has suffered in the hands of teachers and unwelcome by most students over the years (Farombi 1988). This is measured by the enrolment and performance patterns of the students in the subject. Salami (1992) pointed out that there exist low performance of students in the subject. Various explanations were given for the snag, some of which include lack of necessary motivation and interest in the part of the students; dearth of qualified physics teachers; lack of teaching materials and poor physics teaching (the teaching seems so abstract that an average student hardly knows its difference from a mathematics class, so, many students run away from it. the few ones that survived such rotary work can not form any applicable relationship between what they learn in the classroom and what they encounter daily in the Physical Science World, hence they still regard some things as magic of the whites).

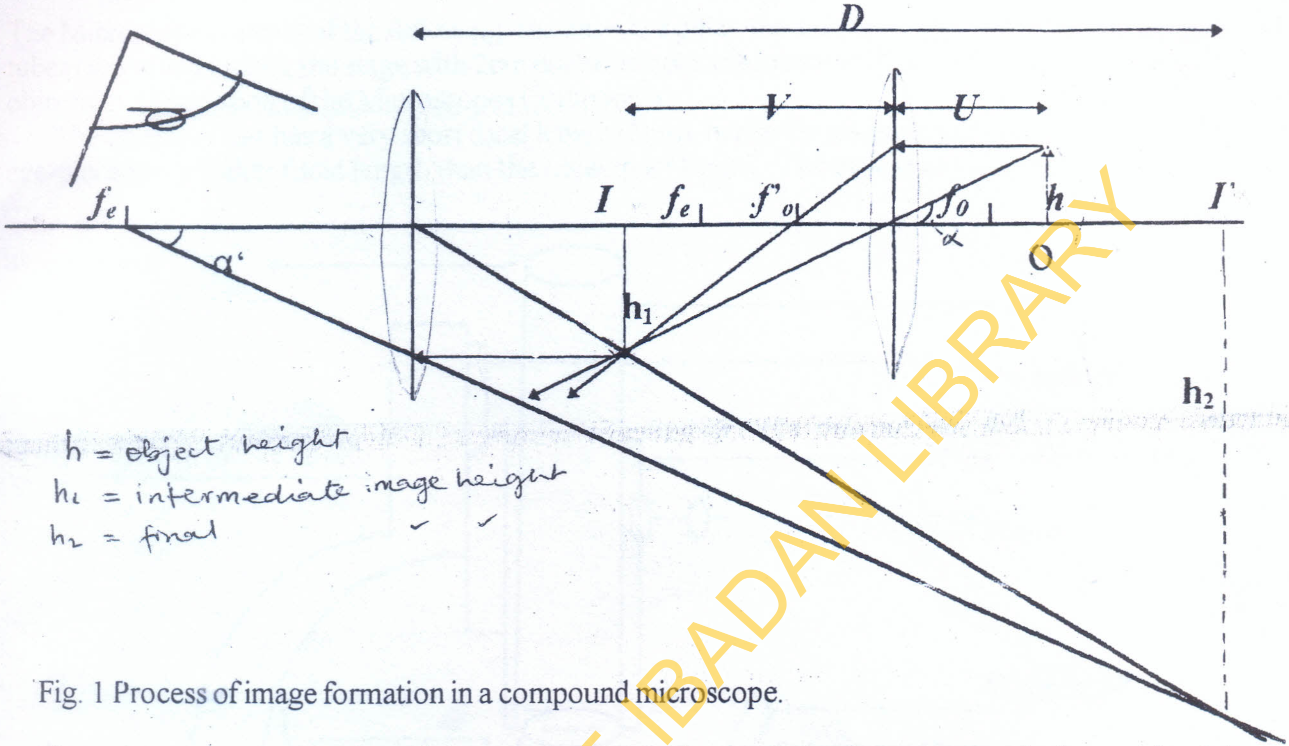
Teaching and learning of Physics in secondary schools cannot be improved if the teaching materials are not available. It is a well known fact that students learn fast when they interact with materials relating to the topic in consideration. For effective teaching and learning of Physics, simple teaching models should be available. Its design, construction, and use should be simple. Such models attract and hold students attention throughout the lesson. It also invites contributions from the dullest of the students

In view of this, teachers are encouraged to improvise simple aids from local materials and adapt such to classroom situation to make Physics teaching and learning more interesting. One of such simple demonstration models is a compound microscope which has been designed, constructed and used on the general principle of optics.

Theoretical Background

The compound microscope was invented by Galileo soon after the invention of his celebrated telescope. In its simplest form, it is constructed in a similar way to that of an astronomical telescope. The essential difference is the position on which the object is placed. In telescope , we view distanct objects, but in microscope, the object is brought near to the instrument (Bray 1930).

Fig. 1 Process of image formation in a compound microscope.



h = object height
h_1 = intermediate image height
h_2 = final

Fig. 1 Process of image formation in a compound microscope.

Fig. 1 shows the arrangement of the eye-piece and objective lenses in a compound microscope. O is the object, a real, magnified and inverted image of this object is formed at I . For this to occur, O must lie between fo , the principal focus and 2fo , the center of the objective lens. In order to produce high magnification, objective lens should have a very short focal length. The eye-piece E serves as a magnifying glass. It receives the image of the objective (within the focal length) as its own object and it produces a virtual, inverted image at I' anywhere between the far and near points.

Magnifying Power of a Compound Microscope

In Fig. 1 above the image at I is formed at the least distance of distinct vision D from the eye. Suppose the eye is close to the eye-piece, the visual angle α' subtended by the image I' is then given by (α'=h2/D, where h2 is the height of the final image. With the unaided eye, the object subtends a visual angle given by (α=h/D where h is the height of the object.

So, angular magnification = $\frac{\alpha'}{\alpha}$ where $\alpha' = \frac{h_2}{D}$ and $\alpha = \frac{h}{D}$

Therefore $\frac{\alpha'}{\alpha} = \frac{h_2/D}{h/D} = \frac{h_2}{h}$ 1

Now $\frac{h_2}{h}$ can be written as $\frac{h_2}{h_1} \times \frac{h_1}{h}$ where h1 is the length of the intermediate image formed at I.

Therefore $M = \frac{h_2}{h_1} \times \frac{h_1}{h}$ 2

The ratio h2/h1 is the linear magnification of the object at I produced by the eye-piece. Linear magnification from the thin lens formula can be written as $\frac{V}{f_2} - 1$. Since V = -D; it follows that (f_2)

$$\frac{h_2}{h_1} = \frac{-D}{f_2} - 1 = -\left[\frac{D}{f_2} + 1\right]$$

→ $\frac{1}{f_2} = \frac{1}{v} + \frac{1}{u}$ (multiply both sides by v

$\frac{v}{f_2} = 1 + \frac{v}{u}$; $\frac{v}{u} = \frac{v}{f_2} - 1$

Since h1 /h is the linear magnification of the object at O produced by the objective lens hence $h_1/h = V/U$

Therefore, $M = \frac{h_2}{h_1} \times \frac{h_1}{h} = \left[\frac{D + f_2}{f_2}\right]\frac{V}{U}$ ....3 (Nelkon and Parker, 1982 and Duncan, 1982)

The Design, and Construction of a Compound Microscope

The Microscope consists of the following: the base, the pillar, the arm, the tube holder, the focusing tubes (wood and metal), the stage with 2cm diameter hole, the mirror and two lenses (eye-piece and objective). Description of the Microscopes Components

The objective lens has a very short focal length (5cm), hence the magnifying power is high. The eye-piece has a higher focal length than the objective (10cm). The base is made of hard wood of

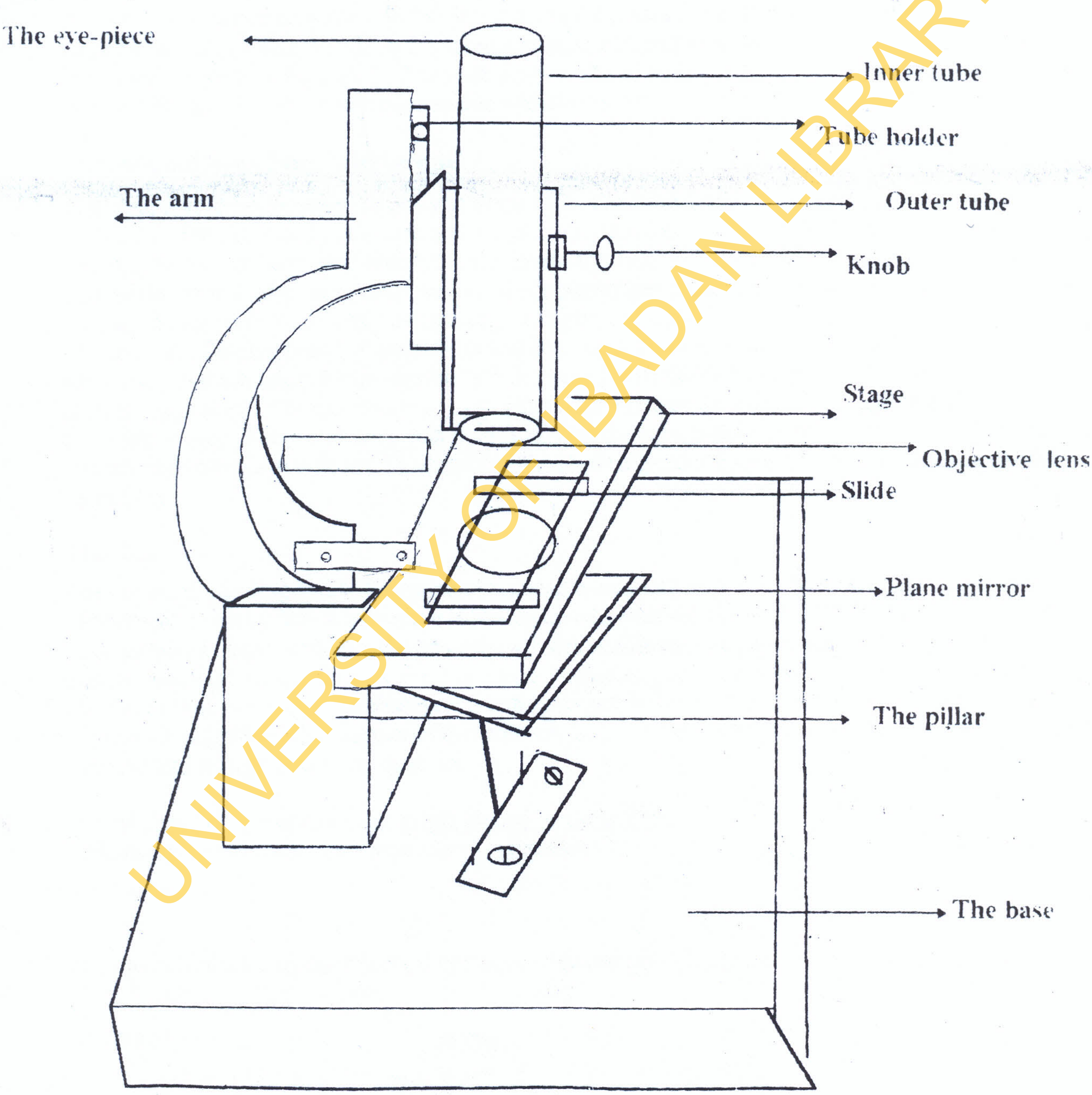


Fig 2: The Compound Microscope

dimension 3cm x 18cm x 12cm. The pillar that serves as the stand of the microscope is made from a piece of wood 6cm x 6cm x 12cm. A slot of 1.6cm wide and 6cm deep was cut on the wood . Through both walls of the slot, a 3mm, 3cm from either sides and 2cm down was drilled. The arm is a semi-circular piece of iron of diameter 14cm, 1.2cm wide and 1.2cm thick. A 3mm hole, 6cm from the lower end was drilled in order to fasten it with the base. Another 3mm hole was drilled on the arm at the 1.5cm mark from the lower end which was used to hold the stage. The arm has a vertical side of about 10cm at the upper end and holes of 2mm at 4cm interval were drilled on it. Bolt and nuts were used to fasten it on the tube holder. The tube holder is made of aluminium of dimension 4cm x 24cm and 5mm thick . A screw was used to fasten it with the outer focusing tube. The focusing tubes are in two parts: the outer and the inner tubes. The outer tube is made of a piece of wood of dimension 4cm x 4cm x 15cm. A 3cm diameter hole was drilled on the wood. Under it is the 4cm x 4cm x 1.5cm wood with 2cm hole to hold the objective lens, the lens was glued on the piece of wood. The inner tube is 25cm long insulating pipe with outer diameter slightly less than 3cm so that it can move snugly inside the outer tube. A 2.5 cm diameter washer is forced into the insulating focusing tube so as to suspend the eye-piece , hence disallow it to fall down through the tube. The stage is made of thick aluminium plate 5mm x 6cm x 8cm on which 2cm diameter hole was drilled. It was made in such a that slide can be pinned down over the hole by 2 copper stripes. The non reflecting surface of a plane mirror was cemented to a wood of the same dimension with the mirror.

The Assemblage of the Microscope

The pillar was strongly nailed to one end of the base. The tube holder was screwed to the vertical side of the arm. The other end of the arm was inserted into the slot cut on the pillar by using a bolt and nut. The stage was fixed with bolt and nut to the lower arm with a piece of aluminium of 5mm and about 2cm wide. At the other end of the stage are copper stripes to hold the slide over the stage . These copper stripes were held firmly on the stage by bolts and nuts. The wooden base of the mirror was screwed on a flexible piece of aluminium and is mounted on the wooden base of the microscope in such a way that the axis in which the mirror bisects the 2cm hole, in this way the axis in which the mirror bisects the projection of the objective lens. This is done so that the mirror will receive sufficient light from the source. The outer tube was held firmly on the tube holder such that the objective lens is directly above the 2cm hole and the distance of the hole is greater than the 5cm (the focal length of the objective).

The Use

The constructed compound Microscope was used to magnify an object. A piece of graph paper sheet of dimension 1cm by 4cm was cut and at the centre two lines were drawn with ink. The two lines were separated by a distance of 2mm to constitute a division. The cut out graph was cello taped on the slide and its image is located through the eye-piece. A similar graph sheet was cut and placed along the diameter of the eye-piece. An observer sees the two graph sheets as coinciding through the eye-piece, the former magnified. The number of divisions on the later sheet which coincides with the former was counted and was given by the equation.

$$M = \frac{\text{Number of divisions on the graph placed on the eye-piece}}{\text{Number of divisions on the image sheet on the slide}}$$

$$= \frac{10}{1} = 10.$$

The theoretical magnifying power of the constructed compound microscope can be obtained as follows:
U = 6.6cm, f1 = 5.0cm, f2 = 10.0cm

Using equation 3,

$$M = \left[\frac{D+f_2}{f_2}\right]\frac{V}{U} \quad \text{but } \frac{V}{U} = \frac{f_1}{U-f_1}$$

knowing that $\frac{1}{v} = \frac{u-f_1}{u f_1}$ $\therefore V = \frac{u f_1}{u-f_1}$

So $\frac{V}{u} = \frac{u f_1}{u(u-f_1)}$

$$= \left[\frac{D + f_2}{f_2}\right]\frac{f1}{U - f_1} \qquad = \left[\frac{25}{10} + 1\right]\frac{5}{6.6 - 5}$$

$$= \frac{35}{3.2}$$

$$= 10.938.$$

$$\text{Percentage error} = \frac{10.938 - 10}{10.938} \times 100\%$$

$$= 8.5\%.$$

Conclusion

The compound microscope constructed can be used both as a model for demonstration in any physics class, and in any biological lesson to determine the magnification of a given specimen.

Acknowledgement Hussein

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