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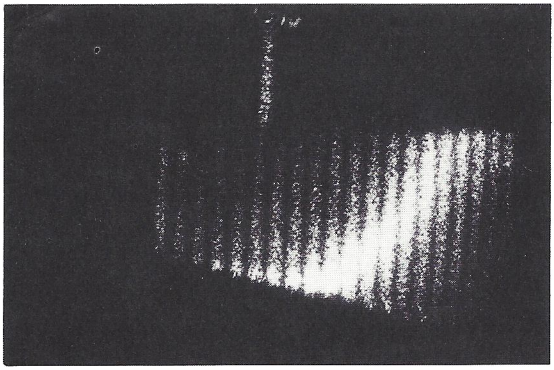

Figure 3 Fringes seen on screen

where $g(x,y)$ is the irradiance distribution from the first exposure and ξ is the displacement of the object along the x axis between the two exposures. This can be rewritten as

$$f(x,y) = g(x,y)^* [\delta(x,y) + \delta(x-\xi,y)]$$

where the symbol * denotes a convolution (Collier *et al* 1971), and $\delta(x,y)$ is a delta function.

The virtual image on the processed film can be seen through the regular reconstruction process; however, if the processed film is illuminated by a parallel laser beam, the real image can be projected and focused on a screen through a lens (figure 2). The amplitude in the farfield (screen) is given by the Fourier transform of $f(x,y)$

$$F(u,v) = G(u,v) [1 + \exp(iu\xi)]$$

where $G(u,v)$ is the Fourier transform of $g(x,y)$. The irradiance on the screen is then

$$A(u,v) = |F(u,v)|^2 = 2|G(u,v)|^2 (1 + \cos u\xi)$$

The irradiance on the screen will have zero value when

$$u\xi = (2n + 1)\pi \qquad n = 0,1,2\ldots$$

Therefore, the irradiance distribution on the screen is modulated by a system of fringes (figure 3). The number of fringes is proportional to the movement so this process offers a method of measurement of a small displacement.

The set-up is placed on the floor, eliminating the need for a vibration-free table. The procedure is simple, and can be completed within an hour.

I wish to thank Professor Brian J Thompson for his valuable comments on the manuscript.

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A new laboratory course for physics students

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Since 1977 we have been developing a new laboratory course in mechanics for second-year students in the Department of Fundamental Physics at the University of Santander. The aim has been to increase the students' participation in the laboratory classes and through this we have seen an improvement in the students' approach to the exercises and in their comprehension of the physics. The course is one of four taken by the students in their second year, and occupies 60 hours over a four-week period.

The course had previously been based on a simple instruction sheet, essentially containing the following parts: classification and identification of the necessary material for doing the practical; theoretical background of the phenomenon under investigation; and presentation of the results. Inquiries made among the students showed that few of them felt that the exercises were of value. Consequently we experimented with a new idea for the 1977–8 course, which we continued testing during the 1978–9 and 1979–80 courses.

The new course consists of three main parts: self-evaluation, analysis of the practical, and discussion of results. In the first part the student must answer easy questions related to the natural phenomenon exhibited in the laboratory exercise. The purpose of the questions is twofold:

(1) From the student's answers the tutor discovers possible gaps or misconceptions in the student's understanding of the topic.

(2) The student is able to make his own evaluation of what he knows about the topic.

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The second part, analysis of the practical, involves a series of questions of increasing difficulty, which requires the student to search the literature to solve them. Whilst he is doing this, the student is setting up the theory of the phenomenon that he is investigating and is finding the laws which govern it and their range of validity. This series of questions needs to be carefully prepared so that the student will understand the aims of the exercise and how they are to be achieved with the apparatus provided. Continuing along this line, we hope to find an ideal sequence of questions based on our experience and the critical opinion of our students.

The presentation of results is not the end, but merely another stage in the course. Of greater importance than the practical work is the discussion of the results. This discussion includes answering questions about the experiment, and having the tutor and student examine the difficulties in performing the exercise.

In view of the good response that we have received from students we are encouraged to develop new exercises following the method described here. A description of one of the current exercises follows.

Example of a practical exercise

Objective: Determination of the coefficient of viscosity of a liquid using Stokes' law.

Material needed: Two test tubes, 50 and 100 cm long, with the same inside radius; eight steel spheres; glycerine and car oil; barometer, thermometer, micrometer and ruler.

Self-evaluation:

(1) Use dimensional anaylsis to establish the expression for the upthrust on a sphere immersed in a liquid.

(2) Are density and specific gravity the same? What is the difference?

(3) What do you understand by viscosity?

(4) What is the value of the upthrust on a sphere of radius r immersed in a liquid of density d?

Analysis of the practical

(1) Use dimensional analysis to establish a formula for the frictional force acting on a sphere (of radius r and mass m), falling through a liquid, knowing that this force depends on (a) the coefficient of viscosity of the liquid, (b) the radius of the sphere, (c) the speed with which the sphere falls through the liquid.

(2) Draw a diagram showing the forces acting on the sphere as it falls through the liquid, and write down an expression for the resultant force F.

(3) If we assume that there is equilibrium when $F=0$, what is the resultant expression for the speed of fall, which we call the terminal velocity?

(4) Are we able to measure the terminal velocity with the instruments available? How?

(5) At this point you should be able to write in a few sentences how you will determine experimentally the coefficient of viscosity. You should show this to your tutor. If you are not sure, you must start again from the beginning.

Discussion of results

(1) If we assume that the resultant force F is zero and use the basic equation of motion we find an expression for the speed

$$v = v_{\text{limit}} [1 - \exp(-\alpha t)]$$

where $\alpha = 6\pi\mu r$, with μ representing the specific coefficient of viscosity and r the radius of the sphere. How is the above expression obtained?

(2) Do you think that the liquid viscosity depends on the temperature? Why?

(3) How do the coefficients of viscosity change when doing the experiment, first in the 50 cm test-tube, then in the 100 cm one?

(4) Do you know of any other methods of measuring the coefficient of viscosity?

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amplifier gain required and consequently also the noise amplification.

The material used for these devices is silicon at 0.85 μm wavelength (since the photon provides sufficient energy for the momentum change of the electron, the indirect gap presents no disadvantage in this case). At 1.3 and 1.55 μm silicon is transparent and Ge or quaternary In, Ga, As, P compound PIN diodes are necessary.

Conclusion

It is hoped that these basic simple explanations will suffice to stimulate interest in opto-electronics. It is a new field of activity in which this country is in the forefront. Considerable future development is likely and should provide much excitement in research, development and production and in many novel applications.

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