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Integrative Strategy for Effective Teaching of Density and Pressure in Senior Secondary Schools: A Guide to Physics teachers

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Abstract

The problem of many teachers throughout the world is not what to teach but how to teach what. In this paper, integrative strategy for effective teaching of density and pressure in senior secondary schools is proposed. The principles involved in integrative teaching approach are outlined. The paper also *outlined some relevant students' activities and tasks that can enrich classroom interaction for meaningful teaching and learning of density and pressure. The application of the strategy proposed in some demonstration experiments on density and pressure to guide both physics teachers and students are shown. The advantages of integrative teaching approach are outlined in this paper. Integrative approach is therefore recommended as an appropriate and effective teaching strategy for physics since the strategy stimulates simultaneously both the sense of vision and the sense of hearing.*

Introduction

One of the aims of physics education is to promote the understanding of the concepts being taught with a view to applying such knowledge to real life situations. The consistent poor academic achievement in physics by secondary school students attests to the fact that physics teaching has not been properly understood (Stephen, 2008). This improper physics teaching has led to a vigorous search for appropriate teaching and learning methods that would be used to achieve the aims of physics teaching and thereby enhance performance (Nwagbo, 2001). Studies on the effect of teaching methods on students' academic achievement in physics are still inconclusive. Increasing amount of significant researches in the past years point out that the interactive process between individual students and the teacher is very important in determining the nature and quality of learning and development that result from instruction (Zywno, 2002). Some researchers have taken the position that it is teaching and not the teachers that is the key to the learning of physic

Some researchers express the view that teachers shy away from activity oriented teaching methods which are known to be effective. Such teachers rely on teaching methods that are easy but inappropriate to the teaching and learning of physics (Nwagbo, 2001). Such methods promote memorization of facts and principles, most of which the students do not understand, only to regurgitate them during examination. As a result, retention of ideas, facts and principles learnt may not be worthwhile. Furthermore, the students may not be able to apply this newly obtained knowledge to new related situations. All physics teachers today are thus faced with the problem of organization of physics instruction in such a way as to facilitate learning for majority of the students. This paper addresses itself to integrative strategy as an appropriate strategy for effective teaching and learning of density and pressure in senior secondary schools.

Research questions

The following research questions are posed to guide not only understanding and presentation but also application of integrative method of teaching by Physics teachers:

1. What is Integrative Teaching Approach?
2. What are the principles involved in the teaching approach?
3. What are the relevant students' activities and tasks that can enrich classroom interaction for meaningful teaching and learning of density and pressure through Integrative Teaching Approach?
4. How can the principles involved in Integrative Teaching Approach be applied in the teaching and learning of density and pressure?

Integrative teaching approach

Integrative teaching strategy is a teaching approach involving practical and theory at the same time. This teaching strategy is likened to audio-visual resource materials which aid learning through the simultaneous stimulation of both sense of vision and the sense of hearing.

Principles of integrative teaching approach

The principles involved in integrative teaching strategy are as follows:

(a) Introducing to the students basic apparatus which they will use constantly in the course of practical activities before they are involved in the rigors of how to use them;

(b) Where possible, starting the lesson with demonstration activity, involving students and allowing them to observe and draw some conclusions before introducing the day's lesson; and

(c) Explaining the need for recording and analyzing data obtained accurately.

Sample Lesson Outlining Students' Activities and Tasks in the Teaching and Learning of Density and Pressure using Integrative Strategy

Subject: Physics

Lesson: Density and Pressure

Class: SS 1

Age: Between 14 and 16 years

Duration: 80 minutes

Objectives: At the end of the lesson students should be able to:

1) define density and pressure;
2) determine experimentally the density of regular and irregular solid by direct method;
3) calculate simple mathematical problems involving pressure and density.

Materials

Measuring cylinder, over-flow can, tracing pins, some weights, water, relative density bottle, nails with blunt ends, thread, regular and irregular solids, and spring balance.

Procedure

The lesson is introduced by identifying and explaining to students the basic apparatus or materials (as mentioned above) and terms which they would encounter in the course of learning about density and pressure.

(i) **Mass:** This is defined as the total material content of a body.

(ii) **Volume:** This is defined as the product of length, breadth and height of a material.

(iii) **Force:** Force is that which moves its point of application in the direction of the force or force is the product of mass and acceleration.

(iv) **Area:** This is defined as the product of length and breadth.

Students Activity

Students are divided into three groups and each group is assigned a task as follows:

Group A: Task 1: Students are to fill the given measuring cylinder to $^1/_3$ of its volume with water. They are to note this first reading of the water volume. They are to immerse the given irregular solid into the water in the given measuring cylinder with the help of thread. The students are to note the 2nd recording of the volume of the water in the measuring cylinder. The students are to find the difference in volume between the first and second readings of the volume of water in the measuring cylinder. The difference in volume of water is the volume of the irregular solid inversed in it. The students are to weigh the mass of irregular solid with the help of spring balance. They are to divide the mass of the irregular solid by its volume. This division of the mass by the volume of the irregular solid is its density. This experiment is as shown in figure one (fig. 1).

Group B: Task 2: This second group is to fill an overflow can with water. A measuring cylinder is placed bellow the spout of the overflowing can. The given irregular solid is then immersed into the overflow can and the volume of water overflowed into the measuring cylinder is noted in figure 2. The students are to measure the mass of the irregular solid with the help of spring balance. Students should be able to know that the volume of the water overflowed into the measuring cylinder gives the volume of the irregular solid immersed. They are to divide this measured mass by the volume of the water overflowed into the measuring cylinder. The answer they get gives the density of the irregular solid.

Groups A and B are to exchange their tasks. When they do, group A should get the result that group B got in her first task while group B in turn will get the result that group A got in her first task.

Group C: Task 3: Group three is to make the given tracing pin stand erect on a tracing board without pressing it in. a weight of about 100kg is placed on its head and the students are to state their observation. The observation is that it penetrates into the tracing board. The group is to repeat the experiment with the blunt nails provided and then state her observation. The observation is that the blunt nail at its tip will not penetrate into the tracing board. The conclusion is that small surface area gives high pressure which caused penetration when tracing pins were used. Large surface area which the blunt end had gave low pressure which was not high enough to force the nail into the tracing board.

Application of the Principles involved in Integrative Teaching Approach in the teaching and learning of Density and Pressure

After the students' activities in groups A, B and C, the concepts of density and pressure are then introduced or taught as shown below:

Density

The density of a substance is its mass per unit volume

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$e = M/V$$ where e (rho) is density

Although the S. I. unit of density is kg/m^3, in laboratory work results may be obtained in g/cm^3. There will be no difficulty in converting to SI units. Example, convert the density of $0.2 g/cm^3$ to S. I. units.

Since $1g = \frac{1}{10^3}$ kg and $1\ cm = \frac{1}{10^2}$ m

We have $0.2g/cm^3 = \frac{0.2 \times 10^{-3}\ kg\ m^3}{(10^{-2})}$

$= 0.2 \times 10^3\ kg/m^3$

Thus, the conversion to kg/m^3 is achieved by multiplying the e in g/cm^3 by 1000. The e of water is about $1g/cm^3$ or $1000kg/m^3$.

Relative Density (r.d)

Since water is the most common substance and its density is $1000kg/m^3$ or $1g/cm^3$, it is convenient to use it as a standard for comparing the densities of other substances. The r.d of a substance is defined as follows

$$\text{r.d} = \frac{\text{density of the substance}}{\text{density of water}}$$

$$\text{r.d} = \frac{\text{mass of substance}}{\text{Mass of equal volume of } H_2O}$$

$$\text{r.d} = \frac{\text{weight of substance}}{\text{Weight of equal volume of } H_2O}$$

It has no unit, e.g. r. d. of mercury is 13.6. It used to be known as specific gravity.

Determination of Density of Solids by Direct Method

Regular Solid: For regular solid, the volume can easily be found by measuring its dimensions. The mass can be obtained by direct weighing. Hence density can be calculated. Examples:

(i) Find density of the material of a cylinder of base radius, r = 0.1m and height, h = 0.5m, if the mass of the cylinder is 44kg. What kind of material is this drum likely to be made of?

$$\text{Volume of cylinder} = \pi r^2 h = \frac{22}{7} \text{ x } (0.10)^2 \text{ x } 0.50\text{m}^3$$

$$\text{Density} = m/v = \frac{44}{\frac{22}{7} x(0.01)^2 x 0.50}$$

$$= \frac{44x7x10^2 x10}{22x5}$$

$$= 2800\text{kg/m}^3$$

(ii) The r.d of an alloy is 6.5, find the mass of a solid alloy cube of side 20cm. What Volume of the alloy has a mass of 13kg?

(a) e = m/v since r.d. = 6.5, $e = 6500\text{kg/m}^3$

vol of cube $= \frac{22 \text{ x } 20 \text{ x } 20}{(100)^3}$

:. $M = \frac{6500 \text{ x } 20 \text{ x } 20 \text{ x } 20}{(100)^3} = \frac{5.2 \text{ x } 10^7}{10^6} = 52\text{kg}$

(b) v = m/e, m = 13kg, e = 6500

:. $v = \frac{13}{6500} = \frac{1}{500} = 2 \text{ x } 10^{-3} \text{ m}^3$

Irregular Solid:

The mass of an irregular solid body can be obtained by direct weighing. The volume is found by immersing the body in water, provided it will sink and that it is not soluble in water. The volume of water displaced will be equal to the volume of the solid. A measuring cylinder or an overflowing can may be used in measuring the volume of liquid displaced. Note the diagrams below:

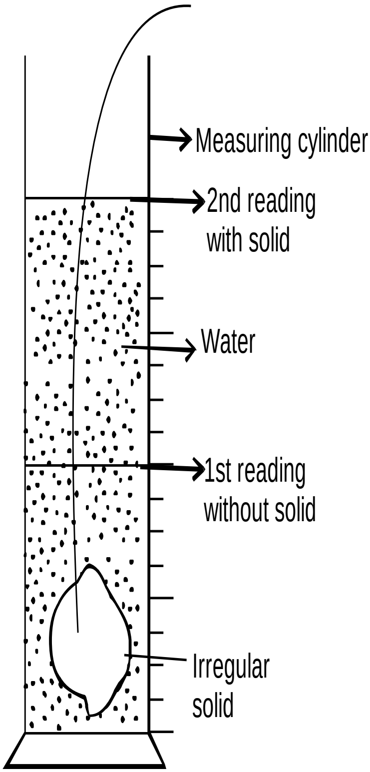

Fig. 1

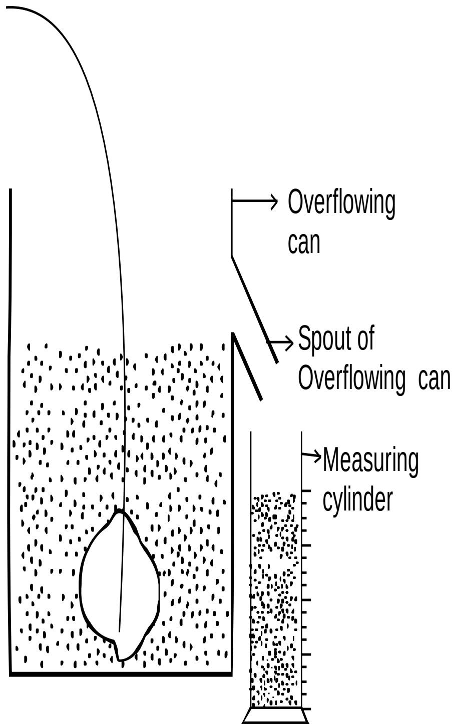

Fig. 2

Relative Density of Liquid by Direct Method

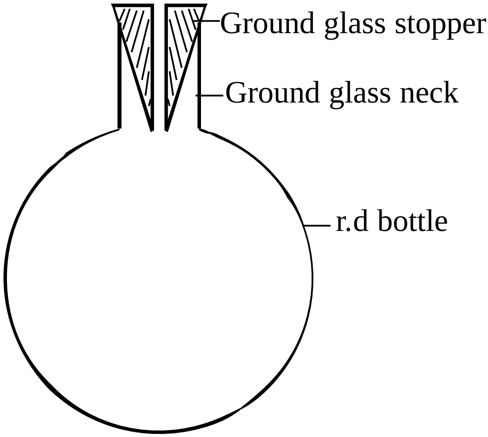

Fig. 3

A relative density bottle can be used to find the density of a liquid directly. The r. d. bottle is weighed empty and it has mass, m. It is then filled with liquid and weighed and it has mass, m_1. Finally it is emptied, dried and refilled with water and weighed again and has mass, m_2.

$$\text{r.d.} = \frac{\text{Density of liquid}}{\text{Density of } H_2O}$$

$$= \frac{\text{Mass of liquid}}{\text{Mass of equal volume of water}}$$

$$= \frac{m_1 - m}{m_2 - m}$$

Examples:

(i) If an empty r. d. bottle weighs 25g, it weighs 65g when filled with a liquid and 75g when filled with H_2O. Calculate the density of the liquid.

$$\text{r. d. of liquid} = \frac{\text{Mass of liquid}}{\text{Mass of equal volume of } H_2O}$$

$$= \frac{65 - 25}{75 - 25} = \frac{40}{50} = 0.8$$

Since density of H_2O = $1 g/cm^3$

Density of liquid = $0.8 g/cm^3$

= $800 \ kg/m^3$

(ii) If 32g of kerosene of e, $0.80 g/cm^3$ are mixed with 8g of water, what is the e of the resulting mixture?

$$\text{Vol of kerosine} = \frac{\text{Mass}}{e} = \frac{32}{0.80} = 40 cm^3$$

Vol of H_2O = $8/1 = 8 cm^3$

Total vol of mixture v = $48 cm^3$

Total mass of mixture m = $32 + 8 = 40 g$

$$\text{e of mixture} = m/v = \frac{40}{48} = 0.83 g/cm^3$$

$$= 830 kg/m^3$$

Pressure

The word pressure is frequently used by people to mean several things. For example, we talk about pressure of work, the pressure of the atmosphere, blood pressure and so on. In physics however, pressure has one meaning. It is defined as the force acting normally or (perpendicular) per unit area of surface. The SI unit of pressure is the Pascal (Pa) or Newton per square metre (Nm^{-2}). If A is an area of a surface per square metres and F, the force in newtons acting on the area, pressure, P is given by

$$P = \frac{F}{A} \quad (\text{Pa or } Nm^{-2})$$

From the above equation it follows that if A is very small, the pressure is large and when A is large, pressure is small. Thus the pressure exerted by tracing pin on the tracing board in task 3 that group C students performed was much greater than that exerted by the nail with blunt ends and hence it penetrated the tracing board. This same argument holds for person wearing narrow heels and the one wearing flat heels. The pressure exerted on the ground by a person wearing narrow heels is much greater than that exerted by the same person wearing flat heels. The sharp point of a needle or the sharp blade of a knife pieces very easily even when a small force is applied because the area involved is very small. An elephant with its large feet can exert less pressure on the ground than a gazelle with small hooves.

Examples:

(1) A force of 80N acts on an area of $10m^2$. Calculate the pressure exerted on the surface.

Solution:

Force applied = 80N

Area of application = $10m^2$

$$\therefore \quad P = \frac{F}{A} = \frac{80N}{10m^2} = 8Nm^{-2}$$

or 8 Pa

(2) What weight of water would exert a pressure of 2000pa on the base of a rectangular water tank with dimensions 20cm by 30cm?

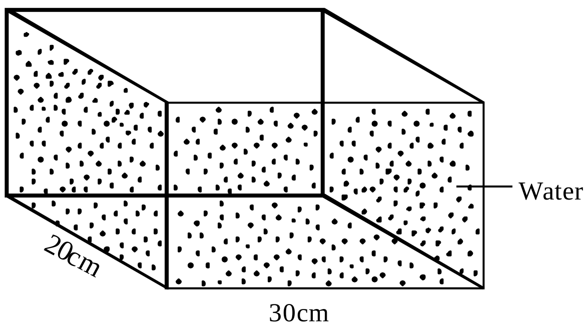

Fig. 4

Length of the water tank	=	30cm
	=	0.3m
Breadth of the water tank	=	20m
	=	0.2m
Pressure, p	=	2000 pa
P	=	$\frac{F}{A}$
F	=	Pa x A
	=	2000 x 0.3 x 0.2N
Weight of water	=	120N

Pressure in Liquid

When considering pressure in liquids it is often useful to consider a property which does not vary. Density is such a property. The density of a substance is the mass of one cubic metre, measured in kilograms.

Consider a column of liquid h metres above the level PQ of liquid in a cylinder as shown in figure 5 below.

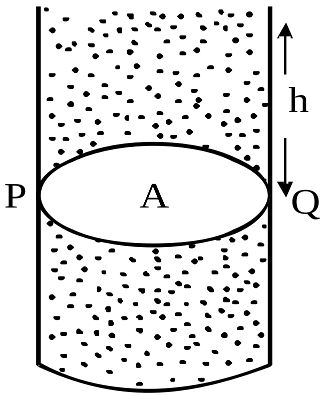

Fig. 5

The volume of liquid resting on a horizontal area A at this level is h A

Mass = Density x Volume

e x h A

= ehA

The weight, W of the liquid is ehAg, since W = mg, the pressure is given by

$$P = \frac{W}{A} = \frac{ehAg}{A} = ehg$$

The characteristics of pressure in a liquid are summarized below:

(i) The pressure in a liquid increases in direct proportion to the depth of the liquid. This can be demonstrated by the experiment below.

Use an empty milo or bournvita container. Make three holes on it at different depth as shown below. Block the holes and fill the milo container with water to the brim. Open the three holes at the same time for water to gorge out. It would be observed that the distance to which the water travels out at the first hole before bending down is greater than that of the second hole which in turn is greater than that of the 3rd hole. This is caused by pressure which increases with depth.

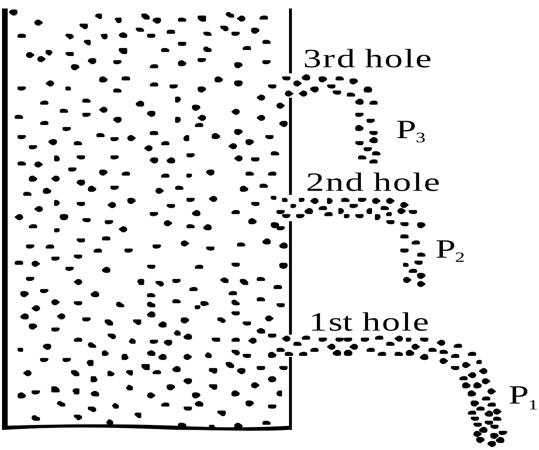

Fig. 6: $P_1 > P_2 > P_3$

(ii) The pressure in different liquids at the same depth varies directly with density. If the experiment in No (i) above is repeated and the container is filled with palm oil instead of water, it will be seen that the distances to which the palm oil travels out before bending down at the 1st, 2nd and 3rd holes will be different from those of water.

(iii) The pressure at any point in the liquid acts equally in all directions

(iv) The pressure at all points at the same level within a liquid is the same.

Examples:

(a) What is the pressure due to water at the bottom of a tank which is 20m deep and is half full of water? (density of water = $10kgm^3$, g = $10Nkg^{-1}$

P = ehg

= 10^3 x 10 x 10 = 10^5pa or 100kpa

(b) A jar, 0.5m deep is full of liquid of density $1800kgm^{-3}$. At what depth below the surface of the liquid is its pressure equal to $900Nm^{-2}$? (take g = $10Nkg^{-1}$).

Let h be the height below the surface of liquid when the pressure is 900pa.

Pressure = ehg

900 = h x 1800 x 10

h = 0.05m

Advantages of Integrative Teaching Approach

The following are the advantages of integrative strategy over the conventional lecture method used by Physics teachers in senior secondary schools.

1. It helps to concretize ideas and concepts and thereby stimulates imagination.
2. It does not only help the teacher to explain the lesson but also makes the lesson practical. This is because the strategy carries along with it appropriate resource materials.

3. The strategy stimulates simultaneous in the learner both the sense of vision and sense of hearing.
4. It creates variety which arouses the learners interest and thereby sustain their attention and retention of the lesson taught.
5. The strategy is student-centred and not teacher-centred.

Class Assignment

(1) Define density, relative density and pressure.

(2) State three characteristics of pressure in liquid.

(3) Describe an experiment to determine the density of:

(i) regular solid (ii) irregular solid, through direct method.

Conclusion

Integrative teaching approach has been clearly defined and the principles involved in it have been discussed. The application of the strategy in teaching the concepts of density and pressure in senior secondary schools has been shown. Furthermore, the paper has outlined some appropriate and relevant students' activities and tasks for enrichment of classroom interaction for the teaching and learning of density and pressure.

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