Swim Blater

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hi!!

I. INTRODUCTION

Intro...

II. PHENOMENOLOGY

When an object is dropped in a swimming pool, there are three possibilities :

1. The object floats in the pool surface.
2. The object dips into the water and stops at some point without reaching the bottom.
3. The object dips until reaching the pool's bottom.

When the object is dropped, it gains kinetic energy before dipping into the pool. In the first case, the motion stops and the object begins to float until reaching the surface; then because of Newton's second law: **there is a force** pulling up the object which is greater than the force of gravity and is balanced when the object is partially inmersed. In the second case when the energy is dissipated because of water friction forces, the object stops and gets stuck at the reached depth; then according to Newton's second law, **there is a force** with the same magnitude and opposed to the force of gravity. Finally, in case three, when the object dips into the water it begins to slow its motion (until it is stopped by the bottom), then again because of Newton's second law : **there is a force** which partially balances the force of gravity.

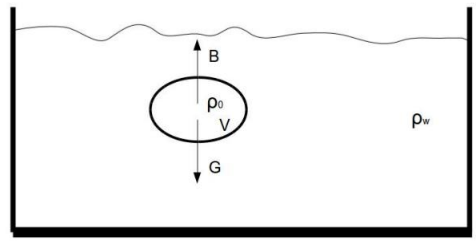
The unknown force is the buoyancy force which was first described by Archimedes of Syracuse about 200 B.C. Archimedes captured this phenomena in the well known Archimedes' principle which is described in the next section.

III. ARCHIMEDES' PRINCIPLE

Archimedes' principle can be found in several general physics textbooks.The definition given in [1] is considered and it states:

"A body wholly or partially immersed in a fluid will be buoyed up by a force equal to the weight of the fluid that the body displaces"

Let's consider an impermeable body of volume V and and mass m with an uniform and constant mass density ρ_0 inmersed in a fluid of density ρ_ω as shown bellow.



Acording to Archimedes' principle and Newton's second law if the force buoying up the body is denoted by B and the weight is G, then the the dynamics of this body is described by the next equation,

$$B - G = ma, \tag{3.1}$$

the phenomenology described in the last session is fully contained in this formula. Indeed, first if force of gravity is smaller than the force of buoyancy then acceleration is positive and the body is pulled up. The force of gravity may be equal to the force of buoyancy and then the body remains at rest, inmersed. Finally if the force of gravity is bigger than the force of buoyancy then the body begins to dip down until reaching the botton.

Actually there is more information in equation (3.1). Archimedes principle for the buoyancy force B and the properties of this body lead to,

$$\begin{aligned} m &= \rho_0 V \\ B &= \rho_\omega V g \\ G &= \rho_0 V g, \end{aligned} \tag{3.2}$$

doing some algebra on equation (3.1), relations (3.2) lead to a formula for accelerarion which depends only on densities; this formula is given by,

$$a = \left(\frac{\rho_\omega - \rho_0}{\rho_0} \right) g. \tag{3.3}$$

Taking a look to this relation, the physics behind it is again the same discussed previously, just with the most accurate result that motion depends on densities. Indeed, first if body's density is smaller than fluid's density then acceleration is positive and the body is pulled up until it is partially inmersed in the fluid. Densities may be equal, then forces are balanced and the body remains at rest, inmersed. Finally if body's density is bigger than fluid's density then the body weight is bigger than buoyancy force and the body goes down until it reaches the botton.

Densities must be handle with care; thats why impermeability was requested since if the body allows the fluid to go inside without changing its shape, its density in average will be bigger. Uniform and constant density avoids the cases in which there is one or more cavities inside the body, in this case the buoyancy does not change but this fact inplies $m \neq \rho_0 V$.

Introduce the fish jeje

IV. FISHES AND THEIR SWIM BLADDER

Talk about the fhish and its swim bladder, then considere a model ilustrated in the picture:

Define the model of the fish to considere, ie, it doesn't have cavities and and its mass in average is unifomly distributed before and after the bladder changes so $m = \rho V$

[1] J Walker D. Halliday, R. Resnick. *Fundamentals of Physics*. John Wiley & Sons, Inc, 1993.