## Buoyancy(Archimedes principle)

An important aspect of hydrostatic pressure deals with determining the net force that is exerted on an entire body that is either completely submerged or floating in a partially submerged position. In case of either completely submerged or floating there is a net upward pressure acting on the body. This force called the buoyancy force, occurs because pressure increase with depth. Thus the pressure acting upward on a bottom surface area is greater than the pressure acting downward. On the other hand the net horizontal pressure force on a completely submerged or floating body equals zero.

### Completely submerged body

Fig.1 below shows:

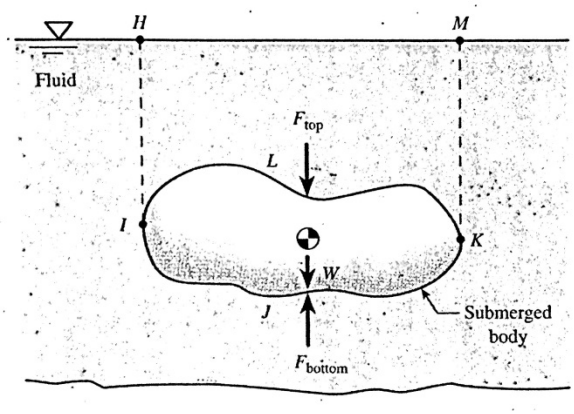


Fig.1

1- The weight W of the submerged body occupying the volume IJKLI.
2- The vertical force Ftop acting downward on the top surface of the body that equals the weight of the fluid in the volume HILKMH:

$$F_{top} = \gamma_{fluid} * V_{fluid} + \gamma_{body} * V_{body}$$

3-The vertical force F bottom acting upward on the surface of the body that equals the weight of the fluid that would occupy the volume HIJKMH if the body were not present:

$$F_{bottom} = \gamma_{fluid} * V_{fluid}$$

Since Fbottom is greater than Ftop there is a net upward pressure force (Fbottom-Ftop) acting on the submerged body. Since Fbottom-Ftop) equals the weight of fluid having a volume equal to volume of the body:

$F_B=\gamma fluid*Vfluid.$

$F_B$ is called buoyancy force.

Floating body

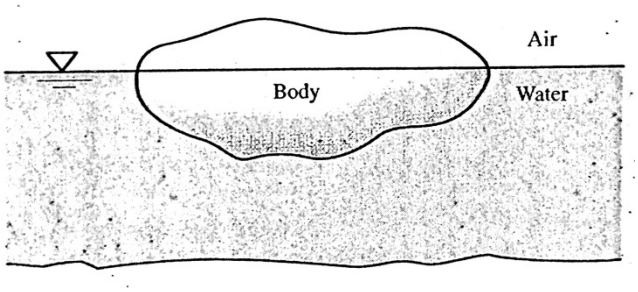


Fig.2

When a person gets weighed the recorded weight called apparent weight really equals the actual weight minus the weight of the atmospheric air displaced by the person's body. Thus the measured weight of a person equals the weight of the person in a perfect vacuum minus the weight of atmospheric air displaced by the person:

Apparent body weight=$\gamma body*Vbody-\gamma air*Vbody$.

وزن الجسم الظاهري =وزن الجسم الحقيقي (حجم الجسم *الكثافة) – كثافة الهواء *حجم الجسم المغمور

وزن الجسم في السائل = وزنه الحقيقي (كثافة *حجم) –وزن السائل المزاح (كثافة السائل *حجم الجزء الغاطس )

اذن قوة دفع السائل او الهواء= كثافة السائل او هواء * حجم الجزء الغاطس فقط

| Wieght air- wieght in water = buoyancy force (FB) |
|---|

Examples

Ex.1

The weight of a person is 180 lb where the specific weight of the atmospheric air is 0.0765 lb/ft$^3$. If the persons total volume is 2.95 ft$^3$. What is the persons actual weight and average specific weight?

Apparent weight=actual W- γair*Vperson

180=actual W-(0.0765)*(2.95)

Actual W=180.23 lb.

Persons average density =actual W/Vol.

=180.23/2.95 =61.1lb/ft$^3$

(human beings have an average specific weight of about 61 lb/ft$^3$ and thus can theoretically float in water because the specific weight of water is 62.4 lb/ft$^3$) الانسان يطفو في الماء لان كثافته اقل من كثافة الماء

Ex.2

Using pressure height relation(P=γh) show that the buoyancy force a completely submerged circular cylinder equals the weight of the liquid displaced by the cylinder (fig.3)? اهمل الضغط الجوي

اثبت ان قوة الطفو على الاسطوانة تساول وزن السائل المزاح

يعني يساوى حجم الاسطوانة * كثافة السائل

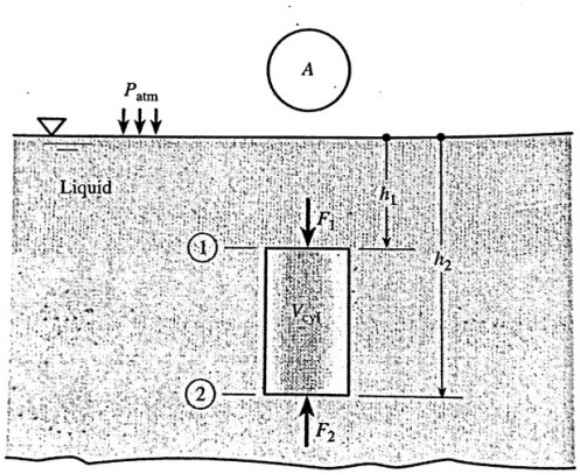

fig.3

$F_B$= F2-F1=P2A-P1A

القوة هي الضغط * المساحة

والضغط هو الكثافة * الارتفاع

$P = \gamma * h$

$F_B$= (γ luquid* h2) A-( γ liquid*h1) A

h*A=vol.

$F_B$= γluquid(h2-h1)A

مساحة القاعدة للاسطوانة * الارتفاع هو حجم الاسطوانة

$F_B$= γluquid V cyl.= weight of the displaced liquid

## Ex.3

A 6 in cube completely submerged in water is balanced by a 10lb weight on the beam scale, determine the specific gravity of the cube material (fig.4)?

لحل هذه الاسئلة نحتاج رسم (free body diagram)

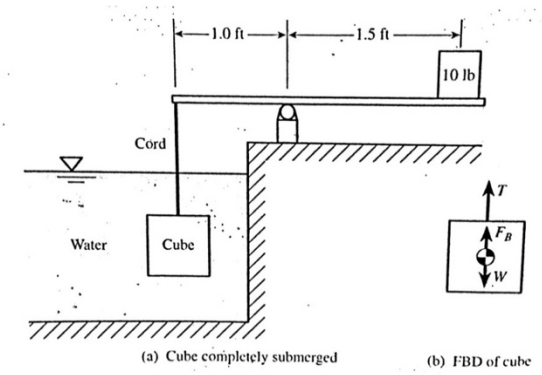


Fig.4

T(tension)*1=10 *1.5

T=15lb

$T+F_B-W=0$

$F_B$=γ water *V disp.water=γ water *V cube

$=62.4*6^3*1/1728=7.8$ lb

W=T+FB

=15+7.8=22.8 lb

γ cube=W cube/V cube

$=22.8/6^3*(1/1728)=182$ lb/ft$^3$

S.G=γ cube/ γ water=182/62.4=2.92 .

Ex. 4

If the floating ball weighs = 50 N and the cable tension =35 N, find the bouncy force?

W+T= Fb

50 + 35 =85 N