Notes by-

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Buoyancy

a) * State the Archemedes principle of ~~buy~~ buoyancy. Draw a sketch to show the relative positions of centre of gravit metacentre and centre of buoyancy for a stable floating body.

Determine the metacentric height of a cube floati in a liquid of Sp. gravity S if the cube of side B has Sp. gravity of S_1. $\frac{B}{2}\left[\frac{S}{6S_1} - \left(1 - \frac{S_1}{S}\right)\right]$ Marks 8

b) Select the correct statement giving reasons in brief.
A floating body in a liquid is in stable equilibrium.
(i) When its centre of gravity is below its centre of buoyancy.
(ii) When its metacentric height is zero.
(iii) When its metacentre is below the centre of buoyancy.
✓(iv) when its metacentre is above the centre of gravity
(v) none of these answers. Marks 4

c) It is well known fact that one can float easily in sea water than in fresh water. Should one also be able to swim faster in sea water? Explain in brief with reasons. (No) $C_D A \frac{1}{2}\rho V^2$ $F_B =$

d) Define metacentre. A rectangular barge is 20m long 7m wide and 3m deep. It has a draft of 2m when fully loaded. The C.G. of barge is on axis of symmetry at the water surface. Determine the stability considerations of the barge and the metacentric height. (Marks 10)

e) A wooden cylinder of diameter d and length 2d floats in water with its axis vertical. Is the equilibrium stable? ~~is~~ Locate the metacentre with reference to water surface. Specific gravity of wood is 0.6. unstable, (0.548d)

f) An iceberg weighing 8976 N/m³ floats in the ocean with a volume of 600 m³ above the surface. Determine the total volume of the iceberg if specific weight of ocean water is 10055 N/m³.

V_{solid} Vol. of solid.

g) An empty balloon and its equipment weighs 441.45 N. When inflated with gas weighing 5.415 N/m³, the balloon is spherical and 7m in diameter. What is the maximum weight of cargo that the balloon can lift, assuming air to weigh 12.066 N/m³. (752.68 N)

h) A conical buoy floating with its apex pointing downward is 3.5m high and 2m diameter. Calculate its weight if it is just stable when floating in sea water weighing 10 055 N/m³.

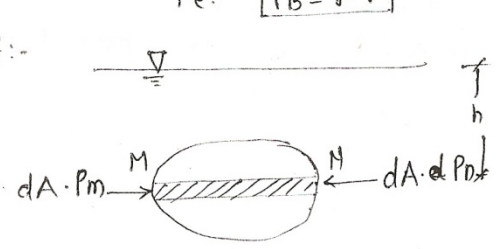
Buoyant force:- When a body is submerged (partially or fully) in a ~~liquid~~ fluid, it is subjected to an upward force known as buoyant force (F_B)

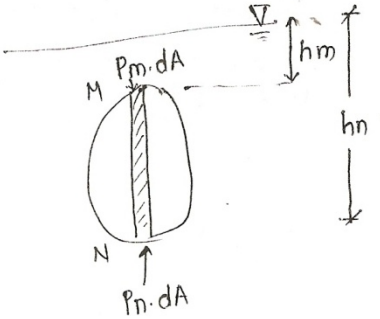
Buoyancy:- Tendancy of body which is immersed in ~~liquid~~ fluid partially or fully to rise in a fluid due to buoyant force is known as buoyancy.

Archimedes Principle:- When a body is submerged partially or fully in fluid, a buoyant force ~~will~~ equal to the wt. of fluid displaced by the body.

i.e. $\boxed{F_B = \gamma \cdot V}$

Proof:-





Consider a body fully submerged in a fluid having sp. wt. 'γ'. The Horizontal pressure at M & N of an elementary strip having area of face = dA.

∴ Pressure at M = Pm · dA

Pressure at N = Pn · dA

∴ $\Sigma F_x = 0 \Rightarrow$ Pm · dA − Pn · dA = Pressure force in horizontal direction

∴ Total hori. pre = $\int (pm - pn) \cdot dA$

But Pm & Pn are situated at same level. ∴ Pm = Pn

∴ No horizontal pressure acts on a fully submerged body.

Considering second case,

Pressure force in vertical direct^n = − Pm dA + Pn dA

But Pm = $\gamma \cdot dA \cdot hm$, Pn = $\gamma \cdot dA \cdot hn$

Total pre. force = $\int (\gamma \cdot dA \cdot hm + \gamma \cdot dA \cdot hn)$.

= $\int \gamma dA (-hm + hn)$

& $(hn - hm) \cdot dA$ = Volume of strip

∴ Total vertical pre. force = $\int \gamma \cdot dV$

∴ Buoyant Force = $\gamma \cdot V$.

$\boxed{F_B = \gamma \cdot V}$

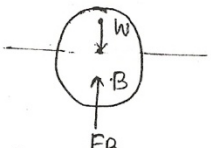
∴ Buoyant force = ~~to~~ Wt. of fluid displaced by body.

Centre of Buoyancy:- The pt. of applicat^n of buoyant force is known as centre of buoyancy.

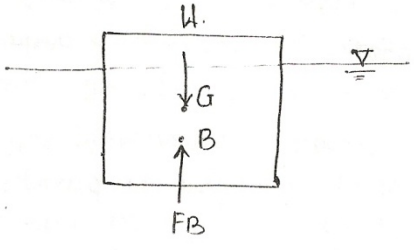
Principle of floation:- When a body floats on fluid, W = F_B

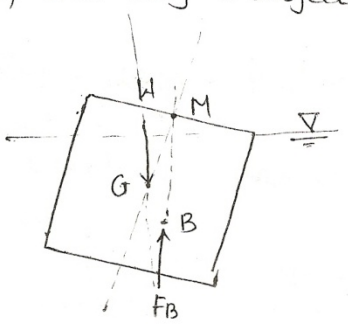
i.e. Buoyant force = Wt. of fluid displaced by body.

This is known as principle of floatation.



Metacentre:- It is the point of intesection of axis of floating body & vertical line passing through new centre of buoyancy after body is subjected small angular deformation. (M)





Metacentric Height:- The dist. bet^n CG of body & metacentre (M) is known as metacentric ht.

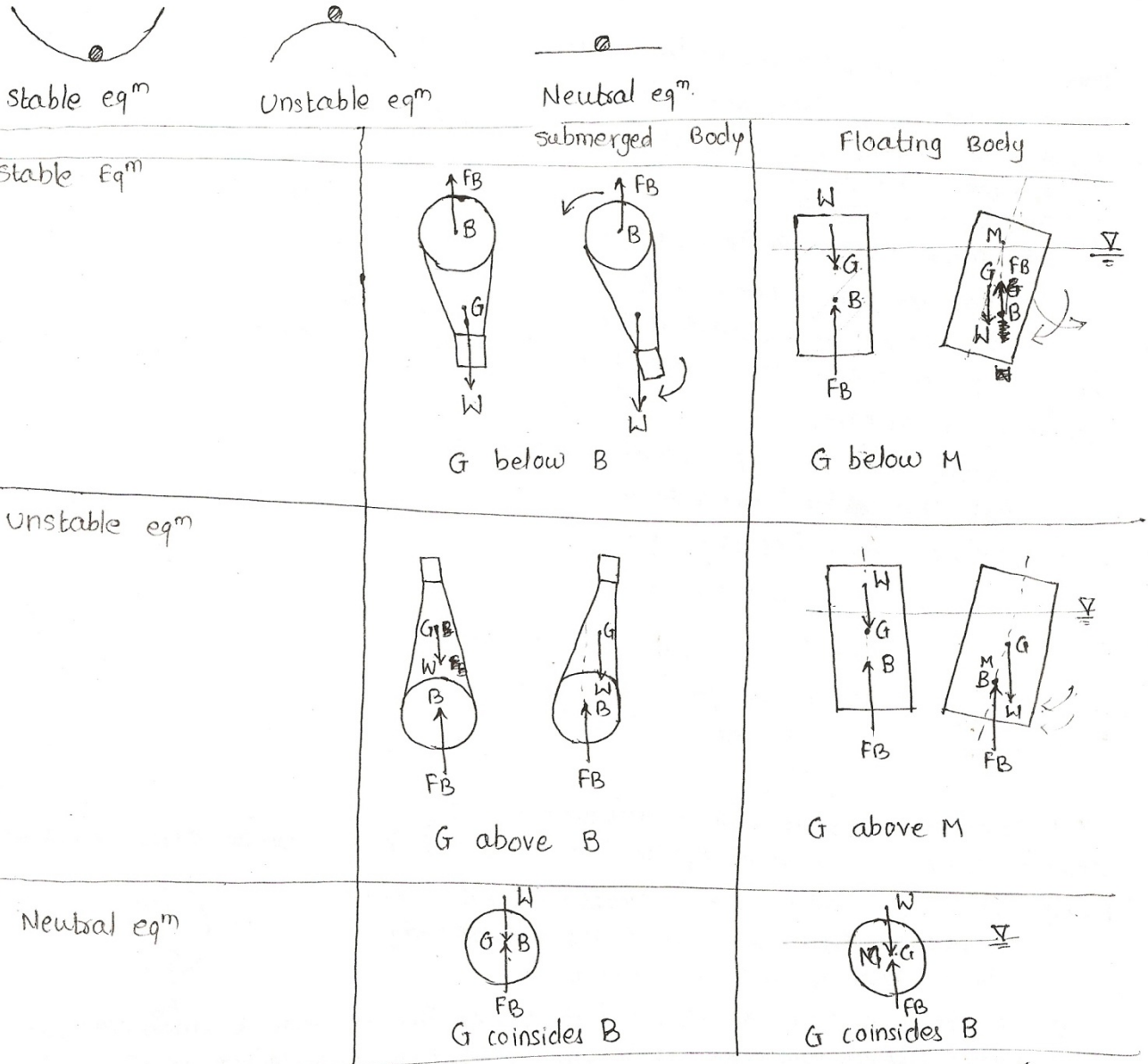
Stability of Submerged & Floating body:

Stability:- The tendency of a submerged or floating body to return its original position after it is subjected to angular displacement is known as stability.

① **Stable equilibrium:-** When body comes back to its original position after it is subjected to angular displacement is known as stable eqm.

② **Unstable equilibrium:-** When body is subjected to angular displacement, it further displaces from original position, is known as unstable eqm.

③ **Neutral eqm:-** When a body is subjected to angular displacement, it remains at displaced position, neither comes back to original position nor displaces further is known as neutral eqm.



Buoyancy

Buoyancy:- When body is immersed partially or fully in a fluid, it is subjected to upward component of pressure force, due to which body rise in a ~~force~~ fluid. This phenomenon is known as buoyancy.

Buoyant force:- The force which ~~which~~ lifts a body submerged partially or fully in a liquid ~~which~~ is known as buoyant force.

Archimedes Principle:- When a body is submerged partially or fully in liquid, the force which lifts the body

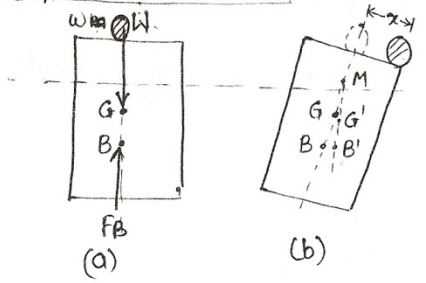
Rolling motion:- The oscillating motion of floating body (ship/boat) about longitudinal axis

Pitching motion: Oscillatory motion of boat or ship @ transverse axis.

Period of Pitching: $T = \frac{K}{\sqrt{g \cdot GM}} \cdot f(\theta)$ K = Radius of gyration w.r.t. axis of rolling.

Determination of metacentric height:-

① Experimental Method:



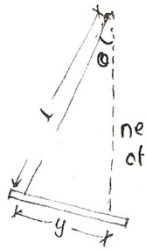
Consider a floating body of wt. kl. A known wt. of a body w is placed on deck such that body remains in horizontal position. At this time G & B are passing through vertical axis as shown in fig (a).

If wt. 'w' is shifted at a dist. 'x', G & B will move to new positions G' & B' resp. passing through same vertical line. fig (b).

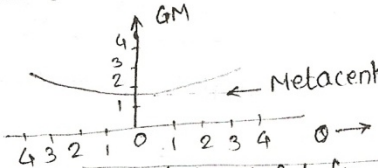
The angle of inclination of body with vertical (θ) can be measured by plumb bob by measuring x & l & y & $\tan\theta = y/l$

$\therefore w \cdot x = W \cdot GM \sin\theta$ as $\theta \to 0$, $\sin\theta = \tan\theta$

$$GM = \frac{w \cdot x}{W \tan\theta}$$



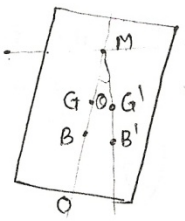
Metacentric ht at 0°∈ angle is calculated by plotting graph of GM on y axis and various values of θ on x axis as,



② Theoretical Mtd:- Experimental mtd. is useful for calculating GM after ship is constructed but while designing the ship, it is necessary to know metacentric ht. so theoretical mtd. is adopted.

$$GM = \frac{I}{V} \pm BG$$

I = Moment of Inertia.
V = Vol. of displaced body
BG = OG − OB.



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