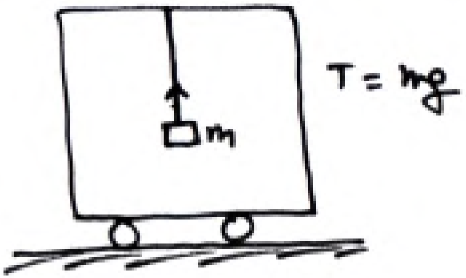
Revision Booster WORKSHOP for NEET & JEE Main

Waves & Fluid

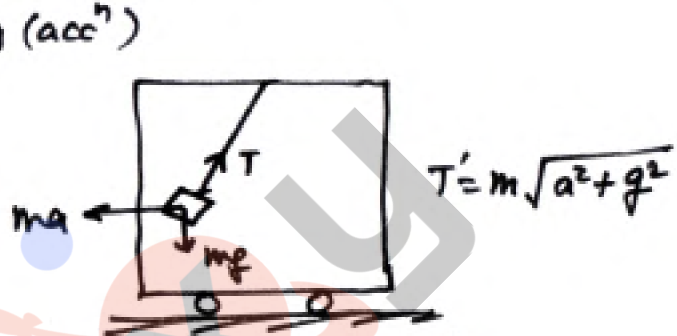
Notes of Revision Booster Workshop for JEE Main & NEET

Questions Based on

Wave Speed in an Accelerating Car

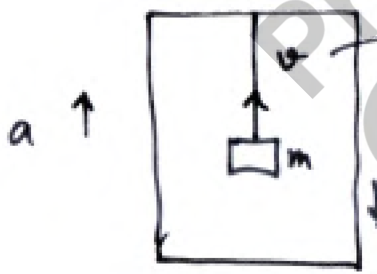


rest



Wave speed in string $v = \sqrt{\frac{T}{\mu}}$

Wave speed $v' = \sqrt{\frac{T'}{\mu}}$



$v \rightarrow \sqrt{\frac{T}{\mu}}$

$T = mg \pm ma$

QUESTIONS BASED ON

PARTICLE SPEED RELATED TO WAVE SPEED

SHW wave eq $y = A \sin(\omega t - kx) = A \sin\left(\frac{2\pi}{T}t - \frac{2\pi}{\lambda}x\right)$

↑ +x dir

wave speed $\left[v_w = f\lambda = \frac{1}{T}\cdot\frac{2\pi}{k} = \frac{\omega}{k}\right]$

particle speed $v_p = \frac{\partial y}{\partial t} = A\omega \cos(\omega t - kx)$

Q → find x where $\left[\begin{array}{l} v_p = 2v_w \\ v_w = 2v_p \end{array}\right]$

Questions Based on

Slope of Displacement Curve & Particle Speed

✓ $y = A\sin(\omega t - kx) \longrightarrow \tan\theta = \frac{\partial y}{\partial x} = -Ak\cos(\omega t - kx)$

$\frac{\partial y}{\partial t} = A\omega\cos(\omega t - kx)$

$\frac{\partial y}{\partial x} = -\frac{1}{v}\frac{\partial y}{\partial t}$

Displacement curve

$\underline{\text{Slope}} = -\frac{1}{v} \times (\text{Particle speed})$

→ $\underline{\text{Strain}}$ in case of longitudinal wave

QUESTIONS BASED ON

DIFFERENTIAL EQUATION OF A SHW

$y = A\sin(\omega t - kx)$

SHW eqⁿ

$$\frac{\partial y}{\partial x} = -Ak\cos(\omega t - kx) \rightarrow \frac{\partial^2 y}{\partial x^2} = -Ak^2\sin(\omega t - kx)$$

$$\frac{\partial y}{\partial t} = A\omega\cos(\omega t - kx) \rightarrow \frac{\partial^2 y}{\partial t^2} = -A\omega^2\sin(\omega t - kx)$$

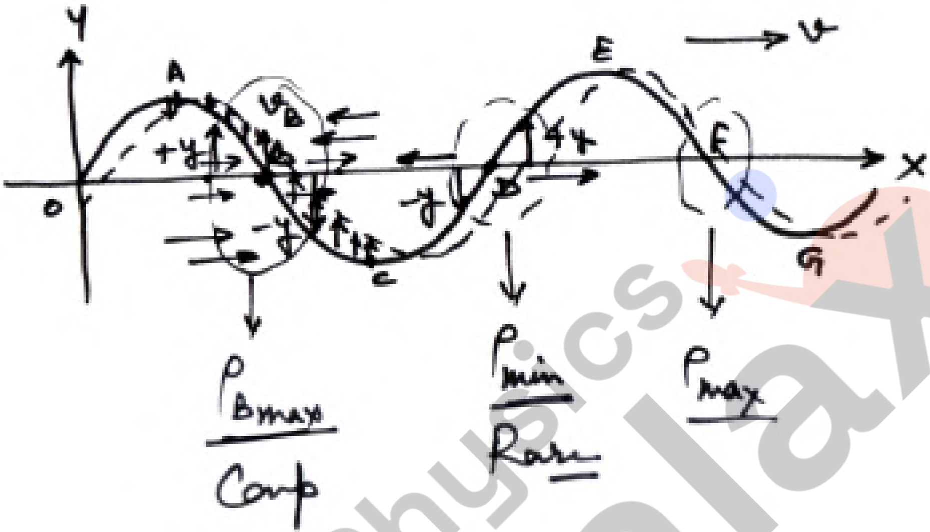
$$\frac{\partial y}{\partial x} = -\frac{1}{v}\frac{\partial y}{\partial t}$$

$$\boxed{\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}}$$

[Curvature of disp curve] = $\frac{1}{v^2}$ [particle accⁿ]

Questions Based on

Compressions & Rarefactions in Displacement Curve



Questions Based on

Wave Equation of a Non-Sinusoidal Wave

$$y = f(a_1 x + a_2 t)$$

$v = \left(\frac{a_2}{a_1}\right)$ wave speed in $-x$ dir

$y = f(x - vt)$

↓

Shift of f^n $y = f(x)$

$$y = e^{-(c_1 x + c_2 t)}$$

wave speed / pulse speed $v = \frac{c_2}{c_1}$

$$v = \frac{\text{Coeff of } t}{\text{Coeff of } x}$$

Questions Based on

Pressure Variation in Sound Waves

Pressure waves

Pressure variation

eqⁿ ⟶

disp max ⟶ ΔP min

disp 0 ⟶ ΔP max

Pressure Amp

Wave Intensity $I = \frac{(\Delta P_0)^2}{2\rho v}$

$\Delta P_0 = \frac{2\pi}{\lambda} AB$

Phase diff between ΔP_x and y_x is 90°

$\Rightarrow$ if $y_x = A \sin(\omega t - kx)$

$\Rightarrow \Delta P_x = \Delta P_0 \cos(\omega t - kx)$

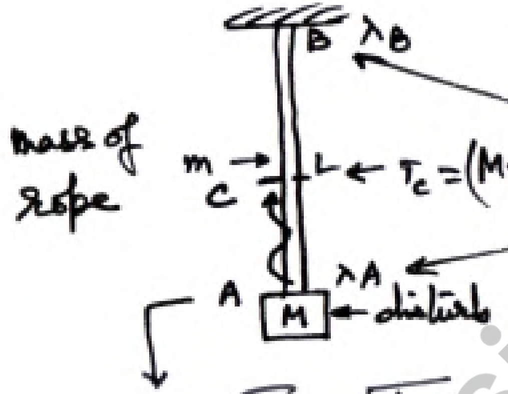
at pos $y = 0$ at these pos of x P_{max} or P_{min}

$P_{atm} + \Delta P_0$ $\quad$ $P_{atm} - \Delta P_0$.

QUESTIONS BASED ON

WAVE PROPAGATING IN A HANGING ROPE

$$\frac{\lambda_A}{\lambda_B} = ?$$



$$T_B = (M+m)g$$

$$T_C = \left(M + \frac{m}{2}\right)g$$

$$T_A = Mg$$

$$v_A = \sqrt{\frac{T_A}{\mu}} = \sqrt{\frac{MgL}{m}} \; ; \quad v_B = \sqrt{\frac{T_B}{\mu}} = \sqrt{\frac{(M+m)gL}{m}}$$

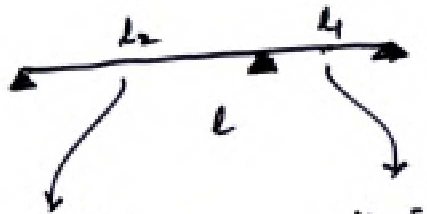
$$\mu = \frac{m}{L}$$

$$v = f\lambda$$

$$\Rightarrow \frac{v_A}{v_B} = \frac{\lambda_A}{\lambda_B} = \sqrt{\frac{M}{M+m}}$$

Questions Based on

Resonance in Different Parts of a String



$$n_f = \frac{v}{2l} = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

$$n_{2f} = \frac{v}{2l_2} \qquad n_{1f} = \frac{v}{2l_1}$$

$$p\, n_{2f} = q\, n_{1f}$$

$$\frac{p}{q} = \frac{n_{1f}}{n_{2f}} = \frac{3}{7} \Rightarrow$$ both parts resonate at $p = 3$ & $q = 7$

$$\Rightarrow n_{fR} = 3n_{2f} = 7n_{1f} = \underline{\quad}$$

QUESTIONS BASED ON

BEATS IN TUNING FORK AND A CLAMPED STRING

$n_1 = \frac{v}{2l}$; $v = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

When tuning fork arms are filed.

$\Rightarrow n_f\uparrow$ or $n_0\uparrow$

on loading arms of fork

$\Rightarrow n_f\downarrow$ or $n_0\downarrow$

(f_B) Beats $= |n_1^{\uparrow} - n_0|$ Beats/s.

$\rightarrow (n_0 - n_1)$

Case-I if $n_1 > n_0$

$\Rightarrow$ on $T\uparrow \Rightarrow f_B$ will increase

Case-II: if $n_1 < n_0$

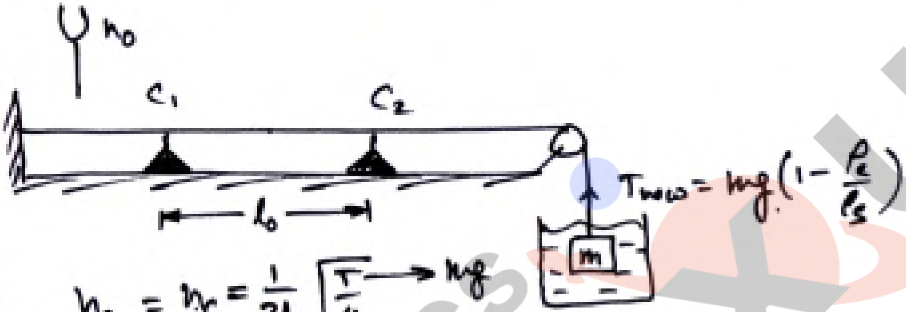
on $T\uparrow \Rightarrow$ first as T increases f_B decrease

but on further inc in T

f_B may increase!

Questions Based on

Submerging Load of Sonometer in a Liquid



Initially

$$n_0 = n_f = \frac{1}{2l_0}\sqrt{\frac{T}{\mu}} \quad (T \rightarrow mg)$$

$\left(\frac{n_0}{3}\right)$ ← if string oscillates in III Harmonic

$$n_f' = \frac{1}{2l_0}\sqrt{\frac{T_{new}}{\mu}} < n_f$$

as $n_f' < n_f \Rightarrow l_0$ is to be decreased to l_f

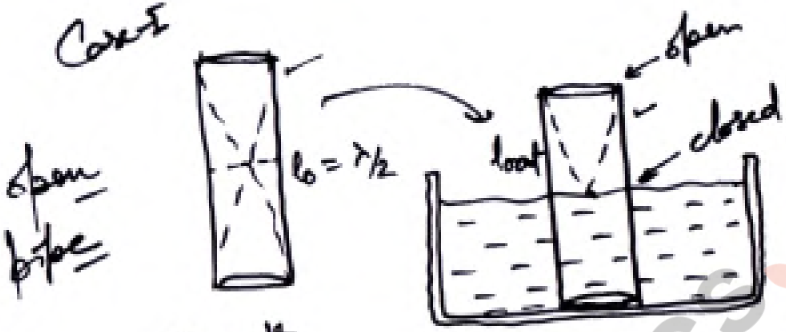
such that

$$\frac{1}{2l_f}\sqrt{\frac{T_{new}}{\mu}} = n_f = n_0.$$

$$l_f = \_\_\_\_$$

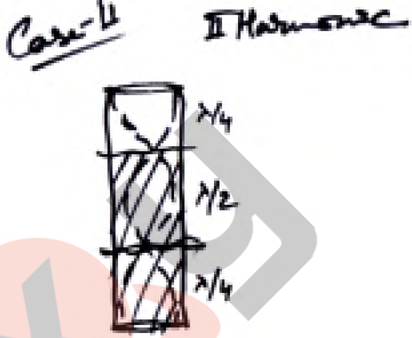
Questions Based on

Dipping of an Organ Pipe in Water



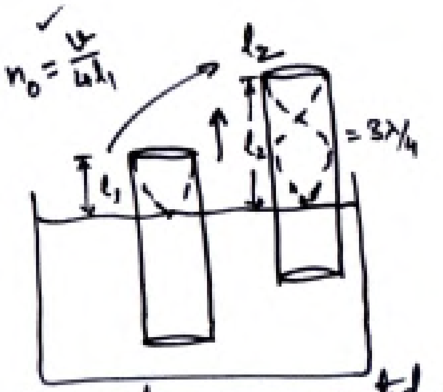
$n_f = \frac{v}{2l_0}$

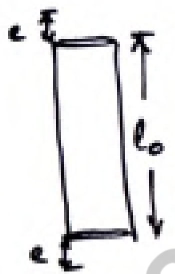
$n = \frac{v}{4l_{out}} = \frac{v}{2l_0} = n_f.$



Questions Based on

Pulling Out a Pipe From Water





$$n_{f0} = \frac{v}{2(l_0+2e)}$$

If end correction is accounted

$$n_0 = \frac{v}{4(l_1+e)} = \frac{3v}{4(l_2+e)}$$

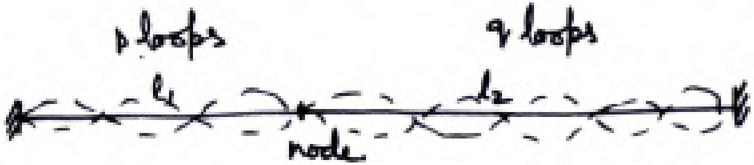
$e = $ ___

Case-I: if $l_2 = 3l_1 \Rightarrow$ ignore 'e'

if $l_2 \neq 3l_1 \Rightarrow$ Consider 'e'

Questions Based on

Oscillations of Composit Strings



$$\frac{p v_1}{2 l_1} = \frac{q v_2}{2 l_2}$$

$$\frac{p}{q} = \frac{v_2 l_1}{v_1 l_2} = \frac{4}{11}$$

→ for min freq of resonance, we use

$p = 4$ & $q = 11$

$$\nu_{min} = \frac{4 v_1}{2 l_1} = \frac{11 v_2}{2 l_2} = \text{—}$$

QUESTIONS BASED ON

SUCCESSIVE RESONANT FREQUENCIES OF AN OSCILLATING DEVICE

for a clamped string n_1 and n_2 are two successive Res. freq.

$n_1 \to$ 75 Hz (5th Harmonic), $n_2 \to$ 90 Hz (6th Harmonic)

$\Delta n = 90 - 75 = 15\,Hz$ fund freq of clamped string

for closed pipe only odd harmonic freq are available for resonance.

n_1 and n_2 are two succ freq of resonance.

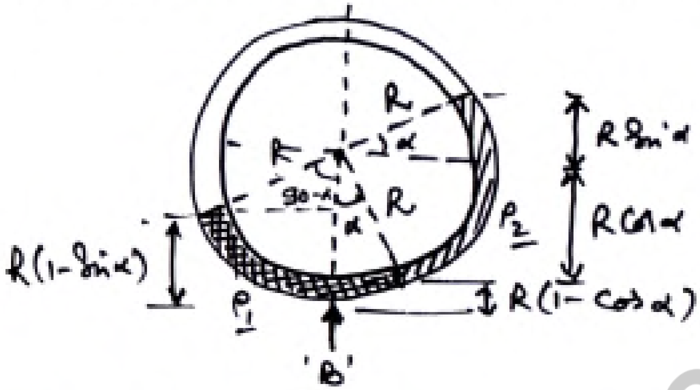
n_1 (3rd), n_2 (5th).

$n_2 - n_1 = 2n_0$

$n_0 \to$ fundamental freq.

QUESTIONS BASED ON

EQUILIBRIUM IN A CIRCULAR TUBE



$\rho_1 > \rho_2$

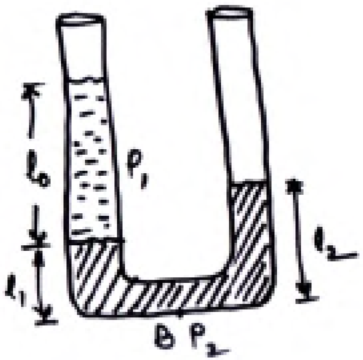
at pt B, we use

$$\rho_1 g R(1-\sin\alpha) = \rho_1 g R(1-\cos\alpha) + \rho_2 g R(\sin\alpha + \cos\alpha)$$

$\alpha =$ ——

QUESTIONS BASED ON

EQUILIBRIUM IN U-TUBE



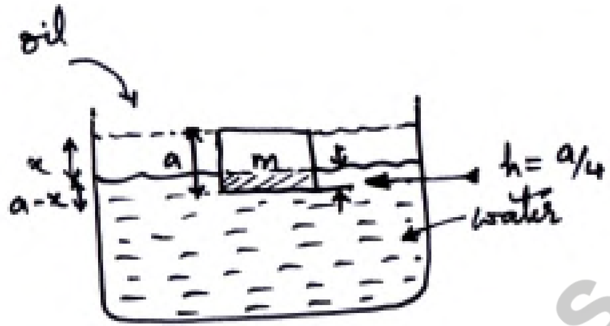
at pt B.

$$l_0 \rho_1 g + l_1 \rho_2 g = l_2 \rho_2 g$$

$\rho_2 > \rho_1$

QUESTIONS BASED ON

SUBMERGING A FLOATING BODY



Initially

$$mg = \rho_w A(a/4)g \quad —(1)$$

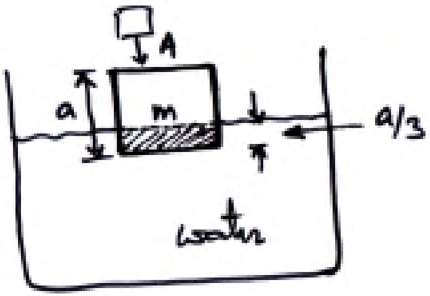
after pouring of oil for eqn of block, we use

$$mg = \rho_w A(a-x)g + \rho_{oil} A x g \quad —(2)$$

$x =$ ______

QUESTIONS BASED ON

WEIGHT REQUIREMENT FOR COMPLETE SUBMERGING



Initially at eqm

$$mg = \rho_\omega A(a/3)g$$

if m_1 is placed over m for complete submerging the block

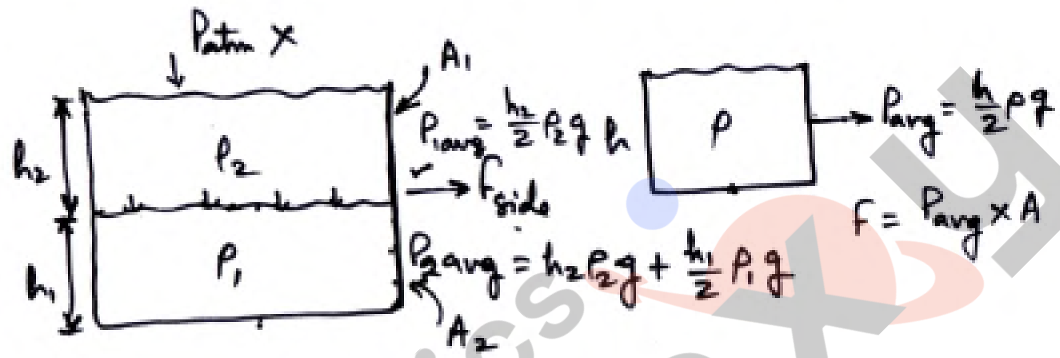
we use

$$(m_1+m)g = \rho_\omega A a g$$

$$m_1 = \_\_\_$$

QUESTIONS BASED ON

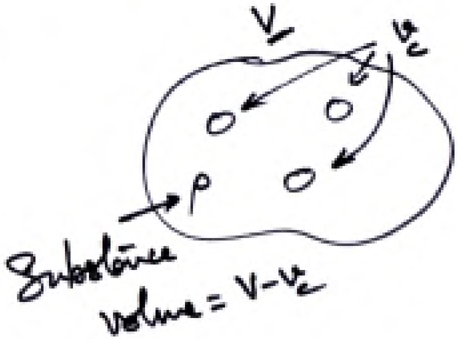
FORCE ON SIDE WALLS OF A CONTAINER



$$f_{side} = \left(\frac{h_2}{2}\rho_2 g\right)A_1 + \left(h_2\rho_2 g + \frac{h_1}{2}\rho_1 g\right)A_2$$

QUESTIONS BASED ON

ANALYSING CAVITY VOLUME IN A SOLID



weight in air = m kgf $= (V - v_c)\rho$

weight in water = m' kgf

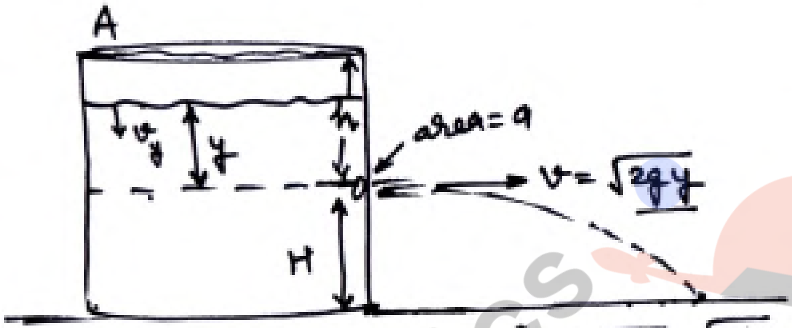
$v_c =$ ——

$m'g = mg - V\rho_\omega g$

$m' = m - V\rho_\omega \rightarrow V =$ ——

QUESTIONS BASED ON

CHANGING WATER LEVEL IN A CONTAINER



$$R = \sqrt{2gy} \cdot \sqrt{2H/g}$$

$$a \cdot \sqrt{2gy} = A \cdot v_y$$

$$-\frac{dy}{dt} = v_y = \frac{a}{A}\sqrt{2gy}$$

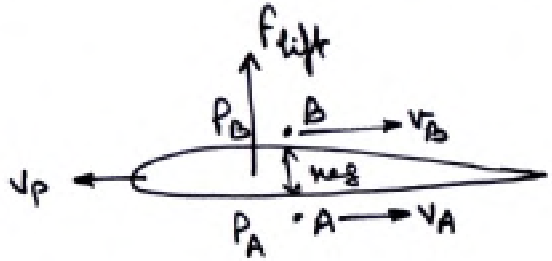
$$-\int_h^y \frac{dy}{\sqrt{y}} = \frac{a}{A}\sqrt{2g}\int_0^t dt$$

$$-2\left(\sqrt{y} - \sqrt{h}\right) = \frac{a}{A}\sqrt{2g}\, t$$

$$h \propto t^2 \quad \& \quad t \propto \sqrt{h}$$

QUESTIONS BASED ON

PRESSURE DIFFERENCE ON SIDES OF AN AEROPLANE WING



using Bernoulli's theorem

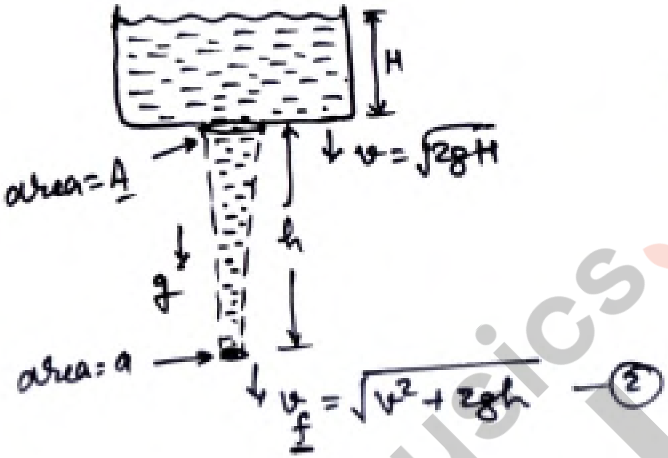
$$P_A + \frac{1}{2}\rho v_A^2 = P_B + \frac{1}{2}\rho v_B^2$$

$$P_A - P_B = \frac{1}{2}\rho (v_B^2 - v_A^2)$$

$$F_{lift} = (P_A - P_B) \times \text{area of wing} = Mg.$$

Questions Based on

Cross-Section of a Vertical Water Stream

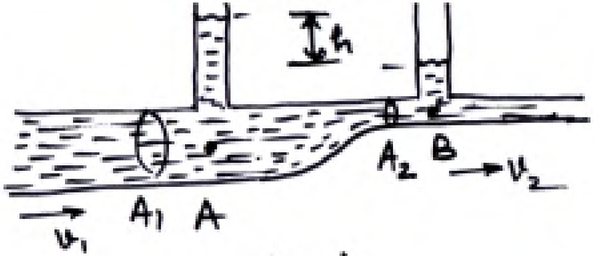


by eqn of Cont

$vA = v_f \cdot a$ — (1)

Questions Based on

Questions Based on Venturi Tube



$$A_1 > A_2$$

$$A_1 v_1 = A_2 v_2 \longrightarrow v_2 = \frac{A_1 v_1}{A_2}$$

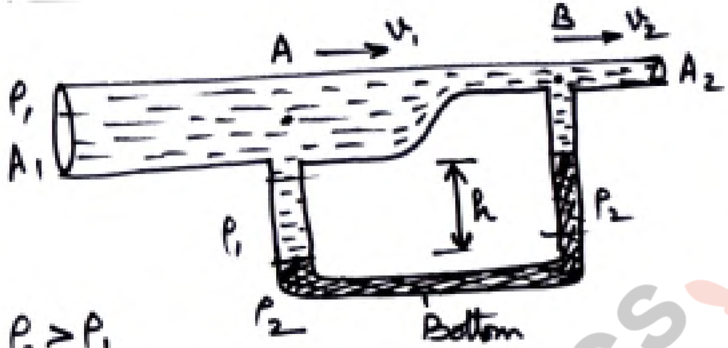
Using Bernoulli's eqn at A and B.

$$P_A + \frac{1}{2}\rho v_1^2 = P_B + \frac{1}{2}\rho v_2^2$$

$$P_A - P_B = h\rho g = \frac{1}{2}\rho(v_2^2 - v_1^2)$$

$$v_1 = \underline{\qquad}$$

Questions Based on Pitot Tube



$A_1 v_1 = A_2 v_2$ — (1)

$\rho_2 > \rho_1$

using B.T. at A & B, we get

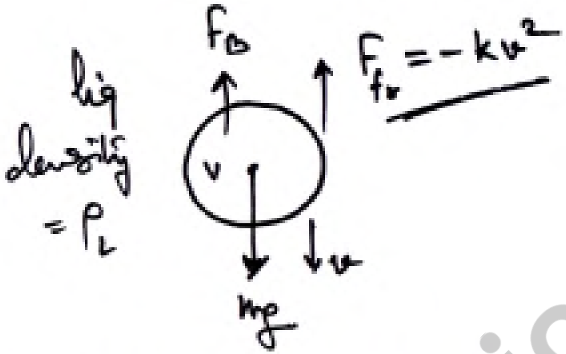
$$P_A + \frac{1}{2}\rho v_1^2 = P_B + \frac{1}{2}\rho v_2^2$$

$$P_A - P_B = h(\rho_2 - \rho_1)g = \frac{1}{2}\rho(v_2^2 - v_1^2) \quad \text{— (2)}$$

$h = $ ____

QUESTIONS BASED ON

TERMINAL SPEED OF A FALLING BALL IN VISCOUS LIQUID



terminal speed is attained when

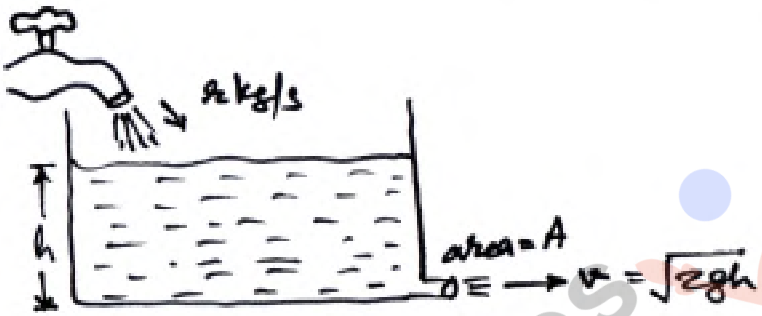
$$mg = F_B + F_{fr}$$

$$V\rho_s g = V\rho_L g + kv_T^2$$

$$v_T = \_\_\_\_\_\_$$

Questions Based on

Equilibrium Level of a Liquid in a container



At eq^n height, we use

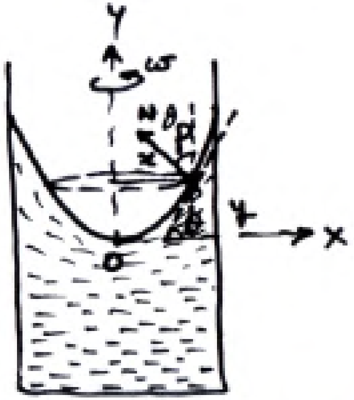
$$\lambda = \rho A v$$

$$\lambda = \rho A \sqrt{2gh}$$

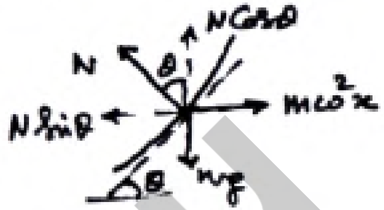
$$\Rightarrow \quad h = \frac{\lambda^2}{2g\rho^2 A^2}$$

Questions Based on

Surface Profile of a Rotating Fluid



$\tan\theta = \frac{dy}{dx}$



for rotation of particle at P

$N\cos\theta = mg$

$N\sin\theta = m\omega^2 x$

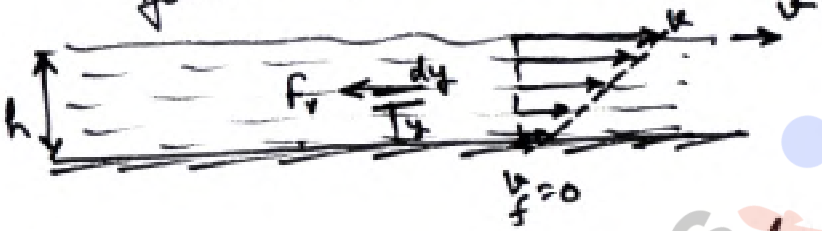
$\tan\theta = \frac{dy}{dx} = \frac{\omega^2 x}{g}$

$\Rightarrow$ $y = \frac{\omega^2 x^2}{2g}$

QUESTIONS BASED ON

SHEAR STRESS IN LAYERS OF FLOWING FLUID

for small h, we consider linear velocity profile



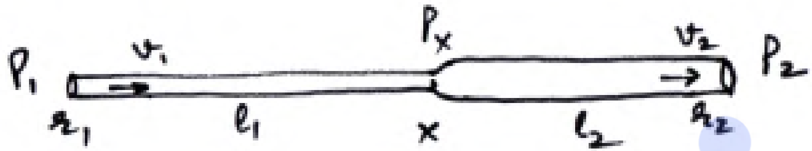
$$\frac{\partial v}{\partial y} = \frac{v}{h}$$

force of viscosity $F_v = \eta A \frac{dv}{dy} = \eta A \frac{v}{h}$

Shear stress $= \left(\frac{F_{tang}}{A}\right) = \frac{\eta v}{h}$ ✓

Questions Based on

Fluid Flowing Through Capillaries in Series



$A_1 v_1 = A_2 v_2$

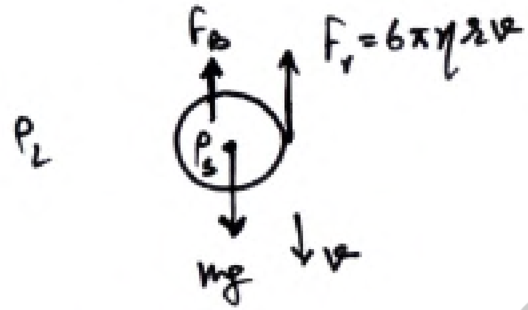
$\pi r_1^2 \quad \pi r_2^2$

volume flow rate of fluid is given as

$$\frac{dQ}{dt} = \frac{\pi r_1^4}{8\eta l_1}(P_1 - P_x) = \frac{\pi r_2^4}{8\eta l_2}(P_x - P_2)$$

QUESTIONS BASED ON

TERMINAL SPEED OF A BALL BY STOKE'S RULE



At terminal speed, $a = 0$

$$\Rightarrow \quad mg = F_B + F_r$$

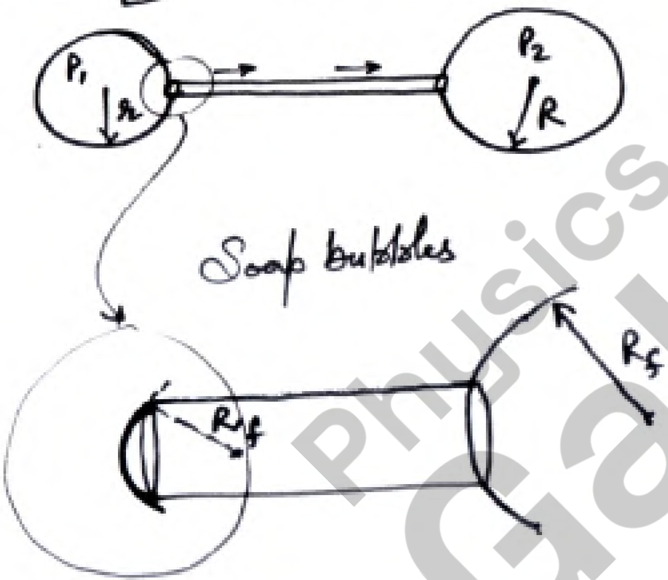
$$\frac{4}{3}\pi r^3 \rho_s g = \frac{4}{3}\pi r^3 \rho_L g + 6\pi\eta r v$$

$$v_T = \_\_\_\_\_\_.$$

QUESTIONS BASED ON

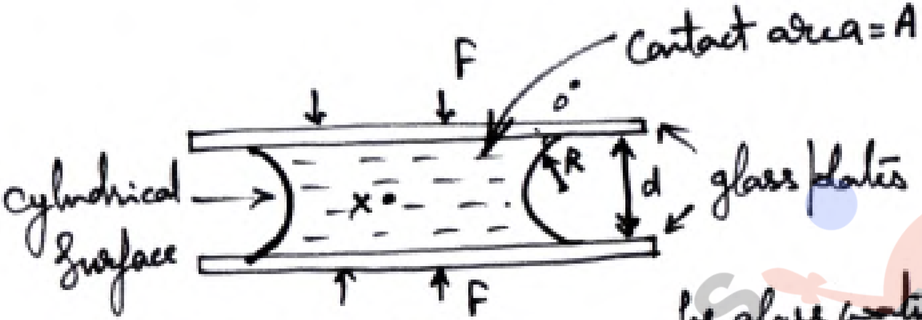
AIR FLOW IN CONNECTED BUBBLES

$P_1 = P_{atm} + \frac{4T}{r}$ $(P_1 > P_2)$ $P_2 = P_{atm} + \frac{4T}{R}$



QUESTIONS BASED ON

FORCE BETWEEN TWO GLASS PLATES



for glass water $\theta_c \approx 0°$

$\Rightarrow R = d/2$

$$P_x = P_{atm} - \frac{T}{R}$$

$$P_x = P_{atm} - \left(\frac{2T}{d}\right)$$

excess pressure in atm

excess force by atm to hold plates together is

$$F = \Delta P . A = \frac{2TA}{d}$$

Questions Based on

Energy Changes in Merging Liquid Drops

n drops (rad = r) ⇒

$$n \cdot \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$$

$$R = n^{1/3} \cdot r$$

Surface energy initial

$$E_i = n \cdot 4\pi r^2 \times T$$

final

$$E_f = 4\pi R^2 \times T$$

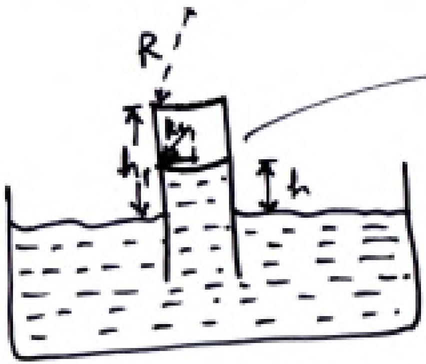
loss in S.E

$$4\pi T\left[n r^2 - n^{2/3} r^2\right] = ms\Delta T$$

$$\Delta T = \text{- - -}$$

Questions Based on

Water Rise in Low Height Capillary



$$h_c = \frac{2T\cos\theta}{r\rho g}$$ ✓

$r_c = R_c \cos\theta$

if $h_1 < h_c$ ⇒ liq will rise to the top and its rad of curvature increases to R such that

$\underline{h_c R_c = hR}$ ← $h_c r = hR$ $\theta \approx 0°$

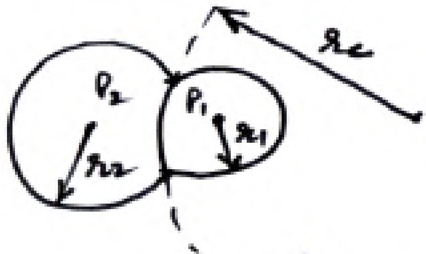
$R =$ ______

↓

$\left(\frac{r_c}{\cos\theta}\right)$

Questions Based on

Common Curvature of Two Soap Bubbles



$$P_1 - P_2 = \frac{4T}{r_c} \longrightarrow \frac{1}{r_1} - \frac{1}{r_2} = \frac{1}{r_c}$$

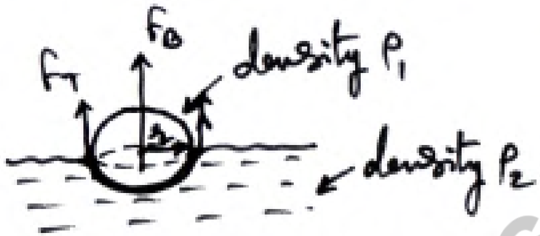
$$r_c = \text{——}$$

$$P_1 = P_{atm} + \frac{4T}{r_1}$$

$$P_2 = P_{atm} + \frac{4T}{r_2}$$

QUESTIONS BASED ON

FLOATING DROP IN ANOTHER LIQUID



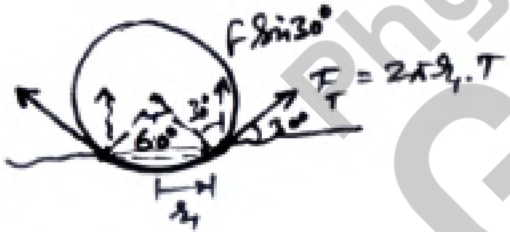
floating conditions $F_T + F_B = mg$

$F_T = T \cdot 2\pi r$

$F_B = \frac{2}{3}\pi r^3 \cdot \rho_2$

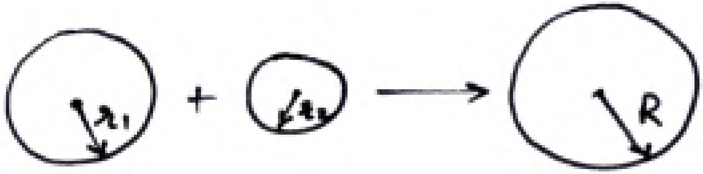
$\rho_2 > \rho_1$

$$\left[T(2\pi r) + \frac{2}{3}\pi r^3 \cdot \rho_2 = \frac{4}{3}\pi r^3 \cdot \rho_1 \right]$$



QUESTIONS BASED ON

COALESCING OF TWO SOAP BUBBLES



If $T = $ Const

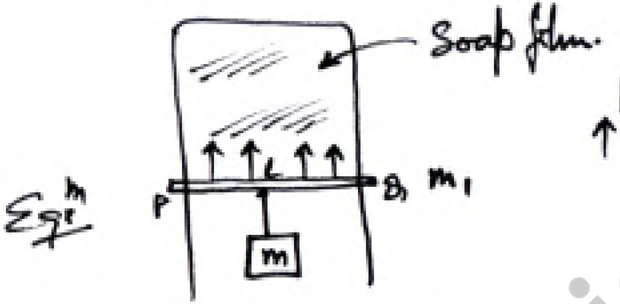
$$P_1 V_1 + P_2 V_2 = P_f V_f$$

$$\left[\left(P_{atm} + \frac{4T}{r_1}\right)\frac{4}{3}\pi r_1^3 + \left(P_{atm} + \frac{4T}{r_2}\right)\frac{4}{3}\pi r_2^3 = \left(P_{atm} + \frac{4T}{R}\right)\frac{4}{3}\pi R^3\right]$$

change in SE $\quad \Delta E = T\left[4\pi r_1^2 + 4\pi r_2^2\right] - T\left[4\pi R^2\right].$

Questions Based on

Liquid Film Supporting a Weight



$$\uparrow F_{up} = Tl \times 2 = (m + m_1)g.$$