① — Tbask WS–10 9th foundation

Refractive index of glass $\mu_g = \frac{3}{2}$

Time taken by light to travel in glass $t_g = ?$

Time taken by light to travel in air $t_a = 4$ sec.

Refractive index of air $\mu_a = 1$

∴ Given distance travelled by the light in air and glass same

$$x_{air} = x_{glass}$$

$$\Rightarrow V_a t_a = V_g t_g$$

But Velocity $\propto \frac{1}{\mu}$

$$\frac{V_a}{V_g} = \frac{\mu_g}{\mu_a}$$

$$\therefore \Rightarrow \mu_g t_a = \mu_a t_g$$

$$\Rightarrow \frac{3}{\cancel{2}} \times \cancel{4}^{2} = 1 \times t_g$$

$$\Rightarrow t_g = 6 \text{ sec.}$$

②

Given wavelength of light $\lambda = 6000 A°$

Refractive index of air $\mu_a = 1.0003$

let the thickness of air column 't'

we know that no. of. wavelengths $n = \frac{t}{\lambda}$

For air $n_{air} = \frac{t_a}{\lambda_a} \Rightarrow t_a = n_{air} \lambda_a$

For vacumn $n_v = \frac{t_v}{\lambda_v} \Rightarrow t_v = n_v \lambda_v$

Given $n_a = 1 + n_v$ $[t_a = t_v]$

$$\Rightarrow \frac{t_a}{\lambda_a} = 1 + \frac{t_v}{\lambda_v}$$

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$$\frac{t_a}{\lambda_a} - \frac{t_v}{\lambda_v} = 1$$

We know $\mu \propto \frac{1}{\lambda}$

$$\Rightarrow t\left[\frac{1}{\lambda_a} - \frac{1}{\lambda_v}\right] = 1$$

$$\Rightarrow \frac{\mu_v}{\mu_a} = \frac{\lambda_a}{\lambda_v}$$

$$\Rightarrow t\left[\frac{\mu_a}{\lambda_v} - \frac{1}{\lambda_v}\right] = 1$$

$$\Rightarrow \lambda_a = \lambda_v \frac{\mu_v}{\mu_a}$$

$$= \frac{\lambda_v}{\mu_a} \quad [\mu_v = 1]$$

$$\Rightarrow \frac{t}{\lambda_v}[\mu_a - 1] = 1$$

$$\Rightarrow t = \frac{\lambda_v}{\mu_a - 1} = \frac{6000 \times 10^{-10}}{1.0003 - 1} = \frac{6 \times 10^{-7}}{.0003} = \frac{6 \times 10^{-7}}{3 \times 10^{-4}} = 2 \text{ mm}$$

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let the two medias are A and B.

Given $\frac{\text{Distance travelled by a light in A}}{\text{Distance travelled by a light in B}} = \frac{2}{3}$

$\Rightarrow$ Distance $\propto$ velocity $\propto \frac{1}{\mu}$.

$$\therefore \frac{d_A}{d_B} = \frac{\mu_B}{\mu_A}$$

$$\Rightarrow \frac{\mu_B}{\mu_A} = \frac{2}{3}$$

$$\Rightarrow \frac{\mu_A}{\mu_B} = \frac{3}{2}$$

(4)

Thickness of slab $t_s = 4cm$

Thickness of water $t_\omega = 5cm$

Refractive index of water $\mu_\omega = \frac{4}{3}$

$$\text{No. of waves} = \frac{\text{thickness of medium}}{\text{wavelength of light}}$$

Given that No. of waves in slab = No. of waves in water

$$\Rightarrow \frac{t_s}{\lambda_s} = \frac{t_\omega}{\lambda_\omega}$$

$$\Rightarrow \frac{\lambda_\omega}{\lambda_s} = \frac{t_\omega}{t_s}$$

∵ we know that $\mu \propto \frac{1}{\lambda}$

$$\Rightarrow \frac{\lambda_\omega}{\lambda_s} = \frac{\mu_s}{\mu_\omega}$$

$$\Rightarrow \frac{\mu_s}{\mu_\omega} = \frac{t_\omega}{t_s}$$

$$\Rightarrow \mu_s = \mu_\omega \times \frac{t_\omega}{t_s}$$

$$\Rightarrow \mu_s = \frac{\cancel{4}}{3} \times \frac{5}{\cancel{4}}$$

$$\Rightarrow \mu_s = \frac{5}{3}$$

(5)

wavelength of light in vacumn $\lambda_v = 5700\,A^\circ$

Refractive index of glass $\mu_g = \frac{3}{2}$

Refractive index of vacumn $\mu_v = 1$

We know that $\mu \propto \frac{1}{\lambda}$

$$\Rightarrow \frac{\lambda_g}{\lambda_v} = \frac{\mu_v}{\mu_g} \Rightarrow \lambda_g = \lambda_v \times \frac{\mu_v}{\mu_g} = \overset{1900}{\cancel{5700}} \times \frac{2}{\cancel{3}}$$

$$\Rightarrow \lambda_g = 3800\,A^\circ$$

⑥

velocity of light in $A = V_A = 2\times10^8$ m/s

velocity of light in $B = V_B = 2.5\times10^8$ m/s

we know that critical angle.

$$\sin c = \frac{1}{\mu} = \frac{V_A}{V_B}$$

$$\Rightarrow \sin c = \frac{2\times10^8}{2.5\times10^8} = \frac{2}{2.5}$$

$$\Rightarrow \sin c = \frac{20}{25}$$

$$\Rightarrow \sin c = \frac{4}{5} \Rightarrow c = \sin^{-1}\left(\frac{4}{5}\right)$$

⑦

Critical angle $c = 45^\circ$; Velocity in vacumn $V_v = c$

Light is travelling from medium to vacumn

we know that $\sin c = \frac{1}{{}_v\mu_m}$

$$\Rightarrow \sin 45^\circ = \frac{\mu_v}{\mu_m} = \frac{V_m}{V_v}$$

$$\Rightarrow \frac{1}{\sqrt{2}} = \cancel{\frac{\mu_v}{\mu_m}}\ \frac{V_m}{V_v}$$

$$\Rightarrow V_m = \frac{V_v}{\sqrt{2}} = \frac{c}{\sqrt{2}}.$$

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let μ_1, μ_2 are the refractive indices for medium$_1$ & medium$_2$

when light travels from medium$_1$ to vaccumn is C_1

$$\therefore \quad \sin C_1 = \frac{1}{{}_v\mu_{m_1}} = \frac{\mu_v}{\mu_{m_1}} \rightarrow (1)$$

when light travels from medium$_2$ to vaccumn is C_2

$$\therefore \quad \sin C_2 = \frac{1}{{}_v\mu_{m_2}} = \frac{\mu_v}{\mu_{m_2}} \rightarrow (2)$$

By dividing (1) & (2) we get

$$\frac{\sin C_1}{\sin C_2} = \frac{\frac{\mu_v}{\mu_{m_1}}}{\frac{\mu_v}{\mu_{m_2}}} = \frac{\mu_{m_2}}{\mu_{m_1}}$$

$$\Rightarrow \text{Refractive index} = \frac{\mu_{m_1}}{\mu_{m_2}} = {}_{m_1}\mu_{m_2} = \frac{\sin C_2}{\sin C_1}$$

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Given that real depth $h = 1m$.

Apparent depth = Real depth − shift

= 1 − 0·1 = 0·9 m

we know that Refractive index $\mu = \frac{\text{Real depth}}{\text{apparent depth}}$

$$\Rightarrow \mu = \frac{1}{0{\cdot}9} = \frac{10}{9}.$$

(9)

velocity of light in medium, is V_1

Refractive index $\mu_1 = 1$ [vacumn]

$V_1 = \frac{x_1}{t_1}$; $V_2 = \frac{x_2}{t_2}$. { x_1, x_2 are distance travelled by the light in two mediums]

The refractive index of second medium $= \mu_2$.

we know that $\frac{V_1}{V_2} = \frac{\mu_2}{\mu_1}$.

$$\Rightarrow \frac{x_1 t_2}{x_2 t_1} = \frac{\mu_2}{\mu_1}$$

Also for critical angle.

$$\sin c = \frac{1}{{}_2\mu_1} = \frac{\mu_1}{\mu_2}$$

$$\therefore \Rightarrow \sin c = \frac{x_2 t_1}{x_1 t_2}$$

$$\Rightarrow c = \sin^{-1}\left[\frac{x_2 t_1}{x_1 t_2}\right]$$

(10)

velocity of light in i^{th} medium $= V_1 = c$

Refractive index of I^{st} medium $= \mu_1 = 1$ [vacumn]

velocity of light in 2^{nd} medium is V_2, it's refractive index is μ_2, $t \to$ time

Given $x \to$ distance travelled by the light in I^{st} medium

$x_0 \to$ distance travelled by the light in vacum

$\therefore V_1 = \frac{x_0}{t}$; $V_2 = \frac{x}{t}$.

we know that $\frac{V_1}{V_2} = \frac{\mu_2}{\mu_1} =$

10th continuation

$$\frac{v_1}{v_2} = \frac{x_0}{x}$$

$$\Rightarrow \frac{\mu_2}{\mu_1} = \frac{x_0}{x} \Rightarrow \mu_2 = \frac{x_0}{x}$$

From $\sin c = \frac{1}{\mu}$

$$\Rightarrow \sin c = \frac{x}{x_0}$$

$$\Rightarrow c = \sin^{-1}\left[\frac{x}{x_0}\right]$$

(12)

we know that when we view from underwater

$$\mu = \frac{\text{apparent height}}{\text{real height}}$$

Apparent height from surface $= 36 - 12 = 24\,m$.

$$\mu = \frac{4}{3}$$

$$\therefore \frac{4}{3} = \frac{24}{\text{real height}}$$

$$\Rightarrow \text{Real height} = 24 \times \frac{3}{4} = 18\,m.$$

(10) The shift produced in the path of the ray is given

(10)

by $d = \frac{t}{\cos r} \sin(i-r) \rightarrow (1)$

Given $\angle i = 60^\circ$; Refractive index of glass slab $= \mu_g = \sqrt{3}$

Thickness $t = \sqrt{3}$ cm

From snells law $\frac{\mu_g}{\mu_a} = \frac{\sin i}{\sin r}$

$\Rightarrow \sqrt{3} = \frac{\sin 60}{\sin r}$

$\Rightarrow \sqrt{3} \sin r = \frac{\sqrt{3}}{2} \Rightarrow \sin r = \frac{1}{2}$

$\Rightarrow r = 30^\circ$

$\therefore$ From (1)

$d = \frac{\sqrt{3}}{\cos 30} \sin(60-30)$

$= \frac{\sqrt{3}}{\frac{\sqrt{3}}{2}} \times \sin 30$

$\Rightarrow 2 \times \frac{1}{2} = 1$ cm

(10)

(15)

(17) Given $_a\mu_{gly} = 1.4$; $_a\mu_{dia} = 2.4$.

Velocity of light in air $c = 3\times10^8$ m/s

$\therefore$ we know that velocity $\propto \frac{1}{\mu}$

$\therefore$ Refractive index of glycerine with respect to air

$$_a\mu_{gly} = \frac{\mu_a}{\mu_{gly}} = \frac{V_{gly}}{c}$$

velocity in glycerine $\Rightarrow V_{gly} = c \times \frac{\mu_a}{\mu_{gly}} = 3\times10^8 \times \frac{1}{1.4}$

$$\Rightarrow V_{gly} = 2.143\times10^8 \text{ m/s}$$

$||^{ly}$ velocity of light in diamond $= c\times\frac{\mu_a}{\mu_{dia}} = 3\times10^8\times\frac{1}{2.4}$

$$V_{dia} = 1.25\times10^8 \text{ m/s}$$

Refractive index of diamond with respect to glycerine

$$_{gly}\mu_d = \frac{\mu_{gly}}{\mu_{dia}} = \frac{1.4}{2.4} = 0.5833$$

Refractive index of glycerine with respect to diamond

$$_d\mu_{gly} = \frac{\mu_d}{\mu_{gly}} = \frac{2.4}{1.4} = 1.714.$$

(18)

we know that No. of waves $= \dfrac{\text{thickness of the medium}}{\text{wavelength of light}}$

Thickness of glass slab $t_g = 4\,cm$.

Thickness of water $t_w = 5\,cm$.

Refractive index of water $\mu_w = \frac{4}{3}$; $\mu_g = ?$

Given

No. of waves in glass slab = No. of waves in water

$$\Rightarrow \frac{t_g}{\lambda_g} = \frac{t_w}{\lambda_w}$$

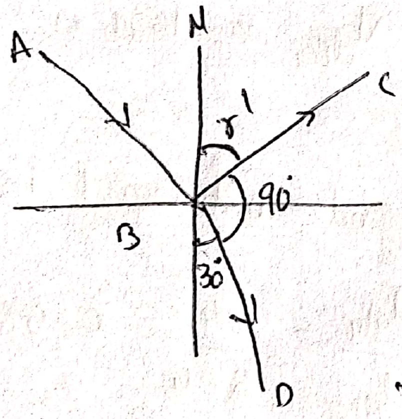
$$\Rightarrow t_g = \frac{\lambda_g}{\lambda_w} t_w \quad \left[\because \lambda \propto \frac{1}{\mu}\right]$$

$$\Rightarrow t_g = \frac{\mu_w}{\mu_g} t_w$$

$$\Rightarrow \mu_g = \mu_w \times \frac{t_w}{t_g} = \frac{4}{3} \times \frac{5}{4} = \frac{5}{3}$$

(20)

(19)



Given angle between Refracted ray and Reflected ray is $90°$

Angle of refraction $= 30° = \angle r$

r' is Angle of reflection.

From fig $\angle r' + 90° + 30° = 180° \Rightarrow \angle r' = 60°$

we know that Angle of incidence $= \angle r' = 60°$.

(20)

Given $\mu_1 = \mu_2$ If the refractive indices for the two media's are same, then no refraction (or) bending takes place

$\mu_1 > \mu_2 \Rightarrow$ If light travels from 1st medium ~~to~~ [denser] to 2nd medium [rarer] it bends away from normal.

$\mu_1 < \mu_2 \Rightarrow$ If light travels from Ist medium [rarer] to 2nd medium [denser]. It bends towards normal.

L Task

jee Mains level

(1) we know that optical Path $\Delta x = c \times t$

$\Rightarrow \mu d = c \times t$

where 'd' → distance travelled (or) thickness of medium

't' → time taken $= 10^{-9}$ sec.

Refractive index $\mu = 1.5$.

$\therefore \Rightarrow 1.5 \times d = 3 \times 10^8 \times 10^{-9}$

$\Rightarrow d = \frac{3}{1.5} \times 10^{-1} \Rightarrow \frac{30}{15} \times 10^{-1}$

$\Rightarrow d = 0.2\ m$

(2)

Time taken by the light in air $t_a = 9 \times 10^{-6}$ sec.

Refractive index of air $\mu_a = 1$.

Refractive index of water $\mu_w = \frac{4}{3}$.

Given that

distance travelled by light in air = distance travelled by light in water

$\therefore \quad \mu_w t_a = \mu_a t_w$

$\Rightarrow \frac{4}{\cancel{3}} \times \overset{3}{\cancel{9}} \times 10^{-6} = 1 \times t_w$

$\Rightarrow 12 \times 10^{-6} = t_w \Rightarrow t_w = 12 \, \mu$sec.

(3)

Refractive index of slab $= \mu_g = \frac{3}{2}$.

Thickness of glass $= d_g = 90$ cm ; time taken in glass $= t_1 = t_g$

Refractive index of water $= \mu_w = \frac{4}{3}$; time taken in water $= t_2 = t_w$

Given

we know that path length $= c \times t = \mu d$

$\Rightarrow t = \frac{\mu d}{c} \Rightarrow t_g = \mu_g \frac{d}{c}$

and $t_w = \mu_w \frac{d}{c}$

$\therefore \quad t_g - t_w = (\mu_g - \mu_w) \frac{d}{c}$

$= \left(\frac{3}{2} - \frac{4}{3}\right) \times \frac{\cancel{90}\,30}{\cancel{3} \times 10^{10}}$

$\Rightarrow \frac{9-8}{6} \times 30 \times 10^{-10}$

$\Rightarrow \frac{1}{\cancel{6}} \times \overset{5}{\cancel{30}} \times 10^{-10} = 5 \times 10^{-10}$ sec.

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The refractive index of glass $\mu_g = 1.5 = \frac{3}{2}$

$\lambda_a = 6000\,A°$

Velocity of light in air $C = 3\times10^8\,m/s$

we know that $\mu \propto \frac{1}{\lambda}$

$$\Rightarrow \frac{\lambda_g}{\lambda_a} = \frac{\mu_a}{\mu_g}$$

$$\Rightarrow \lambda_g = \lambda_a \times \frac{\mu_a}{\mu_g} \Rightarrow 6000 \times \frac{1}{\frac{3}{2}}$$

$$= \cancel{6000}^{\,2} \times \frac{2}{\cancel{3}}$$

$$= 4000\,A°$$

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Distance travelled by the light in a medium is called path length $\Delta x = \mu d = ct$

$\therefore$ time taken by the light $t = \frac{\mu d}{c}$

Here $d = x$ $\quad \therefore t = \frac{\mu x}{c}$

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Refractive index of glass $\mu_g = \frac{3}{2}$

Refractive index of water $\mu_w = \frac{4}{3}$

$\therefore$ Refractive index of glass with respect to water

$$\cancel{{}_w\mu_g = \frac{\mu_w}{\mu_g} = \frac{\frac{4}{3}}{\frac{3}{2}} = \frac{8}{9}} \qquad {}_w\mu_g = \frac{\mu_g}{\mu_w} = \frac{\frac{3}{2}}{\frac{4}{3}}$$

$$= \frac{9}{8}$$

(8)

speed of light in glass $V_g = 2\times10^8$ m/s

speed of light in liquid $V_L = 2.5\times10^8$ m/s

Refractive index of glass $\mu_g = 1.5 = \frac{3}{2}$.

we know that $\mu \propto \frac{1}{V}$

$$\Rightarrow \frac{\mu_L}{\mu_g} = \frac{V_g}{V_L}$$

$$\Rightarrow \mu_L = \mu_g \times \frac{V_g}{V_L}$$

$$= \frac{3}{\cancel{2}} \times \frac{\cancel{2}\times10^8}{2.5\times10^8}$$

$$\mu_L = \frac{3}{2.5} = \frac{30}{25} = \frac{6}{5} = 1.2$$

(9)

Given wavelength of light in air $\lambda_a = 7200$ A°

Refractive index of air $\mu_a = 1$

Refractive index of glass $\mu_g = 1.5 = \frac{3}{2}$.

we know that $\lambda \propto \frac{1}{\mu}$

$$\Rightarrow \frac{\lambda_g}{\lambda_a} = \frac{\mu_a}{\mu_g}$$

$$\Rightarrow \lambda_g = \lambda_a \times \frac{\mu_a}{\mu_g}$$

$$= 7200 \times \frac{1}{\frac{3}{2}} = \overset{24}{\cancel{7200}} \times \frac{2}{\cancel{3}}$$

$$= 2400 \times 2$$

$$\lambda_g = 4800 \text{ A°}$$

(10)

Given thickness of window $= 4\,mm$

$= 4\times10^{-3}\,m.$

Refractive index of glass $\mu_g = 1.5 = \frac{3}{2}$

∴ Distance travelled by the light $= \mu d = ct$

$\Rightarrow t = \frac{\mu d}{c}$

$\Rightarrow t = \frac{1.5\times4\times10^{-3}}{3\times10^{8}} = \frac{6\times10^{-11}}{3} = 2\times10^{-11}\,sec$

(11)

Thickness of glass slab $d_g = 4\,cm$

Thickness of water $d_w = 5\,cm$

Refractive index of water $\mu_w = \frac{4}{3}$

Given that no. of waves in a glass slab = no. of waves in water

$\Rightarrow \mu_g d_g = \mu_w d_w$

$\Rightarrow \mu_g \times \cancel{4} = \frac{\cancel{4}}{3}\times5$

$\Rightarrow \mu_g = \frac{5}{3}.$

(12)

Thickness of glass slab $d_g = 8$ cm

Thickness of water $d_w = 10$ cm

Refractive index of water $\mu_w = \frac{4}{3}$

Given no. of waves in glass = no. of waves in water

$\Rightarrow \mu_g d_g = \mu_w d_w$

$\Rightarrow \mu_g \times \cancel{8}^{2} = \frac{\cancel{4}}{3} \times \cancel{10}^{5}$

$\Rightarrow \mu_g = \frac{5}{3}$

(13)

Thickness of glass slab $t = 4$ cm.

Refractive index of glass $\mu_g = \sqrt{3}$.

Angle of incident $\angle i = 60^\circ$

From snell's law $\mu_g = \frac{\sin i}{\sin r}$

$\Rightarrow \sqrt{3} = \frac{\sin 60^\circ}{\sin r}$

$\Rightarrow \sin r \cancel{\sqrt{3}} = \frac{\cancel{\sqrt{3}}}{2} \Rightarrow \sin r = \frac{1}{2}$

$\Rightarrow r = 30^\circ$

Lateral displacement $= \frac{t}{\cos r} \sin(i-r)$

$\Rightarrow \frac{4}{\cos 30} \sin 30 = \frac{4}{\frac{\sqrt{3}}{\cancel{2}}} \times \frac{1}{\cancel{2}}$

$\Rightarrow \frac{4}{\sqrt{3}}$ cm.

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Velocity of light in water > velocity of light in glass

Because Refractive index of water $\mu_w = \frac{4}{3} = 1.33$

Refractive index of glass $\mu_g = \frac{3}{2} = 1.5$

Clearly $\mu_w < \mu_g$ and we know that $V \propto \frac{1}{\mu}$

Due to this speed changes

18

Given Refractive index of glass with respect to water

$$_w\mu_g = \frac{9}{8} \rightarrow ①$$

wavelength of light in glass is $\lambda_g = 4000\,A°$

From ① $\frac{\mu_g}{\mu_w} = \frac{9}{8}$ we know that $\mu \propto \frac{1}{\lambda}$

$$\frac{\mu_g}{\mu_w} = \frac{\lambda_w}{\lambda_g}$$

$$\Rightarrow \frac{\lambda_w}{\lambda_g} = \frac{9}{8}$$

$$\Rightarrow \lambda_w = \frac{9}{8} \times \lambda_g = \frac{9}{8} \times \overset{5}{\cancel{4000}}$$

$$\Rightarrow \lambda_w = 4500\,A°$$

20 (iii)

$$\frac{\mu_r}{\mu_a} = \frac{V_a}{V_r}$$

$$\Rightarrow \frac{\mu_r}{1} = \frac{3 \times 10^8}{2.25 \times 10^8} = \frac{3}{2.25} = \underline{1.33}$$

(19)

Given optical path length of light in glass and liquid are same i.e.

$$\Delta x = \mu d = \text{constant}$$

$$\Rightarrow \mu_g d_g = \mu_L d_L$$

$$\Rightarrow (1.5) \times 4 = \mu_L \times \cancel{4.5}\,3$$

$$\Rightarrow \mu_L = \frac{4}{3}$$

(20).

Given Refractive index of denser medium with respect to rarer medium ${}_r\mu_d = \frac{\mu_d}{\mu_r} = 1.125 \rightarrow (1)$

$V_r - V_d = 0.25 \times 10^8 \, m/s \rightarrow (2)$

we know that $\mu \propto \frac{1}{V} \Rightarrow \frac{\mu_d}{\mu_r} = \frac{V_r}{V_d}$

$$\Rightarrow 1.125 = \frac{V_r}{V_d} \Rightarrow V_r = 1.125\, V_d$$

sub 'V_r' value in (2) we get

$$\Rightarrow 1.125\, V_d - V_d = 0.25 \times 10^8$$

$$\Rightarrow 0.125\, V_d = 0.25 \times 10^8$$

$$\Rightarrow V_d = \frac{0.25}{0.125} \times 10^8 = 2 \times 10^8 \, m/s$$

∴ Velocity in rarer medium $V_r = 1.125 \times V_d$

$$= 1.125 \times 2 \times 10^8$$

$$V_r = 2.25 \times 10^8 \, m/s$$

$2\cdot25\times10^{8}$

2v)

20(iii) $\dfrac{\mu_r}{\mu_a} = \dfrac{V_{air}}{V_r} = \dfrac{3\times10^8}{2\cdot25\times10^8} = \dfrac{3}{2\cdot25} = 1\cdot333$