

①

Task 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 $t_a = 4 \text{ sec.}$ Refractive index of air $\mu_a = 1$ $\therefore$ Given distance travelled by the light in air and glass

Same

$$x_{\text{air}} = x_{\text{glass}}$$

$$= v_a t_a = v_g t_g$$

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

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

$$\frac{v_a}{v_g} = \frac{\mu_g}{\mu_a}$$

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

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

②

Given wavelength of light $\lambda = 6000 \text{ \AA}$ Refractive index of air $\mu_a = 1.0003$ let the thickness of air column t' we know that no. of wavelengths $n = \frac{t}{\lambda}$

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

$$\text{For vacuum } n_v = \frac{t_v}{\lambda_v} \Rightarrow t_v = n_v \lambda_v$$

$$\text{Given } n_a = 1 + n_v \quad [t_a = t_v]$$

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

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

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

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

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

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

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

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

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

$$\Rightarrow t = \frac{\lambda_v}{\mu_a - 1} = \frac{6000 \times 10^{-10}}{1.0003 - 1} = \frac{6 \times 10^{-7}}{0.0003} = \frac{6 \times 10^{-7}}{3 \times 10^{-4}} = 2 \text{ mm}$$

(3)

let the two medias are A and B.

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

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

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

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

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

(4)

Thickness of slab $t_s = 4 \text{ cm}$ Thickness of water $t_w = 5 \text{ cm}$ Refractive index of water $\mu_w = \frac{4}{3}$

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

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

$$\Rightarrow \frac{t_s}{\lambda_s} = \frac{t_w}{\lambda_w}$$

$$\Rightarrow \frac{\lambda_w}{\lambda_s} = \frac{t_w}{t_s} \quad \because \text{we know that } \mu \propto \frac{1}{\lambda}$$

$$\Rightarrow \frac{\mu_s}{\mu_w} = \frac{t_w}{t_s} \quad \Rightarrow \frac{\lambda_w}{\lambda_s} = \frac{\mu_s}{\mu_w}$$

$$\Rightarrow \frac{\mu_s}{\mu_w} = \mu_w \times \frac{t_w}{t_s}$$

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

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

(5)

wavelength of light in vacuum $\lambda_v = 5700 \text{ \AA}$ Refractive index of glass $\mu_g = \frac{3}{2}$ Refractive index of vacuum $\mu_v = 1$ we know that $\mu \propto \frac{1}{\lambda}$

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

$$\Rightarrow \lambda_g = 3800 \text{ \AA}$$

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velocity of light in A = $v_A = 2 \times 10^8$ m/s

velocity of light in B = $v_B = 2.5 \times 10^8$ m/s

we know that critical angle.

$$\sin c = \frac{1}{\mu} = \frac{v_A}{v_B}$$

$$\Rightarrow \sin c = \frac{2 \times 10^8}{2.5 \times 10^8} = \frac{2}{2.5}$$

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

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

⑦

Critical angle $c = 45^\circ$; Velocity in vacuum $v_v = c$

Light is travelling from medium to vacuum

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

$$\Rightarrow \sin 45^\circ = \frac{\mu_v}{\mu_m} = \frac{v_m}{v_v}$$

$$\Rightarrow \frac{1}{\sqrt{2}} = \frac{1}{\mu_m} \frac{v_m}{v_v}$$

$$\Rightarrow \mu_m = \frac{v_v}{\sqrt{2}} = \frac{c}{\sqrt{2}}$$

(3)

(8)

let μ_1, μ_2 are the refractive indices for medium, & medium₂

when light travels from medium₁ to vacuum is C_1

$$\therefore \sin C_1 = \frac{1}{\mu_1 \mu_{m_1}} = \frac{\mu_v}{\mu_{m_1}} \rightarrow (1)$$

when light travels from medium₂ to vacuum is C_2

$$\therefore \sin C_2 = \frac{1}{\mu_2 \mu_{m_2}} = \frac{\mu_v}{\mu_{m_2}} \rightarrow (2)$$

By dividing (1) & (2) we get

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

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

(11)

Given that real depth $h = 1 \text{ m}$

$$\begin{aligned} \text{Apparent depth} &= \text{Real depth} - \text{shift} \\ &= 1 - 0.1 = 0.9 \text{ m} \end{aligned}$$

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

$$\therefore \mu = \frac{1}{0.9} = \frac{10}{9}$$

(9)

velocity of light in medium, is v_1

Refractive index $\mu_1 = 1$ [vacuum]

$$v_1 = \frac{x_1}{t_1}; \quad v_2 = \frac{x_2}{t_2} \quad \{x_1, x_2 \text{ are distance travelled by the light in two mediums}\}$$

The refractive index of second medium = μ_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.

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

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

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

(10)

velocity of light in 1st medium = $v_1 = c$

Refractive index of 1st medium = $\mu_1 = 1$ [vacuum]

velocity of light in 2nd medium is v_2 , its refractive index is μ_2 , $t \rightarrow$ time

given $x \rightarrow$ distance travelled by the light in 1st medium

$x_0 \rightarrow$ distance travelled by the light in vacuum

$$\therefore v_1 = \frac{x_0}{t}; \quad v_2 = \frac{x}{t}$$

we know that $\frac{v_1}{v_2} = \frac{\mu_2}{\mu_1} =$

10th combustion

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

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

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

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

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

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we know that when we view from underwater

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

Apparent height from surface = $36 - 12 = 24 \text{ m}$.

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

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

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

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

⑩ by $d = \frac{k}{\cos r} \sin(i-r) \rightarrow \text{①}$

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

Thickness $k = \sqrt{3} \text{ cm}$

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

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

$$\Rightarrow \sqrt{3} \sin r = \frac{\sqrt{3}}{2} \Rightarrow \sin r = \frac{1}{2}$$
$$\Rightarrow r = 30^\circ$$

∴ From ①

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

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

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

⑩

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Given ${}_a\mu_{gly} = 1.04$; ${}_a\mu_{dia} = 2.04$.

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Velocity of light in air $c = 3 \times 10^8 \text{ m/s}$

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

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

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

$$\text{velocity in glycerine} \Rightarrow v_{gly} = c \times \frac{\mu_a}{\mu_{gly}} = 3 \times 10^8 \times \frac{1}{1.04}$$

$$\Rightarrow v_{gly} = 2.8846 \times 10^8 \text{ m/s}$$

$$\text{velocity of light in diamond} = c \times \frac{\mu_a}{\mu_{dia}} = 3 \times 10^8 \times \frac{1}{2.04}$$

$$v_{dia} = 1.4706 \times 10^8 \text{ m/s}$$

Refractive index of diamond with respect to glycerine

$${}_{gly}\mu_d = \frac{\mu_{gly}}{\mu_{dia}} = \frac{1.04}{2.04} = 0.5098$$

Refractive index of glycerine with respect to diamond

$${}_d\mu_{gly} = \frac{\mu_d}{\mu_{gly}} = \frac{2.04}{1.04} = 1.9615$$

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We know that No. of waves = $\frac{\text{Thickness of the medium}}{\text{wavelength of light}}$

Thickness of glass slab $t_g = 4 \text{ cm}$.

Thickness of water $t_w = 5 \text{ cm}$.

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

Given

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

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

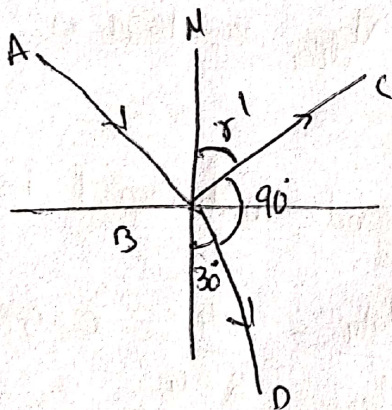
$$\Rightarrow t_g = \frac{\lambda_g}{\lambda_w} t_w \quad \left[\because \lambda \propto \frac{1}{\mu} \right]$$

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

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

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Given angle between Refracted ray and Reflected ray is 90°

Angle of refraction = $30^\circ = r$

r' is Angle of reflection.

From fig $r' + 90^\circ + 30^\circ = 180^\circ \Rightarrow r' = 60^\circ$

We know that Angle of incidence = $r' = 60^\circ$.

(20)

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

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

$\mu_1 < \mu_2 \Rightarrow$ if light travels from 1st medium [rarer] to 2nd medium [denser], it bends towards normal.

Task

see main lew

①

we know that optical path $\Delta x = c \times t$
 $\Rightarrow \mu d = c \times t$

where 'd' $\rightarrow$ distance travelled (or) thickness of medium
 't' $\rightarrow$ time taken $= 10^{-9}$ sec.

Refractive index $\mu = 1.5$.

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

$$\Rightarrow d = \frac{3}{1.5} \times 10^{-1} \Rightarrow \frac{30}{15} \times 10^{-1} = 0.2$$

$$\therefore d = 0.2 \text{ m}$$

②

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

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

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

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

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

③

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

Thickness of glass $= d_g = 90 \text{ cm}$; 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 $= c \times t = \mu d$

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

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

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

$$= \left(\frac{3}{2} - \frac{4}{3} \right) \times \frac{90 \times 10^2}{3 \times 10^{10} \text{ m}}$$

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

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

⑤

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

$$\lambda_a = 6000 \text{ \AA}$$

Velocity of light in air $c = 3 \times 10^8 \text{ m/s}$

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

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

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

$$= 6000 \times \frac{2}{3}$$

$$= 4000 \text{ \AA}$$

⑥

Distance travelled by the light in a medium

is called path length $\Delta x = \mu d = c h$

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

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

⑦

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

$$\mu_{g/w} = \frac{\mu_g}{\mu_w} = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{3}{2} \times \frac{3}{4} = \frac{9}{8}$$



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speed of light in glass $v_g = 2 \times 10^8 \text{ m/s}$

speed of light in liquid $v_L = 2.5 \times 10^8 \text{ m/s}$

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

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

$$\Rightarrow \frac{\mu_L}{\mu_g} = \frac{v_g}{v_L}$$

$$\Rightarrow \mu_L = \mu_g \times \frac{v_g}{v_L}$$

$$= \frac{3}{2} \times \frac{2 \times 10^8}{2.5 \times 10^8}$$

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

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given wavelength of light in air $\lambda_a = 7200 \text{ \AA}$

Refractive index of air $\mu_a = 1$

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

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

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

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

$$= 7200 \times \frac{1}{\frac{3}{2}} = 7200 \times \frac{2}{3}$$

$$= 4800 \times 2$$

$$\lambda_g = 9600 \text{ \AA}$$

(10)

Given thickness of window $= 4 \text{ mm}$
 $= 4 \times 10^{-3} \text{ m}$

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

$\therefore$ distance travelled by the light $= \mu d = ct$

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

$$\Rightarrow t = \frac{1.5 \times 4 \times 10^{-3}}{3 \times 10^8} = \frac{6 \times 10^{-11}}{3} = 2 \times 10^{-11} \text{ s}$$

(11)

Thickness of glass slab $d_g = 4 \text{ cm}$

Thickness of water $d_w = 5 \text{ cm}$

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

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

$$\Rightarrow \mu_g d_g = \mu_w d_w$$

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

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

(12)

Thickness of glass slab $d_g = 8 \text{ cm}$ Thickness of water $d_w = 10 \text{ cm}$ Refractive index of water $\mu_w = \frac{4}{3}$

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

$$\Rightarrow \mu_g d_g = \mu_w d_w$$

$$\Rightarrow \mu_g \times 8 = \frac{4}{3} \times 10$$

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

(13)

Thickness of glass slab $t = 4 \text{ cm}$ Refractive index of glass $\mu_g = \sqrt{3}$ Angle of incidence $i = 60^\circ$

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

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

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

$$\Rightarrow r = 30^\circ$$

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

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

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

(10)

(17)

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 $\lambda_g = 4000 \text{ \AA}$

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

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

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

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

$$\Rightarrow \lambda_w = 4500 \text{ \AA}$$

(20) (ii)

$$\frac{\mu_r}{\mu_a} = \frac{v_a}{v_r}$$

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

(19)

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

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

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

$$\Rightarrow (1.5) \times 4 = \mu_L \times 4.5^3$$

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

(20)

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

$$v_r - v_d = 0.25 \times 10^8 \text{ m/s} \rightarrow (2)$$

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

$$\Rightarrow 1.125 v_d - v_d = 0.25 \times 10^8$$

$$\Rightarrow 0.125 v_d = 0.25 \times 10^8$$

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

$\therefore$ Velocity in rarer medium $v_r = 1.125 \times v_d$
 $= 1.125 \times 2 \times 10^8$
 $v_r = 2.25 \times 10^8 \text{ m/s}$

20 (iii)

$$\frac{\mu_r}{\mu_a} = \frac{V_{ar}}{V_r} = \frac{3 \times 10^8}{2.25 \times 10^8} = \frac{3}{2.25} = 1.333$$