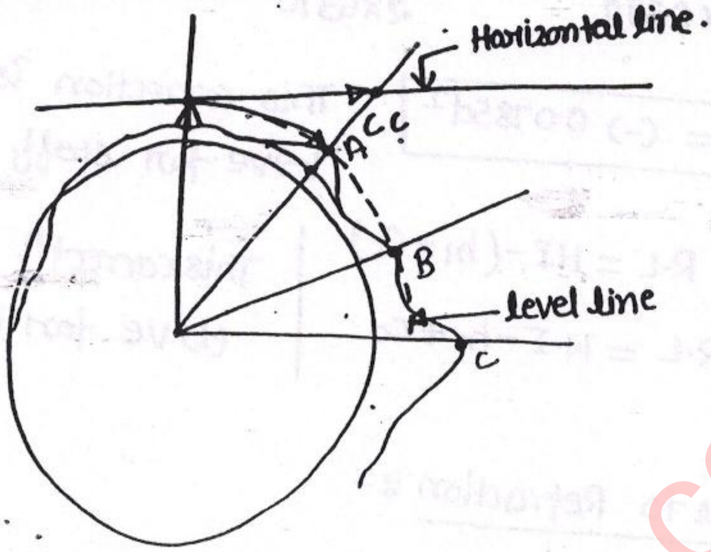
Correction due to earth curvature and refraction :-

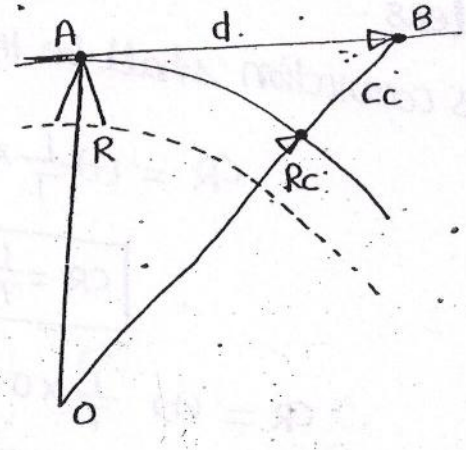
(1) Due to earth curvature :-



(#) **Horizontal line :** A line tangent to any point on earth surface. line of sight setup by an instrument will show a horizontal line.

(#) **level line :** A line ||el to earth surface. The R.L of different points should be measured w.r.t level line.

(#) **Correction due to curvature :-** is the difference b/w horizontal line and level line for any point.



$R \neq R_c$

$(R+C_c)^2 = R^2 + d^2$

$R^2 + C_c^2 + 2 \cdot R \cdot C_c = R^2 + d^2$

$C_c(2R + C_c) = d^2$

$$C_c = \frac{d^2}{2R}$$

correction due to curvature $= \frac{d^2}{2R}$

$$C_c = \frac{d^2}{2\times 6370}\ km = \frac{d^2}{2\times 6370}\times 1000\ meter$$

$$\boxed{C_c = (-)\ 0.0785 d^2}$$

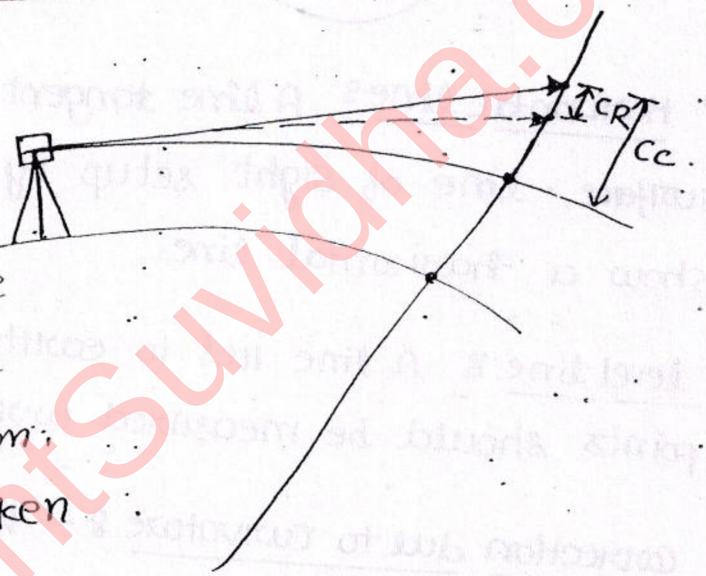
This correction is always (−)ve for staff reading.

$$R.L = HI - (h_1 - C_c)$$

$$R.L = H.I - h_1 + C_c$$

This correctn. will become (+) ve for R.L.

(2) Correction due to Refraction :-



Due to refraction, line of sight get deflected in downward direction, thus the reading taken is less.

This correction shall be (+)ve for staff reading.

$$CR = (+)\frac{1}{7}\times\frac{d^2}{2R} = \frac{1}{7}\times C_c$$

$$\boxed{CR = \frac{1}{7} C_c}$$

$$CR = (+)\ \frac{1}{7}\times 0.0785\ d^2$$

$$\boxed{CR = (+)\ 0.0112 d^2} \quad -②$$

(3) Combined correction due to curvature & Refraction :

$$C = C_c + C_R$$

$$= -\frac{d^2}{2R} + \frac{1}{7}\frac{d^2}{2R}$$

$$C = -\frac{6}{7} \cdot \frac{d^2}{2R}$$

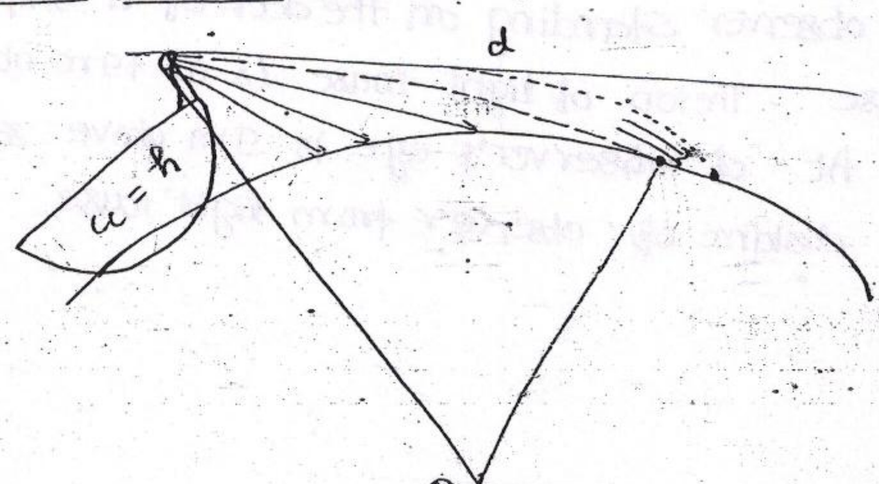
$$= -\frac{6}{7} \times 0.0785 d^2$$

$$\boxed{C = (-)\, 0.0673 d^2} \quad \text{—③}$$

Example :- Calculate C_c, C_R & C due to curvature & Refraction. For (i) 120m (ii) 1500m.

	For 120m	For 1500m
d in km	0.12 km	1.5 km
$C_c = 0.0785 d^2$	$= 1.13 \times 10^{-3}$ m $= (-)\ 0.113$cm	$= 0.1766$m $= (-) 17.66$ cm
$C_R = \frac{1}{7} C_c$	+ 0.016cm	(+) 2.52 cm
combined	(-) 0.096 cm	(-) 15.14cm.

(4) Distance of Visible horizon :-



⇒ Distance of visible horizon is max^m distance up to which A person can see on the surface of earth.

⊕ If only earth curvature is considered –

$$h_{(m)} = C_c = \frac{d^2}{2R} = 0.0785\, d^2 \quad (d \to km)$$

$$d = \sqrt{\frac{h}{0.0785}}$$

$$d = 3.57\sqrt{h}$$

$$\boxed{d = 3.57\sqrt{h}} \quad d \to \text{in km}, \; h \to \text{in m}.$$

⊕ If combined effect of earth curvature & refraction is considered :-

The person will be able to see some more distance.

$$h = \frac{6}{7}\frac{d^2}{2R} = 0.0673\, d^2$$

$$d = \sqrt{\frac{h}{0.0673}} = 3.855\sqrt{h}$$

$$\boxed{d = 3.855\sqrt{h}} \leftarrow \text{Distance of visible horizon}$$

h – in m

d — in km

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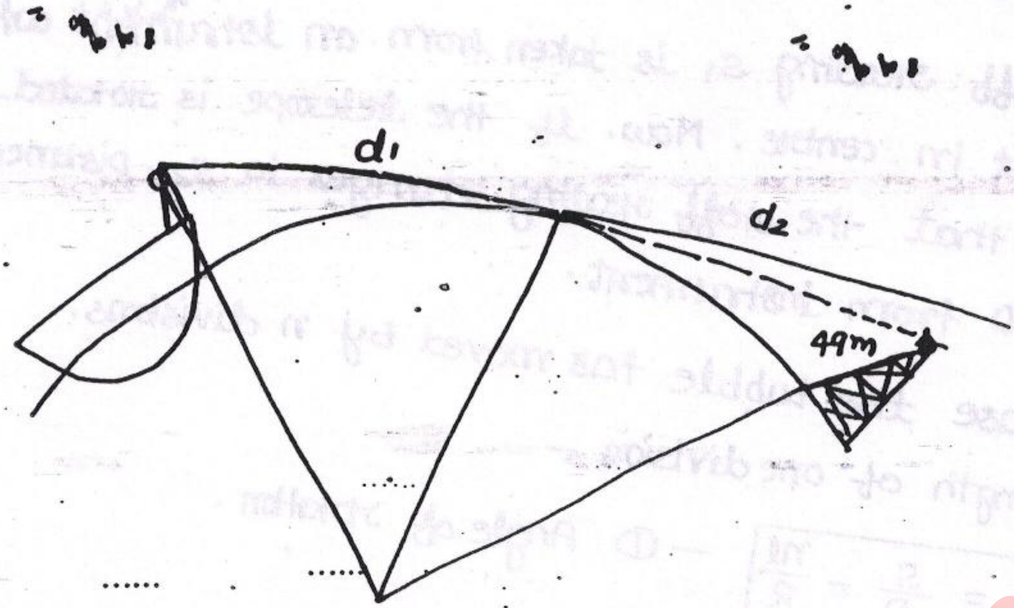
Que 4(b): An observer standing on the deck of a ship just sees a light house. The top of light house is at 49 m above sea level and the ht. of observer's eye is 9 m above sea level. Find the distance of observer from light house.



Total distance

$= d_1 + d_2$

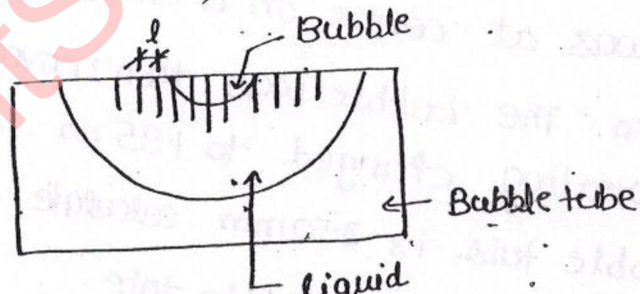
$= 3.855\sqrt{h_1} + 3.855\sqrt{h_2}$

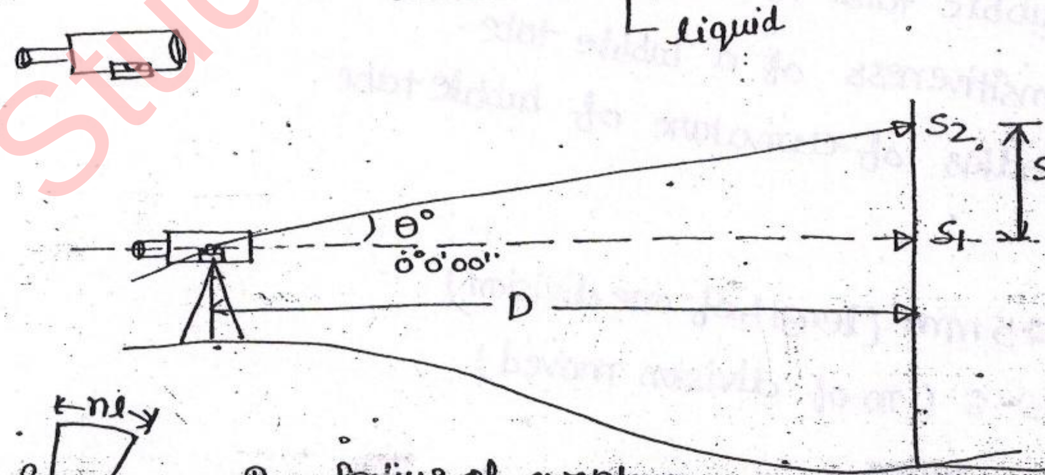
$= 3.855(\sqrt{49} + \sqrt{9}) = 3.855(7+3)$

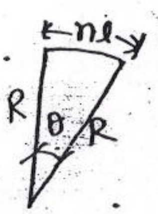
$= \underline{38.55 \text{ km}}$

3|12|13

(#) Sensitivity of a Bubble tube :
(Also called Sensitiveness)







R = Radius of curvature of bubble tube.

If a staff reading S_1 is taken from an instrument when bubble is just in centre. Now, if the telescope is rotated by θ angle so that the staff reading changes to S_2. Distance of staff = D from instrument.

In this case the bubble has moved by n divisions.

If l = length of one division —

$$\boxed{\theta = \frac{S}{D} = \frac{nl}{R}}$$ — ① Angle of rotation.

sensitivity or sensitiveness of bubble tube is the angle of movement due to one division movement of bubble. (say α angle).

Sensitiveness —

$$\boxed{\alpha = \frac{\theta}{n} = \frac{S}{nD} = \frac{l}{R}}$$ — ②

Ques.(1) The staff reading taken from an instrument when bubble was at centre on a staff kept at 250 m distance was 1.62 m. The bubble was then moved by 6 division & staff reading changed to 1.95 m. If length of on division of bubble tube is 2.50 mm calculate —

(i) Sensitiveness of a bubble tube.

(ii) Radius of curvature of bubble tube.

Solns

$l = 2.5$ mm (length of one division)

$n = 6$ (no. of division moved).

$D = 250$ m

s = staff intercept $= S_2 - S_1$

$= 1.95 - 1.62 = 0.33$ m

(i) Sensitiveness of bubble tube

$$\alpha = \frac{s}{nD} = \frac{0.33}{6\times 250} = \frac{11}{50000} = 2.2\times 10^{-4}\text{rad}.$$

$$= (2.2\times10^{-4})\left(\frac{180}{\pi}\times60\times60\right)\text{sec}.$$

$$= 45''.38$$

(ii) Radius of curvature -

$$R \Rightarrow \left| \begin{array}{l} \alpha = \frac{l}{R} = 2.2\times10^{-4} \\ R = \frac{l}{\alpha} = \frac{2.5\text{mm}}{2.2\times10^{-4}} = 11363.64\text{mm} \\ = 11.364\text{m}. \end{array}\right.$$

Prob :- if length of a bubble tube of one division is 3mm and sensitivity of bubble tube is 20 sec. find out the Radius of curvature of bubble tube.

Soln

$l = 3$ m

$$\alpha = 20\text{ sec.} = \frac{20\times\pi}{180\times60\times60} = 9.7\times10^{-5}$$

$$R = \frac{l}{\alpha} = \frac{3}{9.7\times10^{-5}} = 30939.7\text{ mm}$$

30.94 m