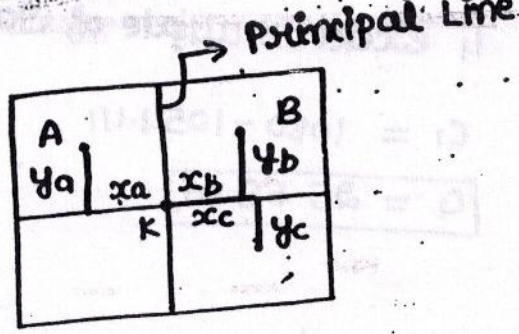
PHOTOGRAMMETRY



Photograph :

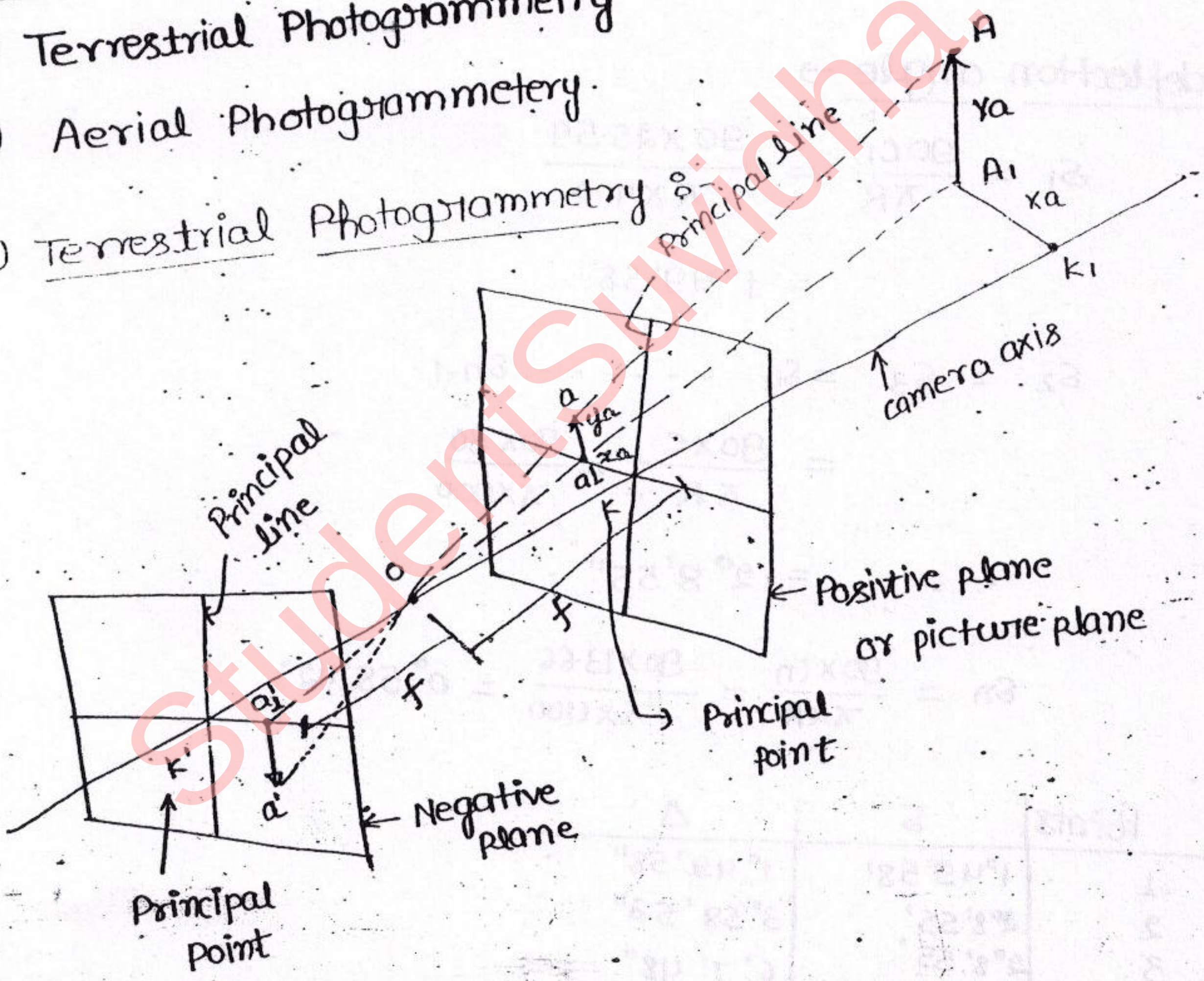
K = Principal point

Types :-

(1) Terrestrial Photogrammetry

(2) Aerial Photogrammetery

(1) Terrestrial Photogrammetry :-



Imp definitions :-

(A) Camera Axis : Line joining the principal points and focal point is called camera axis.

(B) Picture Plane : Positive photograph on which image are in same dirn as of objects.

(C) Negative Plate : When the image is inverted.

(D) Focal length (f) Distance from focal point 'o' to principal point.

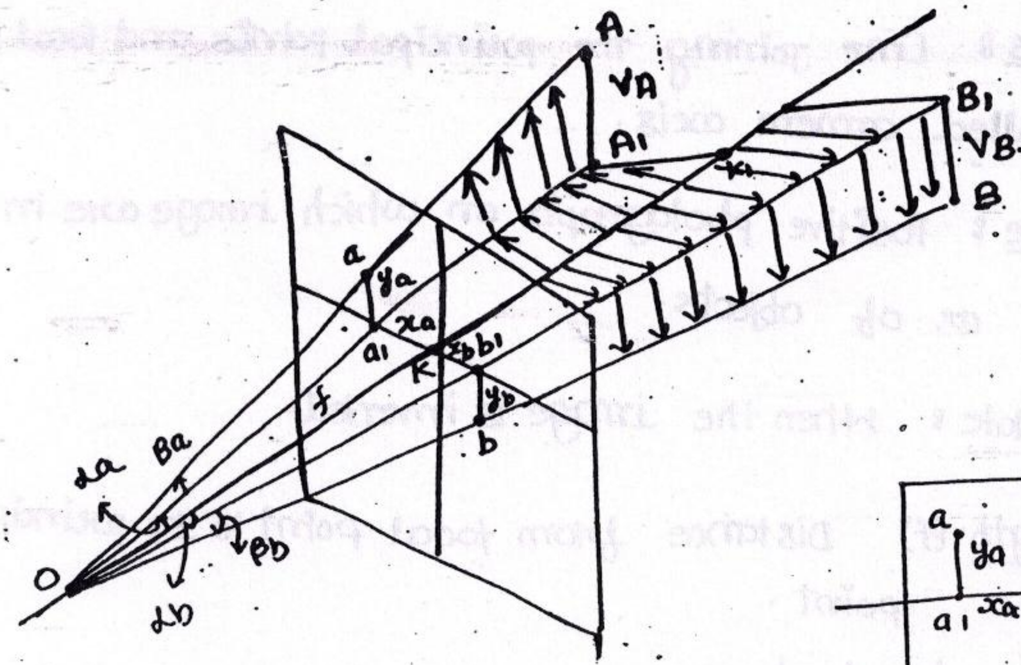
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

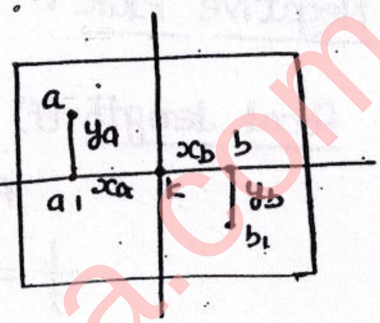
(E) Principal Points : Intersection of 2 axis drawn on the photograph. Intersection of camera axis and principal line

(F) Principal Line : The vertical line passing from k of photograph.

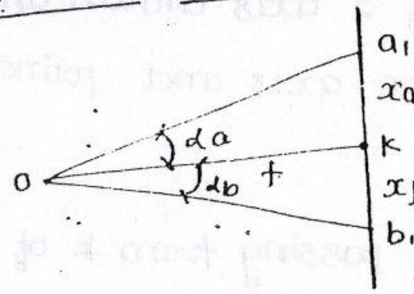
(G) Principal Plane : The line plane containing camera axis and principal line.

(H) Horizontal and Vertical Angles from a Horizontal Photograph :





In Horizontal triangle



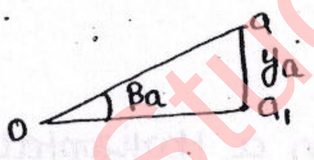
$\tan \alpha_a = \dfrac{x_a}{f}$ — (I)

$\tan \alpha_b = \dfrac{x_b}{f}$ — (II)

$oa_1 = \sqrt{f^2 + x_a^2} = \dfrac{f}{\cos\alpha_a} = f\sec\alpha_a$

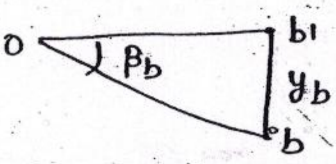
$ob_1 = \sqrt{f^2 + x_b^2} = \dfrac{f}{\cos\alpha_b} = f\sec\alpha_b$

In vertical Triangle:



$\tan \beta_a = \dfrac{y_a}{oa_1} = \dfrac{y_a}{\sqrt{f^2+x_a^2}} = \dfrac{y_a}{f\sec\alpha_a}$

$\tan \beta_b = \dfrac{y_b}{ob_1} = \dfrac{y_b}{\sqrt{f^2+x_b^2}} = \dfrac{y_b}{f\sec\alpha_b}$



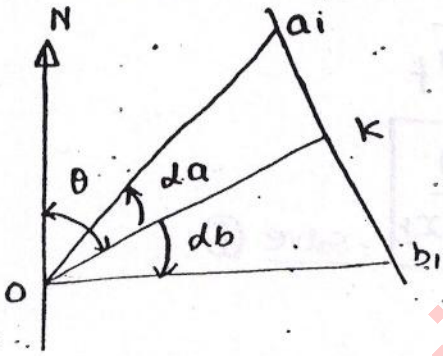
Height of a Point (A) If $OA_1 = D$

$$\frac{V_A}{y_a} = \frac{D_A}{oa_1}$$

$$\boxed{V_A = \frac{D_A y_a}{f \sec\alpha_a}}$$

Similarly

$$\boxed{V_B = \frac{D_B \cdot y_b}{f \cdot \sec\alpha_b}}$$



Bearing of Different lines

→ If bearing of $OK = \theta$

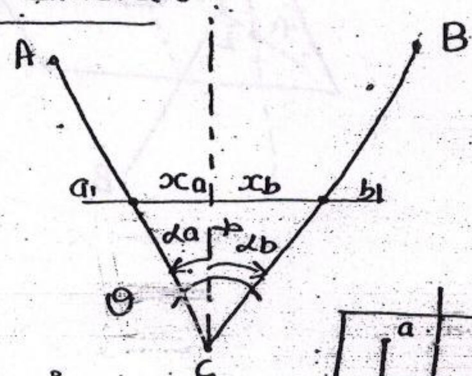
→ bearing of $OA = \theta - \alpha a$

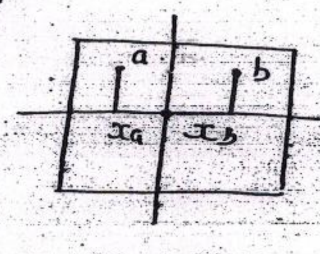
→ bearing of $OB = \theta + \alpha b$

(iii) Determination of Focal Length of Camera :-

→ Take 2 point on the ground. Measure total horizontal angle b/w A & B at a third point C.

→ Setup the camera at C and take photograph of A or B





→ measure x_a & x_b on the Photograph.

$$\tan\alpha_a = \frac{x_a}{f}$$

$$\tan\alpha_b = \frac{x_b}{f}$$

$$\tan\theta = \tan(\alpha_a + \alpha_b)$$

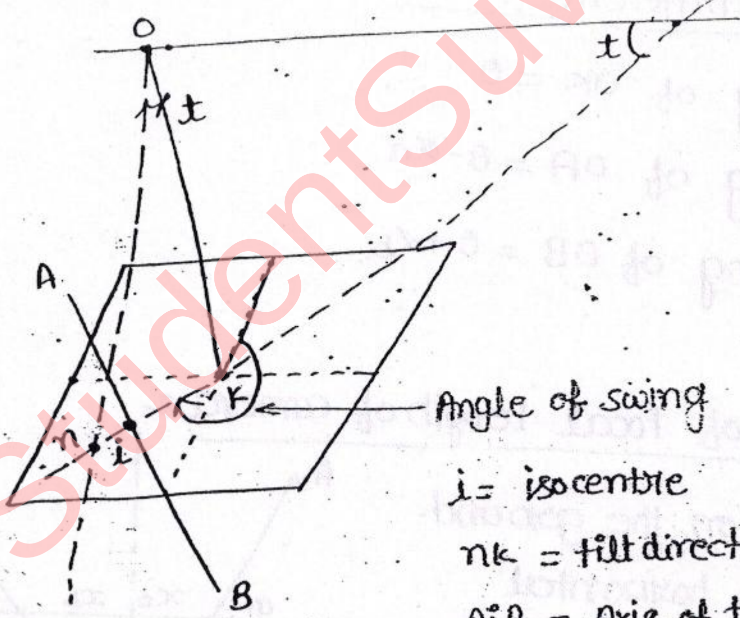
$$= \frac{\tan\alpha_a + \tan\alpha_b}{1 - \tan\alpha_a \cdot \tan\alpha_b}$$

$$= \frac{x_a/f + x_b/f}{1 - x_a/f \times x_b/f}$$

$$\boxed{\tan\theta = \frac{f(x_a + x_b)}{f^2 - x_a \cdot x_b}}$$

Solve (f).

(2) Aerial Photogrammetry :-

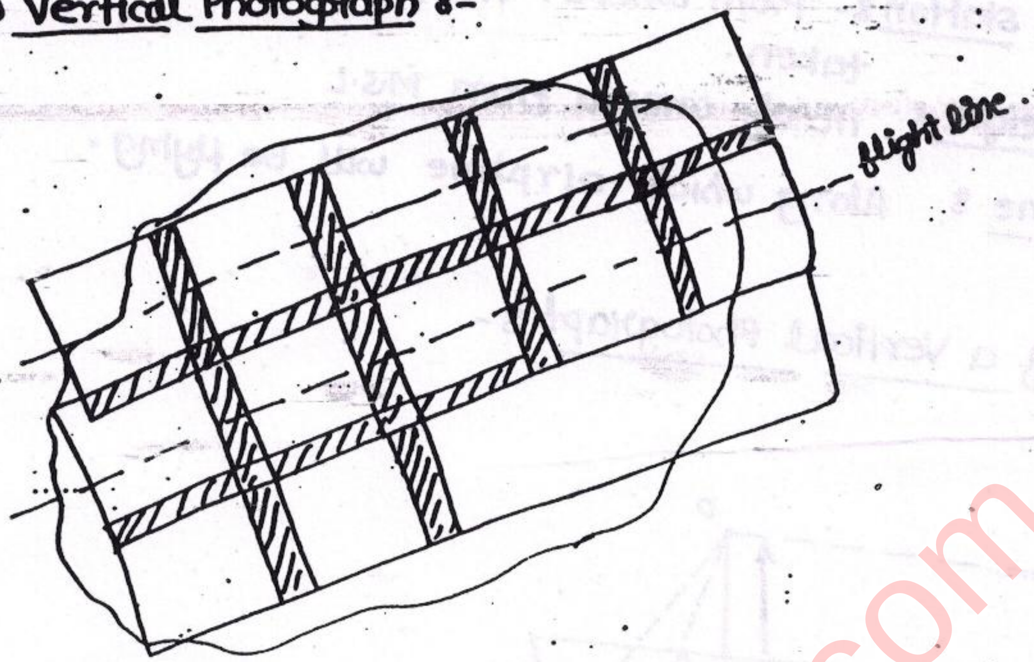


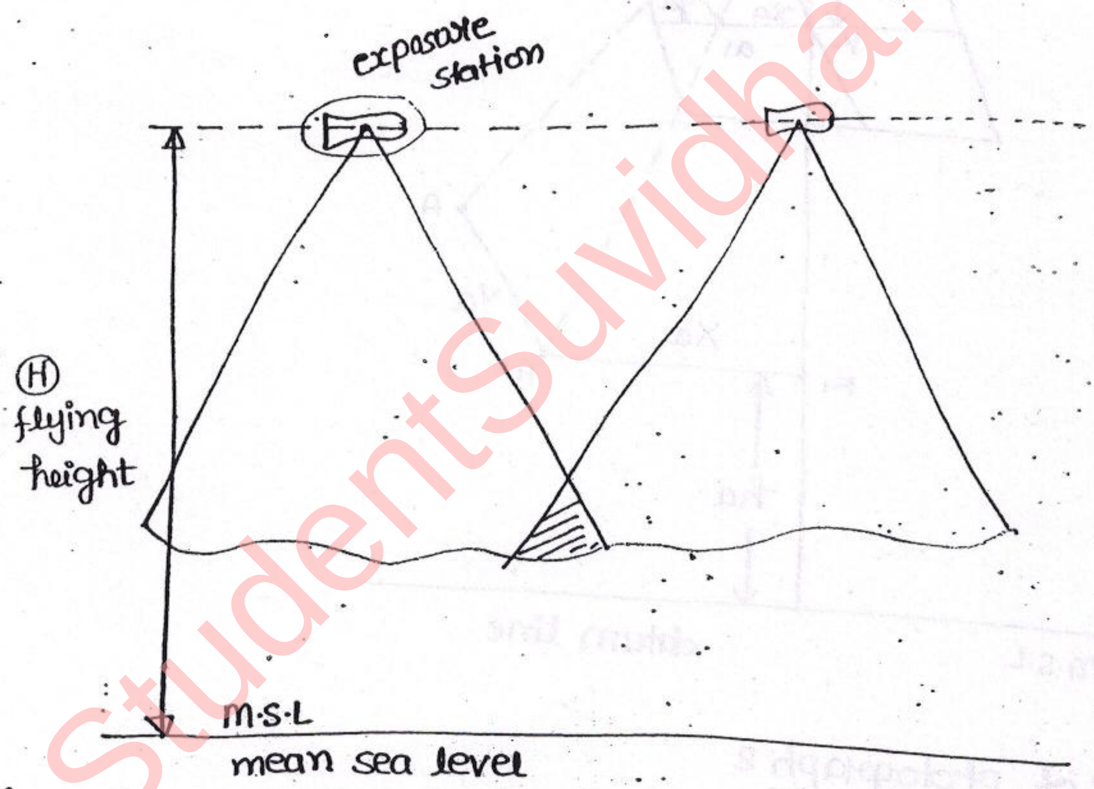
i = isocentre

nk = tilt direction

AiB = Axis of tilt

Vertical Photograph :-





Imp definition :-

(1) Vertical Photograph : If camera axis is vertical.

(2) Tilted Photograph :
camera axis at an inclination.

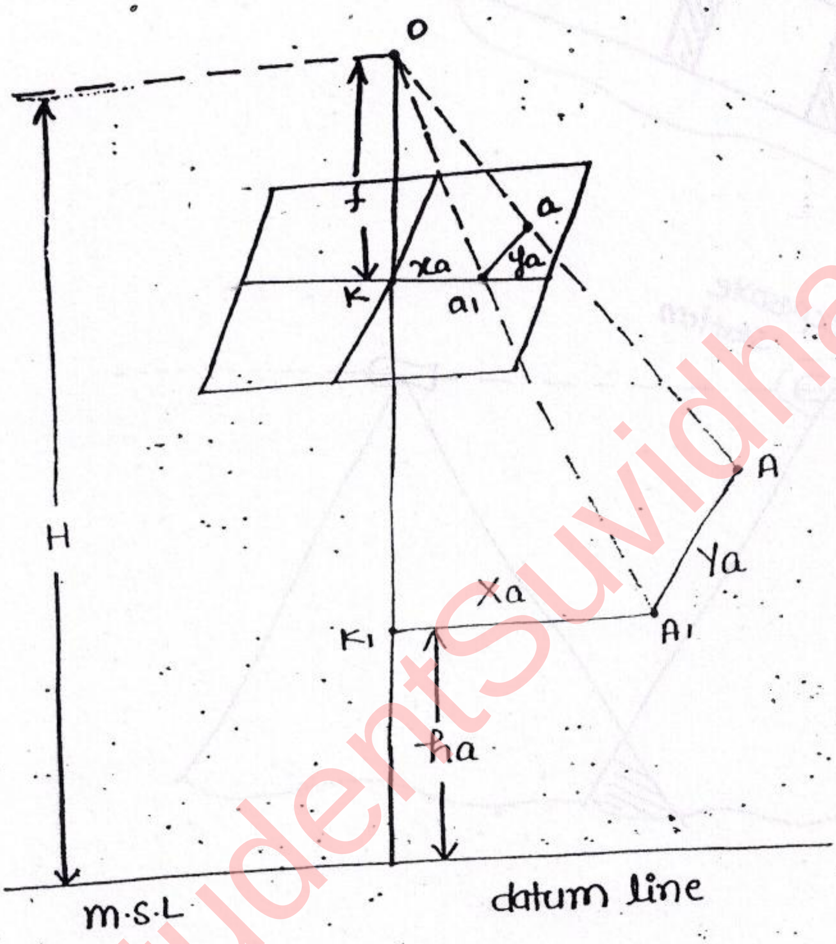
Terestrial | High oblique : If sky is visible in photograph.
Low oblique : If sky is not visible. (Horizon is not visible)

(3) Exposure station :- From where, the photographs have been taken.

(4) Flying Height :- Ht. of camera from M.S.L

(5) flight line : Along which airplane will be flying.

(#) scale of a Vertical Photograph :-



scale of photograph :

$$= \frac{\text{map distance}}{\text{Ground distance}}$$

$$= \frac{x_a}{X_a} = \frac{y_a}{Y_a}.$$

$ok a_1 \simeq ok_1 A_1$

$$\frac{f}{H-h_a} = \frac{x_a}{X_a} = \frac{oa_1}{OA_1}$$

In Δle:-

$oa_1 a \simeq OA_1 A$

$$\frac{oa_1}{OA_1} = \frac{y_a}{Y_a}$$

Scale of photograph

$$= \frac{f}{H-h_a} = \frac{x_a}{X_a} = \frac{y_a}{Y_a}$$

Ground Distances

$$X_a = \left(\frac{H-h_a}{f}\right) x_a$$

$$Y_a = \left(\frac{H-h_a}{f}\right) y_a$$

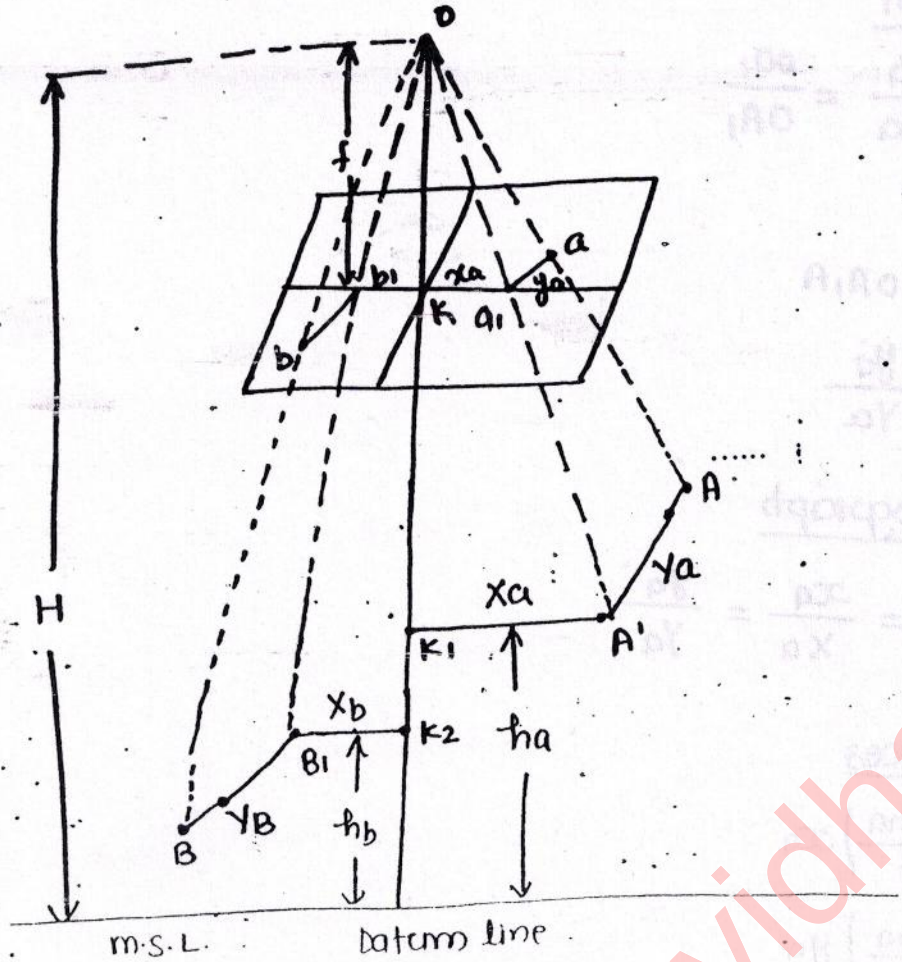
(1) Datum scale: $h_a = 0$

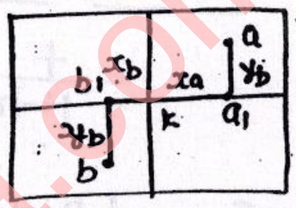
$$\boxed{\text{Scale} = \frac{f}{H}}$$

(2) Average scale:- For an average ht $= h_{av}$

$$\boxed{\text{Scale} = \frac{f}{H-h_{av}}}$$

(#) Horizontal Distance b/w two points on the ground:





for point A

$$\frac{x_a}{X_a} = \frac{y_a}{Y_a} = \frac{f}{H-h_a}$$

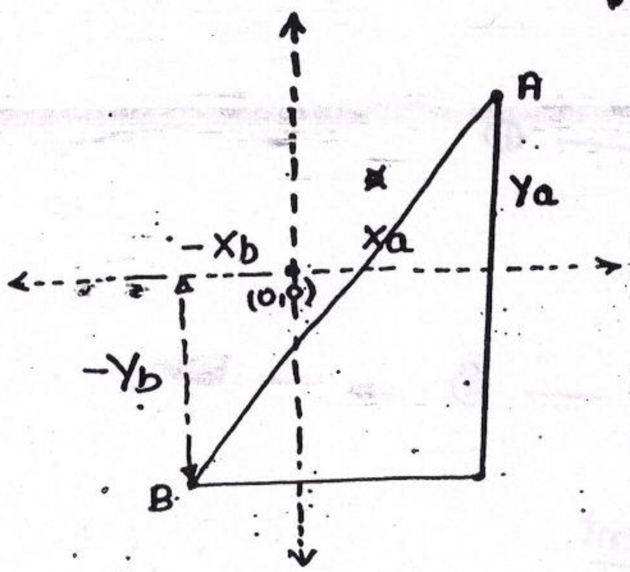
for Point B

$$\frac{x_b}{X_b} = \frac{y_b}{Y_b} = \frac{f}{H-h_b}$$

Ground distances :

$$\boxed{X_a = \left(\frac{H-h_a}{f}\right) x_a \qquad Y_a = \left(\frac{H-h_a}{f}\right) y_a}$$

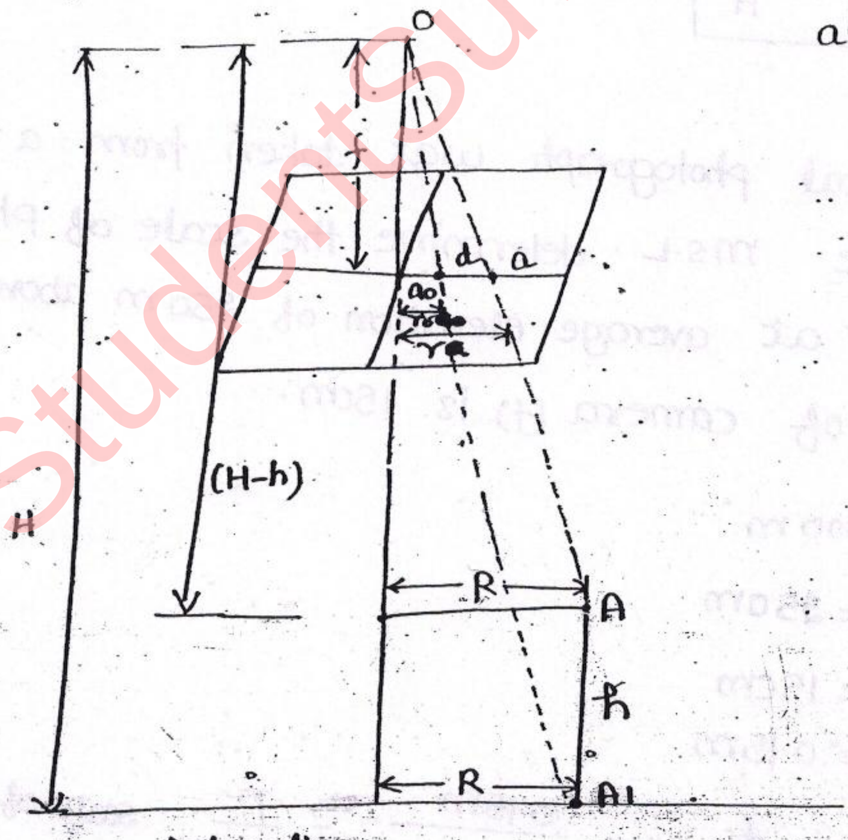
$$\boxed{X_b = \left(\frac{H-h_b}{f}\right) x_b \qquad Y_b = \left(\frac{H-h_b}{f}\right) y_b}$$



General Formula For Horizontal distance AB

$$\boxed{AB = \sqrt{(X_a - X_b)^2 + (Y_a - Y_b)^2}}$$

(H) **Relief Displacement** :-



$aa_0 = d$

$=$ Releif Displacement

$$\frac{r_0}{f} = \frac{R}{H}$$

$$r_0 = \frac{f \cdot R}{H} \quad \text{—— (1)}$$

$$\frac{r}{f} = \frac{R}{H-h}$$

$$r = \frac{Rf}{(H-h)} \quad \text{—— (2)}$$

Relief Displacement

$$d = r - r_0$$

$$= \frac{fR}{H-h} - \frac{fR}{H}$$

$$d = f \cdot R \left[\frac{H - H + h}{(H-h)H} \right] = f \cdot R \left[\frac{h}{(H-h)H} \right] = \frac{r \cdot h}{H}$$

$$\boxed{d = \frac{r \cdot h}{H}}$$ Relief Displacement

Ques (1) A vertical photograph was taken from a ht. of 1600 m above m.s.L. determine the scale of photograph for an area at average elevation of 250 m above m.s.L. Focal length of camera (f) is 15cm.

$H = 1600\text{ m}$

$h_{av} = 250\text{m}$

$f = 15\text{cm}$

$= 0.15\text{m}$

Scale: $\frac{f}{H - h_{av}} = \frac{0.15\text{m}}{1600 - 250} = \frac{1}{9000}$ scale of P.g.

Ques:(2) A camera of focal length 20cm is used for a vertical photograph the average elevation of a terrain is 1800m. At what ht. the aircraft should fly so that a scale of $\frac{1}{10000}$ can be obtained on the photograph.

$f = 0.2m$

$h_{av} = 1800m$

$H = ?$

$$\text{Scale} = \frac{1}{10{,}000} = \frac{f}{H - h_{av}}$$

$$H - h_{av} = f \times 10{,}000$$

$$= 0.2 \times 10{,}000$$

$$H = h_{av} + 2000$$

$$\boxed{H = 3800m} \text{ Ans}$$

2(c)

Ques: (3) A section line AB 300m long on a flat terrain measures 102.4 mm on a vertical photograph

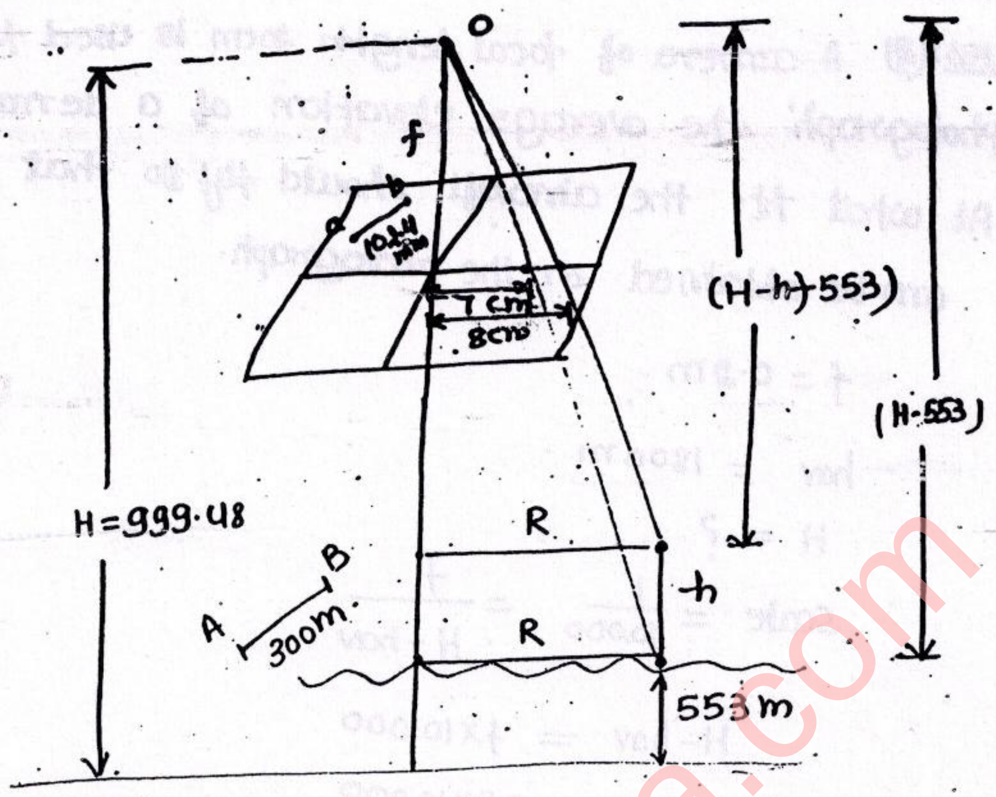
ES: 2001

a radiotower also appear on the photograph. The distance of bottom & top image of the radiotower from principal point is 7cm & 8cm respe. Average elevation of terrain is 553 m. Determine the Ht. of tower. Focal length of camera (f) is 152.4mm.

Salution: $f = 152.4mm$

Scale:

$$\frac{ab}{AB} = \frac{102.4mm}{300 \times 10^3 mm} = \frac{f}{H - h_{av}} = \frac{152.4 \times mm}{(H - 553) \times 1000\, mm}$$



$$H = 553 + \frac{152.4}{102.4} \times 300$$

$$\boxed{H = 999.48m}$$

In Δgle :-

$$\frac{7cm}{R} = \frac{f}{(H-553)} \quad \text{— (I)}$$

$$\frac{8cm}{R} = \frac{f}{(H-553-h)} \quad \text{— (II)}$$

$$7 \times (H-553) = 8(H-553-h)$$

$$7 \times (999.48 - 553) = 8(999.48 - 553 - h)$$

$$\boxed{h = 55.81m}$$

(OR)

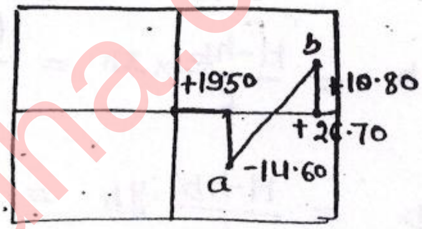
$$d = \frac{rh}{(H-hav)} \Rightarrow h = \frac{d(H-hav)}{r} = \frac{1cm(999.48-553)}{8cm}$$

$$= 55.81m$$

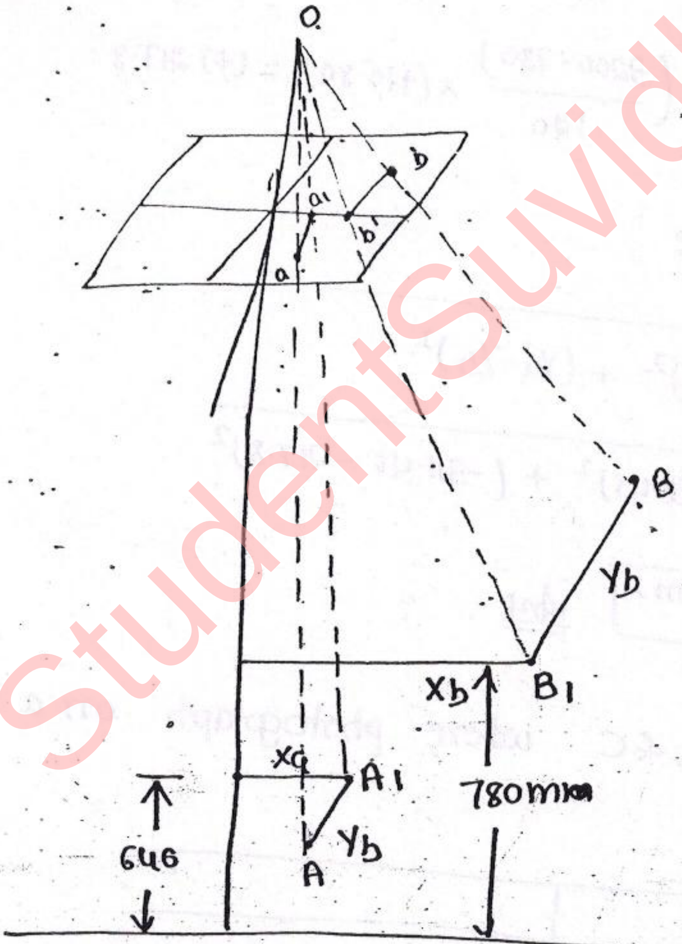
Ques 4 (ES: 1997) A vertical photograph was taken from a
2(b) ht. of 3200 m above m.s.l. with a camera of focal length 120 mm. It contain 2 pt. a & b corresponding to ground pt. A & B.

Photo points	Elevation (m) above msl	Photo co-ordinates x	y
a	640	+ 19.50	−14.60
b	780	+ 26.70	+10.80

Find out Horizontal length AB.



Solu^n:



Scale for Point A

$$x_a/X_a = \frac{y_a}{Y_a} = \frac{f}{H-h_a}$$

Scale for Point B

$$\frac{x_b}{X_b} = \frac{y_b}{Y_b} = \frac{f}{H-h_b}$$

$$X_a = \frac{H-h_a}{f} \times x_a = \frac{(3200-640)}{120} \times (+19.50) = (+)\,416.0$$

$$Y_a = \frac{H-h_a}{f} \times y_a = \frac{(3200-640)}{120} \times (-14.60) = (-)\,311.46$$

$$X_b = \frac{H-h_b}{f} \times x_b = \frac{(3200-780)}{120} \times (26.70) = (+)\,538.45$$

$$Y_b = \frac{H-h_b}{f} \cdot y_b = \left(\frac{3200-780}{120}\right) \times (+10.80) = (+)\,217.8$$

Horizontal Distance :

$$AB = \sqrt{(X_a-X_b)^2 + (Y_a-Y_b)^2}$$

$$= \sqrt{(416-538.45)^2 + (-311.46-217.8)^2}$$

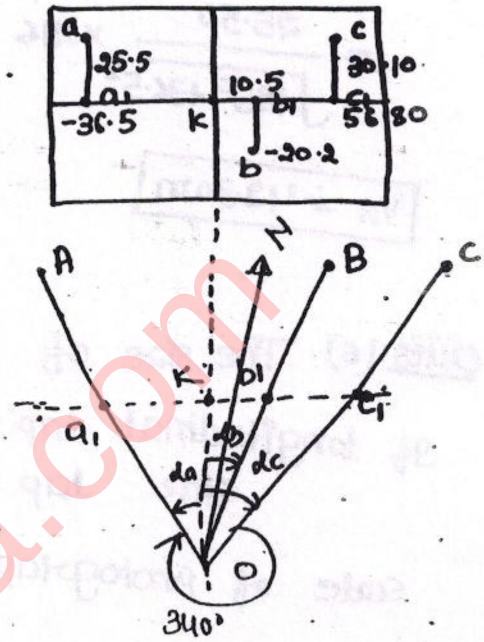
$$\boxed{AB = 543.24\,m.}$$ Ans

(T.P.)

Ques: (5) 3 points A, B, & C where photograph on a horizontal photograph :

Point	x	y
A	−36.50	+25.50
B	+10.50	−20.20
C	+56.80	+30.10

Focal length of camera is 125 mm. If Bearing of line OA is 340° and hor. Distance of A from O is 216 m. Calculate the bearing of other lines and ht. of point A.



Soln :-

$$\tan \alpha_a = \frac{x_a}{f} = \frac{36.50}{125}$$

$$\boxed{\alpha_a = 16.27° = 16°16'40''}$$

$$\tan \alpha_b = \frac{x_b}{f} = \frac{10.50}{125}$$

$$\boxed{\alpha_b = 4°48'5''}$$

$$\tan \alpha_c = \frac{x_c}{f} = \frac{56.86}{125}$$

$$\boxed{\alpha_c = 24°26''13.37''}$$

Bearing of OA $= 340°$

$+ \alpha_a = 16°16'40''$

Bearing of OK $= 356°16'40''$

Bearing of OB

$=$ Bearing of OK $+ \alpha_b$

$= 356°16'40'' + 4°48'5'' - 360$

$= 1°4'45''$

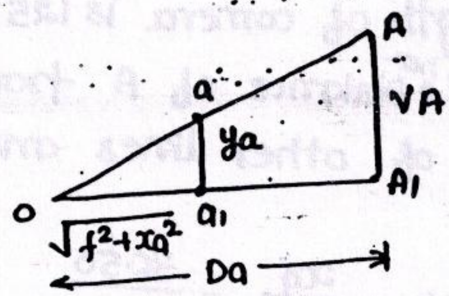
Bearing of OC

$=$ Bearing of OK $+ \alpha_c$

$= 356°16'40'' + 24°26'13.37'' - 360°$

$= 20°42'53.37''$

$$VA = \frac{ya}{\sqrt{f^2 + x_a^2}} \times 216 \text{ m}$$



$$= \frac{25.50}{\sqrt{125^2 + 36.5^2}} \times 216$$

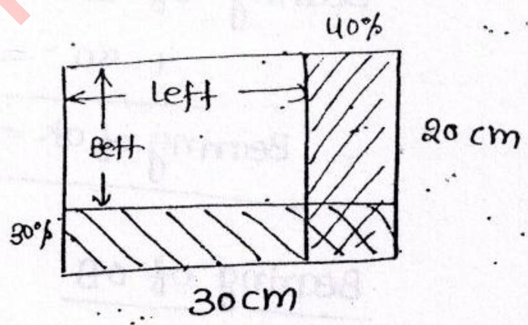
$$\boxed{VA = 42.30 \text{m}}$$

Ques:(6) The size of 1 vertical photograph is 30cm × 20cm. If longitudinal lap = 40%

side lap = 30%

scale of photograph is 1 cm = 200 m.

Findout total no. of photograph required to cover a total area of 1200 km² on ground.



Soln:

$$L_{eff} = L \times \left(1 - \frac{WL}{100}\right) = 30 \times \left(1 - \frac{40}{100}\right)$$

$$= 30 \times 0.6$$

L_{eff} = 18cm.

$$B_{eff} = B \times \left(1 - \frac{Ws}{100}\right) = 20\left(1 - \frac{30}{100}\right)$$

$$= 20 \times .70$$

B_{eff} = 14cm .

Actual effective area covered on ground :

$= (18 \times 200) \times (14 \times 200)$ m²

$= 10080000 / 10^6$ km² $= 10.08$ km²

Total N

Total No. required -

$$= \frac{1200}{10.08} = \underline{119.05}. \quad (\text{say } 120 \text{ photography})$$