CV2015 AY2021

1a) hydraulically smooth : $e < \delta_v$
transitional rough : $\delta_v < e < 14\delta_v$
fully rough : $e > 14\delta_v$

(b) $\tau = \rho l^2 \left(\frac{du}{dy}\right)^2$ —①
$l = ky$ —②
subs ② into ①.
$\tau = \rho k^2 y^2 \left(\frac{du}{dy}\right)^2$

$\sqrt{\frac{\tau}{\rho k^2 y^2}} = \frac{du}{dy}$

$du = \frac{1}{k}\sqrt{\frac{\tau}{\rho}} \cdot \frac{dy}{y}$

$\int du = \frac{1}{k} u_* \cdot \int \frac{dy}{y}$, where $u_* = \sqrt{\frac{\tau_0}{\rho}}$, $k = 0.4$

$u = 2.5 u_* \ln y + C$

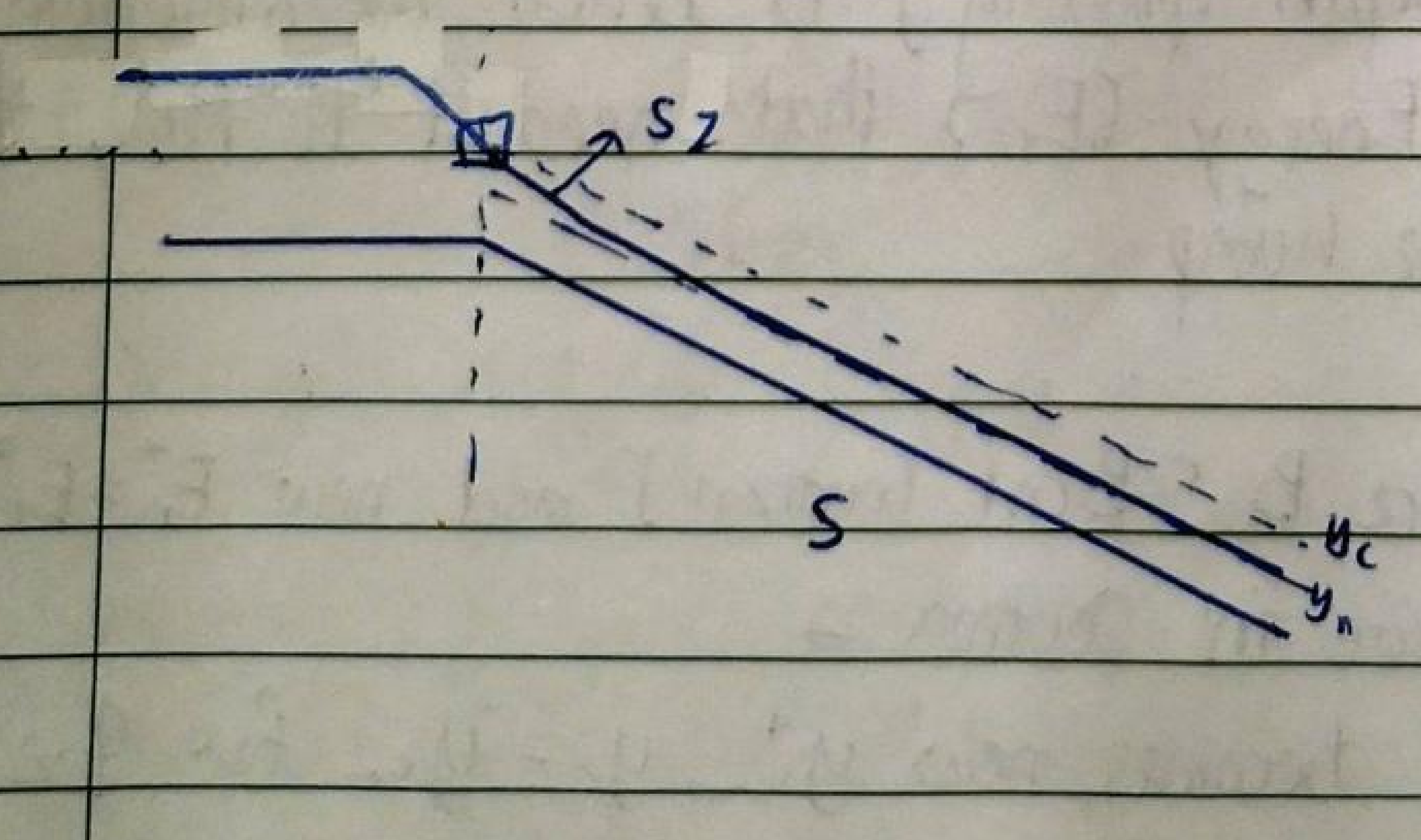
(Ci) $E = 2m$ (measured from bed lv to upstream section)

$E = \frac{3y_c}{2}$

$y_c = \frac{4}{3} m.$

$y_c = \sqrt[3]{\frac{q^2}{g}}$

$q = 4.82 m^2/s$



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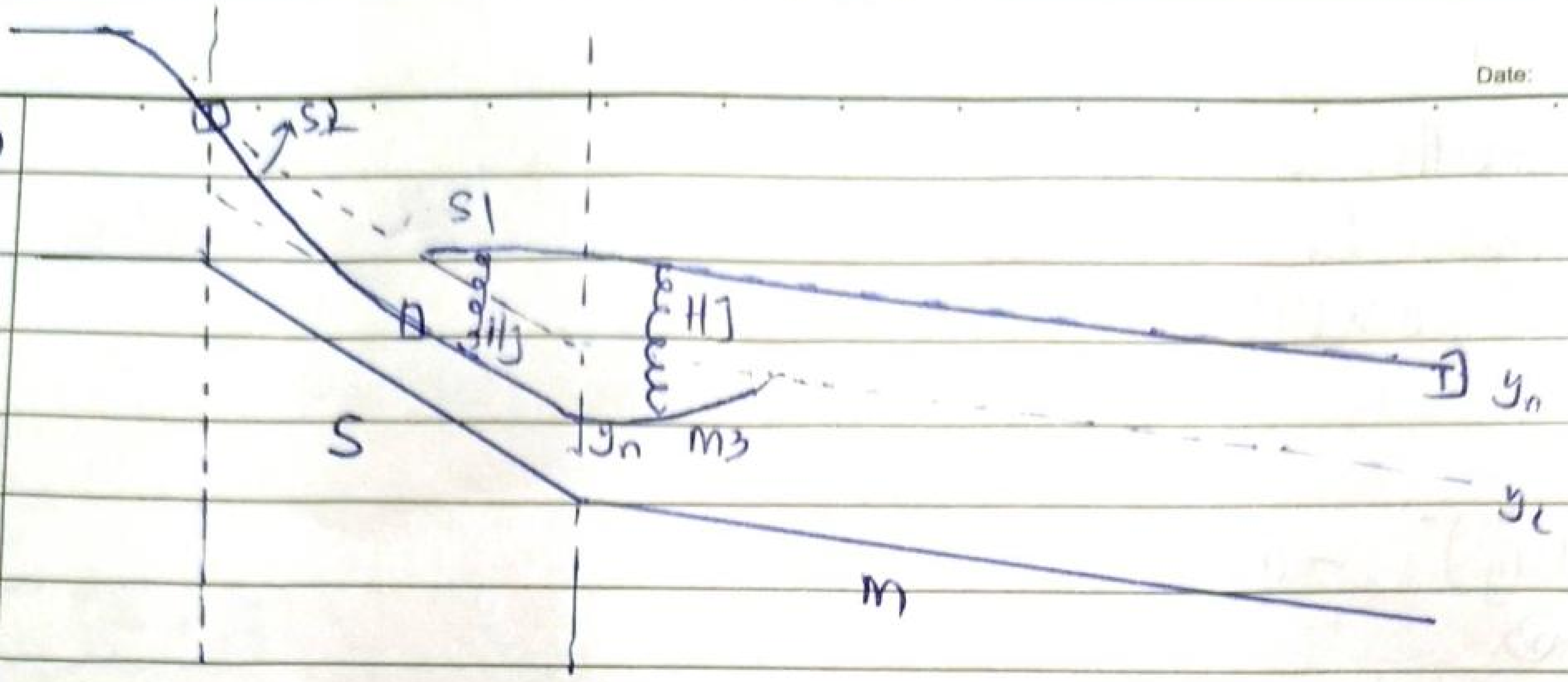
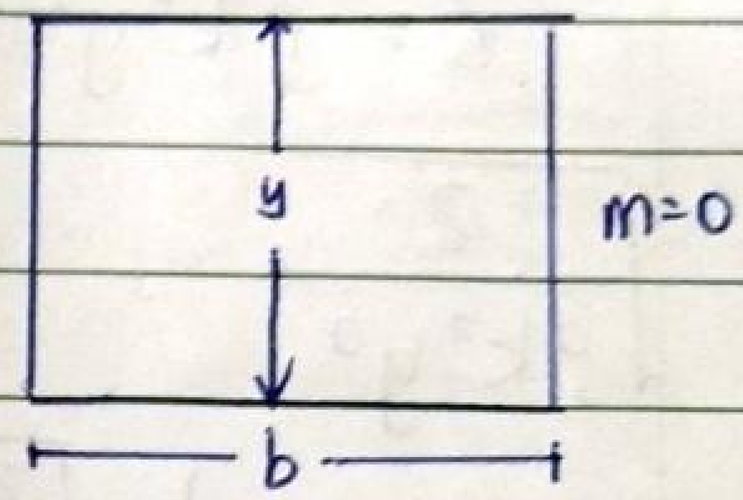
(ii)



(2a) $R_h = \frac{A}{P_w}$



$P = 2y + b$

$A = by$

$b = \frac{A}{y}$

$P = 2y + \frac{A}{y}$

$\frac{dP}{dy} = 2 - \frac{A}{y^2} = 0$ (for min P_w)

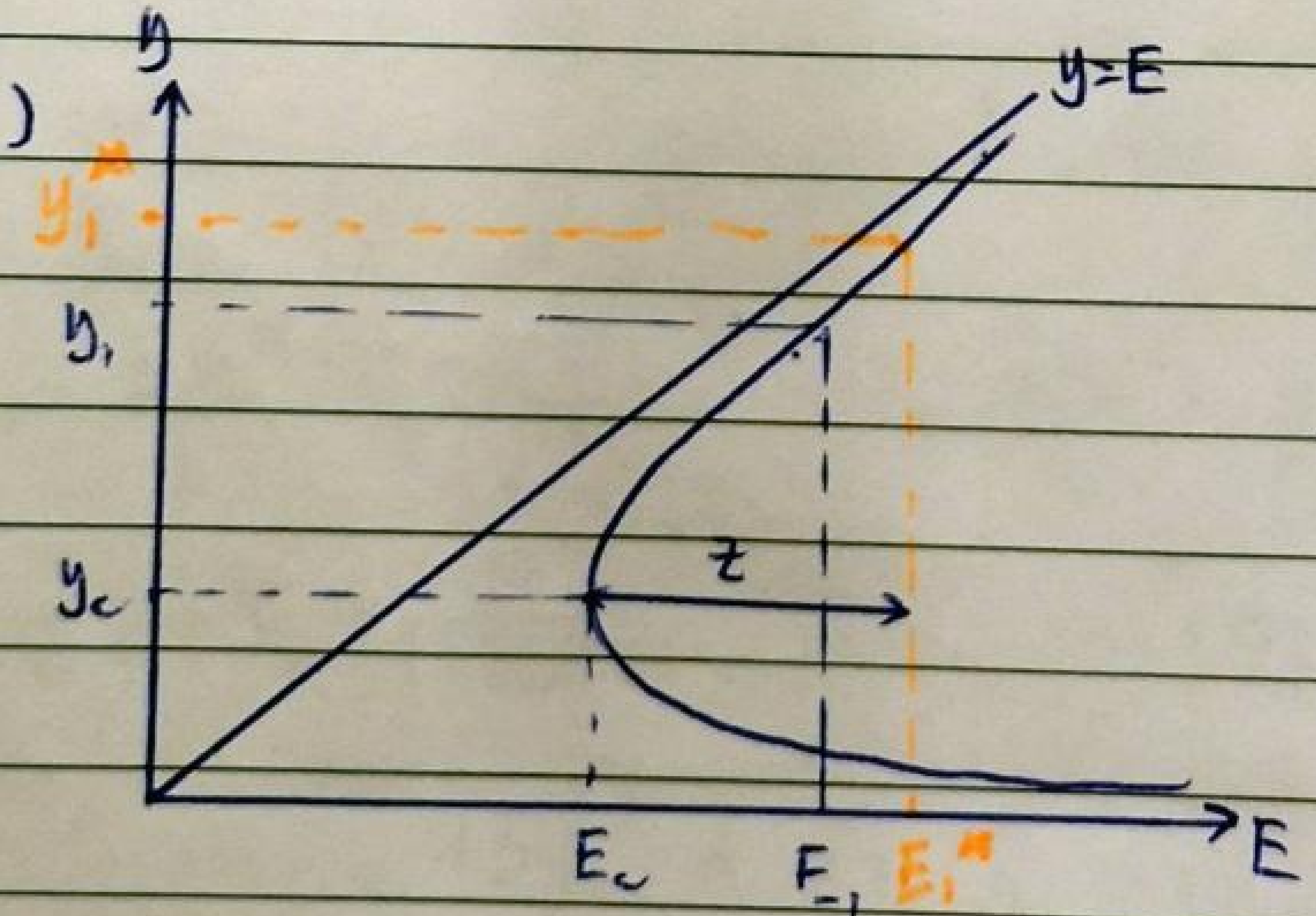
$\frac{A}{y^2} = 2$

$A = 2y^2$

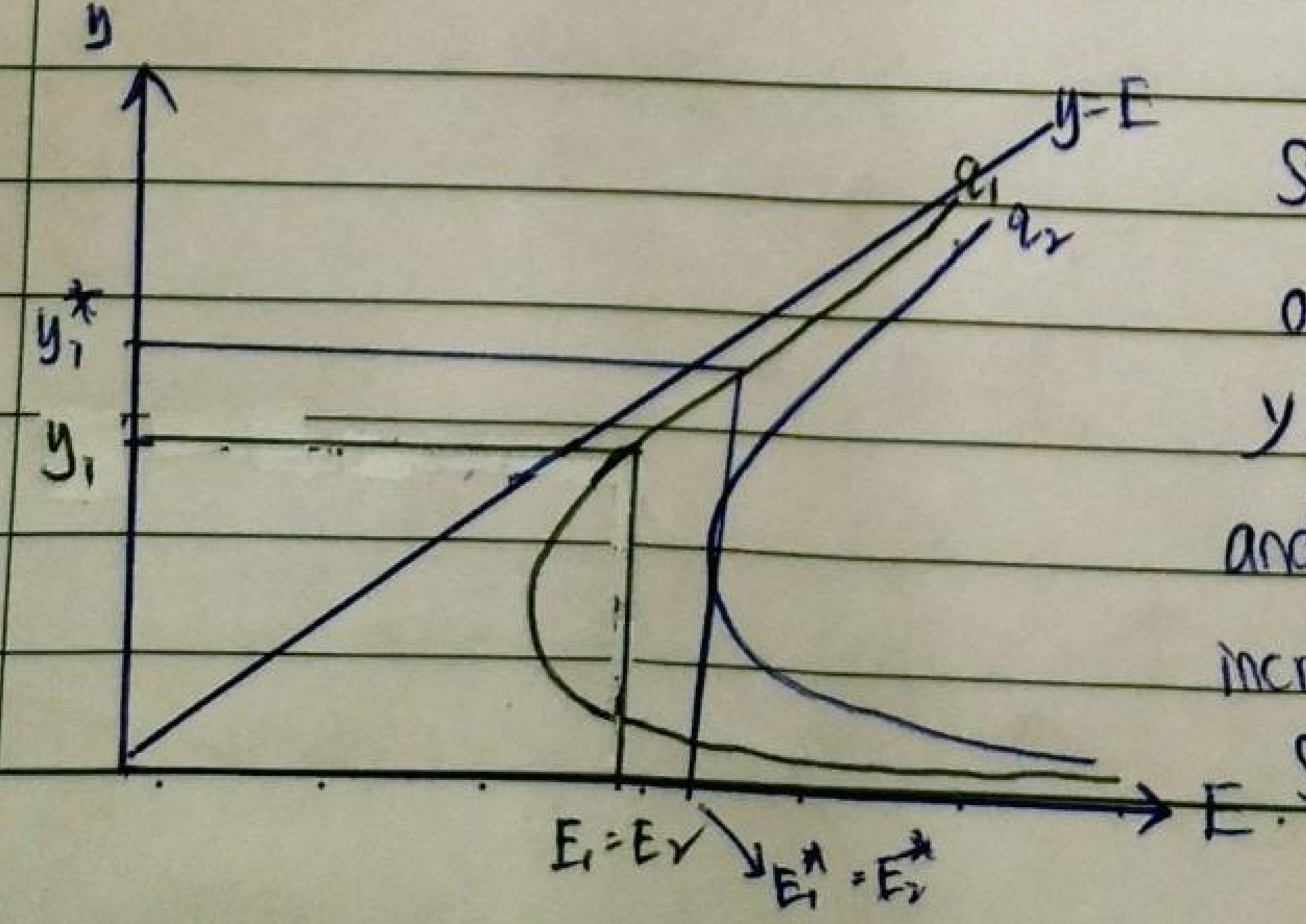
$by = 2y^2$

$b = 2y$

(b)(i)



In this condition, choking and ponding both occur since $\Delta Z > \Delta Z_{crit}$.
Since E_1 is too small for water to flow through the hump with a height of ΔZ thus, the flow increases its upstream flow depth (ponding) to reach the minimum Energy (E_c) that needed to flow through the hump.



Since $B < B_{crit}$ (critical) and new $E_1^* = E_2^*$ occur at Section 2
y_1 becomes new y_1^*, $y_2 = y_{c2}$ for q_2 and choking occur at Section 2, Since y_1 increases its depth to y_1^*, ponding occurs at Section 1

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(ii) $F_1 - F_2 = \rho Q(V_2 - V_1)$

$$\rho g h_{c_1} A_1 + \frac{\rho Q^2}{A_1} = \rho g h_{c_2} + \frac{\rho Q^2}{A_2}$$

From (3a) $A = by + my^2$

$$h_c = \frac{\frac{my^3}{3} + \frac{by^2}{2}}{by + my^2}$$

$$g\left(\frac{\frac{my_1^3}{3} + \frac{by_1^2}{2}}{by_1 + my_1^2}\right)A_1 + \frac{Q^2}{by_1 + my_1^2} = g\left(\frac{\frac{my_2^3}{3} + \frac{by_2^2}{2}}{by_2 + my_2^2}\right)A_2 + \frac{Q^2}{by_2 + my_2^2}$$

$$9.81\left(\frac{\frac{2(0.4)^3}{3} + \frac{6(0.4)^2}{2}}{6(0.4)+2(0.4)^2}\right)A + \frac{40^2}{6(0.4)+2(0.4)^2} = 9.81\left(\frac{\frac{2y_2^3}{3} + \frac{6y_2^2}{2}}{2y_2 + 6y_2^2}\right)A + \frac{40^2}{2y_2 + 6y_2^2}$$

$$5.127 + 588.24 = 6.54y_2^3 + 29.43y_2^2 + \frac{1600}{2y_2 + 6y_2^2}$$

$$593.367 = 6.54y_2^3 + 29.43y_2^2 + \frac{1600}{2y_2 + 6y_2^2}$$

by trial and error,
$y \approx 3.3\text{m}$.

Yes the answer computed in part (i) and part (ii) should be the same since equation from part (i) is derived from part (ii)

(c) $m = 0$. $b = 6\text{m}$

$$F_x = \frac{by^2}{2} + \frac{Q^2}{gyb}$$

$$\frac{6y_1^2}{2} + \frac{40^2}{9.81y_1(6)} = \frac{6y_2^2}{2} + \frac{40^2}{9.81(6y_2)}$$

$$3(0.4)^2 + \frac{40^2}{9.81(6)(0.4)} = 3y_2^2 + \frac{40^2}{9.81(6y_2)}$$

$$-68.44y_2 + 3y_2^3 + 27.18 = 0$$

$y_2 = 4.56\text{m}$.

$$\frac{y_2}{y_1} = \frac{4.56}{0.4} = 11.4$$

Checking:

$$F_{r_1} = \frac{V_1}{\sqrt{gy_1}} \qquad V_1 = 16.67$$

$= 8.42$

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8(8.42)^2} - 1\right)$$

$= 11.4$

Ans: SHJ eqn can be used since SHJ eqn is derived based on the condition that the channel is rectangle.

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4a) In S2 profile,
At downstream limit, $y \to y_n$ $\therefore S_0 \to S_f$, $\frac{dy}{dx} \to 0$ $\therefore$ y asymptotes to y_n

In S3 profile.
At downstream limit, $y \to y_n$ $\therefore S_0 \to S_f$, $\frac{dy}{dx} \to 0$ $\therefore$ y asymptotes to y_n.

4b) i) $B = 5m$ $Q = 17m^3/s$ $S_0 = 0.001$, $n = 0.024$ $q = 3.4m^2/s$

$y_c = \sqrt[3]{\frac{q^2}{g}} = 1.06m$

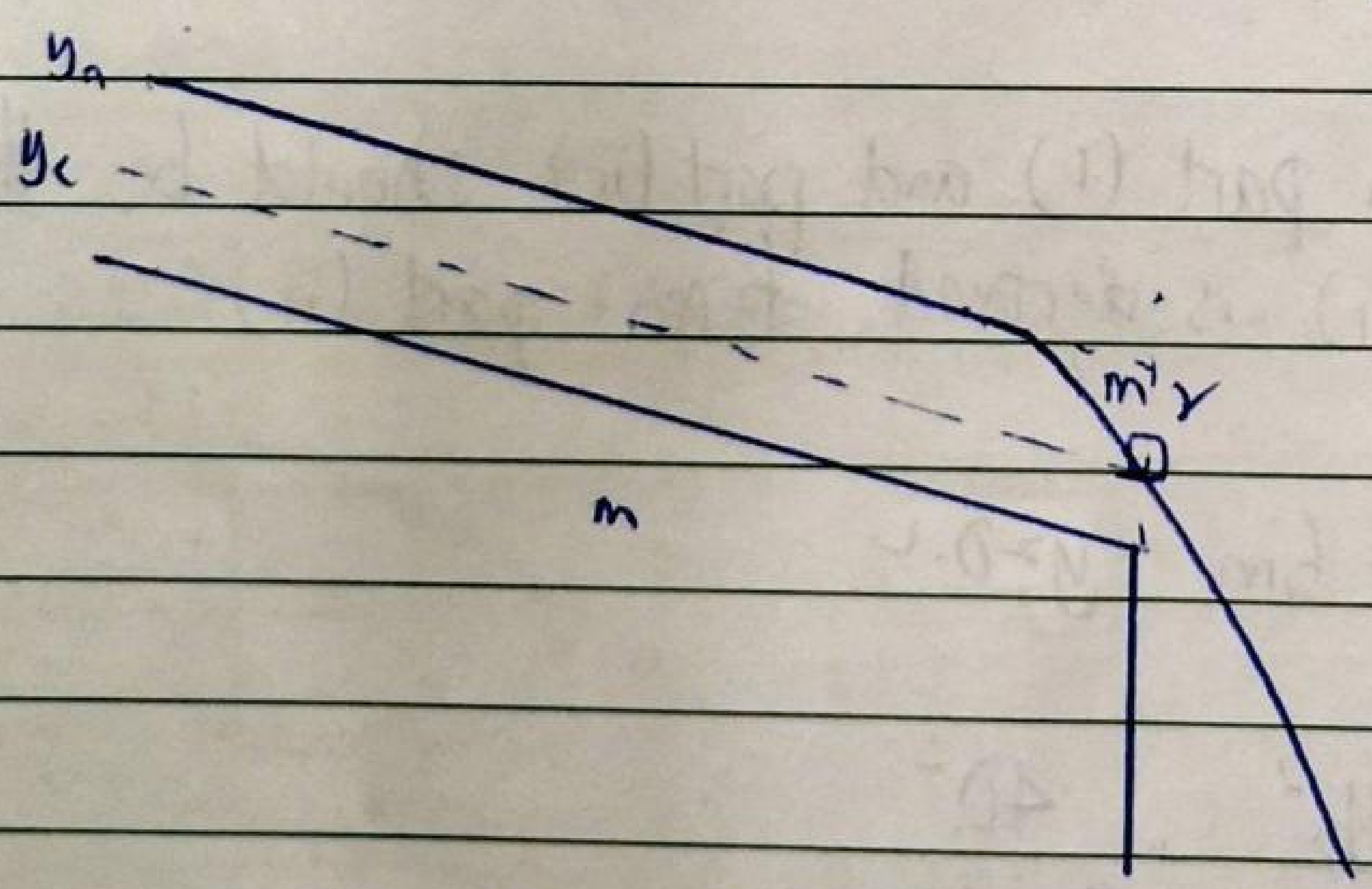
$R_h = \frac{A}{P_w} = \frac{by}{2y + b}$

$Q = \frac{1}{n} A R_h^{2/3} S_0^{1/2}$

$17 = \frac{1}{0.024}(5y)\left(\frac{5y}{2y+5}\right)^{2/3}(0.001)^{1/2}$

by trial and error,
$y_n = 2.3m$. $\therefore$ mild slope $\because y_n > y_c$

(ii)



[illegible]

(b iii) $y_1 = 0.99(2.3)$ $V_1 = 1.49 m/s$.

$= 2.277$

$R_1 = \frac{2.277 \times 5}{2 \times 2.277 + 5} = 1.19$

$y_2 = y_c = 1.06 m$.

$R_2 = \frac{1.06 \times 5}{2 \times 1.06 + 5} = 0.744$. $V_2 = 3.2 m/s$.

$\bar{R} = 0.967$ $\bar{V} = 2.345 m/s$

$S_f = \frac{n^2 V^2}{R^{\frac{4}{3}}} = 3.31 \times 10^{-3}$

$\Delta E = \left[2.277 + \frac{1.49^2}{2(9.81)}\right] - \left[1.06 + \frac{3.2^2}{2(9.81)}\right)$

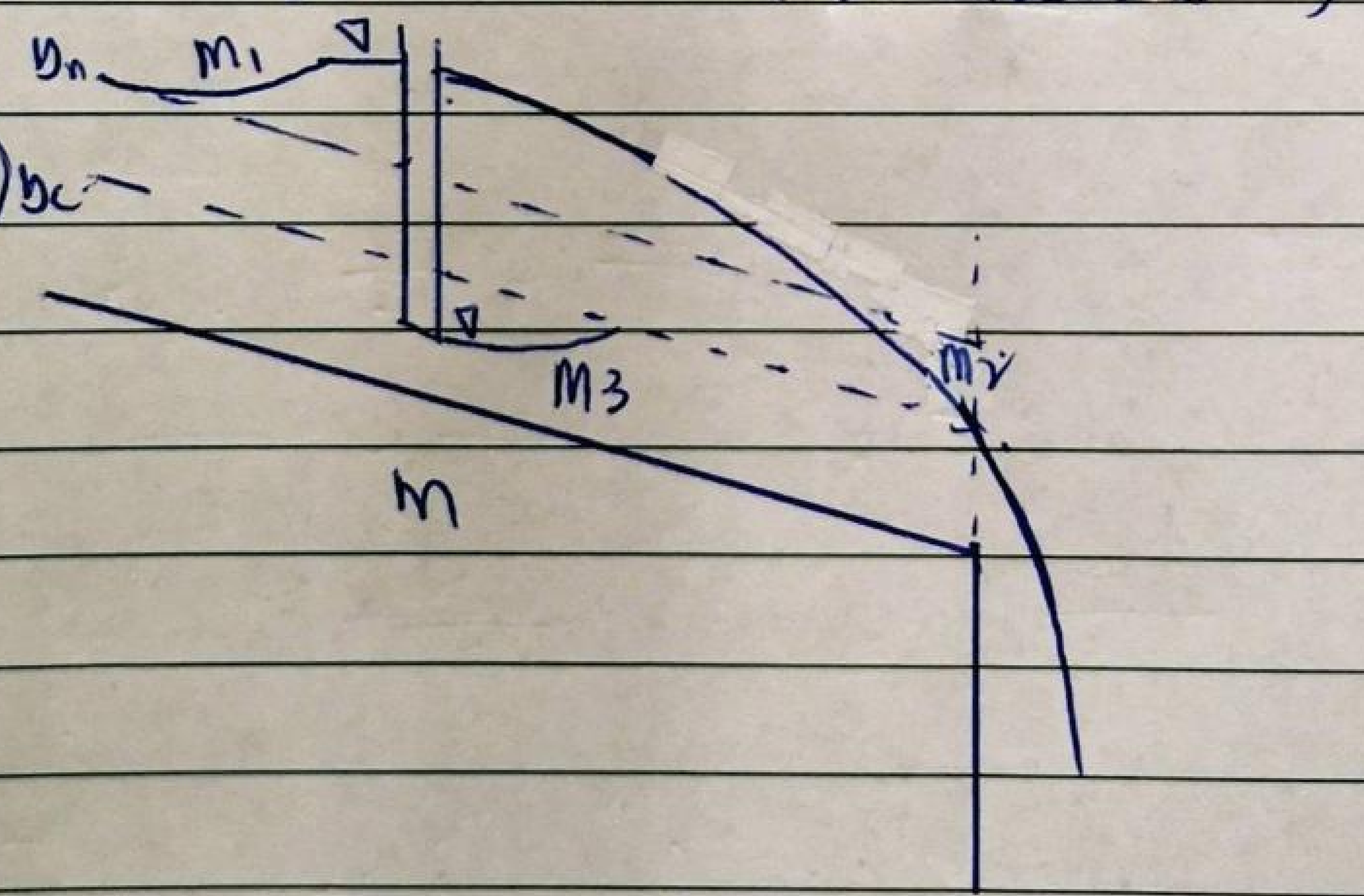
$= 0.808 m$.

$\Delta X = \frac{\Delta E}{S_0 - S_f}$

$= \frac{0.808}{0.001 - 3.31 \times 10^{-3}}$

$= 349.42 m$ (from free fall)

(Ci)



(Cii)