University Of Technology
Building and Construction Eng. Dept.
Final Exam 2014/2015 (1^{st} Attempt)

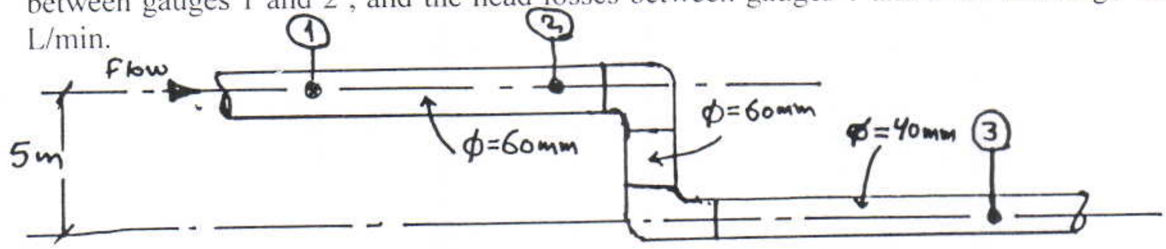
Subject :HY.Structures
Branch :Water & Dams
Examiner : Dr.J.S.Maatooq

Class:3^{rd}
Time : 3 Hours
Date :13 / 6/ 2015

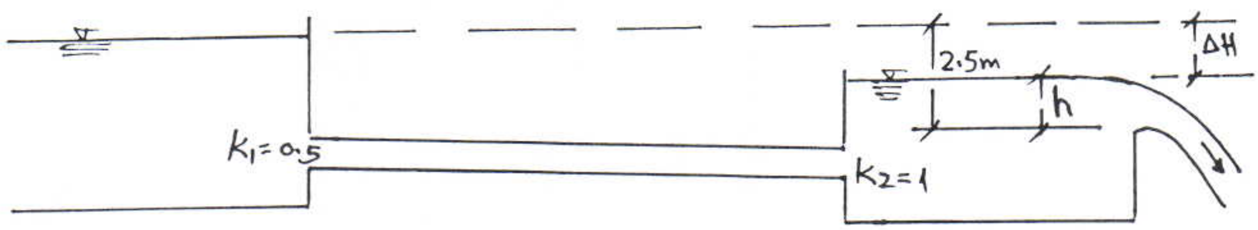
Notes : - Attempt all Questions

Q1] Answer "Two" of the following :-

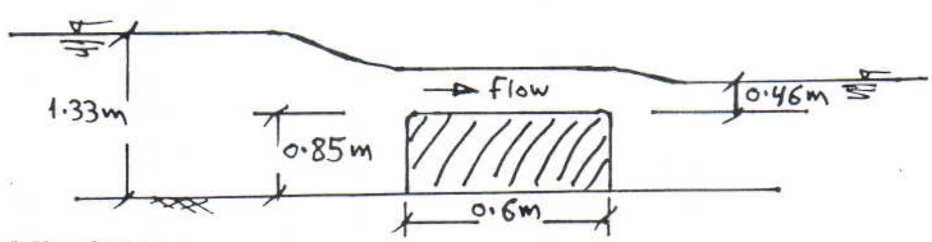
(A) For the simple pipe system shown in figure below , the pressures are ; P1=14kPa , P2=12.5kPa , and P3=10kPa . Neglect the minor losses and determine the head loss between gauges 1 and 2 , and the head losses between gauges 1 and 3 for discharge 420 L/min.



(B) The flow over weir from a second reservoir as shown in figure below is calculated by ; $Q = 0.4\sqrt{2g}\,Bh^{3/2}$. The pipe line length 40m and its diameter is 100mm , the crest length B=0.25 . Calculate the discharge and the head of flow over a weir crest , use f=0.024



(C) The flow over a broad crested weir as shown in figure below . Calculate a unit discharge by using a general equation and by Ranga-Raju equation . Also show is the flow modular or non-modular ? . (use A*/A=0.86 , and $Vo^2/2g=0.12$)



Q2] Answer "Two" of the following :-

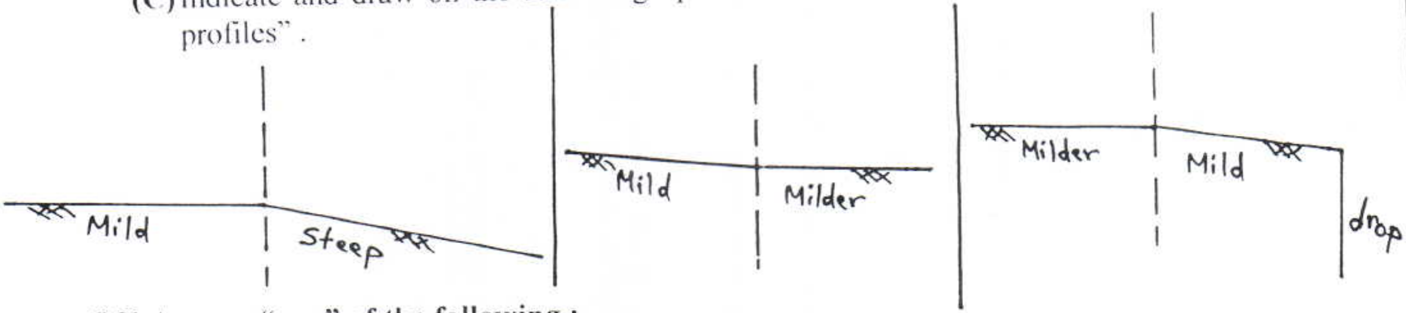
(A) A flow rate of $2.1m^3/s$ is to be carried in an open channel at velocity 1.3m/s . Determine the cross section for 1:1 side slope , and a required bed slope for the following normal depths :-

a) The same bottom width .

b) The half of bottom width .

(B) A rectangular channel 2m wide has a flow of $2.4m^3/s$ at a depth 1m . Determine if a critical depth occurs at a section where a hump of Δz 20cm height is installed across a channel bed ? . If need to constrict the width of a channel so as a critical depth to occur , compute the constriction width . (Use $\Delta z_{crit} = E - E_{min}$)

(C) Indicate and draw on the following open channels systems the possible "water surface profiles".



Q3| Answer "one" of the following :-

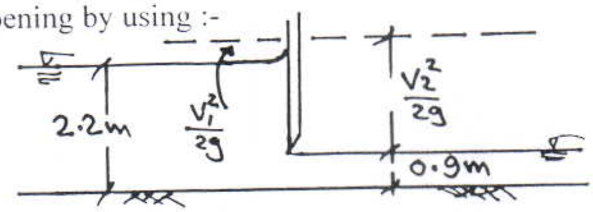
(A) The depth of runoff over a car parking is 5cm , flows towards 100m length open rectangular concrete lining (n=0.013) drain . If the bank top edge of the drain considered as a sharp crested suppressed weir its crest width along the length of drain . Determine the bottom width required for drain for a flow depth 0.7m, use $S_0 = 0.002$. (assume $P = 0$)

(B) For flow under sluice gate shown in figure below , neglect the effect of velocity approach and calculate the unit discharge and gate opening by using :-

a) Energy balance equation

b) Sluice gate equation

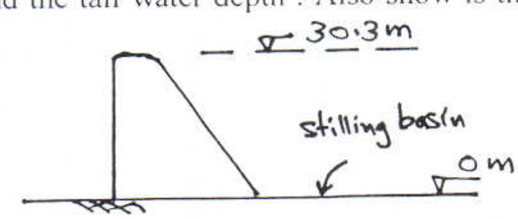
(use Cc=0.62)



Q4| Answer "one" of the following :-

(A) A maximum discharge 5700m^3/s and a maximum total head 19.5m over a 18m height Ogee crested spillway. If the ratio of total head to the design head is 1.3m , determine the crest length , and the discharge at a design head .

(B) The discharge over 30.3m wide Ogee crested spillway is 417.5m^3/s , for the ratios L/y2=4.4 , and Tw/y1=14.5 , find ; the suitable type of stilling basin , the length of stilling basin , and the tail water depth . Also show is the hydraulic jump submerged or free ? .



Q5| Answer "one" of the following :-

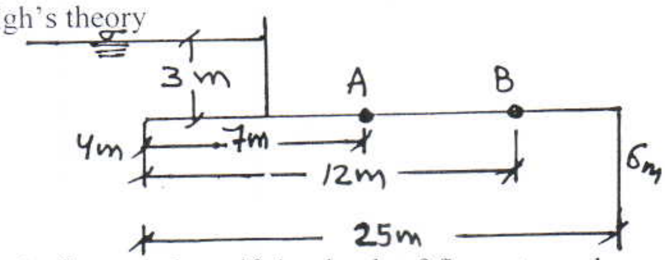
(A) For Barrage floor shown in figure . .Use Bligh's theory and find :-

a) Average hydraulic gradient and creep coefficient .

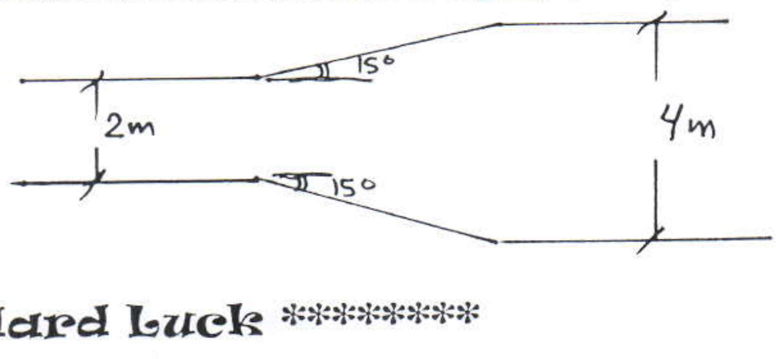
b) Uplift Pressure at points A and B

c) Safe thickness of floor at points A and B

(use $\gamma_c = 24\ kN/m^3$)



(B) For rectangular expansion transition shown in figure below, if the depth of flow at canal before transition is 1m . Find the depth of flow at end of transition for Q=5m^3/s , and the length of transition for a constant bed level along a transition . (use Ce=0.3)



********** **Hard Luck** *********

Water & Dams Branch

Hydraulic Structures Exam / 1st Attempt

Poblems Solutions

Q1 (A)

between 1 & 2:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_{L(1-2)}$$

$$\frac{V_1^2}{2g} = \frac{V_2^2}{2g} \quad \& \quad Z_1 = Z_2$$

then :- $h_{L(1-2)} = \frac{P_1 - P_2}{\gamma} = \frac{14 - 12.5}{9.81} \simeq \boxed{0.153\ m}$

between 1 & 3

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + Z_3 + h_{L(1-3)}$$

$$V_1 = \frac{Q}{A_1} = \frac{\left(\frac{420}{60*1000}\right)}{\frac{\pi}{4}\left(\frac{60}{1000}\right)^2} \simeq 2.48\ m/s$$

$$V_3 = \frac{Q}{A_3} = 5.38\ m/s$$

then :- $\frac{14}{9.81} + \frac{2.48^2}{2*9.81} + 5 = \frac{10}{9.81} + \frac{5.38^2}{2*9.81} + 0 + h_{L(1-3)}$

$$\Rightarrow h_{L(1-3)} = \boxed{4.24\ m}$$

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Problems Solutions

Q1 (B)

$$2.5-h = f\frac{L}{D}\frac{V^2}{2g} + 0.5\frac{V^2}{2g} + 1\frac{V^2}{2g}$$

$$2.5-h = \frac{V^2}{2g}\left[0.024 * \frac{40}{0.1} + 0.5 + 1\right]$$

$$2.5-h = 11.1\frac{V^2}{2g} \quad \text{—— (1)}$$

also $Q = 0.4\sqrt{2*9.81} * 0.25\, h^{3/2}$

$Q = 0.443\, h^{3/2}$ & $Q = V.A = V * \frac{\pi}{4}(0.1)^2$

$$\Longrightarrow Q = 0.00785\, V$$

then $V^2 = 3184.7\, h^3$ —— (2)

Put 2 in 1

$$2.5-h = \frac{11.1}{2*9.81}(3181.47)h^3$$

$\Longrightarrow 1801.74h^3 + h = 2.5 \Longrightarrow h \simeq$ **0.11 m**

& $Q = 0.443(0.11)^{3/2} =$ **0.0162 m³/s**

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Problems Solutions

Q1 (c)

$h = 1.33 - 0.85 = 0.48\,m$

$H = 0.48 + 0.12 = 0.6\,m$

$0.8 * 0.6 = 0.48\,m$

$H_2 = 0.46\,m < 0.48\,m$; hence the flow is "Modular"

$$C_v = \left(\frac{H}{h}\right)^{1.5} = \left(\frac{0.6}{0.48}\right)^{1.5} = 1.398$$

$$C_d = \frac{\left[1.398^{2/3} - 1\right]^{0.5}}{0.385 * 1.398} * \frac{1}{0.86} \simeq 1.081$$

$$q = C_d\, C_v\, \frac{2}{3}\sqrt{\frac{2}{3}g}\; H^{3/2}$$

$$= 1.081 * 1.398 * \frac{2}{3}\sqrt{2/3 * 9.81} * (0.6)^{3/2}$$

$$\Rightarrow q = \boxed{1.2\ m^3/s/m}$$

by Ranga - Raju Eq.

$$\frac{0.48}{0.48 + 0.85} = \frac{\sqrt{3}\left(C_w^{1.5} - \frac{2}{3}\right)^{1/2}}{C_w} \Rightarrow C_w = 0.78$$

$$\Rightarrow q = 0.78\sqrt{9.81} * (0.6)^{1.5} \simeq \boxed{1.14\ m^3/s/m}$$

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Problems Solutions

Q2 (A)

$Q = A \cdot V$ & $R = \frac{A}{P} = \frac{(b+y)y}{b+2y\sqrt{2}} = \frac{by+y^2}{b+\sqrt{6}\,y}$

$2.1 = 1.3(by+y^2) \Rightarrow \boxed{by+y^2-1.6154=0}$

(a) If $y=b \Rightarrow y^2+y^2-1.6154=0$

$\Rightarrow \boxed{y=0.899\,m}$ & $\boxed{b=0.899\,m}$

(b) $y^2+2y^2-1.6154=0$

$\Rightarrow \boxed{y=0.734\,m}$ & $\boxed{b=1.468\,m}$

for (a)

$R = 0.521$ & $S = \frac{V^2 n^2}{R^{4/3}} = \frac{1.3^2\, n^2}{(0.521)^{4/3}}$

$\boxed{S = 4.03\, n^2}$

for (b) $R = 0.6384 \Rightarrow \boxed{S = 3.074\, n^2}$

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problems Solutions

Q2 (B)

$$q = \frac{Q}{b} = \frac{2.4}{2} = 1.2 \ m^3/s/m$$

$$E = y + \frac{V^2}{2g} = y + \frac{q^2}{2gy^2} = 1 + \frac{1.2^2}{2*9.81*1^2} = 1.07 \ m$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} = 0.528 \ m \ \ \& \ \ E_{min.} = 1.5 y_c = 0.792 m$$

then $\Delta Z_{crit.} = E - E_{min.} = 1.07 - 0.792 \cong \boxed{0.28 \ m}$

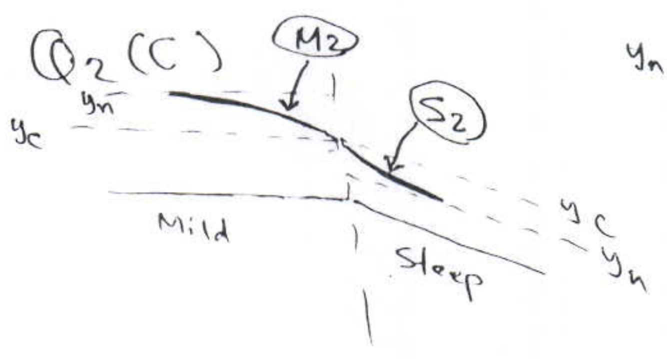
$\because \Delta Z < \Delta Z_{crit.}$ $\therefore$ y_c does not occur over hump.

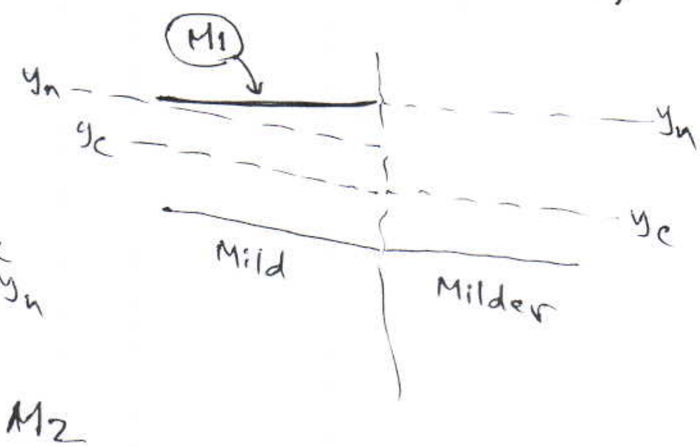
If $E_{min.} = E = 1.07 = 1.5 y_c \implies y_c = 0.715 m$

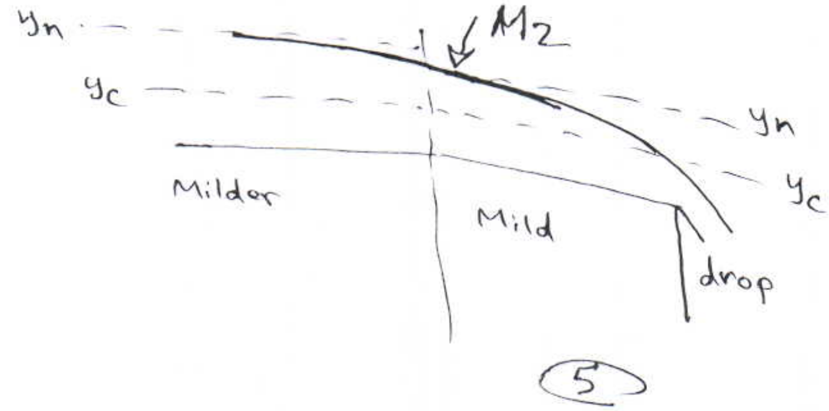
$$\implies y_c = \sqrt[3]{\frac{\frac{Q^2}{B^2}}{9.81}} = 0.715 \implies \boxed{B = 1.26 m}$$

(constriction width)

Q2 (C)







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Problems Solutions

Q3 (A)

From Fig.(5.5) at $\frac{B}{B_1} = 1$ & $\frac{H}{P} = 2.4$

$\Rightarrow C_d \simeq 0.78$

$$Q = \frac{2}{3}\sqrt{2*9.81} * 0.78 * 100 * \left(\frac{5}{100}\right)^{1.5} = 2.58 \ m^3/s$$

$$Q = \frac{1}{n} A R^{2/3} S_o^{1/2}$$

$$2.58 = \frac{1}{0.013}\left(\frac{b*0.7}{2*0.7+b}\right)^{2/3}(0.7b)(0.002)^{1/2}$$

$\Rightarrow$ **$b \simeq 2 m$**

Q3 (B)

(a) $y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \Rightarrow V_2 = \sqrt{2g(y_1 - y_2)}$

$\Rightarrow V_2 = 5.05$ m & $q = V_2 y_2 = 5.05 * 0.9 = \underline{4.54 \ m^3/s/m}$

& $G = \frac{y}{C_c} = \frac{0.9}{0.62} = \underline{1.45 \ m}$

(b) $C_d = \frac{0.62}{\sqrt{1 + \frac{0.62*1.45}{2.2}}} \simeq 0.52$

$q = 0.52 * 1.45 * 1 \sqrt{2*9.81(2.2 - 0.62*1.45)} \simeq \underline{3.81 \ m^3/s/m}$

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Problems Solutions

Q4 (A)

$\frac{H_e}{H_o} = 1.3 \longrightarrow H_o = \frac{19.5}{1.3} = 15\ m$

from Fig.(5) $\longrightarrow \frac{C}{C_o} = 1.03$

$\frac{P}{H_o} = \frac{18}{15} = 1.2$ then from Fig.4 $\longrightarrow C_o = 3.9$

$\Longrightarrow C = 3.9 * 1.03 = 4.017$

$\therefore L = \frac{Q}{C H_e^{3/2}} = \frac{5700}{4.017 * (19.5)^{1.5}} \simeq \underline{16.5\ m}$

& $Q_{des.} = C_o L H_o^{3/2} = 3.9 * 16.5 * 15^{1.5} \simeq \boxed{3738\ m^3/s}$

(B)

$q = \frac{Q}{L} = \frac{417.5}{30.3} = 13.77\ m^3/s/m$

$Z + y_c + \frac{V_c^2}{2g} = y_1 + \frac{V_1^2}{2g}$ & $E_c = y_c + \frac{V_c^2}{2g} = \frac{3}{2} y_c = \frac{3}{2}\sqrt[3]{\frac{13.77^2}{9.81}}$

$\Longrightarrow E_c = 1.68\ m$; $V_1 = \frac{q}{y_1} = \frac{13.77}{y_1}$

$\therefore 30.3 + 1.68 = y_1 + \frac{\frac{13.77^2}{y_1^2}}{2 * 9.81} \Longrightarrow \boxed{y_1 = 0.57\ m}$

$V_1 = 24.16\ m/s$ & $Fr_1 = \frac{V_1}{\sqrt{g y_1}} = 10.22 > 4.5$ & due to $V_1 > 15\ m/s$

then use type II USBR Stilling basin

$y_2 = \frac{y_1}{2}\left(\sqrt{1 + 8Fr_1^2} - 1\right) \Longrightarrow \underline{y_2 = 7.67\ m}$

$\Longrightarrow L = 4.4 * 7.67 = 33.75\ m$

& $T_W = 14.5 * 0.57 = \underline{8.265\ m} > y_2$ $\therefore$ Jump is Submerged

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problems Solutions

Q5 (A)

(a) $L = 4*2 + 25 + 6*2 = 45\ m$

$$\frac{H_L}{L} = \frac{3}{45} = \frac{1}{15} = G_e$$

∴ exit gradient is 1/15 & creep coefficient $C = 15$

(b) UP head at point A

$L_A = 4*2 + 7 = 15$

$H_A = \frac{L_A}{15} = \frac{15}{15} = 1\ m$ ∴ $UP_A^H = H_L - H_A = 3 - 1 = 2\ m$

$U.P_A = \gamma H_A = 9.81 * 2 = 19.62\ kN/m^2$

UP at point B

$L_B = 4*2 + 12 = 20\ m$ $UPH_B = \frac{H_L}{L}(L - L_B) = \frac{3}{45}(45 - 20)$

∴ $UPH_B = 1.667\ m$ & $UP_B = 9.81 * 1.667 = 16.35$

(c) thickness

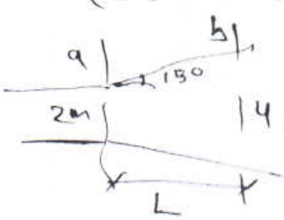
$$t_A = \frac{4 H_A}{3(\frac{\gamma_c}{\gamma_w} - 1)} = \frac{4 * 2}{3(2.4 - 1)} \simeq 1.9\ m$$

$$t_B = \frac{4 * 1.667}{3(2.4 - 1)} \simeq 1.6\ m$$

Q5 (B)

$V_a = Q / A_a = 5 / 1*2 = 2.5\ m/s$; $F_{r1} = \frac{2.5}{\sqrt{9.81*1}} = 0.8$ (subcritical flow)

then from energy Eq between two canals:-



$$y_b + (1 - C_e)\frac{V_b^2}{2g} = y_a + (1 - C_e)\frac{V_a^2}{2g}$$

$$\therefore y_b + 0.7\left(\frac{5^2}{2*9.81(4 y_b)^2}\right) = 1 + 0.7 * \frac{2.5^2}{2*9.81}$$

$\Rightarrow y_b \simeq 1.18$ then: $L_T = \frac{0.5\,\Delta t}{\tan\theta} = \frac{0.5(4-2)}{\tan 15^\circ} \simeq 3.7\ m$