Group No - 04
St. ID. 1016022

8.8 Data sheet:

Development of generalized specific Energy and specific force curves

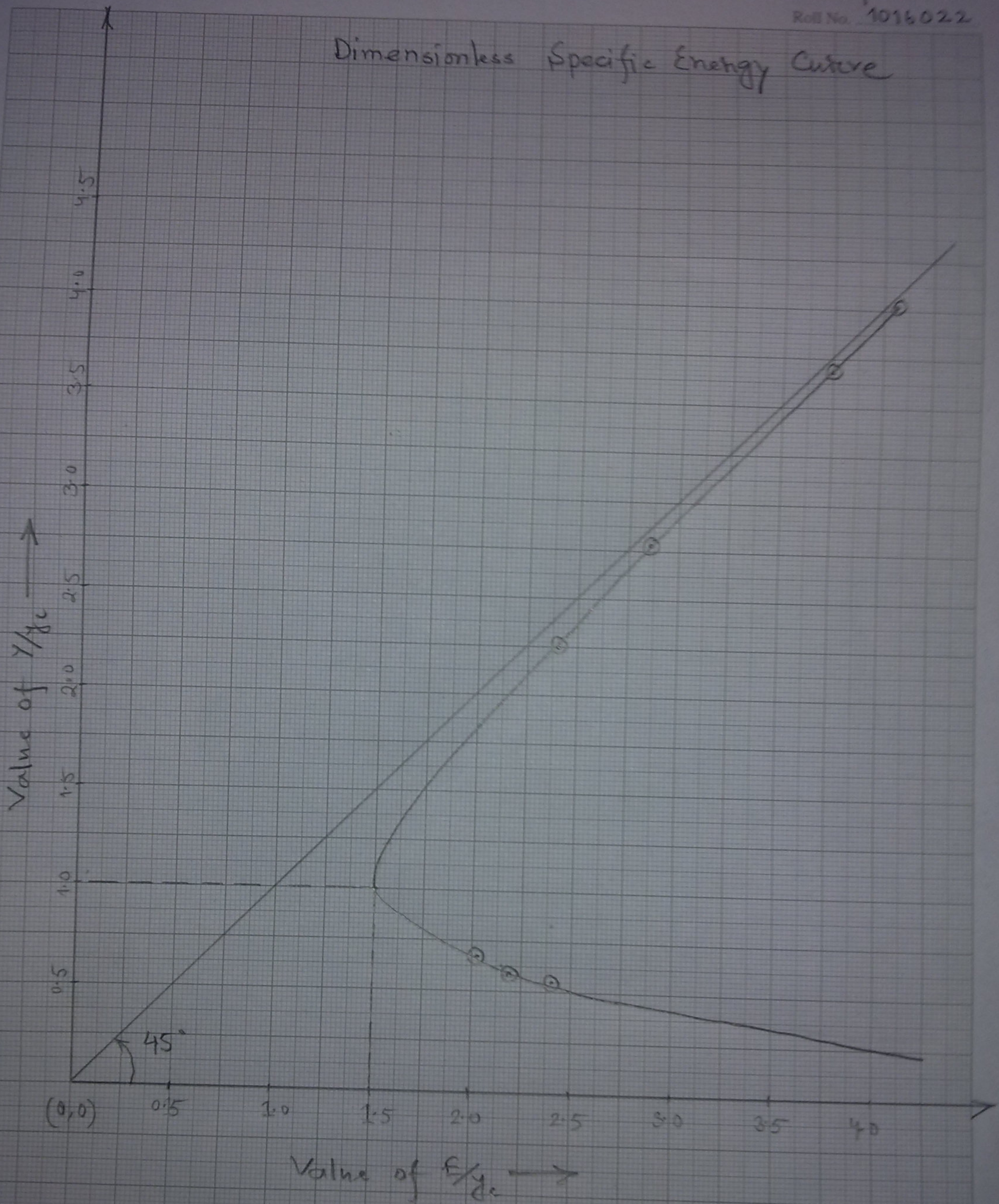
Q = 0.0184 m^3/s
b = 0.3048 m
$y_c = (Q^2/gb^2)^{1/3}$ = 0.0718 m

Section	y_1 (~~m~~) cm	y_2 (~~m~~) cm	y_3 (~~m~~) cm	$y = \frac{y_1+y_2+y}{3}$ (m)	y/y_c	E/y_c	$\frac{F}{y_c^2 \rho g b}$	y_c/y
1	29.05	29.05	29.05	0.2905	4.05	4.077	8.432	0.25
2	26.68	26.68	26.68	0.2668	3.72	3.752	7.173	0.27
3	19.45	19.45	19.45	0.1945	2.71	2.777	4.038	0.37
4	16.16	16.16	16.16	0.1616	2.25	2.349	2.977	0.44
5	3.51	4.32	3.46	0.0376	0.52	2.347	2.047	1.91
6	3.99	3.98	3.86	0.0394	0.55	2.209	1.973	1.82
7	3.75	4.14	4.34	0.0417	0.58	2.063	1.890	1.72

~~Ahmad~~ 01.03

Group No-01
Roll No. 1016022

Dimensionless Specific Energy Curve



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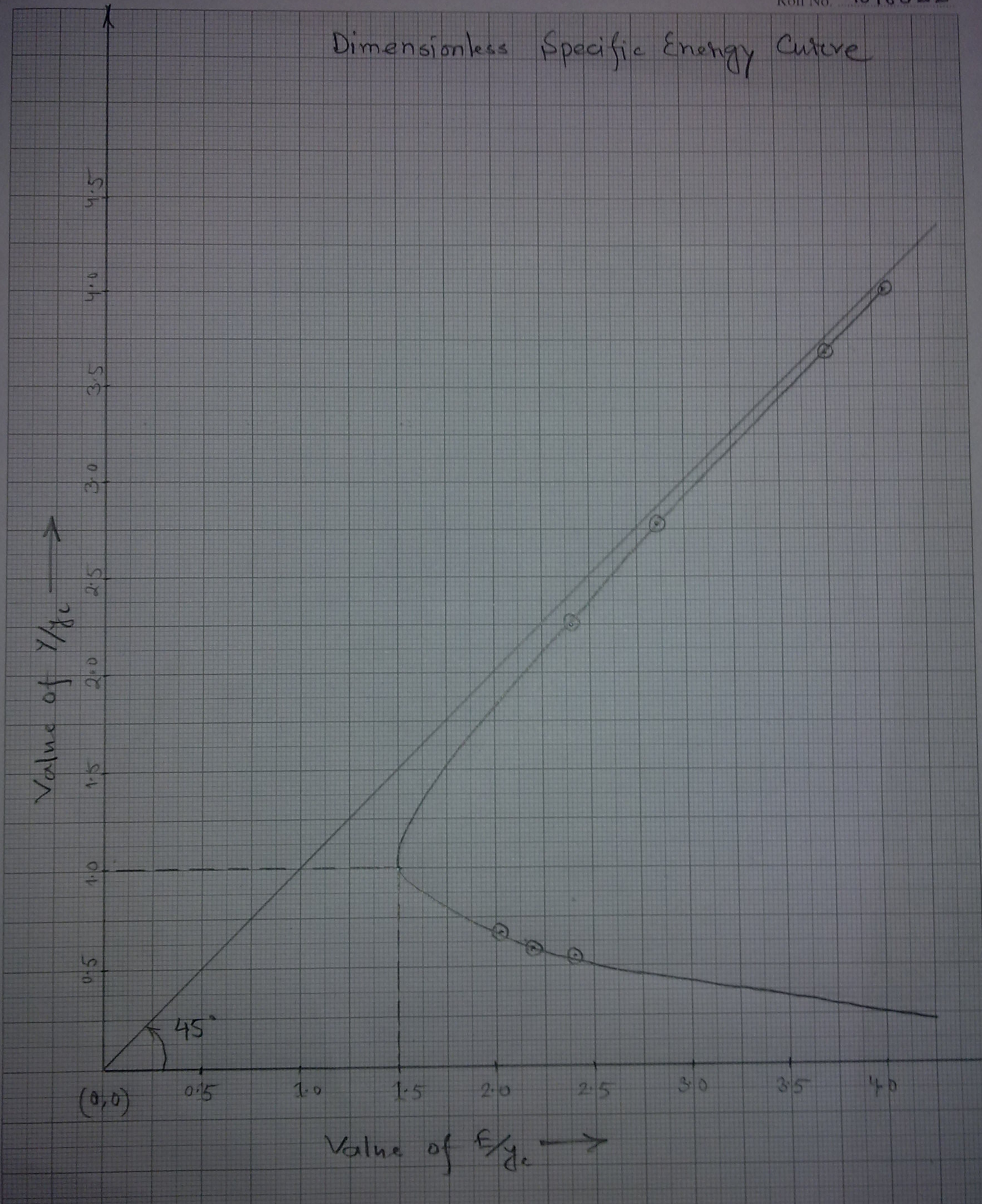

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20 cm x 25 cm

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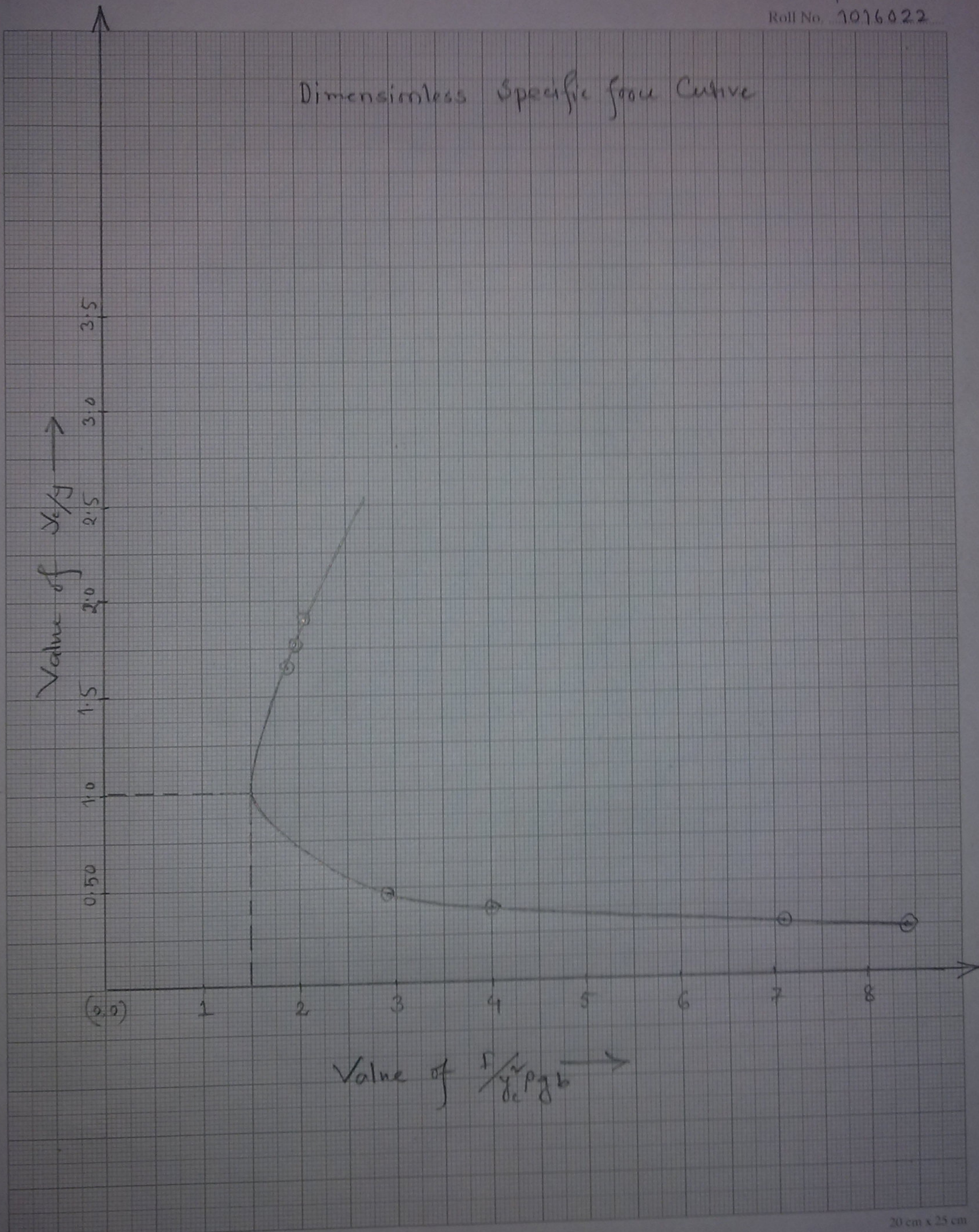
Dimensionless Specific force Curve



Bangladesh University of Engineering & Technology

Department of Water Resources Engineering

Course No. : WRE 302

Course Title: Open Channel Hydraulics Sessional

Experiment no.:08
Experiment name: Development of Generalized Specific Energy and Specific Force Curves

Date of performance:01/03/14
Date of submission: 15/03/14

Name: MD. Raiful islam
Student ID : 1016022
Level: 3 Term: 1
Session: 2012-13

Objective :

- Observe the flow profile in the experimental setup which depicts the variation of depth with change in energy.
- To plot the generalized specific energy and specific force curve from observed data.

Experimental Setup :

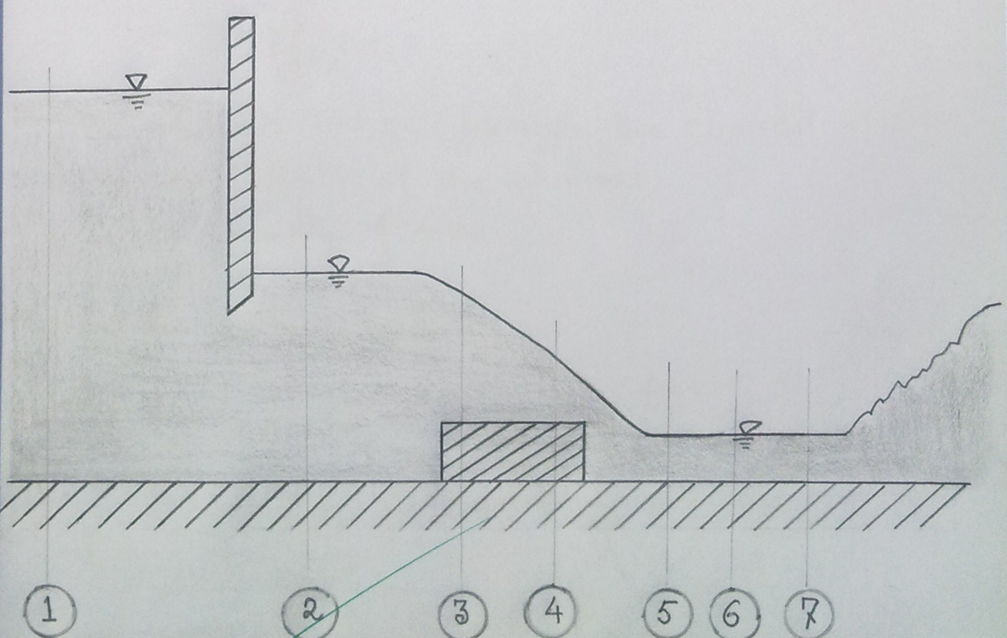


figure: Setup for development of generalized specific energy and specific force curve

☐ Related formula :

* Specific Energy -

Total energy at any section is given by,

$$H = z + y + \frac{v^2}{2g}$$

then the specific energy at any section of a channel is obtained by putting $z = 0$, i.e

$$E = y + \frac{v^2}{2g}$$

$$= y + \frac{Q^2}{2gA^2}$$

for a rectangular channel, $A = by$, therefore,

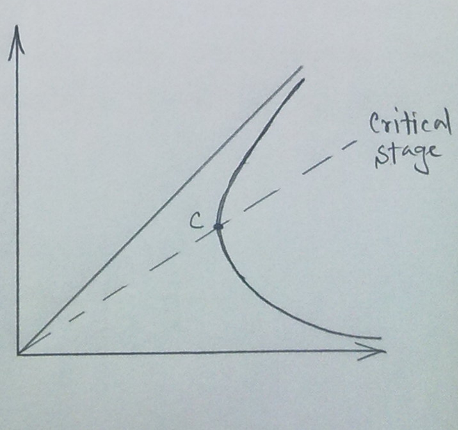
$$E = y + \frac{Q^2}{2gb^2y^2}$$

where, Q = Discharge through the channel section

b = width of the channel

y = depth of flow.

* Specific energy curve :



at point c, $E = E_c$

for critical flow,

$$E = y_c + \frac{Q^2}{2gA_c^2}$$

$$\frac{dE}{dy} = 1 - \frac{v^2}{gD}$$

Again, at point c, $E = E_c = E_{min}$

$\therefore \frac{dE}{dy} = 0$

$\Rightarrow 1 - \frac{V^2}{gD} = 0$ $\quad [\because F_r = \sqrt{V/gD}]$

$\Rightarrow F_r^2 = 1$

$\therefore F_r = 1$

Therefore, point c represents critical flow condition.

* Generealized specific energy curve:

$$E = y + \frac{Q^2}{2gb^2y^2}$$

Dividing this equation by y_c on both sides we get,

$$E/y_c = y/y_c + \frac{1}{2}\left(\frac{y_c}{y}\right)^2$$

* Specific force

It is the sum of hydrostatic force and momentum of the flow passing the section per unit time. For a rectangular channel the specific force is given by,

$$F = \frac{1}{2}\rho g b y^2 + \rho \frac{Q^2}{by}$$

Where, ρ = density of water

g = acceleration due to gravity.

* Generalized specific force curve:

$$f = \tfrac{1}{2}\rho g b y^2 + \rho \frac{Q^2}{by}$$

differentiating this equation with respect to y we get,

$$\frac{df}{dy} = \rho g b y - \rho Q^2 \frac{1}{by^2}$$

$$= \rho g A - \rho \frac{Q^2}{AD}$$

at point c

$f = f_c = f_{min}$

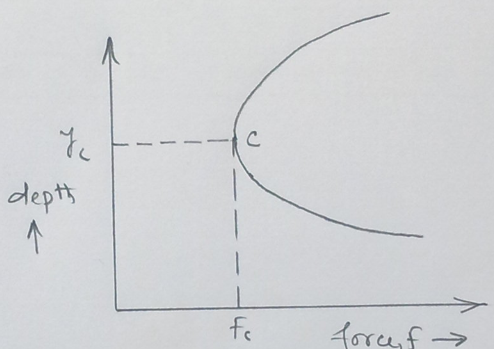
$\therefore \frac{df}{dy} = 0$

$\Rightarrow \rho g A = \rho \frac{Q^2}{AD}$

$\Rightarrow \frac{Q^2}{gDA^2} = 1$

$\Rightarrow \frac{V^2}{gD} = 1$

$\therefore F_r = 1$; therefore point c represents critical flow condition.



specific force curve

Again, dividing the above equation by $y_c^2 \rho g b$ we get,

$$\frac{f}{y_c^2 \rho g b} = \frac{y_c}{y} + \frac{1}{2}\left(\frac{y}{y_c}\right)^2$$

which represents the generalized specific force equation.

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01.03

Sample Calculation :

Discharge, $Q = 0.0184\ m^3/sec.$

Width of the channel, $b = 0.3048\ m$

Critical depth for the given discharge,

$$y_c = \sqrt[3]{\frac{Q^2}{gb^2}}$$

$$= \sqrt[3]{\frac{(0.0184)^2}{9.81 * (0.3048)^2}}$$

$$= 0.0718\ m$$

Detailed calculation for section 1

depth of flow, $y_1 = 29.05\ cm$

$y_2 = 29.05\ cm$

$y_3 = 29.05\ cm$

Average depth of flow, $y = \frac{y_1 + y_2 + y_3}{3}$

$$= \frac{29.05 + 29.05 + 29.05}{3}$$

$$= 29.05\ cm$$

$$= 0.2905\ m$$

Ratio of depth of flow to critical depth of flow, $y/y_c = \frac{0.2905}{0.0718}$

$$= 4.05$$

Cross sectional area at section ①,

$$A_1 = b * y$$
$$= 0.3048 * 0.2905$$
$$= 0.0885 \ m^2$$

Velocity at section ①, $V_1 = \frac{Q}{A_1}$

$$= \frac{0.0184}{0.0885}$$
$$= 0.2078 \ ms^{-1}$$

∴ Specific energy at section ①,

$$E = y + \frac{v_1^2}{2g}$$
$$= 0.2905 + \frac{(0.2078)^2}{2 \times 9.81}$$
$$= 0.2927 \ m$$

Ratio of specific energy to critical depth,

$$E/y_c = \frac{0.2927}{0.0718}$$
$$= 4.077$$

Specific force at section ①,

$$f = \tfrac{1}{2} \rho g \, b y^2 + \rho \frac{Q^2}{by}$$
$$= \tfrac{1}{2} * 1000 * 9.81 * 0.3048 * (0.2905)^2$$
$$+ 1000 \frac{(0.0184)^2}{0.3048 * 0.2905}$$
$$= 129.99$$

Dimensionless value of specific force,

$$\frac{f}{y_c^2 \rho g b} = \frac{129.99}{(0.0718)^2 * 1000 * 9.81 * 0.3048}$$

$$= 8.43$$

Ratio of critical depth to the depth of flow,

$$y_c/y = \frac{0.0718}{0.2905}$$

$$= 0.25$$

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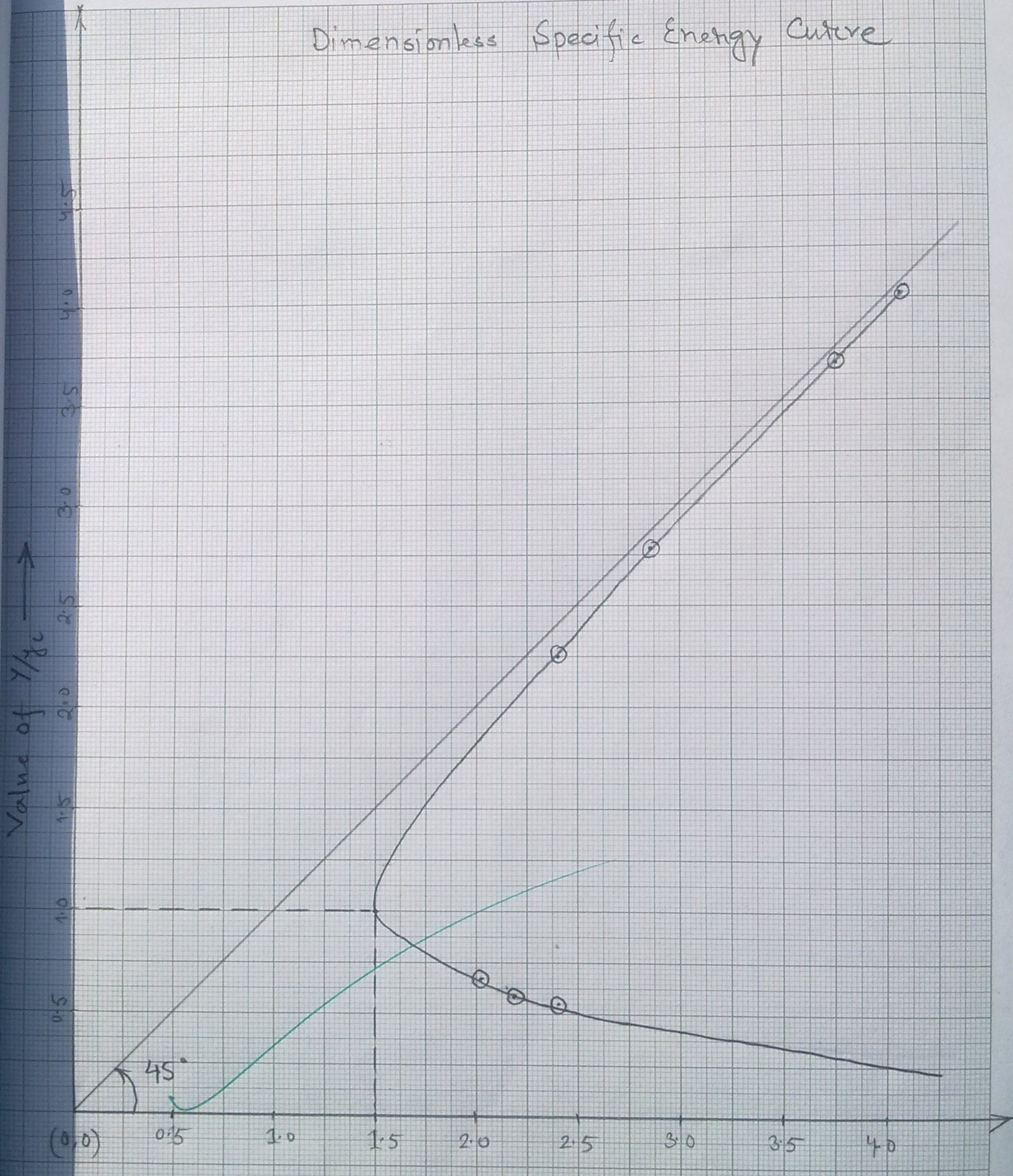

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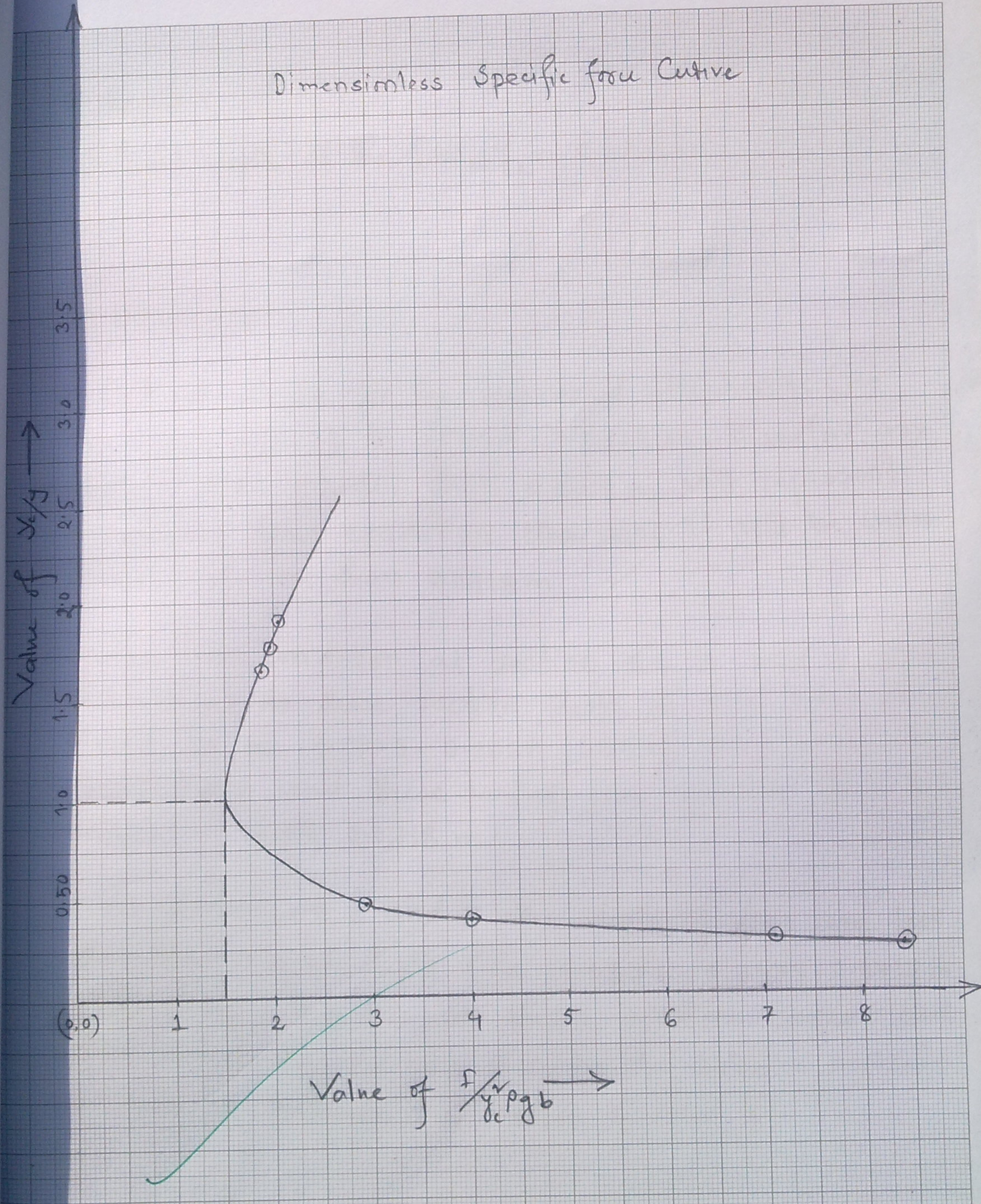

20 cm x 25 cm

☐ Result :

Critical depth of the flow, $y_c = 0.0718\ m$

☐ Discussion :

– Critical depth for the measured discharge (i.e $Q = 0.0184\ m^3/sec$) is found 0.0718 m. Therefore, any depth of flow greater than 0.0718 m will represent subcritical flow condition. otherwise it will be super critical if less than 0.0718 m

– The flow condition at section 1, 2, 3 and 4 was subcritical as these section depth of flow was measured to be 0.2905, 0.2668, 0.1945 and 0.1616 m respectively and these values are greater than the critical depth 0.0718 m

– At sections 5, 6 and 7 the depth of flow were less than the critical depth (i.e 0.0376, 0.0394, 0.0417 m respectively) Therefore, at these sections supercritical flow exist. So, we can assume to have a critical section in between the section 4 and 5.

Result :

Critical depth of the flow, $y_c = 0.0718$ m

Discussion :

- Critical depth for the measured discharge (i.e $Q = 0.0184$ m^3/sec) is found 0.0718 m. Therefore, any depth of flow greater than 0.0718 m will represent subcritical flow condition. Otherwise it will be super-critical if less than 0.0718 m

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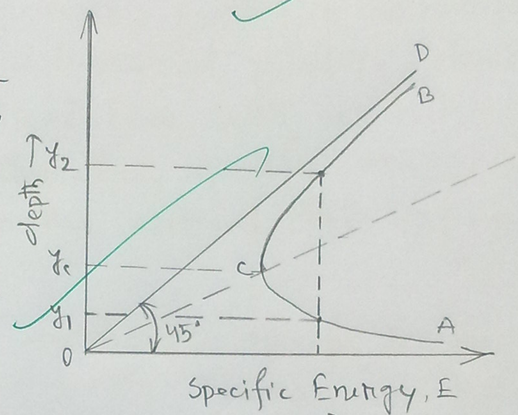
— An observation is made to find out the salient features of specific energy curve. They are

* It has two limbs CA and CB. Limbs CA increases asymptotically towards horizontal axis whereas limb CB approaches to OD line. In no case they touch the axis or OD line.



* At point c, $E = E_{min}$ and c point represents the critical flow condition

* for any given value of specific energy there are two depth of flow, one is low stage and another high stage.

* Thoroughout the limb CB, $y > y_c$ and at any point on limb CA, $y < y_c$. Therefore limb CB exhibits subcritical flow and limb CA represents supercritical flow condition.

* at point c, the curve is nearly vertical and small deviation in energy will cause large change in depth. for this reason flow behavior is unstable at or near critical point.

- Dimensionless specific energy curve is found symmetrical with the specific energy curve. In this case $y/y_c = 1$ represents the condition for critical flow. This curve has established relation between specific energy at critical flow with its critical depth i.e $E_c/y_c = 1.5$. Therefore, specific energy is 1.5 times greater than the critical depth of flow.

- With the increase in discharge specific energy curve will change accordingly. We can establish specific energy curve for any discharge from the dimensionless specific energy curve.

- Both the dimensionless specific energy curve and specific force curve shows its point of inflection at (1.5, 1). At this point depth of flow will merge with the value of critical depth.

⊞ Assigned Question:

Q.1 How can you apply the dimensionless specific energy and specific force curves for computing specific energy and specific force for different discharge?

With the increase of dischatge, critical depth will change. At the same time, the depth of flow will also change accordingly. Thus, effect of changing discharge for a given channel section will maintain a constant ratio betwen actual depth of flow at different section to critical depth of flow i.e y/y_c = constant.

Dimensionless specific energy curve and the specific force curve are also based on the ratio of y/y_c or y_c/y. So, for the given ~~ch.~~ discharge we can measure y/y_c ratio at different sections then read the value of E/y_c from the dimensionless specific energy curve and finally multiplying these values with the computed critical depth of flow. Same measurement can be adopted for calculation of specific force.

Q.2 Can you use the dimensionless specific energy curve to find out the specific force curve or vice-versa.

We can easily use the dimensionless specific energy curve to find out specific force or vice-versa.

Specific force from specific energy curve:

- Measure the values y/y_c from the different values of E/y_c in dimensionless specific energy curve
- Using the obtaining values of y/y_c in the eqn $\frac{F}{y_c^2 \rho g b} = \frac{y_c}{y} + \frac{1}{2}\left(\frac{y}{y_c}\right)^2$ we will get dimensionless specific force.
- finally multiplying this value with $y_c^2 \rho g b$ we will get the value of specific force.
- Now plotting "y vs F" graph we will get the specific force curve.