'G' BY PROJECTILE METHOD

Manohar Lal Verma

Former *Principal*
Y.D. Inter College, Oel
Lakhimpur- Kheri (U.P)
Email: ram.verma46@gmail.com

Introduction

This method is based on the principle of a projectile. Water is projected from a glass tube of narrow internal diameter. This tube is fitted in a vertical plane making an angle 'a' to the horizon. It is connected to a constant level water tank by means of a rubber tube. Water is sent at constant pressure in this tube, so that it comes at constant velocity. After leaving the glass tube, the stream of water forms a parabolic path due to gravity. Its range is measured by a meter scale and initial velocity is calculated with the relation given after this formula.

We know that:

$$R = \frac{u^2 \sin^2 \alpha}{g} \quad \text{..................(1)}$$

Here, R= Range on the horizontal plane.

u= Initial velocity of water just leaving tube)

a= Angle of projection (slope of glass tube with the horizon)

g = Acceleration due to gravity equations

$$\frac{u^2 \sin^2}{} \quad \text{........................ (2)}$$

The value of 'g' can also be calculated by measuring the maximum height 'H' on the horizontal plane instead of measuring the range because we know that:

$$R = \frac{u^2 \sin^2 \alpha}{2g}$$

$$\therefore g = \frac{u^2 \sin^2 \alpha}{2H} \quad \text{....................................(2a)}$$

Now, suppose 'r' be the radius of the glass tube and 'Q' the volume of water collected per second

$$\pi r^2 \times u = Q$$

$$u = Q / \pi r^2$$

From this relation, the initial velocity of water can be calculated. Substituting the value of 'u' in equation (2),

$$g = \frac{(Q^2) \sin 2\alpha}{(\pi r^2)^2 \times R} \quad \text{....................................(3)}$$

First of all, the value of 'g' was measured by this method. It was 979.7 cm/sec2.

A glass tube of internal diameter 0.325 cm was taken. The smaller arm is about 2 cm. The bigger arm is connected to a constant level water tank. The smaller arm is fitted at an angle 45° to the horizon. This tube can be named projecting tube. A meter scale is fitted horizontally in the level of projecting tube. Now, water was sent to this tube at different velocities by adjusting the constant level of the water tank at a different height.

The corresponding values of 'Q' is determined by graduated cylinder and stop-watch. but here, 'r' is constant for a tube, 'g' is also constant

Therefore, R = K Q2

Now, Q2 plotted against R,

The graph was a straight line passing through origin which is shown in figures 3 and 4. But in this apparatus 2a = 90°

$Q^2 = 90$, $R = 13.33$cms, $\sin^2\alpha = \sin 90^0 = 1$

$\pi = 22/7$, and $r = 0.1625$

$$R = \frac{Q^2}{\pi r^2}.1/g \quad \therefore g = \frac{Q^2}{\pi r^2}\times 1/R$$

$$g = \frac{90}{(22/7)^2 \times (.1625)^4 \times 13.33}$$

$g = 979.7$cms/ Sec^2

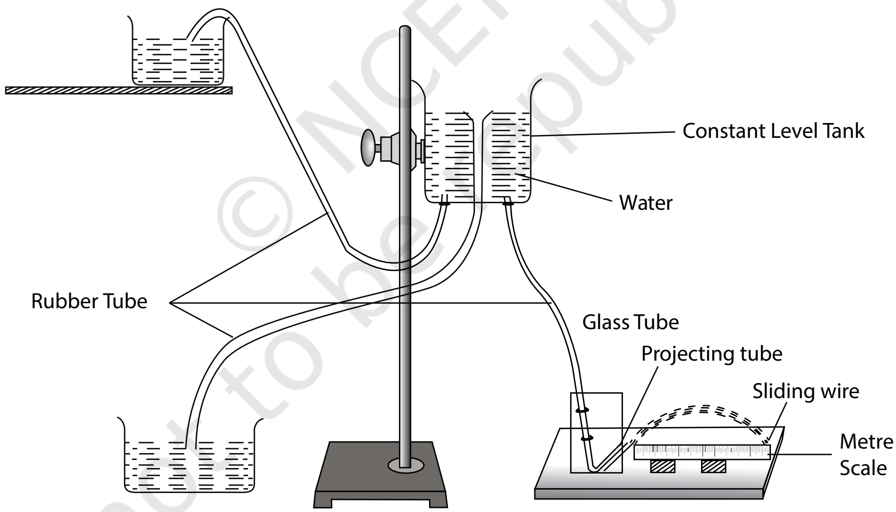

Fig. 1: 'g' by Projectile Method

Observation by discharging Nacl solution

Similarly, observations were taken by discharging the solution of Nacl through the glass tube at a constant angle of 45^0. The heights of constant level water is same as in case of water. In this case, the corresponding values of Q and R are decreased due to increase in viscosity. The Q vs R graph is given in fig. 2.

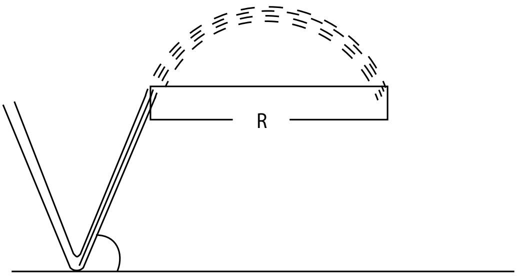

Fig. 2

S. No.	**Range R Cms**	**Time taken Seconds**	**Volume collected C.**	**QC Cs/ Sec.**
1.	7.3	40	278	6.950
2.	11.6	40	355	8.875
3.	15.5	40	410	10.250
4.	18.4	40	455	11.125
5.	21.4	40	480	12.00
S. No.	**R. Cms.**	**O^2**		
1.	7.1	48.3		
2.	11.6	78.7		
3.	15.5	105.0		
4.	18.4	124.7		
5.z	21.4	144.0		
For point 'B' in the graph : Q^2-90, R-13.33 Cms. r-1625 Cms,				

Observations by discharging water				
S. No.	**Range R Cm**	**Time taken (Seconds)**	**Volume collected C.**	**QC Cs/ Sec.**
1.	7.3	40	280	7
2.	11.5	40	357	8.925
3.	16.1	40	417	10.425
4.	19.3	40	457	11.425
5.	22	40	485	12.125
S. No.	**R. Cms.**	**O^2**		
1.	7.3	49.0		
2.	11.5	79.6		
3.	16.1	108.6		
4.	19.3	130.5		
5.	22.0	147.0		

The value of 'g' can be calculated from the following relation with the help of graph in figure 3.

1. There should be no insoluble impurities in the water or solution used. In the presence of these impurities the rate of discharging will not be constant.
2. The diameter of the glass tube should be measured accurately by a micrometer microscope as we need only the internal diameter of the top of the glass tube.
3. The range should be measured horizontally in the level of projecting tube. It will be equal to the horizontal distance from the mid-point of the top of the glass tube to the mid-point of falling stream of water as shown in fig. 2.
4. The volume collected in the graduated cylinder should be correct, because the square of the volume collected per second occurs in the relation 3.
5. The range is the maximum at 45°. Hence, it is better to make an observation at this

angle, both for simplicity of calculation and accuracy.

6. Water is better than other highly viscous substances.
7. The velocity of water should not be very high. The initial velocity of water will be the average velocity of all layers. The velocity of water should be so adjusted that the stream of water could not break up into droplets. If the initial velocity of water is high, the stream of water breaks into many parts. In this case, it will be difficult to adjust the sliding wire in the middle. The velocity of internal layers will be the maximum and outer layers will be the minimum. Therefore, the range will also differ for different layers. For low velocities stream WI U be cylindrical and we can easily adjust the sliding wire in the middle of the streams. lt is good for accuracy to take this tube of least internal diameter (2 or 3 milimetre.) The value of 'g' is free from all factors, such as radius of the tube and the liquid used.
8. Resistance of air can be neglected. If it is not neglected, the supposed range would be greater by 'x'. The factor 'x' had there been no air can be eliminated by taking two observations at different heights.

For first (1) $g = \dfrac{u_1^2 \sin^2\alpha}{R_1 + x}$ (or) $g R_1 + gx$

$= u_1^2 \sin^2\alpha$

(2) $g = \dfrac{u_2^2 \sin^2\alpha}{R_2 + x}$ or $gR_2 + gx$

$= u_2^2 \sin^2\alpha$

$$\therefore g = \frac{(u_2^2 - u_1^2)\sin^2\alpha}{(R_2 - R_1)}$$

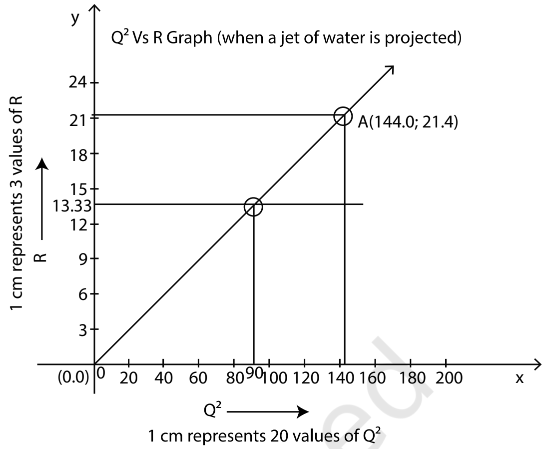

Fig. 3

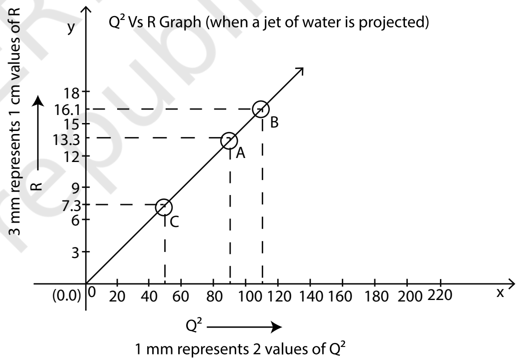

Fig. 4

The range should be measured by a sliding wire fitted on the horizontal metre scale. At the time of measuring the range, it should be adjusted in the middle of the falling stream. For small differences of two ranges error 'x' can be taken approximately the same. Actually, it will be different from different ranges. This method of elimination error due to resistance of air needs further detailed examination and experimental trial, which someone among the readers may perhaps like to take up.