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# Area-Velocity and Ultrasonic Method of Streamflow Measurement Formulas

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# List of 27 Area-Velocity and Ultrasonic Method of Streamflow Measurement Formulas

## Area-Velocity and Ultrasonic Method of Streamflow Measurement

### Area-Velocity Method

#### 1) Flow Velocity

$$fx \quad V_f = V \cdot \sin(\theta)$$

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2\_img.jpg\)](#)

$$ex \quad 7.660444\text{m/s} = 10\text{m/s} \cdot \sin(50^\circ)$$

#### 2) Moving Boat Velocity

$$fx \quad v_b = V \cdot \cos(\theta)$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa\_img.jpg\)](#)

$$ex \quad 6.427876\text{m/s} = 10\text{m/s} \cdot \cos(50^\circ)$$

#### 3) Moving Boat Velocity given Width between Two Verticals

$$fx \quad v_b = \frac{W}{\Delta t}$$

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d\_img.jpg\)](#)

$$ex \quad 6.382979\text{m/s} = \frac{300\text{m}}{47\text{s}}$$



#### 4) Partial Discharge in Sub-Area between Two Verticals given Flow Velocity

$$\text{fx } \Delta Q_i = \left( \frac{y_i + y_{i+1}}{2} \right) \cdot W + 1 \cdot V_f$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$\text{ex } 1057.6\text{m}^3/\text{s} = \left( \frac{3\text{m} + 4\text{m}}{2} \right) \cdot 300\text{m} + 1 \cdot 7.6\text{m}/\text{s}$$

#### 5) Partial Discharge in Sub-Area between Two Verticals given Resultant Velocity

$$\text{fx } \Delta Q_i = \left( \frac{y_i + y_{i+1}}{2} \right) \cdot V^2 \cdot \sin(\theta) \cdot \cos(\theta) \cdot \Delta t$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$\text{ex } 135.0007\text{m}^3/\text{s} = \left( \frac{3\text{m} + 4\text{m}}{2} \right) \cdot (10\text{m}/\text{s})^2 \cdot \sin(50^\circ) \cdot \cos(50^\circ) \cdot 47\text{s}$$

#### 6) Resultant Velocity given Flow Velocity

$$\text{fx } V = \frac{V_f}{\sin(\theta)}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$\text{ex } 9.921095\text{m}/\text{s} = \frac{7.6\text{m}/\text{s}}{\sin(50^\circ)}$$



## 7) Resultant Velocity given Moving Boat Velocity

$$fx \quad V = \frac{v_b}{\cos(\theta)}$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)

$$ex \quad 9.987747m/s = \frac{6.42m/s}{\cos(50^\circ)}$$

## 8) Time of Transit between two Verticals given Width between Verticals

$$fx \quad \Delta t = \frac{W}{v_b}$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$ex \quad 46.72897s = \frac{300m}{6.42m/s}$$

## 9) Width between Two Verticals

$$fx \quad W = v_b \cdot \Delta t$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7\_img.jpg\)](#)

$$ex \quad 5.029m = 6.42m/s \cdot 47s$$

## Measurement of Velocity

### 10) Average Stream Velocity given Minimum Weight

$$fx \quad v = \frac{N}{50 \cdot d}$$

[Open Calculator !\[\]\(c1168d6a8b365d11e842ece304635fa7\_img.jpg\)](#)

$$ex \quad 20m/s = \frac{3300N}{50 \cdot 3.3m}$$



### 11) Average Velocity in Moderately Deep Streams

$$fx \quad v = \frac{v_{0.2} + v_{0.8}}{2}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

$$ex \quad 20m/s = \frac{26m/s + 14m/s}{2}$$

### 12) Average Velocity obtained by using Reduction Factor

$$fx \quad v = K \cdot v_s$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021\_img.jpg\)](#)

$$ex \quad 20.9m/s = 0.95 \cdot 22m/s$$

### 13) Depth of Flow at Vertical given Sounding Weights

$$fx \quad d = \frac{N}{50 \cdot v}$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd\_img.jpg\)](#)

$$ex \quad 3.3m = \frac{3300N}{50 \cdot 20m/s}$$

### 14) Distance Travelled given Surface Velocity

$$fx \quad S = v_s \cdot t$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80\_img.jpg\)](#)

$$ex \quad 110m = 22m/s \cdot 5s$$



### 15) Revolutions per Second of Horizontal Axis Meter given Stream Velocity

$$fx \quad N_s = \frac{v - b}{a}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0\_img.jpg\)](#)

$$ex \quad 32 = \frac{20\text{m/s} - 0.8}{0.6}$$

### 16) Sounding Weights

$$fx \quad N = 50 \cdot v \cdot d$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5\_img.jpg\)](#)

$$ex \quad 3300N = 50 \cdot 20\text{m/s} \cdot 3.3\text{m}$$

### 17) Stream Velocity at Instrument Location

$$fx \quad v = a \cdot N_s + b$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60\_img.jpg\)](#)

$$ex \quad 20.6\text{m/s} = 0.6 \cdot 33 + 0.8$$


### 18) Surface Velocity

$$fx \quad v_s = \frac{S}{t}$$

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487\_img.jpg\)](#)

$$ex \quad 22\text{m/s} = \frac{110\text{m}}{5\text{s}}$$



19) Surface Velocity given Average of Velocity 

$$fx \quad v_s = \frac{v}{K}$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5\_img.jpg\)](#)

$$ex \quad 21.05263m/s = \frac{20m/s}{0.95}$$

20) Time of Distance Travelled given Surface Velocity 

$$fx \quad t = \frac{S}{v_s}$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5\_img.jpg\)](#)

$$ex \quad 5s = \frac{110m}{22m/s}$$

21) Velocity Distribution in Rough Turbulent Flow 

$$fx \quad v = 5.75 \cdot v_{\text{shear}} \cdot \log_{10} \left( 30 \cdot \frac{y}{k_s} \right)$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2\_img.jpg\)](#)

$$ex \quad 20.77107m/s = 5.75 \cdot 6m/s \cdot \log_{10} \left( 30 \cdot \frac{2m}{15} \right)$$



## Ultrasonic Method

### 22) Average Velocity along Path AB at certain Height above Bed

**fx**Open Calculator 

$$v_{\text{avg}} = \left( \left( \frac{L}{2} \right) \cdot \cos(\theta) \right) \cdot \left( \left( \frac{1}{t_1} \right) - \left( \frac{1}{t_2} \right) \right)$$

**ex**

$$2.351318\text{m/s} = \left( \left( \frac{3000\text{m}}{2} \right) \cdot \cos(50^\circ) \right) \cdot \left( \left( \frac{1}{2.02\text{s}} \right) - \left( \frac{1}{2.03\text{s}} \right) \right)$$

### 23) Elapse Time of Ultrasonic Signal sent by A

**fx**

$$t_1 = \frac{L}{C + v_p}$$

Open Calculator **ex**

$$2.020188\text{s} = \frac{3000\text{m}}{1480\text{m/s} + 5.01\text{m/s}}$$

### 24) Elapse Time of Ultrasonic Signal sent by B

**fx**

$$t_2 = \frac{L}{C - v_p}$$

Open Calculator **ex**

$$2.033912\text{s} = \frac{3000\text{m}}{1480\text{m/s} - 5.01\text{m/s}}$$





25) Length of Path for Elapse Time of Ultrasonic Signal 

$$fx \quad L = t_1 \cdot (C + v_p)$$

[Open Calculator !\[\]\(c3d993ca47bfe2a953c700506ce31fa0\_img.jpg\)](#)

$$ex \quad 2999.72m = 2.02s \cdot (1480m/s + 5.01m/s)$$

26) Length of Path given Elapse Time of Ultrasonic Signal 

$$fx \quad L = t_1 \cdot (C - v_p)$$

[Open Calculator !\[\]\(17413706fd4997a1a4bdf85c6864eee1\_img.jpg\)](#)

$$ex \quad 2979.48m = 2.02s \cdot (1480m/s - 5.01m/s)$$

27) Velocity of Sound in Water given Elapse Time of Ultrasonic Signal sent by A 

$$fx \quad C = \left( \frac{L}{t_1} \right) - v_p$$

[Open Calculator !\[\]\(4b7a79268f6ba26c1471d4232fffa85a\_img.jpg\)](#)

$$ex \quad 1480.139m/s = \left( \frac{3000m}{2.02s} \right) - 5.01m/s$$



## Variables Used







- **a** Constant a
- **b** Constant b
- **C** Velocity of Sound in Water (Meter per Second)
- **d** Depth of Flow in Vertical (Meter)
- **K** Reduction Factor
- **k<sub>s</sub>** Equivalent Sand-Grain Roughness
- **L** Length of Path from A to B (Meter)
- **N** Minimum Weight (Newton)
- **Ns** Revolutions per Second of Meter
- **S** Distance Travelled (Meter)
- **t** Time Taken to Travel (Second)
- **t<sub>1</sub>** Elapse Time t1 (Second)
- **t<sub>2</sub>** Elapse Time t2 (Second)
- **v** Average Velocity in Vertical (Meter per Second)
- **V** Resultant Velocity (Meter per Second)
- **v<sub>0.2</sub>** Velocity at 0.2 Times Depth of Flow (Meter per Second)
- **v<sub>0.8</sub>** Velocity at 0.8 Times Depth of Flow (Meter per Second)
- **v<sub>avg</sub>** Average Velocity along Path (Meter per Second)
- **v<sub>b</sub>** Boat Velocity (Meter per Second)
- **v<sub>f</sub>** Flow Velocity (Meter per Second)
- **v<sub>p</sub>** Component of Flow Velocity in Sound Path (Meter per Second)
- **v<sub>s</sub>** Surface Velocity of River (Meter per Second)



- $V_{\text{shear}}$  Shear Velocity (Meter per Second)
- $W$  Width between Two Verticals (Meter)
- $y$  Height above Bed (Meter)
- $y_i$  Depth 'yi' of Flow in Sub-Area (Meter)
- $y_{i+1}$  Depth 'i+1' of Flow in Sub-Area (Meter)
- $\Delta Q_i$  Partial Discharges (Cubic Meter per Second)
- $\Delta t$  Time of Transit between Two Verticals (Second)
- $\theta$  Angle (Degree)



## Constants, Functions, Measurements used

- **Function:** **cos**,  $\cos(\text{Angle})$   
*Trigonometric cosine function*
- **Function:** **log10**,  $\log_{10}(\text{Number})$   
*Common logarithm function (base 10)*
- **Function:** **sin**,  $\sin(\text{Angle})$   
*Trigonometric sine function*
- **Measurement:** **Length** in Meter (m)  
*Length Unit Conversion* 
- **Measurement:** **Time** in Second (s)  
*Time Unit Conversion* 
- **Measurement:** **Speed** in Meter per Second (m/s)  
*Speed Unit Conversion* 
- **Measurement:** **Force** in Newton (N)  
*Force Unit Conversion* 
- **Measurement:** **Angle** in Degree ( $^{\circ}$ )  
*Angle Unit Conversion* 
- **Measurement:** **Volumetric Flow Rate** in Cubic Meter per Second ( $\text{m}^3/\text{s}$ )  
*Volumetric Flow Rate Unit Conversion* 



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