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Three-Dimensional Incompressible Flow Formulas

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List of 29 Three-Dimensional Incompressible Flow Formulas

Three-Dimensional Incompressible Flow

3D Elementary Flows

1) Doublet Strength for 3D Incompressible Flow

$$\text{fx } \mu = -\frac{4 \cdot \pi \cdot \phi \cdot r^2}{\cos(\theta)}$$

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2_img.jpg\)](#)

$$\text{ex } 9463.181\text{m}^3/\text{s} = -\frac{4 \cdot \pi \cdot -75.72\text{m}^2/\text{s} \cdot (2.758\text{m})^2}{\cos(0.7\text{rad})}$$

2) Radial Coordinate for 3D Doublet Flow given Velocity Potential

$$\text{fx } r = \sqrt{\frac{\text{modulus}(\mu) \cdot \cos(\theta)}{4 \cdot \pi \cdot \text{modulus}(\phi_s)}}$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

$$\text{ex } 8.484972\text{m} = \sqrt{\frac{\text{modulus}(9463\text{m}^3/\text{s}) \cdot \cos(0.7\text{rad})}{4 \cdot \pi \cdot \text{modulus}(-8\text{m}^2/\text{s})}}$$



3) Radial Coordinate for 3D Source Flow given Radial Velocity

[Open Calculator !\[\]\(4729e517bc6a7cd81c8025b9646574fb_img.jpg\)](#)

$$fx \quad r = \sqrt{\frac{\Lambda}{4 \cdot \pi \cdot V_r}}$$

$$ex \quad 2.756995m = \sqrt{\frac{277m^2/s}{4 \cdot \pi \cdot 2.9m/s}}$$

4) Radial Coordinate for 3D Source Flow given Velocity Potential

[Open Calculator !\[\]\(e474458956c9a37fbf9586ddb60a7fa1_img.jpg\)](#)

$$fx \quad r = -\frac{\Lambda}{4 \cdot \pi \cdot \phi_s}$$

$$ex \quad 2.75537m = -\frac{277m^2/s}{4 \cdot \pi \cdot -8m^2/s}$$

5) Radial Velocity for 3D Incompressible Source Flow

[Open Calculator !\[\]\(4fe57c3593bf1b21d272ae7ac8dfaf77_img.jpg\)](#)

$$fx \quad V_r = \frac{\Lambda}{4 \cdot \pi \cdot r^2}$$

$$ex \quad 2.897887m/s = \frac{277m^2/s}{4 \cdot \pi \cdot (2.758m)^2}$$

6) Source Strength for 3D Incompressible Source Flow given Radial Velocity

[Open Calculator !\[\]\(2bae76de5ebbd5c4d7d47162f1673734_img.jpg\)](#)

$$fx \quad \Lambda = 4 \cdot \pi \cdot V_r \cdot r^2$$

$$ex \quad 277.202m^2/s = 4 \cdot \pi \cdot 2.9m/s \cdot (2.758m)^2$$



7) Source Strength for 3D Incompressible Source Flow given Velocity Potential

$$\text{fx } \Lambda = -4 \cdot \pi \cdot \phi_s \cdot r$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95_img.jpg\)](#)

$$\text{ex } 277.2644\text{m}^2/\text{s} = -4 \cdot \pi \cdot -8\text{m}^2/\text{s} \cdot 2.758\text{m}$$

8) Velocity Potential for 3D Incompressible Doublet Flow

$$\text{fx } \phi = -\frac{\mu \cdot \cos(\theta)}{4 \cdot \pi \cdot r^2}$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2_img.jpg\)](#)

$$\text{ex } -75.71855\text{m}^2/\text{s} = -\frac{9463\text{m}^3/\text{s} \cdot \cos(0.7\text{rad})}{4 \cdot \pi \cdot (2.758\text{m})^2}$$

9) Velocity Potential for 3D Incompressible Source Flow

$$\text{fx } \phi_s = -\frac{\Lambda}{4 \cdot \pi \cdot r}$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7_img.jpg\)](#)

$$\text{ex } -7.992371\text{m}^2/\text{s} = -\frac{277\text{m}^2/\text{s}}{4 \cdot \pi \cdot 2.758\text{m}}$$

Flow over Sphere



Pressure Coefficient

10) Polar Coordinate given Surface Pressure Coefficient

$$\text{fx } \theta = a \sin \left(\sqrt{\frac{4}{9} \cdot (1 - C_p)} \right)$$

[Open Calculator !\[\]\(74d4806277d7e73349d8e8c0897931e9_img.jpg\)](#)

$$\text{ex } 0.700096\text{rad} = a \sin \left(\sqrt{\frac{4}{9} \cdot (1 - 0.066)} \right)$$

11) Surface Pressure Coefficient for Flow over Sphere

$$\text{fx } C_p = 1 - \frac{9}{4} \cdot (\sin(\theta))^2$$

[Open Calculator !\[\]\(8bba887393ca45b761e5cb49e755e762_img.jpg\)](#)

$$\text{ex } 0.066213 = 1 - \frac{9}{4} \cdot (\sin(0.7\text{rad}))^2$$

Radial Velocity

12) Doublet Strength given Radial Velocity

$$\text{fx } \mu = 2 \cdot \pi \cdot r^3 \cdot \left(V_\infty + \frac{V_r}{\cos(\theta)} \right)$$

[Open Calculator !\[\]\(799877f5c2f906134441300079881630_img.jpg\)](#)

$$\text{ex } 9463.166\text{m}^3/\text{s} = 2 \cdot \pi \cdot (2.758\text{m})^3 \cdot \left(68\text{m/s} + \frac{2.9\text{m/s}}{\cos(0.7\text{rad})} \right)$$




13) Freestream Velocity given Radial Velocity 

$$fx \quad V_{\infty} = \frac{\mu}{2 \cdot \pi \cdot r^3} - \frac{V_r}{\cos(\theta)}$$

Open Calculator 


$$ex \quad 67.99874m/s = \frac{9463m^3/s}{2 \cdot \pi \cdot (2.758m)^3} - \frac{2.9m/s}{\cos(0.7rad)}$$

14) Polar Coordinate given Radial Velocity 

$$fx \quad \theta = a \cos \left(\frac{V_r}{\frac{\mu}{2 \cdot \pi \cdot r^3} - V_{\infty}} \right)$$

Open Calculator 

$$ex \quad 0.699604rad = a \cos \left(\frac{2.9m/s}{\frac{9463m^3/s}{2 \cdot \pi \cdot (2.758m)^3} - 68m/s} \right)$$

15) Radial Coordinate given Radial Velocity 

$$fx \quad r = \left(\frac{\mu}{2 \cdot \pi \cdot \left(V_{\infty} + \frac{V_r}{\cos(\theta)} \right)} \right)^{\frac{1}{3}}$$

Open Calculator 

$$ex \quad 2.757984m = \left(\frac{9463m^3/s}{2 \cdot \pi \cdot \left(68m/s + \frac{2.9m/s}{\cos(0.7rad)} \right)} \right)^{\frac{1}{3}}$$




16) Radial Velocity for Flow over Sphere 

$$fx \quad V_r = - \left(V_\infty - \frac{\mu}{2 \cdot \pi \cdot r^3} \right) \cdot \cos(\theta)$$

Open Calculator 


$$ex \quad 2.899034\text{m/s} = - \left(68\text{m/s} - \frac{9463\text{m}^3/\text{s}}{2 \cdot \pi \cdot (2.758\text{m})^3} \right) \cdot \cos(0.7\text{rad})$$

Stagnation Point 17) Doublet Strength given Radial Coordinate of Stagnation Point 

$$fx \quad \mu = 2 \cdot \pi \cdot V_\infty \cdot R_s^3$$

Open Calculator 

$$ex \quad 9469.87\text{m}^3/\text{s} = 2 \cdot \pi \cdot 68\text{m/s} \cdot (2.809\text{m})^3$$


18) Freestream Velocity at Stagnation Point for Flow over Sphere 

$$fx \quad V_\infty = \frac{\mu}{2 \cdot \pi \cdot R_s^3}$$

Open Calculator 

$$ex \quad 67.95067\text{m/s} = \frac{9463\text{m}^3/\text{s}}{2 \cdot \pi \cdot (2.809\text{m})^3}$$



19) Radial Coordinate of Stagnation Point for Flow over Sphere 

$$\text{fx } r = \left(\frac{\mu}{2 \cdot \pi \cdot V_{\infty}} \right)^{\frac{1}{3}}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$\text{ex } 2.808321\text{m} = \left(\frac{9463\text{m}^3/\text{s}}{2 \cdot \pi \cdot 68\text{m}/\text{s}} \right)^{\frac{1}{3}}$$

Surface Velocity 20) Freestream Velocity given Maximum Surface Velocity 

$$\text{fx } V_{\infty} = \frac{2}{3} \cdot V_{s,\text{max}}$$

[Open Calculator !\[\]\(f95dab70c751fda7d824b8b03650f7aa_img.jpg\)](#)

$$\text{ex } 68\text{m}/\text{s} = \frac{2}{3} \cdot 102\text{m}/\text{s}$$


21) Freestream Velocity given Surface Velocity for Flow over Sphere 

$$\text{fx } V_{\infty} = \frac{2}{3} \cdot \frac{V_{\theta}}{\sin(\theta)}$$

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c_img.jpg\)](#)

$$\text{ex } 68.29989\text{m}/\text{s} = \frac{2}{3} \cdot \frac{66\text{m}/\text{s}}{\sin(0.7\text{rad})}$$



22) Maximum Surface Velocity for Flow over Sphere 

$$\text{fx } V_{s,\max} = \frac{3}{2} \cdot V_{\infty}$$

[Open Calculator !\[\]\(c3d993ca47bfe2a953c700506ce31fa0_img.jpg\)](#)

$$\text{ex } 102\text{m/s} = \frac{3}{2} \cdot 68\text{m/s}$$

23) Polar Coordinate given Surface Velocity for Flow over Sphere 

$$\text{fx } \theta = a \sin\left(\frac{2}{3} \cdot \frac{V_{\theta}}{V_{\infty}}\right)$$

[Open Calculator !\[\]\(17413706fd4997a1a4bdf85c6864eee1_img.jpg\)](#)

$$\text{ex } 0.703721\text{rad} = a \sin\left(\frac{2}{3} \cdot \frac{66\text{m/s}}{68\text{m/s}}\right)$$

24) Surface Velocity for Incompressible Flow over Sphere 

$$\text{fx } V_{\theta} = \frac{3}{2} \cdot V_{\infty} \cdot \sin(\theta)$$

[Open Calculator !\[\]\(4b7a79268f6ba26c1471d4232fffa85a_img.jpg\)](#)

$$\text{ex } 65.7102\text{m/s} = \frac{3}{2} \cdot 68\text{m/s} \cdot \sin(0.7\text{rad})$$



Tangential Velocity

25) Doublet Strength given Tangential Velocity

$$fx \quad \mu = 4 \cdot \pi \cdot r^3 \cdot \left(\frac{V_\theta}{\sin(\theta)} - V_\infty \right)$$

[Open Calculator !\[\]\(339a16584d5da0f0a3ca4e9ec17bf6a1_img.jpg\)](#)

$$ex \quad 9081.966m^3/s = 4 \cdot \pi \cdot (2.758m)^3 \cdot \left(\frac{66m/s}{\sin(0.7rad)} - 68m/s \right)$$

26) Freestream Velocity given Tangential Velocity

$$fx \quad V_\infty = \frac{V_\theta}{\sin(\theta)} - \frac{\mu}{4 \cdot \pi \cdot r^3}$$

[Open Calculator !\[\]\(6059a5aa8b4ca7bb793408023d6c6e42_img.jpg\)](#)

$$ex \quad 66.55466m/s = \frac{66m/s}{\sin(0.7rad)} - \frac{9463m^3/s}{4 \cdot \pi \cdot (2.758m)^3}$$

27) Polar Coordinate given Tangential Velocity

$$fx \quad \theta = a \sin \left(\frac{V_\theta}{V_\infty + \frac{\mu}{4 \cdot \pi \cdot r^3}} \right)$$

[Open Calculator !\[\]\(e3275251d0893157c3584e20c81dc3ba_img.jpg\)](#)

$$ex \quad 0.688339rad = a \sin \left(\frac{66m/s}{68m/s + \frac{9463m^3/s}{4 \cdot \pi \cdot (2.758m)^3}} \right)$$



28) Radial Coordinate given Tangential Velocity [Open Calculator](#) 

$$\text{fx } r = \left(\frac{\mu}{4 \cdot \pi \cdot \left(\frac{V_\theta}{\sin(\theta)} - V_\infty \right)} \right)^{\frac{1}{3}}$$

$$\text{ex } 2.796043\text{m} = \left(\frac{9463\text{m}^3/\text{s}}{4 \cdot \pi \cdot \left(\frac{66\text{m/s}}{\sin(0.7\text{rad})} - 68\text{m/s} \right)} \right)^{\frac{1}{3}}$$

29) Tangential Velocity for Flow over Sphere [Open Calculator](#) 

$$\text{fx } V_\theta = \left(V_\infty + \frac{\mu}{4 \cdot \pi \cdot r^3} \right) \cdot \sin(\theta)$$

$$\text{ex } 66.93112\text{m/s} = \left(68\text{m/s} + \frac{9463\text{m}^3/\text{s}}{4 \cdot \pi \cdot (2.758\text{m})^3} \right) \cdot \sin(0.7\text{rad})$$





Variables Used




- C_p Pressure Coefficient
- r Radial Coordinate (Meter)
- R_s Radius of Sphere (Meter)
- V_∞ Freestream Velocity (Meter per Second)
- V_r Radial Velocity (Meter per Second)
- $V_{s,max}$ Maximum Surface Velocity (Meter per Second)
- V_θ Tangential Velocity (Meter per Second)
- θ Polar Angle (Radian)
- Λ Source Strength (Square Meter per Second)
- μ Doublet Strength (Cubic Meter per Second)
- ϕ Velocity Potential (Square Meter per Second)
- ϕ_s Source Velocity Potential (Square Meter per Second)



Constants, Functions, Measurements used




- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Function:** **acos**, `acos(Number)`
The inverse cosine function, is the inverse function of the cosine function. It is the function that takes a ratio as an input and returns the angle whose cosine is equal to that ratio.
- **Function:** **asin**, `asin(Number)`
The inverse sine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given ratio.
- **Function:** **cos**, `cos(Angle)`
Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- **Function:** **modulus**, `modulus`
Modulus of a number is the remainder when that number is divided by another number.
- **Function:** **sin**, `sin(Angle)`
Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- **Function:** **sqrt**, `sqrt(Number)`
A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- **Measurement:** **Length** in Meter (m)
Length Unit Conversion 
- **Measurement:** **Speed** in Meter per Second (m/s)
Speed Unit Conversion 



- **Measurement: Angle** in Radian (rad)
Angle Unit Conversion 
- **Measurement: Volumetric Flow Rate** in Cubic Meter per Second (m^3/s)
Volumetric Flow Rate Unit Conversion 
- **Measurement: Velocity Potential** in Square Meter per Second (m^2/s)
Velocity Potential Unit Conversion 



Check other formula lists

- [Fundamentals of Inviscid and Incompressible Flow Formulas](#) 
- [Two-Dimensional Incompressible Flow Formulas](#) 
- [Three-Dimensional Incompressible Flow Formulas](#) 

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