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# Relation between Forces on the Prototype and Forces on the Model Formulas

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# List of 18 Relation between Forces on the Prototype and Forces on the Model Formulas

## Relation between Forces on the Prototype and Forces on the Model

### 1) Density of Fluid for Ratio of Inertial Forces and Viscous Forces

$$\text{fx } \rho_{\text{fluid}} = \frac{F_i \cdot \mu_{\text{viscosity}}}{F_v \cdot V_f \cdot L}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b\_img.jpg\)](#)

$$\text{ex } 1.226429\text{kg/m}^3 = \frac{3.636\text{kN} \cdot 10.2\text{P}}{0.0504\text{kN} \cdot 20\text{m/s} \cdot 3\text{m}}$$

### 2) Dynamic Viscosity for Ratio of Inertial Forces and Viscous Force

$$\text{fx } \mu_{\text{viscosity}} = \frac{F_v \cdot \rho_{\text{fluid}} \cdot V_f \cdot L}{F_i}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d\_img.jpg\)](#)

$$\text{ex } 10.18812\text{P} = \frac{0.0504\text{kN} \cdot 1.225\text{kg/m}^3 \cdot 20\text{m/s} \cdot 3\text{m}}{3.636\text{kN}}$$

### 3) Force on Model for Scale Factor Parameters

$$\text{fx } F_m = \frac{F_p}{\alpha\rho \cdot \alpha V^2 \cdot \alpha L^2}$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d\_img.jpg\)](#)

$$\text{ex } 12.006\text{N} = \frac{69990.85\text{N}}{0.9999 \cdot (4.242)^2 \cdot (18)^2}$$



4) Force on Model given Force on Prototype 

$$fx \quad F_m = \frac{F_p}{\alpha F}$$

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

$$ex \quad 12N = \frac{69990.85N}{5832.571}$$

5) Force on Prototype 

$$fx \quad F_p = \alpha F \cdot F_m$$

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

$$ex \quad 69990.85N = 5832.571 \cdot 12N$$

6) Inertial Forces given Kinematic Viscosity 

$$fx \quad F_i = \frac{F_v \cdot V_f \cdot L}{\nu}$$

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

$$ex \quad 3.636364kN = \frac{0.0504kN \cdot 20m/s \cdot 3m}{0.8316m^2/s}$$

7) Inertial Forces using Newton's Friction Model 

$$fx \quad F_i = \frac{F_v \cdot \rho_{fluid} \cdot V_f \cdot L}{\mu_{viscosity}}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754\_img.jpg\)](#)

$$ex \quad 3.631765kN = \frac{0.0504kN \cdot 1.225kg/m^3 \cdot 20m/s \cdot 3m}{10.2P}$$



8) Kinematic Viscosity for Ratio of Inertial Forces and Viscous Force 

$$fx \quad v = \frac{F_v \cdot V_f \cdot L}{F_i}$$

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


$$ex \quad 0.831683m^2/s = \frac{0.0504kN \cdot 20m/s \cdot 3m}{3.636kN}$$

9) Length for Ratio of Inertial Forces and Viscous Forces 

$$fx \quad L = \frac{F_i \cdot \mu_{\text{viscosity}}}{F_v \cdot \rho_{\text{fluid}} \cdot V_f}$$

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

$$ex \quad 3.003499m = \frac{3.636kN \cdot 10.2P}{0.0504kN \cdot 1.225kg/m^3 \cdot 20m/s}$$

10) Length given Kinematic Viscosity, Ratio of Inertial forces and Viscous forces 

$$fx \quad L = \frac{F_i \cdot v}{F_v \cdot V_f}$$

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

$$ex \quad 2.9997m = \frac{3.636kN \cdot 0.8316m^2/s}{0.0504kN \cdot 20m/s}$$

11) Relation between Forces on Prototype and Forces on Model 

$$fx \quad F_p = \alpha \rho \cdot (\alpha V^2) \cdot (\alpha L^2) \cdot F_m$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b\_img.jpg\)](#)

$$ex \quad 69955.87N = 0.9999 \cdot ((4.242)^2) \cdot ((18)^2) \cdot 12N$$



## 12) Scale Factor for Density of Fluid given Forces on Prototype and Model

$$\text{fx } \alpha\rho = \frac{F_p}{\alpha V^2 \cdot \alpha L^2 \cdot F_m}$$

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

$$\text{ex } 1.0004 = \frac{69990.85\text{N}}{(4.242)^2 \cdot (18)^2 \cdot 12\text{N}}$$

## 13) Scale Factor for Inertia Forces given Force on Prototype

$$\text{fx } \alpha F = \frac{F_p}{F_m}$$

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

$$\text{ex } 5832.571 = \frac{69990.85\text{N}}{12\text{N}}$$

## 14) Scale Factor for Length given Forces on Prototype and Force on Model

$$\text{fx } \alpha L = \sqrt{\frac{F_p}{\alpha\rho \cdot \alpha V^2 \cdot F_m}}$$

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

$$\text{ex } 18.0045 = \sqrt{\frac{69990.85\text{N}}{0.9999 \cdot (4.242)^2 \cdot 12\text{N}}}$$



### 15) Scale Factor for Velocity given Forces on Prototype and Force on Model

[Open Calculator !\[\]\(eafc244b53721dd1ec133f0772f70fc7\_img.jpg\)](#)

$$\text{fx } \alpha V = \sqrt{\frac{F_p}{\alpha \rho \cdot \alpha L^2 \cdot F_m}}$$

$$\text{ex } 4.24306 = \sqrt{\frac{69990.85\text{N}}{0.9999 \cdot (18)^2 \cdot 12\text{N}}}$$

### 16) Velocity given Kinematic Viscosity, Ratio of Inertial Forces and Viscous Forces

[Open Calculator !\[\]\(10f8862fc183b400327470ea85afe9ae\_img.jpg\)](#)

$$\text{fx } V_f = \frac{F_i \cdot \nu}{F_v \cdot L}$$

$$\text{ex } 19.998\text{m/s} = \frac{3.636\text{kN} \cdot 0.8316\text{m}^2/\text{s}}{0.0504\text{kN} \cdot 3\text{m}}$$

### 17) Velocity given Ratio of Inertial Forces and Viscous Forces using Newton's Friction model

[Open Calculator !\[\]\(35dc653d59570f8f891c312eeece91a2\_img.jpg\)](#)

$$\text{fx } V_f = \frac{F_i \cdot \mu_{\text{viscosity}}}{F_v \cdot \rho_{\text{fluid}} \cdot L}$$

$$\text{ex } 20.02332\text{m/s} = \frac{3.636\text{kN} \cdot 10.2\text{P}}{0.0504\text{kN} \cdot 1.225\text{kg}/\text{m}^3 \cdot 3\text{m}}$$



**18) Viscous Forces using Newton's Friction model** [Open Calculator](#) 

$$\text{fx } F_v = \frac{F_i \cdot \mu_{\text{viscosity}}}{\rho_{\text{fluid}} \cdot V_f \cdot L}$$

$$\text{ex } 0.050459\text{kN} = \frac{3.636\text{kN} \cdot 10.2\text{P}}{1.225\text{kg/m}^3 \cdot 20\text{m/s} \cdot 3\text{m}}$$









## Variables Used

- $F_i$  Inertia Forces (Kilonewton)
- $F_m$  Force on Model (Newton)
- $F_p$  Force on Prototype (Newton)
- $F_v$  Viscous Force (Kilonewton)
- $L$  Characteristic length (Meter)
- $V_f$  Velocity of Fluid (Meter per Second)
- $\alpha F$  Scale Factor for Inertia Forces
- $\alpha L$  Scale Factor for Length
- $\alpha V$  Scale Factor for Velocity
- $\alpha \rho$  Scale Factor for Density of Fluid
- $\mu$  viscosity Dynamic Viscosity (Poise)
- $\nu$  Kinematic Viscosity for Model Analysis (Square Meter per Second)
- $\rho_{\text{fluid}}$  Density of Fluid (Kilogram per Cubic Meter)







## Constants, Functions, Measurements used

- **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:** **Force** in Kilonewton (kN), Newton (N)  
*Force Unit Conversion* 
- **Measurement:** **Dynamic Viscosity** in Poise (P)  
*Dynamic Viscosity Unit Conversion* 
- **Measurement:** **Kinematic Viscosity** in Square Meter per Second ( $\text{m}^2/\text{s}$ )  
*Kinematic Viscosity Unit Conversion* 
- **Measurement:** **Density** in Kilogram per Cubic Meter ( $\text{kg}/\text{m}^3$ )  
*Density Unit Conversion* 



## Check other formula lists

- [Froude Scaling and Scale Factor Formulas](#) 
- [Relation between Forces on the Prototype and Forces on the Model Formulas](#) 

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