Important Formulas of Mooring Forces PDF

Formulas
Examples
with Units

List of 29
Important Formulas of Mooring Forces

1) Angle of Current Relative to Longitudinal Axis of Vessel given Reynolds Number Formula

Evaluate Formula

Formula

$$\theta_c = acos\left(\frac{Re_m \cdot \nu'}{V_c \cdot l_{wl}}\right)$$

Example with Units

$$1.4727 = acos\left(\frac{200 \cdot 7.25\,St}{728.2461\,m/h \cdot 7.32\,m}\right)$$

2) Area Ratio given Expanded or Developed Blade Area of Propeller Formula

Evaluate Formula

Formula

$$A_r = l_{wl} \cdot \frac{B}{A_p \cdot 0.838}$$

Example with Units

$$1.1647 = 7.32\,m \cdot \frac{2\,m}{15\,m^2 \cdot 0.838}$$

3) Average Current Speed for Form Drag of Vessel Formula

Evaluate Formula

Formula

$$V = \sqrt{\frac{F_{c,\,form}}{0.5} \cdot \rho_{water} \cdot C_{c,\,form} \cdot B \cdot T \cdot \cos\left(\theta_c\right)}$$

Example with Units

$$1434.8438\,m/s = \sqrt{\frac{0.15\,kN}{0.5} \cdot 1000\,kg/m^3 \cdot 5 \cdot 2\,m \cdot 1.68\,m \cdot \cos\left(1.150\right)}$$

4) Average Current Speed given Reynolds Number Formula

Evaluate Formula

Formula

$$V_c = \frac{Re \cdot \nu'}{l_{wl}} \cdot \cos\left(\theta_c\right)$$

Example with Units

$$728.2461\,m/h = \frac{5000 \cdot 7.25\,St}{7.32\,m} \cdot \cos\left(1.150\right)$$

5) Axial Tension or Load given Individual Stiffness of Mooring Line Formula

Evaluate Formula

Formula

$$T_{n'} = \Delta l_n \cdot k_n$$

Example with Units

$$160\,kN = 1600\,m \cdot 100.0$$

6) Coefficient of Drag for Winds Measured at 10 m given Drag Force due to Wind Formula

Evaluate Formula

Formula

$$C_{D'} = \frac{F_D}{0.5 \cdot \rho_{air} \cdot A \cdot V_{10}^2}$$

Example with Units

$$0.0024 = \frac{37.0\,\text{N}}{0.5 \cdot 1.225\,\text{kg/m}^3 \cdot 52\,\text{m}^2 \cdot 22\,\text{m/s}^2}$$

7) Displacement of Vessel for Wetted Surface Area of Vessel Formula

Evaluate Formula

Formula

$$D = \frac{T \cdot \left(S' - \left(1.7 \cdot T \cdot l_{wl} \right) \right)}{35}$$

Example with Units

$$27.7965\,\text{m}^3 = \frac{1.68\,\text{m} \cdot \left(600\,\text{m}^2 - \left(1.7 \cdot 1.68\,\text{m} \cdot 7.32\,\text{m} \right) \right)}{35}$$

8) Drag Force due to Wind Formula

Evaluate Formula

Formula

$$F_D = 0.5 \cdot \rho_{air} \cdot C_{D'} \cdot A \cdot V_{10}^2$$

Example with Units

$$38.5385\,\text{N} = 0.5 \cdot 1.225\,\text{kg/m}^3 \cdot 0.0025 \cdot 52\,\text{m}^2 \cdot 22\,\text{m/s}^2$$

9) Elongation in Mooring Line given Individual Stiffness of Mooring Line Formula

Evaluate Formula

Formula

$$\Delta l_n = \frac{T_{n'}}{k_n}$$

Example with Units

$$1600\,\text{m} = \frac{160\,\text{kN}}{100.0}$$

10) Elongation in Mooring Line given Percent Elongation in Mooring Line Formula

Evaluate Formula

Formula

$$\Delta l_{\eta'} = \ln \cdot \left(\frac{\varepsilon_m}{100} \right)$$

Example with Units

$$4.999\,\text{m} = 10\,\text{m} \cdot \left(\frac{49.99}{100} \right)$$

11) Expanded or Developed Blade Area of Propeller Formula

Evaluate Formula

Formula

$$A_p = \frac{l_{wl} \cdot B}{0.838} \cdot A_r$$

Example with Units

$$20.2654\,\text{m}^2 = \frac{7.32\,\text{m} \cdot 2\,\text{m}}{0.838} \cdot 1.16$$

12) Form Drag Coefficient given Form Drag of Vessel Formula

Evaluate Formula

Formula

$$C_{c,\,form} = \frac{F_{c,\,form}}{0.5 \cdot \rho_{water} \cdot B \cdot T \cdot V_c^{\,2} \cdot \cos\left(\theta_c\right)}$$

Example with Units

$$5.3414 = \frac{0.15\,\text{kN}}{0.5 \cdot 1000\,\text{kg/m}^3 \cdot 2\,\text{m} \cdot 1.68\,\text{m} \cdot 728.2461\,\text{m/h}^{\,2} \cdot \cos\left(1.150\right)}$$

13) Individual Stiffness of Mooring Line Formula

Evaluate Formula

Formula

$$k_{n'} = \frac{T_{n'}}{\Delta l_{\eta'}}$$

Example with Units

$$32064.1283 = \frac{160\,\text{kN}}{4.99\,\text{m}}$$

14) Mass of Vessel given Virtual Mass of Vessel Formula

Evaluate Formula

Formula

$$m = m_v - m_a$$

Example with Units

$$80\,\text{kN} = 100\,\text{kN} - 20\,\text{kN}$$

15) Projected Area of Vessel above Waterline given Drag Force due to Wind Formula

Evaluate Formula

Formula

$$A = \frac{F_D}{0.5 \cdot \rho_{air} \cdot C_{D'} \cdot V_{10}^{\,2}}$$

Example with Units

$$49.9241\,\text{m}^2 = \frac{37.0\,\text{N}}{0.5 \cdot 1.225\,\text{kg/m}^3 \cdot 0.0025 \cdot 22\,\text{m/s}^{\,2}}$$

16) Propeller Drag Coefficient given Propeller Drag Formula

Evaluate Formula

Formula

$$C_{c,\,prop} = \frac{F_{c,\,prop}}{0.5 \cdot \rho_{water} \cdot A_p \cdot V_c^{\,2} \cdot \cos\left(\theta_c\right)}$$

Example with Units

$$1.9861 = \frac{249\,\text{N}}{0.5 \cdot 1000\,\text{kg/m}^3 \cdot 15\,\text{m}^2 \cdot 728.2461\,\text{m/h}^{\,2} \cdot \cos\left(1.150\right)}$$

17) Propeller Drag due to Form Drag of Propeller with Locked Shaft Formula

Evaluate Formula

Formula

$$F_{c,\,prop} = 0.5 \cdot \rho_{water} \cdot C_{c,\,prop} \cdot A_p \cdot V_c^{\,2} \cdot \cos\left(\theta_c\right)$$

Example with Units

$$249.485\,\text{N} = 0.5 \cdot 1000\,\text{kg/m}^3 \cdot 1.99 \cdot 15\,\text{m}^2 \cdot 728.2461\,\text{m/h}^{\,2} \cdot \cos\left(1.150\right)$$

18) Reynolds Number given Skin Friction Coefficient Formula

Evaluate Formula

Formula

$$Re_s = \frac{V_c \cdot l_{wl} \cdot \cos\left(\theta_c\right)}{\nu'}$$

Example with Units

$$834.31 = \frac{728.2461\,\text{m/h} \cdot 7.32\,\text{m} \cdot \cos\left(1.150\right)}{7.25\,\text{St}}$$

19) Skin Friction Coefficient given Skin Friction of Vessel Formula

Evaluate Formula

Formula

$$c_f = \frac{F_{c,fric}}{0.5 \cdot \rho_{water} \cdot S \cdot V_{cs}^{\,2} \cdot \cos\left(\theta_c\right)}$$

Example with Units

$$0.7605 = \frac{42}{0.5 \cdot 1000\,\text{kg/m}^3 \cdot 4\,\text{m}^2 \cdot 0.26\,\text{m/s}^{\,2} \cdot \cos\left(1.150\right)}$$

20) Skin Friction of Vessel due to Flow of Water over Wetted Surface Area of Vessel Formula

Evaluate Formula

Formula

$$F_{c,fric} = 0.5 \cdot \rho_{water} \cdot c_f \cdot S \cdot V_{cs}^{\,2} \cdot \cos\left(\theta_c\right)$$

Example with Units

$$39.7638 = 0.5 \cdot 1000\,\text{kg/m}^3 \cdot 0.72 \cdot 4\,\text{m}^2 \cdot 0.26\,\text{m/s}^{\,2} \cdot \cos\left(1.150\right)$$

21) Undamped Natural Period of Vessel Formula

Evaluate Formula

Formula

$$T_n = 2 \cdot \pi \cdot \left(\sqrt{\frac{m_v}{k_{tot}}}\right)$$

Example with Units

$$0.1745\,\text{h} = 2 \cdot 3.1416 \cdot \left(\sqrt{\frac{100\,\text{kN}}{10.0\,\text{N/m}}}\right)$$

22) Velocity at Desired Elevation Formula

Evaluate Formula

Formula

$$V_z = V_{10} \cdot \left(\frac{z}{10}\right)^{0.11}$$

Example with Units

$$28.6258\,\text{m/s} = 22\,\text{m/s} \cdot \left(\frac{109.50\,\text{m}}{10}\right)^{0.11}$$

23) Vessel Draft given Form Drag of Vessel Formula

Evaluate Formula

Formula

$$T = \frac{F_{c,\,form}}{0.5 \cdot \rho_{water} \cdot C_{c,\,form} \cdot B \cdot V_c^{\,2} \cdot \cos\left(\theta_c\right)}$$

Example with Units

$$1.7947\,\text{m} = \frac{0.15\,\text{kN}}{0.5 \cdot 1000\,\text{kg/m}^3 \cdot 5 \cdot 2\,\text{m} \cdot 728.2461\,\text{m/h}^{\,2} \cdot \cos\left(1.150\right)}$$

24) Virtual Mass of Vessel Formula

Evaluate Formula

Formula

$$m_v = m + m_a$$

Example with Units

$$100\,\text{kN} = 80\,\text{kN} + 20\,\text{kN}$$

25) Waterline Length of Vessel for Wetted Surface Area of Vessel Formula

Evaluate Formula

Formula

$$l_{wl} = \frac{S' - \left(35 \cdot \frac{D}{T'}\right)}{1.7} \cdot T'$$

Example with Units

$$7.0588\,\text{m} = \frac{600\,\text{m}^2 - \left(35 \cdot \frac{27\,\text{m}^3}{1.595\,\text{m}}\right)}{1.7} \cdot 1.595\,\text{m}$$

26) Waterline Length of Vessel given Expanded or Developed Blade Area Formula

Evaluate Formula

Formula

$$l_{wl} = \frac{A_p \cdot 0.838 \cdot A_r}{B}$$

Example with Units

$$7.2906\,\text{m} = \frac{15\,\text{m}^2 \cdot 0.838 \cdot 1.16}{2\,\text{m}}$$

27) Waterline Length of Vessel given Reynolds Number Formula

Evaluate Formula

Formula

$$l_{wl} = \frac{Re \cdot \nu'}{V_c} \cdot \cos\left(\theta_c\right)$$

Example with Units

$$7.32\,\text{m} = \frac{5000 \cdot 7.25\,\text{St}}{728.2461\,\text{m/h}} \cdot \cos\left(1.150\right)$$

28) Wetted Surface Area of Vessel Formula

Evaluate Formula

Formula

$$S' = \left(1.7 \cdot T \cdot l_{wl}\right) + \left(\frac{35 \cdot D}{T}\right)$$

Example with Units

$$583.4059\,\text{m}^2 = \left(1.7 \cdot 1.68\,\text{m} \cdot 7.32\,\text{m}\right) + \left(\frac{35 \cdot 27\,\text{m}^3}{1.68\,\text{m}}\right)$$

29) Wind Speed at Standard Elevation of 10 m given Velocity at Desired Elevation Formula

Evaluate Formula

Formula

$$V_{10} = \frac{V_z}{\left(\frac{z}{10}\right)^{0.11}}$$

Example with Units

$$20.3662\,\text{m/s} = \frac{26.5\,\text{m/s}}{\left(\frac{109.50\,\text{m}}{10}\right)^{0.11}}$$

Variables used in list of Important Formulas of Mooring Forces above

- **A** Projected Area of the Vessel *(Square Meter)*
- A_p Expanded or Developed Blade Area of a Propeller *(Square Meter)*
- A_r Area Ratio
- **B** Vessel Beam *(Meter)*
- $C_{c,\ form}$ Form Drag Coefficient
- $C_{c,\ prop}$ Propeller Drag Coefficient
- $C_{D'}$ Coefficient of Drag
- c_f Skin Friction Coefficient
- **D** Displacement of a Vessel *(Cubic Meter)*
- $F_{c,\ form}$ Form Drag of a Vessel *(Kilonewton)*
- $F_{c,\ prop}$ Vessel Propeller Drag *(Newton)*
- $F_{c,fric}$ Skin Friction of a Vessel
- F_D Drag Force *(Newton)*
- k_n Individual Stiffness of a Mooring Line
- $k_{n'}$ Individual Mooring Line Stiffness
- k_{tot} Effective Spring Constant *(Newton per Meter)*
- l_{wl} Waterline Length of a Vessel *(Meter)*
- **ln** Length of Mooring Line *(Meter)*
- **m** Mass of a Vessel *(Kilonewton)*
- m_a Mass of Vessel due to Inertial Effects *(Kilonewton)*
- m_v Virtual Mass of the Ship *(Kilonewton)*
- **Re** Reynolds Number
- Re_m Reynolds Number for Mooring Forces
- Re_s Reynolds Number for Skin Friction
- **S** Wetted Surface Area *(Square Meter)*
- **S'** Wetted Surface Area of Vessel *(Square Meter)*
- **T** Vessel Draft *(Meter)*
- T_n Undamped Natural Period of a Vessel *(Hour)*
- $T_{n'}$ Axial Tension or Load on a Mooring Line *(Kilonewton)*

Constants, Functions, Measurements used in list of Important Formulas of Mooring Forces above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- Functions: **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.*
- Functions: **cos**, cos(Angle) *Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.*
- Functions: **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: **Time** in Hour (h) *Time Unit Conversion*
- Measurement: **Volume** in Cubic Meter (m³) *Volume Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Speed** in Meter per Hour (m/h), Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Force** in Kilonewton (kN), Newton (N) *Force Unit Conversion*
- Measurement: **Surface Tension** in Newton per Meter (N/m) *Surface Tension Unit Conversion*
- Measurement: **Kinematic Viscosity** in Stokes (St) *Kinematic Viscosity Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*

- T' Draft in Vessel *(Meter)*
- V Longshore Current Speed *(Meter per Second)*
- V_{10} Wind Speed at Height of 10 m *(Meter per Second)*
- V_c Average Current Speed *(Meter per Hour)*
- V_{cs} Average Current Speed for Skin Friction *(Meter per Second)*
- V_z Velocity at the Desired Elevation z *(Meter per Second)*
- z Desired Elevation *(Meter)*
- Δl_n Mooring Line Elongation *(Meter)*
- $\Delta l_{\eta'}$ Elongation in the Mooring Line *(Meter)*
- ε_m Percent Elongation in a Mooring Line
- θ_c Angle of the Current
- ν' Kinematic Viscosity in Stokes *(Stokes)*
- ρ_{air} Air Density *(Kilogram per Cubic Meter)*
- ρ_{water} Water Density *(Kilogram per Cubic Meter)*

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