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Important Formulas of Mooring Forces

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List of 29 Important Formulas of Mooring Forces

Important Formulas of Mooring Forces ⤴

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

Open Calculator ⤴

fx $\theta_c = a\cos\left(\dfrac{Re_m \cdot v'}{V_c \cdot l_{wl}}\right)$

ex $1.472717 = a\cos\left(\dfrac{200 \cdot 7.25St}{728.2461m/h \cdot 7.32m}\right)$

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

Open Calculator ⤴

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

ex $1.164678 = 7.32m \cdot \dfrac{2m}{15m^2 \cdot 0.838}$

3) Average Current Speed for Form Drag of Vessel

fx   **Open Calculator**

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

ex $1434.844 \text{m/s} = \sqrt{\frac{0.15 \text{kN}}{0.5} \cdot 1000 \text{kg/m}^3 \cdot 5 \cdot 2\text{m} \cdot 1.68\text{m} \cdot \cos(1.150)}$

4) Average Current Speed given Reynolds Number

fx $V_c = \frac{Re \cdot v'}{l_{wl}} \cdot \cos(\theta_c)$ **Open Calculator**

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

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

fx $T_{n'} = \Delta l_n \cdot k_n$ **Open Calculator**

ex $160 \text{kN} = 1600\text{m} \cdot 100.0$

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

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

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

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

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

Open Calculator ⎘

ex $27.79652 m^3 = \dfrac{1.68m \cdot (600m^2 - (1.7 \cdot 1.68m \cdot 7.32m))}{35}$

8) Drag Force due to Wind ⎘

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

Open Calculator ⎘

ex $38.5385N = 0.5 \cdot 1.225 kg/m^3 \cdot 0.0025 \cdot 52m^2 \cdot (22m/s)^2$

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

fx $\Delta l_n = \dfrac{T_{n'}}{k_n}$

Open Calculator ⎘

ex $1600m = \dfrac{160kN}{100.0}$

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

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

Open Calculator ⎘

ex $4.999m = 10m \cdot \left(\dfrac{49.99}{100}\right)$

11) Expanded or Developed Blade Area of Propeller ⤴

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

Open Calculator ⤴

ex $20.26539 m^2 = \dfrac{7.32m \cdot 2m}{0.838} \cdot 1.16$

12) Form Drag Coefficient given Form Drag of Vessel ⤴

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

Open Calculator ⤴

ex

$$5.341361 = \dfrac{0.15kN}{0.5 \cdot 1000 kg/m^3 \cdot 2m \cdot 1.68m \cdot (728.2461 m/h)^2 \cdot \cos(1.150)}$$

13) Individual Stiffness of Mooring Line ⤴

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

Open Calculator ⤴

ex $32064.13 = \dfrac{160kN}{4.99m}$

14) Mass of Vessel given Virtual Mass of Vessel ⤴

fx $m = m_v - m_a$

Open Calculator ⤴

ex $80kN = 100kN - 20kN$

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

Open Calculator ⎘

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

$$ex \quad 49.9241m^2 = \frac{37.0N}{0.5 \cdot 1.225kg/m^3 \cdot 0.0025 \cdot (22m/s)^2}$$

16) Propeller Drag Coefficient given Propeller Drag ⎘

Open Calculator ⎘

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

$$ex \quad 1.986132 = \frac{249N}{0.5 \cdot 1000kg/m^3 \cdot 15m^2 \cdot (728.2461m/h)^2 \cdot \cos(1.150)}$$

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

Open Calculator ⎘

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

$$ex \quad 249.485N = 0.5 \cdot 1000kg/m^3 \cdot 1.99 \cdot 15m^2 \cdot (728.2461m/h)^2 \cdot \cos(1.150)$$

18) Reynolds Number given Skin Friction Coefficient ⌷

Open Calculator ⌷

$$fx \quad Re_s = \frac{V_c \cdot l_{wl} \cdot \cos(\theta_c)}{\nu}$$

$$ex \quad 834.31 = \frac{728.2461 m/h \cdot 7.32 m \cdot \cos(1.150)}{7.25 St}$$

19) Skin Friction Coefficient given Skin Friction of Vessel ⌷

Open Calculator ⌷

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

$$ex \quad 0.760491 = \frac{42}{0.5 \cdot 1000 kg/m^3 \cdot 4m^2 \cdot (0.26 m/s)^2 \cdot \cos(1.150)}$$

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

Open Calculator ⌷

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

$$ex \quad 39.7638 = 0.5 \cdot 1000 kg/m^3 \cdot 0.72 \cdot 4m^2 \cdot (0.26 m/s)^2 \cdot \cos(1.150)$$

21) Undamped Natural Period of Vessel ⌷

Open Calculator ⌷

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

$$ex \quad 0.174533 h = 2 \cdot \pi \cdot \left(\sqrt{\frac{100 kN}{10.0 N/m}} \right)$$

22) Velocity at Desired Elevation ⤢

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

Open Calculator ⤢

ex $28.62584 \text{m/s} = 22 \text{m/s} \cdot \left(\dfrac{109.50 \text{m}}{10} \right)^{0.11}$

23) Vessel Draft given Form Drag of Vessel ⤢

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

Open Calculator ⤢

ex $1.794697 \text{m} = \dfrac{0.15 \text{kN}}{0.5 \cdot 1000 \text{kg/m}^3 \cdot 5 \cdot 2\text{m} \cdot (728.2461 \text{m/h})^2 \cdot \cos(1.150)}$

24) Virtual Mass of Vessel ⤢

fx $m_v = m + m_a$

Open Calculator ⤢

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

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

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

Open Calculator ⤢

ex $7.058824 \text{m} = \dfrac{600 \text{m}^2 - \left(35 \cdot \dfrac{27 \text{m}^3}{1.595 \text{m}} \right)}{1.7} \cdot 1.595 \text{m}$

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

Open Calculator

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

$$ex \quad 7.2906m = \frac{15m^2 \cdot 0.838 \cdot 1.16}{2m}$$

27) Waterline Length of Vessel given Reynolds Number

Open Calculator

$$fx \quad l_{wl} = \frac{Re \cdot v^{'}}{V_c} \cdot \cos(\theta_c)$$

$$ex \quad 7.32m = \frac{5000 \cdot 7.25St}{728.2461m/h} \cdot \cos(1.150)$$

28) Wetted Surface Area of Vessel

Open Calculator

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

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

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

Open Calculator 🔗

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

$$ex \quad 20.36621 \mathrm{m/s} = \frac{26.5 \mathrm{m/s}}{\left(\frac{109.50 \mathrm{m}}{10}\right)^{0.11}}$$

Variables Used

- **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)*
- **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)*
- **Δl$_{n'}$** 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)*

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: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.

- 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: **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 🔗

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- **Important Formulas of Harbor Hydrodynamics**

- **Wave Transmission Coefficient and Water Surface Amplitude Formulas**

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