



# Estimating Marine and Coastal Winds Formulas

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# List of 28 Estimating Marine and Coastal Winds Formulas

# **Estimating Marine and Coastal Winds**

#### **Measured Wind Directions**

1) Ambient Pressure at Periphery of Storm

$$\mathbf{p}_{\mathrm{n}} = \left(rac{\mathrm{p} - \mathrm{p}_{\mathrm{c}}}{\mathrm{exp}\left(-rac{\mathrm{A}}{\mathrm{e}^{\mathrm{B}}}
ight)}
ight) + \mathrm{p}_{\mathrm{c}}$$

Open Calculator 🗗

$$egin{aligned} egin{aligned} egin{aligned} egin{aligned} 975 ext{mbar} & = \left(rac{975 ext{mbar} - 965 ext{mbar}}{ ext{exp} \left(-rac{50 ext{m}}{\left(48 ext{m}
ight)^5}
ight)} 
ight) + 965 ext{mbar} \end{aligned}$$

2) Characteristic Wave Height given Dimensionless Wave Height

$$\mathbf{H} = rac{\mathrm{H'}\cdot\mathrm{V}_\mathrm{f}^2}{[\mathrm{g}]}$$

Open Calculator

$$extbf{ex} 110.1294 ext{m} = rac{30 \cdot (6 ext{m/s})^2}{ ext{[g]}}$$



#### 3) Cyclostrophic Approximation to Wind Speed

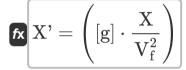
$$\textbf{FE} \boxed{ U_c = \left( A \cdot B \cdot (p_n - p_c) \cdot \frac{exp\left(-\frac{A}{r^B}\right)}{\rho \cdot r^B} \right)^{0.5} }$$

Open Calculator

ex

$$0.027408 = \left(50 ext{m} \cdot 5 \cdot (974.90 ext{mbar} - 965 ext{mbar}) \cdot rac{ ext{exp} \left(-rac{50 ext{m}}{(48 ext{m})^5}
ight)}{1.293 ext{kg/m}^3 \cdot (48 ext{m})^5}
ight)^{0.5}$$

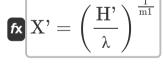
### 4) Dimensionless Fetch



Open Calculator

$$oxed{4.086104} = \left( [\mathrm{g}] \cdot rac{15\mathrm{m}}{\left( 6\mathrm{m/s} 
ight)^2} 
ight)$$

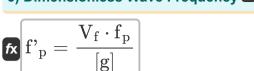
# 5) Dimensionless Fetch given Fetch-limited Dimensionless Wave Height



Open Calculator



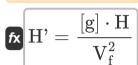
#### 6) Dimensionless Wave Frequency



Open Calculator

 $= 7.953786 = rac{6 ext{m/s} \cdot 13 ext{Hz}}{[ ext{g}]}$ 

#### 7) Dimensionless Wave Height

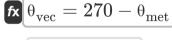


Open Calculator

 $29.96476 = \frac{[g] \cdot 110m}{(6m/s)^2}$ 

#### 8) Direction in Cartesian Coordinate System 🗗

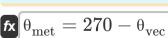
9) Direction in Standard Meteorological Terms

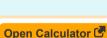


Open Calculator G

$$= 270 - 90$$

|90| = 270 - 180









# 10) Distance from Center of Storm Circulation to Location of Maximum Wind Speed

fx  $m R_{max} = A^{rac{1}{B}}$ 

Open Calculator

 $\mathbf{ex} \ 2.186724 \mathrm{m} = (50 \mathrm{m})^{rac{1}{5}}$ 

#### 11) Fetch-Limited Dimensionless Wave Height

fx  $H' = \lambda \cdot (X'^{m1})$ 

Open Calculator

 $\texttt{ex} \left[ 29.584 = 1.6 \cdot \left( \left( 4.3 \right)^2 \right) \right]$ 

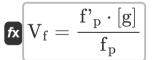
#### 12) Frequency of Spectral Peak for Dimensionless Wave Frequency

 $\mathbf{f}_{\mathrm{p}} = rac{\mathbf{f'}_{\mathrm{p}} \cdot [\mathrm{g}]}{V_{\mathrm{f}}}$ 

Open Calculator 🗗

=  $13.07553 ext{Hz} = rac{8 \cdot [ ext{g}]}{6 ext{m/s}}$ 

#### 13) Friction Velocity for Dimensionless Wave Frequency



Open Calculator

 $oxed{ 6.034862 m/s} = rac{8 \cdot [g]}{13 Hz}$ 



#### 14) Friction Velocity given Dimensionless Fetch

 $V_{\mathrm{f}} = \sqrt{[\mathrm{g}] \cdot rac{\mathrm{X}}{\mathrm{X}}},$ 

Open Calculator

 $extbf{ex} 5.848867 ext{m/s} = \sqrt{[ ext{g}] \cdot rac{15 ext{m}}{4.3}}$ 

## 15) Friction Velocity given Dimensionless Wave Height

 $V_{\mathrm{f}} = \sqrt{rac{[\mathrm{g}] \cdot \mathrm{H}}{\mathrm{H'}}}$ 

Open Calculator

ex  $5.996475 \text{m/s} = \sqrt{\frac{[\text{g}] \cdot 110 \text{m}}{30}}$ 

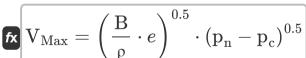
# 16) Fully Developed Wave Height 🗗

 $\mathbf{H}_{\infty} = rac{\lambda \cdot \mathrm{U}^2}{[\mathrm{g}]}$ 

Open Calculator 🗗

 $2.610474 ext{m} = rac{1.6 \cdot (4 ext{m/s})^2}{ ext{[g]}}$ 

# 17) Maximum Velocity in Storm 🗗



Open Calculator 🗗

 $ext{ex} 102.0118 ext{m/s} = \left(rac{5}{1.293 ext{kg/m}^3} \cdot e
ight)^{0.5} \cdot (974.90 ext{mbar} - 965 ext{mbar})^{0.5}$ 





#### 18) Pressure Profile in Hurricane Winds



Open Calculator

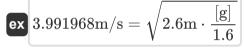
Open Calculator

$$\mathbf{p} = \mathbf{p}_{\mathrm{c}} + (\mathbf{p}_{\mathrm{n}} - \mathbf{p}_{\mathrm{c}}) \cdot \exp \left( -rac{\mathbf{A}}{\mathbf{r}^{\mathrm{B}}} 
ight)$$

$$\boxed{974.9 \text{mbar} = 965 \text{mbar} + \left(974.90 \text{mbar} - 965 \text{mbar}\right) \cdot \exp\left(-\frac{50 \text{m}}{\left(48 \text{m}\right)^5}\right)}$$

## 19) Wind Speed given Fully Developed Wave Height





## Wave Hindcasting and Forecasting

# 20) Drag Coefficient for Wind Speed at 10m Elevation

$$C_{
m D} = 0.001 \cdot (1.1 + (0.035 \cdot {
m V}_{10}))$$

 $0.00187 = 0.001 \cdot (1.1 + (0.035 \cdot 22 \text{m/s}))$ 

Open Calculator

$$\mathbf{T}_{\mathrm{p}} = 9.78 \cdot \left( \left( rac{\mathrm{D_w}}{\mathrm{[g]}} 
ight)^{0.5} 
ight)$$

Open Calculator 🗗



#### 22) Spectral Energy Density

 $\mathbf{E}_{(\mathrm{f})} = rac{\lambda \cdot \left( \left[ \mathrm{g} 
ight]^2 
ight) \cdot \left( \mathrm{f}^{-5} 
ight)}{\left( 2 \cdot \pi 
ight)^4}$ 

Open Calculator

Open Calculator

### 23) Spectral Energy Density or Classical Moskowitz Spectrum

$$\overline{\mathrm{E}_{\mathrm{(f)}} = \left(rac{\lambda \cdot \left(\mathrm{[g]}^2
ight) \cdot \left(\mathrm{f}^{-5}
ight)}{\left(2 \cdot \pi
ight)^4}
ight) \cdot \exp{\left(0.74 \cdot \left(rac{\mathrm{f}}{\mathrm{f_{\mathrm{u}}}}
ight)^{-4}
ight)}$$

#### 24) Straight-Line Distance given Time required for Waves Crossing Fetch under Wind Velocity

$$\mathbf{x} = \left( rac{t_{\mathrm{x,u}} \cdot U^{0.34} \cdot [g]^{0.33}}{77.23} 
ight)^{rac{1}{0.67}}$$

Open Calculator

ex 
$$15.11712 ext{m} = \left(rac{140 ext{s} \cdot (4 ext{m/s})^{0.34} \cdot [ ext{g}]^{0.33}}{77.23}
ight)^{rac{1}{0.67}}$$



fx



#### 25) Straight-Line Distance over which Wind Blows

 $\mathbf{fx} \middle| X = \left( \frac{V_f^2}{[g]} \right) \cdot 5.23 \cdot 10^{-3} \cdot \left( [g] \cdot \frac{t}{V_f} \right)^{\frac{3}{2}}$ 

Open Calculator 🗗

 $\boxed{ 14.99991 m = \left( \frac{\left( 6m/s \right)^2}{[g]} \right) \cdot 5.23 \cdot 10^{-3} \cdot \left( [g] \cdot \frac{51.9s}{6m/s} \right)^{\frac{3}{2}} }$ 

# 26) Time required for Waves Crossing Fetch under Wind Velocity to become Fetch Limited

 $\mathbf{fx}$   $\mathbf{t}_{\mathrm{x,u}} = 77.23 \cdot \left( rac{\mathrm{X}^{0.67}}{\mathrm{U}^{0.34} \cdot [\mathrm{g}]^{0.33}} 
ight)$ 

Open Calculator

 $\boxed{ 139.2724 \mathrm{s} = 77.23 \cdot \left( \frac{\left(15\mathrm{m}\right)^{0.67}}{\left(4\mathrm{m/s}\right)^{0.34} \cdot \left[\mathrm{g}\right]^{0.33}} \right) }$ 

### 27) Water Depth for given Limiting Wave Period

 $\mathbf{fx} \left[ \mathrm{D_w} = [\mathrm{g}] \cdot \left( \overline{\frac{\mathrm{T_p}}{9.78}} \right)^{\frac{1}{0.5}} 
ight]$ 

Open Calculator

 $ext{ex} \left[ 45.2149 ext{m} = [ ext{g}] \cdot \left( rac{21 ext{s}}{9.78} 
ight)^{rac{1}{0.5}} 
ight]$ 



# 28) Wind Speed given Time required for Waves crossing Fetch under Wind Velocity

 $\mathbf{E} \left[ \mathbf{U} = \left( rac{77.23 \cdot \mathbf{X}^{0.67}}{\mathbf{t}_{\mathrm{x,u}} \cdot [\mathrm{g}]^{0.33}} 
ight)^{rac{1}{0.34}} 
ight]$ 

Open Calculator

$$= \left( \frac{77.23 \cdot (15\text{m})^{0.67}}{140\text{s} \cdot [\text{g}]^{0.33}} \right)^{\frac{1}{0.34}}$$



#### Variables Used

- A Scaling Parameter (Meter)
- B Parameter Controlling Peakedness
- C<sub>D</sub> Drag Coefficient
- **D**<sub>w</sub> Water Depth from Bed (Meter)
- E<sub>(f)</sub> Spectral Energy Density
- f Coriolis Frequency
- f<sub>p</sub> Frequency at Spectral Peak (Hertz)
- **f**'<sub>p</sub> Dimensionless Wave Frequency
- **f**<sub>11</sub> Limiting Frequency
- **H** Characteristic Wave Height (Meter)
- H' Dimensionless Wave Height
- H<sub>∞</sub> Fully Developed Wave Height (Meter)
- m1 Dimensionless Exponent
- p Pressure at Radius (Millibar)
- pc Central Pressure in Storm (Millibar)
- p<sub>n</sub> Ambient Pressure at Periphery of Storm (Millibar)
- r Arbitrary Radius (Meter)
- R<sub>max</sub> Distance from Center of Storm Circulation (Meter)
- t Wind Duration (Second)
- T<sub>p</sub> Limiting Wave Period (Second)
- $t_{x,u}$  Time required for Waves crossing Fetch (Second)
- **U** Wind Speed (Meter per Second)
- U<sub>c</sub> Cyclostrophic Approximation to Wind Speed





- V<sub>10</sub> Wind Speed at Height of 10 m (Meter per Second)
- **V**<sub>f</sub> Friction Velocity (Meter per Second)
- V<sub>Max</sub> Maximum Velocity of Wind (Meter per Second)
- X Straight Line Distance over which Wind Blows (Meter)
- X' Dimensionless Fetch
- θ<sub>met</sub> Direction in Standard Meteorological Terms
- θ<sub>vec</sub> Direction in Cartesian Coordinate system
- λ Dimensionless Constant
- p Density of Air (Kilogram per Cubic Meter)





#### **Constants, Functions, Measurements used**

- Constant: pi, 3.14159265358979323846264338327950288
   Archimedes' constant
- Constant: [g], 9.80665 Meter/Second<sup>2</sup>
   Gravitational acceleration on Earth
- Constant: e, 2.71828182845904523536028747135266249
   Napier's constant
- Function: exp, exp(Number)
   Exponential function
- Function: sqrt, sqrt(Number)
   Square root function
- Measurement: Length in Meter (m)
   Length Unit Conversion
- Measurement: Time in Second (s)

  Time Unit Conversion
- Measurement: Pressure in Millibar (mbar)
   Pressure Unit Conversion
- Measurement: Speed in Meter per Second (m/s)
   Speed Unit Conversion
- Measurement: Frequency in Hertz (Hz)
   Frequency Unit Conversion
- Measurement: Density in Kilogram per Cubic Meter (kg/m³)
   Density Unit Conversion





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