# Important Subsurface Pressure Formulas PDF

Formulas
Examples
with Units

**List of 35**
**Important Subsurface Pressure Formulas**

## 1) Group Velocity Formulas

### 1.1) Deepwater Celerity Formula

Evaluate Formula

Formula: $C_o = \frac{Vg_{deep}}{0.5}$

Example with Units: $0.332\,\text{m/s} = \frac{0.166\,\text{m/s}}{0.5}$

### 1.2) Deepwater Wavelength Formula

Evaluate Formula

Formula: $\lambda_o = \frac{Vg_{deep} \cdot P}{0.5}$

Example with Units: $0.342\,\text{m} = \frac{0.166\,\text{m/s} \cdot 1.03}{0.5}$

### 1.3) Group Velocity for Deepwater Formula

Evaluate Formula

Formula: $Vg_{deep} = 0.5 \cdot \left(\frac{\lambda_o}{P_{sz}}\right)$

Example with Units: $0.1672\,\text{m/s} = 0.5 \cdot \left(\frac{0.341\,\text{m}}{1.02}\right)$

### 1.4) Group Velocity for Shallow Water Formula

Evaluate Formula

Formula: $Vg_{shallow} = \frac{\lambda}{P}$

Example with Units: $26.0194\,\text{m/s} = \frac{26.8\,\text{m}}{1.03}$

### 1.5) Group Velocity given Deepwater Celerity Formula

Evaluate Formula

Formula: $Vg_{deep} = 0.5 \cdot C_o$

Example with Units: $0.166\,\text{m/s} = 0.5 \cdot 0.332\,\text{m/s}$

### 1.6) Group Velocity of Wave given Wavelength and Wave Period Formula

Evaluate Formula

Formula: $Vg_{shallow} = 0.5 \cdot \left(\frac{\lambda}{P}\right) \cdot \left(1 + \frac{4 \cdot \pi \cdot \frac{d}{\lambda}}{\sinh\left(4 \cdot \pi \cdot \frac{d}{\lambda}\right)}\right)$

Example with Units: $25.5083\,\text{m/s} = 0.5 \cdot \left(\frac{26.8\,\text{m}}{1.03}\right) \cdot \left(1 + \frac{4 \cdot 3.1416 \cdot \frac{1.05\,\text{m}}{26.8\,\text{m}}}{\sinh\left(4 \cdot 3.1416 \cdot \frac{1.05\,\text{m}}{26.8\,\text{m}}\right)}\right)$

### 1.7) Wave Period given Group Velocity for Shallow Water Formula

Evaluate Formula

Formula: $P = \frac{\lambda}{Vg_{shallow}}$

Example with Units: $1.0304 = \frac{26.8\,\text{m}}{26.01\,\text{m/s}}$

### 1.8) Wavelength given Group Velocity of Shallow Water Formula

Evaluate Formula

Formula: $\lambda = Vg_{shallow} \cdot P_{wave}$

Example with Units: $27.3365\,\text{m} = 26.01\,\text{m/s} \cdot 1.051\,\text{s}$

## 2) Energy per unit Length of Wave Crest Formulas

### 2.1) Kinetic Energy per unit Length of Wave Crest Formula

Evaluate Formula

Formula: $KE = \left(\frac{1}{16}\right) \cdot \rho \cdot [g] \cdot H^2 \cdot \lambda$

Example with Units: $147.3917\,\text{KJ} = \left(\frac{1}{16}\right) \cdot 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2 \cdot 3\,\text{m}^2 \cdot 26.8\,\text{m}$

## 2.2) Potential Energy per unit Length of Wave Crest Formula

Evaluate Formula

Formula

$$PE = \left(\frac{1}{16}\right) \cdot \rho \cdot [g] \cdot H^2 \cdot \lambda$$

Example with Units

$$147391.743\,\mathrm{J} = \left(\frac{1}{16}\right) \cdot 997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 3\,\mathrm{m}^2 \cdot 26.8\,\mathrm{m}$$

## 2.3) Wave Height given Kinetic Energy per unit Length of Wave Crest Formula

Evaluate Formula

Formula

$$H = \sqrt{\frac{KE}{\left(\frac{1}{16}\right) \cdot \rho \cdot [g] \cdot \lambda}}$$

Example with Units

$$3.0031\,\mathrm{m} = \sqrt{\frac{147.7\,\mathrm{KJ}}{\left(\frac{1}{16}\right) \cdot 997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 26.8\,\mathrm{m}}}$$

## 2.4) Wave Height given Potential Energy per unit Length of Wave Crest Formula

Evaluate Formula

Formula

$$H = \sqrt{\frac{PE}{\left(\frac{1}{16}\right) \cdot \rho \cdot [g] \cdot \lambda}}$$

Example with Units

$$3\,\mathrm{m} = \sqrt{\frac{147391.7\,\mathrm{J}}{\left(\frac{1}{16}\right) \cdot 997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 26.8\,\mathrm{m}}}$$

## 2.5) Wavelength for Kinetic Energy per unit Length of Wave Crest Formula

Evaluate Formula

Formula

$$\lambda = \frac{KE}{\left(\frac{1}{16}\right) \cdot \rho \cdot [g] \cdot H^2}$$

Example with Units

$$26.856\,\mathrm{m} = \frac{147.7\,\mathrm{KJ}}{\left(\frac{1}{16}\right) \cdot 997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 3\,\mathrm{m}^2}$$

## 2.6) Wavelength given Potential Energy per unit Length of Wave Crest Formula

Evaluate Formula

Formula

$$\lambda = \frac{PE}{\left(\frac{1}{16}\right) \cdot \rho \cdot [g] \cdot H^2}$$

Example with Units

$$26.8\,\mathrm{m} = \frac{147391.7\,\mathrm{J}}{\left(\frac{1}{16}\right) \cdot 997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 3\,\mathrm{m}^2}$$

# 3) Pressure Component Formulas

## 3.1) Atmospheric Pressure given Gauge Pressure Formula

Evaluate Formula

Formula

$$P_{atm} = P_{abs} - P_g$$

Example with Units

$$99987\,\mathrm{Pa} = 100000\,\mathrm{Pa} - 13\,\mathrm{Pa}$$

## 3.2) Atmospheric Pressure given Total or Absolute Pressure Formula

Evaluate Formula

Formula

$$P_{atm} = P_{abs} - \left(\rho \cdot [g] \cdot H \cdot \cosh\left(2 \cdot \pi \cdot \frac{D_{Z+d}}{\lambda}\right)\right) \cdot \frac{\cos(\theta)}{2 \cdot \cosh\left(2 \cdot \pi \cdot \frac{d}{\lambda}\right)} + (\rho \cdot [g] \cdot Z)$$

Example with Units

$$100964.782\,\mathrm{Pa} = 100000\,\mathrm{Pa} - \left(997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 3\,\mathrm{m} \cdot \cosh\left(2 \cdot 3.1416 \cdot \frac{2\,\mathrm{m}}{26.8\,\mathrm{m}}\right)\right) \cdot \frac{\cos(60°)}{2 \cdot \cosh\left(2 \cdot 3.1416 \cdot \frac{1.05\,\mathrm{m}}{26.8\,\mathrm{m}}\right)} + (997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 0.908)$$

## 3.3) Correction Factor given Height of Surface Waves based on Subsurface Measurements Formula

Evaluate Formula

Formula

$$f = \eta \cdot \rho \cdot [g] \cdot \frac{k}{P_{ss} + (\rho \cdot [g] \cdot z)}$$

Example with Units

$$0.507 = 19.2\,\mathrm{m} \cdot 997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot \frac{1.32}{800\,\mathrm{Pa} + (997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot 49.906\,\mathrm{m})}$$

## 3.4) Depth below SWL of Pressure Gauge Formula

Evaluate Formula

Formula

$$z = \frac{\left(\eta \cdot \rho \cdot [g] \cdot \frac{k}{f}\right) - P_{ss}}{\rho \cdot [g]}$$

Example with Units

$$49.9063\,\mathrm{m} = \frac{\left(19.2\,\mathrm{m} \cdot 997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2} \cdot \frac{1.32}{0.507}\right) - 800\,\mathrm{Pa}}{997\,\mathrm{kg/m^3} \cdot 9.8066\,\mathrm{m/s^2}}$$

## 3.5) Friction Velocity given Dimensionless Time Formula

Evaluate Formula

Formula

$$V_f = \frac{[g] \cdot t_d}{t'}$$

Example with Units

$$6\,\mathrm{m/s} = \frac{9.8066\,\mathrm{m/s^2} \cdot 68\,\mathrm{s}}{111.142}$$

## 3.6) Phase Angle for Total or Absolute Pressure Formula

Evaluate Formula

Formula

$$\theta = acos\left(\frac{P_{abs} + (\rho \cdot [g] \cdot Z) - (P_{atm})}{\frac{\rho \cdot [g] \cdot H \cdot cosh\left(2 \cdot \pi \cdot \frac{D_{Z+d}}{\lambda}\right)}{2 \cdot cosh\left(2 \cdot \pi \cdot \frac{d}{\lambda}\right)}}\right)$$

Example with Units

$$55.8208° = acos\left(\frac{100000\,Pa + (997\,kg/m^3 \cdot 9.8066\,m/s^2 \cdot 0.908) - (99987\,Pa)}{\frac{997\,kg/m^3 \cdot 9.8066\,m/s^2 \cdot 3\,m \cdot cosh\left(2 \cdot 3.1416 \cdot \frac{2\,m}{26.8\,m}\right)}{2 \cdot cosh\left(2 \cdot 3.1416 \cdot \frac{1.05\,m}{26.8\,m}\right)}}\right)$$

## 3.7) Radian Frequency given Wave Period Formula

Evaluate Formula

Formula

$$\omega = \frac{1}{T'}$$

Example with Units

$$0.3846\,rad/s = \frac{1}{2.6\,s}$$

## 3.8) Total or Absolute Pressure Formula

Evaluate Formula

Formula

$$P_{abs} = \left(\rho \cdot [g] \cdot H \cdot cosh\left(2 \cdot \pi \cdot \frac{D_{Z+d}}{\lambda}\right) \cdot \frac{cos(\theta)}{2} \cdot cosh\left(2 \cdot \pi \cdot \frac{d}{\lambda}\right)\right) - (\rho \cdot [g] \cdot Z) + P_{atm}$$

Example with Units

$$99511.5029\,Pa = \left(997\,kg/m^3 \cdot 9.8066\,m/s^2 \cdot 3\,m \cdot cosh\left(2 \cdot 3.1416 \cdot \frac{2\,m}{26.8\,m}\right) \cdot \frac{cos(60°)}{2} \cdot cosh\left(2 \cdot 3.1416 \cdot \frac{1.05\,m}{26.8\,m}\right)\right) - (997\,kg/m^3 \cdot 9.8066\,m/s^2 \cdot 0.908) + 99987\,Pa$$

## 3.9) Total Pressure given Gauge Pressure Formula

Evaluate Formula

Formula

$$P_T = P_g + P_{atm}$$

Example with Units

$$100000\,Pa = 13\,Pa + 99987\,Pa$$

## 3.10) Water Depth given Wave Celerity for Shallow Water Formula

Evaluate Formula

Formula

$$d = \frac{C^2}{[g]}$$

Example with Units

$$1.0442\,m = \frac{3.2\,m/s^2}{9.8066\,m/s^2}$$

## 3.11) Water Surface Elevation Formula

Evaluate Formula

Formula

$$\eta'' = \left(\frac{H}{2}\right) \cdot cos(\theta)$$

Example with Units

$$0.75\,m = \left(\frac{3\,m}{2}\right) \cdot cos(60°)$$

## 3.12) Water Surface Elevation of Two Sinusoidal Wave Formula

Evaluate Formula

Formula

$$\eta'' = \left(\frac{H}{2}\right) \cdot cos\left(\left(2 \cdot \pi \cdot \frac{x}{L1}\right) - \left(2 \cdot \pi \cdot \frac{t}{T_1}\right)\right) + \left(\frac{H}{2}\right) \cdot cos\left(\left(2 \cdot \pi \cdot \frac{x}{L2}\right) - \left(2 \cdot \pi \cdot \frac{t}{T_2}\right)\right)$$

Example with Units

$$1.5009\,m = \left(\frac{3\,m}{2}\right) \cdot cos\left(\left(2 \cdot 3.1416 \cdot \frac{50.0}{50}\right) - \left(2 \cdot 3.1416 \cdot \frac{24.99}{25.0\,s}\right)\right) + \left(\frac{3\,m}{2}\right) \cdot cos\left(\left(2 \cdot 3.1416 \cdot \frac{50.0}{25}\right) - \left(2 \cdot 3.1416 \cdot \frac{24.99}{100\,s}\right)\right)$$

## 3.13) Wave celerity for shallow water given water depth Formula

Evaluate Formula

Formula

$$C = \sqrt{[g] \cdot d}$$

Example with Units

$$3.2089\,m/s = \sqrt{9.8066\,m/s^2 \cdot 1.05\,m}$$

## 3.14) Wave Period given Average Frequency Formula

Evaluate Formula

Formula

$$P = \frac{1}{\omega}$$

Example with Units

$$2.6316 = \frac{1}{0.38\,rad/s}$$

# 4) Pressure Reference Factor Formulas

## 4.1) Pressure given Height of Surface Waves based on Subsurface Measurements Formula

Evaluate Formula

Formula

$$p = \left( \frac{\eta \cdot \rho \cdot [g] \cdot K}{f} \right) - \left( \rho \cdot [g] \cdot z'' \right)$$

Example with Units

$$320.5254\,\text{kPa} = \left( \frac{19.2\,\text{m} \cdot 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2 \cdot 0.9}{0.507} \right) - \left( 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2 \cdot 1.3\,\text{m} \right)$$

## 4.2) Pressure given Pressure Response Factor Formula

Evaluate Formula

Formula

$$P_{ss} = \rho \cdot [g] \cdot \left( \left( \left( \left( \frac{H}{2} \right) \cdot \cos(\theta) \cdot k \right) - Z \right) \right)$$

Example with Units

$$801.7329\,\text{Pa} = 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2 \cdot \left( \left( \left( \left( \frac{3\,\text{m}}{2} \right) \cdot \cos(60°) \cdot 1.32 \right) - 0.908 \right) \right)$$

## 4.3) Pressure Reference Factor Formula

Evaluate Formula

Formula

$$K = \frac{\cosh\left( 2 \cdot \pi \cdot \frac{D_{Z+d}}{\lambda} \right)}{\cosh\left( 2 \cdot \pi \cdot \frac{d}{\lambda} \right)}$$

Example with Units

$$1.0791 = \frac{\cosh\left( 2 \cdot 3.1416 \cdot \frac{2\,\text{m}}{26.8\,\text{m}} \right)}{\cosh\left( 2 \cdot 3.1416 \cdot \frac{1.05\,\text{m}}{26.8\,\text{m}} \right)}$$

## 4.4) Pressure Reference Factor given Height of Surface Waves based on Subsurface Measurements Formula

Evaluate Formula

Formula

$$K = f \cdot \frac{p + \left( \rho \cdot [g] \cdot z'' \right)}{\eta \cdot \rho \cdot [g]}$$

Example with Units

$$0.9 = 0.507 \cdot \frac{320.52\,\text{kPa} + \left( 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2 \cdot 1.3\,\text{m} \right)}{19.2\,\text{m} \cdot 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2}$$

## 4.5) Pressure Response Factor at Bottom Formula

Evaluate Formula

Formula

$$K = \frac{1}{\cosh\left( 2 \cdot \pi \cdot \frac{d}{\lambda} \right)}$$

Example with Units

$$0.9704 = \frac{1}{\cosh\left( 2 \cdot 3.1416 \cdot \frac{1.05\,\text{m}}{26.8\,\text{m}} \right)}$$

## 4.6) Pressure taken as Gauge Pressure relative to Wave Mechanics Formula

Evaluate Formula

Formula

$$p = \left( \rho \cdot [g] \cdot H \cdot \cosh\left( 2 \cdot \pi \cdot \frac{D_{Z'+d'}}{\lambda} \right) \right) \cdot \frac{\cos(\theta)}{2 \cdot \cosh\left( 2 \cdot \pi \cdot \frac{d}{\lambda} \right)} - \left( \rho \cdot [g] \cdot Z \right)$$

Example with Units

$$320.2747\,\text{kPa} = \left( 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2 \cdot 3\,\text{m} \cdot \cosh\left( 2 \cdot 3.1416 \cdot \frac{19.31\,\text{m}}{26.8\,\text{m}} \right) \right) \cdot \frac{\cos(60°)}{2 \cdot \cosh\left( 2 \cdot 3.1416 \cdot \frac{1.05\,\text{m}}{26.8\,\text{m}} \right)} - \left( 997\,\text{kg/m}^3 \cdot 9.8066\,\text{m/s}^2 \cdot 0.908 \right)$$

## 4.7) Wavelength for Pressure Response Factor at bottom Formula

Evaluate Formula

Formula

$$\lambda = 2 \cdot \pi \cdot \frac{d}{acosh\left( \frac{1}{K} \right)}$$

Example with Units

$$14.1227\,\text{m} = 2 \cdot 3.1416 \cdot \frac{1.05\,\text{m}}{acosh\left( \frac{1}{0.9} \right)}$$

## Variables used in list of Subsurface Pressure Formulas above

- **C** Wave Celerity *(Meter per Second)*
- **$C_o$** Deep Water Wave Celerity *(Meter per Second)*
- **d** Water Depth *(Meter)*
- **$D_{z'+d'}$** Upper Bottom Distance *(Meter)*
- **$D_{Z+d}$** Distance above the Bottom *(Meter)*
- **f** Correction Factor
- **H** Wave Height *(Meter)*
- **k** Pressure Response Factor
- **K** Pressure Factor
- **KE** Kinetic Energy of Wave Crest *(Kilojoule)*
- **L1** Wavelength of Component Wave 1
- **L2** Wavelength of Component Wave 2
- **p** Sub Surface Pressure *(Kilopascal)*
- **P** Wave Period
- **$P_{abs}$** Absolute Pressure *(Pascal)*
- **$P_{atm}$** Atmospheric Pressure *(Pascal)*
- **$P_g$** Gauge Pressure *(Pascal)*
- **$P_{ss}$** Pressure *(Pascal)*
- **$P_{sz}$** Surf Zone Wave Period
- **$P_T$** Total Pressure *(Pascal)*
- **$P_{wave}$** Annual Wave Period *(Second)*
- **PE** Potential Energy *(Joule)*
- **t** Temporal Progressive Wave
- **t'** Dimensionless Time
- **T'** Mean Wave Period *(Second)*
- **$T_1$** Wave Period of Component Wave 1 *(Second)*
- **$T_2$** Wave Period of Component Wave 2 *(Second)*
- **$t_d$** Time for Dimensionless Parameter Calculation *(Second)*
- **$V_f$** Friction Velocity *(Meter per Second)*
- **$Vg_{deep}$** Group Velocity for Deep Water *(Meter per Second)*
- **$Vg_{shallow}$** Group Velocity for Shallow Water *(Meter per Second)*
- **x** Spatial Progressive Wave
- **z** Depth below the SWL of Pressure Gauge *(Meter)*
- **Z** Seabed Elevation
- **$z''$** Depth of Pressure Gauge *(Meter)*
- **η** Water Surface Elevation *(Meter)*
- **$\eta''$** Water Elevation *(Meter)*
- **θ** Phase Angle *(Degree)*
- **λ** Wavelength *(Meter)*
- **$\lambda_o$** Deep Water Wavelength *(Meter)*
- **ρ** Mass Density *(Kilogram per Cubic Meter)*
- **ω** Wave Angular Frequency *(Radian per Second)*

## Constants, Functions, Measurements used in list of Subsurface Pressure Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288
  *Archimedes' constant*
- constant(s): **[g]**, 9.80665
  *Gravitational acceleration on Earth*
- 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: **acosh**, acosh(Number)
  *Hyperbolic cosine function, is a function that takes a real number as an input and returns the angle whose hyperbolic cosine is that number.*
- 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: **cosh**, cosh(Number)
  *The hyperbolic cosine function is a mathematical function that is defined as the ratio of the sum of the exponential functions of x and negative x to 2.*
- Functions: **sinh**, sinh(Number)
  *The hyperbolic sine function, also known as the sinh function, is a mathematical function that is defined as the hyperbolic analogue of the sine function.*
- 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 Second (s)
  *Time Unit Conversion*
- Measurement: **Pressure** in Pascal (Pa), Kilopascal (kPa)
  *Pressure Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s)
  *Speed Unit Conversion*
- Measurement: **Energy** in Kilojoule (KJ), Joule (J)
  *Energy Unit Conversion*
- Measurement: **Angle** in Degree (°)
  *Angle Unit Conversion*
- Measurement: **Wavelength** in Meter (m)
  *Wavelength Unit Conversion*
- Measurement: **Mass Concentration** in Kilogram per Cubic Meter (kg/m³)
  *Mass Concentration Unit Conversion*
- Measurement: **Angular Frequency** in Radian per Second (rad/s)
  *Angular Frequency Unit Conversion*

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