# Package 'sonar'

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**Type** Package

**Title** Fundamental Formulas for Sonar

**Version** 1.0.2

**Encoding** UTF-8

**Description** Formulas for calculating sound velocity, water pressure, depth, density, absorption and sonar equations.

**License** GPL (>= 3)

**Depends** R (>= 2.7.0)

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**NeedsCompilation** no

**Repository** CRAN

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## R topics documented:

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`AbsorptionAlphaAinslieMcColm`

*Calculation of absorption in sea water from Ainslie and McColm 1998*

---

## Description

Returns the absorption in sea water from Ainslie and McColm 1998

## Usage

```
AbsorptionAlphaAinslieMcColm(f, temperatureC, S, D, pH)
```

## Arguments

| | |
|---|---|
| `f,` | frequency (kHz) |
| `temperatureC,` | temperature in degrees C |
| `S,` | salinity in % |
| `D,` | depth in meters |
| `pH,` | pH |

## Value

the absorption

### Author(s)

Jose Gama

### Source

National Physical Laboratory, 2015 Calculation of absorption of sound in seawater http://resource.npl.co.uk/acoustics/techguides/seaabsorption/

### References

Ainslie and McColm 1998 J. Acoust. Soc. Am., Vol. 103, No. 3

### Examples

```
AbsorptionAlphaAinslieMcColm(20, 0, 30, 0, 7)
```

---

## AbsorptionAlphaFisherSimmons

*Calculation of absorption in sea water from Fisher and Simmons 1977*

---

### Description

Returns the absorption in sea water from Fisher and Simmons 1977

### Usage

```
AbsorptionAlphaFisherSimmons(f, temperatureC, D)
```

### Arguments

| | |
|---|---|
| f, | frequency (kHz) |
| temperatureC, | temperature in degrees C |
| D, | depth in meters |

### Value

the absorption

### Author(s)

Jose Gama

### Source

Fisher and Simmons, 1977 J. Acoust. Soc. Am., Vol. 62, No. 3, September 1977

### Examples

```
AbsorptionAlphaFisherSimmons(20, 0, 1)
```

`AbsorptionSoundFreshWaterFrancoisGarrison` *Calculation of absorption of sound in fresh water From Francois & Garrison 1982*

## Description

Returns the absorption of sound in fresh water From Francois & Garrison 1982 Total absorption = Pure Water Contrib.

## Usage

```
AbsorptionSoundFreshWaterFrancoisGarrison(SonarFreq, temperatureC, D)
```

## Arguments

| | |
|---|---|
| `SonarFreq,` | sonar frequency (kHz) |
| `temperatureC,` | temperature (degC) |
| `D,` | depth in meters |

## Value

the absorption of sound

## Author(s)

Jose Gama

## Source

Echoview, 2016 Sonar calculator algorithms http://support.echoview.com/WebHelp/Reference/Algorithms/Sonar_calculator_algorithms.htm

## References

Francois & Garrison 1982 Sound absorption based on ocean measurements: Part I:Pure water and magnesium sulfate contributions J. Acoust. Soc. Am., Vol. 72, No. 6

## Examples

```
AbsorptionSoundFreshWaterFrancoisGarrison(50, 0, 0)
```

`AbsorptionSoundSeaWaterFrancoisGarrison` *Calculation of absorption of sound in sea water From Francois & Garrison 1982*

## Description

Returns the absorption of sound in sea water From Francois & Garrison 1982 Total absorption = Boric Acid Contrib. + Magnesium Sulphate Contrib. + Pure Water Contrib.

## Usage

```
AbsorptionSoundSeaWaterFrancoisGarrison(SonarFreq, temperatureC, Salinity, D,
  pH)
```

## Arguments

| | |
|---|---|
| `SonarFreq,` | sonar frequency (kHz) |
| `temperatureC,` | temperature (degC) |
| `Salinity,` | Salinity (ppt) |
| `D,` | depth in meters |
| `pH,` | pH |

## Value

the absorption of sound

## Author(s)

Jose Gama

## Source

NPL, 2016 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://resource.npl.co.uk/acoustics/techguides/seaabsorption/

## References

Francois & Garrison 1982 Sound absorption based on ocean measurements: Part I:Pure water and magnesium sulfate contributions J. Acoust. Soc. Am., Vol. 72, No. 6

## Examples

```
AbsorptionSoundSeaWaterFrancoisGarrison(50, 0, 35, 0, 6)
```

## BandLevelFlatSpectrum *band level (BL) for flat spectrum*

### Description

Returns the total intensity of the sound in a band for flat spectrum

### Usage

```
BandLevelFlatSpectrum(SpL, deltaf)
```

### Arguments

| | |
|---|---|
| SpL | spectrum level |
| deltaf | band frequency |

### Value

band level (BL)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 10.

### Examples

```
BandLevelFlatSpectrum( 3, 2 )
```

## BandLevelFromCompleteBand *band level (BL) from complete band*

### Description

Returns the band level from integrating the intensity over the complete band

### Usage

```
BandLevelFromCompleteBand(I0, f1, f2)
```

### Arguments

| | |
|---|---|
| I0 | spectrum level |
| f1 | lower frequency |
| f2 | upper frequency |

### Value

band level (BL)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 10.

### Examples

```
BandLevelFromCompleteBand( 10000, 40000, 50000 )
```

---

## BasicActiveSonarEquation

*basic active sonar equation*

---

### Description

Returns the basic active sonar equation SE = (SL + TS - 2 * PL) - N - DT

### Usage

```
BasicActiveSonarEquation(SL, TS, PL, N, DT)
```

### Arguments

| | |
|---|---|
| SL | is the source level of the target |
| TS | target strength |
| PL | propagation loss |
| N | noise |
| DT | detection threshold |

### Value

SE signal excess (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 120.

---

`BasicPassiveSonarEquation`
*basic passive sonar equation*

---

### Description

Returns the basic passive sonar equation SE = (SL - PL) - N = DT

### Usage

```
BasicPassiveSonarEquation(SL, PL, N)
```

### Arguments

| | |
|---|---|
| `SL` | is the source level of the target |
| `PL` | propagation loss |
| `N` | noise |

### Value

SE signal excess (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 120.

## BasicSonarEquation *basic sonar equation*

### Description

Returns the basic sonar equation SE = S - N + DT

### Usage

```
BasicSonarEquation(S, N, DT)
```

### Arguments

| | |
|---|---|
| S | signal |
| N | noise |
| DT | detection threshold |

### Value

SE signal excess (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 120.

## CavitationThresholdEstimateFunctionOfDepth *Cavitation threshold estimate as a function of depth*

### Description

Returns the Cavitation threshold estimate as a function of depth line passing by (5, 2) and (50, 50)

### Usage

```
CavitationThresholdEstimateFunctionOfDepth(d)
```

### Arguments

| | |
|---|---|
| d, | depth (meters) |

### Value

Cavitation threshold

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 6.

### Examples

```
CavitationThresholdEstimateFunctionOfDepth( 1 )
```

---

## CavitationThresholdEstimateFunctionOfRadiatedAcousticPowerIntensity

*Cavitation threshold estimate as a function of radiated acoustic power intensity*

---

### Description

Returns the Cavitation threshold estimate as a function of radiated acoustic power intensity line passing by (2, 5) and (50, 50)

### Usage

```
CavitationThresholdEstimateFunctionOfRadiatedAcousticPowerIntensity(Ir)
```

### Arguments

| | |
|---|---|
| `Ir,` | radiated acoustic power intensity |

### Value

Cavitation threshold

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 6.

### Examples

```
CavitationThresholdEstimateFunctionOfRadiatedAcousticPowerIntensity ( 1000 )
```

---

`CorrectiveTermsDepthFromPressure`
*Corrective terms to be added for obtaining depth from pressure*

---

## Description

Corrective terms to be added for obtaining depth (m) from pressure (MPa)

## Usage

```
CorrectiveTermsDepthFromPressure
```

## Format

dataframe with 13 rows and 5 columns:

**No** Number

**Area.of.applicability** Area of applicability

**Expression.for.deltaf** Expression for deltaf

**Latitude** Latitude in degrees

**Accuracy** Accuracy

## Author(s)

Jose Gama

## References

C. C. Leroy and F Parthiot, 1998 Depth-pressure relationship in the oceans and seas. J. Acoust. Soc. Am. 103(3) pp 1346-1352

---

`CorrectiveTermsPressureFromDepth`
*Corrective terms to be subtracted for obtaining pressure from depth*

---

## Description

Corrective terms to be added for obtaining pressure (MPa) from depth (m)

## Usage

```
CorrectiveTermsPressureFromDepth
```

### Format

dataframe with 14 rows and 5 columns:

**No** Number

**Area.of.applicability** Area of applicability

**Expression.for.deltaf** Expression for deltaf

**Latitude** Latitude in degrees

**Accuracy** Accuracy

### Author(s)

Jose Gama

### References

C. C. Leroy and F Parthiot, 1998 Depth-pressure relationship in the oceans and seas. J. Acoust. Soc. Am. 103(3) pp 1346-1352

---

## CutoffFrequencyShallowWater

*Calculation of cutoff frequency in shallow water from Jensen et Al 2011*

---

### Description

Returns the cutoff frequency in shallow water from Jensen et Al 2011

### Usage

```
CutoffFrequencyShallowWater(Cw, Cb, D)
```

### Arguments

| | |
|---|---|
| Cw, | velocity of sound in water |
| Cb, | velocity of sound in homogeneous bottom |
| D, | depth in meters |

### Value

the cutoff frequency (Hz)

### Author(s)

Jose Gama

## Source

Finn B. Jensen, William A. Kuperman, Michael B. Porter, Henrik Schmidt, 2011 Computational Ocean Acoustics, 2nd Edition. Springer. pp. 29

## Examples

```
CutoffFrequencyShallowWater(3000, 2500, 1)
```

---

`CutoffFrequencyWater` *Calculation of cutoff frequency in water from Jensen et Al 2011*

---

## Description

Returns the cutoff frequency in water from Jensen et Al 2011

## Usage

```
CutoffFrequencyWater(Cw, D)
```

## Arguments

| | |
|---|---|
| `Cw,` | velocity of sound in water |
| `D,` | depth in meters of isothermal surface layer |

## Value

the cutoff frequency (Hz)

## Author(s)

Jose Gama

## Source

Finn B. Jensen, William A. Kuperman, Michael B. Porter, Henrik Schmidt, 2011 Computational Ocean Acoustics, 2nd Edition. Springer. pp. 26

## Examples

```
CutoffFrequencyWater(3000, 1)
```

DepthToPressureLeroyParthiot
*Depth To Pressure from Leroy Parthiot 1998*

## Description

Returns the Depth To Pressure from Leroy Parthiot 1998

## Usage

```
DepthToPressureLeroyParthiot(D, latitude, CorrectiveTerm = NA)
```

## Arguments

| | |
|---|---|
| D, | depth in meters |
| latitude, | latitude in degrees |
| CorrectiveTerm, | optional corrective term |

## Value

the Pressure

## Author(s)

Jose Gama

## Source

C. C. Leroy and F Parthiot, 1998 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://resource.npl.co.uk/acoustics/techguides/soundseawater/

## References

C. C. Leroy and F Parthiot, 1998 Depth-pressure relationship in the oceans and seas (1998) J. Acoust. Soc. Am. 103(3) pp 1346-1352

## Examples

```
DepthToPressureLeroyParthiot(0, 0)
```

## DetectionIndex *Detection index*

### Description

Returns the Detection index

### Usage

```
DetectionIndex(S, N)
```

### Arguments

| | |
|---|---|
| S | signal |
| N | noise |

### Value

Detection index

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 120.

## fuelStabilizer *Number of milliliters or drops of stabilizer are needed to stabilize a certain amount of fuel*

### Description

Returns the number of milliliters or drops of stabilizer are needed to stabilize a certain amount of fuel

### Usage

```
fuelStabilizer(Lfuel, mLstabilizer = 25, Lstabilizer2fuel = 20,
  dropml = 0.05)
```

### Arguments

| | |
|---|---|
| Lfuel | numeric, liters of fuel to stabilize |
| mLstabilizer | numeric, manufacturer's recommended milliliters of stabilizer per liters of fuel |
| Lstabilizer2fuel | numeric, manufacturer's recommended liters of fuel per mms of stabilizer |
| dropml | numeric, how many milliliters per drop |

### Value

the number of milliliters or drops of stabilizer

### Author(s)

Jose Gama

### Examples

```
# liqui moly, petrol stabilizer CNG/LPG gasoline stabilizer
# 25ml of stabilizer are the recommended amount for 20 litres of gasoline
# stabilizer for 1l of gasoline
fuelStabilizer(1)
# stabilizer for 0.5l of gasoline
fuelStabilizer(0.5)
```

---

## HydrophoneSensitivity *Hydrophone Sensitivity*

---

### Description

Returns the Hydrophone Sensitivity

### Usage

```
HydrophoneSensitivity(p, v)
```

### Arguments

| | |
|---|---|
| p | sound pressure in micropascals at the hydrophone |
| v | voltage at the open circuit terminals |

### Value

Hydrophone Sensitivity (dB/V)

### Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 9.

## Examples

```
HydrophoneSensitivity( 1000, 2 )
```

---

`InternationalFormulaForGravity`
*International Formula For Gravity*

---

## Description

Returns the average gravity at certain latitude

## Usage

```
InternationalFormulaForGravity(latitude, CorrectiveTerm = NA)
```

## Arguments

| | |
|---|---|
| `latitude,` | latitude in degrees |
| `CorrectiveTerm,` | optional corrective term |

## Value

the average gravity

## Author(s)

Jose Gama

## Source

Fofonoff and R.C. Millard, 1983 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://resource.npl.co.uk/acoustics/techguides/soundseawater/

## References

Saunders P.M., Fofonoff N.P., 1976 Conversion of pressure to depth in the ocean. Deep Sea Research 23:109-111.

## Examples

```
InternationalFormulaForGravity(0)
```

---

`MaximumRadiatedPowerToAvoidCavitation`
*Maximum radiated power to avoid cavitation*

---

## Description

Returns the Maximum radiated power to avoid cavitation

## Usage

```
MaximumRadiatedPowerToAvoidCavitation(radiatingSurfaceArea, cavitationThreshold)
```

## Arguments

`radiatingSurfaceArea`,
Radiating surface area
`cavitationThreshold`,
Cavitation threshold

## Value

Maximum radiated power

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 5.

## Examples

```
MaximumRadiatedPowerToAvoidCavitation( 50, 0.7 )
```

---

`MolecularRelaxationAttenuationCoeficient`
*Molecular relaxation attenuation coeficient (alpha)*

---

## Description

Returns the attenuation coeficient of absorption losses due to molecular relaxation

## Usage

```
MolecularRelaxationAttenuationCoeficient
```

### Format

dataframe with 3 rows and 11 columns:

**temperatureC** numeric, temperature in degrees Celsius

**0.5** attenuation coeficient for 0.5 kHz

**1** attenuation coeficient for 1 kHz

**2** attenuation coeficient for 2 kHz

**5** attenuation coeficient for 5 kHz

**10** attenuation coeficient for 10 kHz

**20** attenuation coeficient for 20 kHz

**50** attenuation coeficient for 50 kHz

**100** attenuation coeficient for 100 kHz

**200** attenuation coeficient for 200 kHz

**500** attenuation coeficient for 500 kHz

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 47.

---

## MolecularRelaxationAttenuationCoeficientApproximation

*Molecular relaxation attenuation coeficient approximation*

---

### Description

Returns the Molecular relaxation attenuation coeficient approximation

### Usage

```
MolecularRelaxationAttenuationCoeficientApproximation(f)
```

### Arguments

| | |
|---|---|
| `f,` | frequency (Hz) |

### Value

alpha Molecular relaxation attenuation coeficient

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 47.

### Examples

```
MolecularRelaxationAttenuationCoeficientApproximation( 1000 )
```

---

## PeakTS *peak pressure of the incident and reflected pulses*

---

### Description

Returns the peak pressure of the incident and reflected pulses

### Usage

```
PeakTS(Pr, Pi)
```

### Arguments

| | |
|---|---|
| Pr | pressure of the reflected pulse |
| Pi | pressure of the incident pulse |

### Value

Target Strength (TS)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 68.

### Examples

```
PeakTS( 900, 1000 )
```

## PlaneWaveIntensity *Plane wave intensity*

### Description

Returns the intensity

### Usage

```
PlaneWaveIntensity(p, rho, C)
```

### Arguments

| | |
|---|---|
| p, | pressure (Pa or N/m2) |
| rho, | fluid density = 10^3kg/m^3 for sea water |
| C, | velocity of sound wave propagation = 1.5 x 10^3m/s in sea water |

### Value

intensity of the wave (power / unit area) (Watt / m^2)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 3.

### Examples

```
PlaneWaveIntensity( 1e3, 1.5e3,  1)
```

## PlaneWavePressure *Plane wave pressure*

### Description

Returns the pressure

### Usage

```
PlaneWavePressure(rho, C, u)
```

### Arguments

| | |
|---|---|
| rho, | fluid density = 10^3kg/m^3 for sea water |
| C, | velocity of sound wave propagation = 1.5 x 10^3m/s in sea water |
| u | particle velocity (m/s) |

### Value

pressure (Pa or N/m2)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 2.

### Examples

```
PlaneWavePressure( 1e3, 1.5e3,  1)
```

---

## PLcylindricalSpreadingLaw

*PL to range r cylindrical spreading law in logarithmic form*

---

### Description

Returns the PL to range r cylindrical spreading law in logarithmic form

### Usage

```
PLcylindricalSpreadingLaw(r)
```

### Arguments

| | |
|---|---|
| r | radius (meters) |

### Value

Propagation loss (PL) (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 45.

## Examples

```
PLcylindricalSpreadingLaw( 1000 )
```

---

`PLSphericalSpreadingAndAbsorption`
*PL Spherical Spreading and Absorption*

---

## Description

Returns the PL Spherical Spreading and Absorption

## Usage

```
PLSphericalSpreadingAndAbsorption(r, alpha)
```

## Arguments

| | |
|---|---|
| `r` | radius (meters) |
| `alpha` | Molecular relaxation attenuation coeficient |

## Value

Propagation loss (PL) (dB)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 48.

## Examples

```
PLSphericalSpreadingAndAbsorption( 1000, 0.9 )
```

PLsphericalSpreadingLaw *PL to range r spherical spreading law in logarithmic form*

## Description

Returns the PL to range r spherical spreading law in logarithmic form

## Usage

```
PLsphericalSpreadingLaw(r)
```

## Arguments

| | |
|---|---|
| r | radius (meters) |

## Value

Propagation loss (PL) (dB)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 44.

## Examples

```
PLsphericalSpreadingLaw( 1000 )
```

PowerCylindricalSpreadingLaw *Power cylindrical spreading law*

## Description

Returns the Power cylindrical spreading law

## Usage

```
PowerCylindricalSpreadingLaw(r, h, Ir)
```

### Arguments

| | |
|---|---|
| r | radius (meters) |
| h | distance between 2 planes (meters) |
| Ir | intensity at radius r |

### Value

total power (Watts)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 45.

### Examples

```
PowerCylindricalSpreadingLaw( 1000, 100, 500 )
```

---

## PowerSphericalSpreadingLaw

*Power spherical spreading law*

---

### Description

Returns the Power spherical spreading law

### Usage

```
PowerSphericalSpreadingLaw(r, Ir)
```

### Arguments

| | |
|---|---|
| r | radius (meters) |
| Ir | intensity at radius r |

### Value

total power (Watts)

### Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 44.

## Examples

```
PowerSphericalSpreadingLaw( 1000, 500 )
```

---

# PressureBalticSimplifiedLeroy

*Calculation of pressure in the Baltic from Leroy 1969*

---

## Description

Returns the pressure in the Baltic from Leroy 1969

## Usage

```
PressureBalticSimplifiedLeroy(Z, lat)
```

## Arguments

| | |
|---|---|
| Z, | depth in meters |
| lat, | latitude n degrees |

## Value

the pressure

## Author(s)

Jose Gama

## Source

Leroy C. C. 1969 Development of simple equations for accurate and more realistic calculations of the speed of sound in sea water J. Acoust. Soc. Am. 46, 216-226.

## Examples

```
PressureBalticSimplifiedLeroy(0, 0)
```

## PressureBlackSeaSimplifiedLeroy

*Calculation of pressure in the Black Sea from Leroy 1969*

### Description

Returns the pressure in the Black Sea from Leroy 1969

### Usage

```
PressureBlackSeaSimplifiedLeroy(Z, lat)
```

### Arguments

| | |
|---|---|
| Z, | depth in meters |
| lat, | latitude n degrees |

### Value

the pressure

### Author(s)

Jose Gama

### Source

Leroy C. C. 1969 Development of simple equations for accurate and more realistic calculations of the speed of sound in sea water J. Acoust. Soc. Am. 46, 216-226.

### Examples

```
PressureBlackSeaSimplifiedLeroy(0, 0)
```

## PressureModifiedSimplifiedLeroy

*Calculation of pressure in water (Leroy modified) from Lovett 1978*

### Description

Returns the pressure in water (Leroy simplified modified) from Lovett 1978

### Usage

```
PressureModifiedSimplifiedLeroy(Z, lat)
```

### Arguments

| | |
|---|---|
| Z, | depth in meters |
| lat, | latitude n degrees |

### Value

the pressure

### Author(s)

Jose Gama

### Source

Lovett, J.R. 1978 Merged seawater sound-speed equations J. Acoust. Soc. Am., 63, 1713-18.

### Examples

```
PressureModifiedSimplifiedLeroy(0, 0)
```

---

## PressureSimplifiedLeroy

*Calculation of pressure in water simplified from Leroy 1969*

---

### Description

Returns the pressure in water simplified from Leroy 1969

### Usage

```
PressureSimplifiedLeroy(Z, lat)
```

### Arguments

| | |
|---|---|
| Z, | depth in meters |
| lat, | latitude n degrees |

### Value

the pressure

### Author(s)

Jose Gama

## Source

Leroy C. C. 1969 Development of simple equations for accurate and more realistic calculations of the speed of sound in sea water J. Acoust. Soc. Am. 46, 216-226.

## Examples

```
PressureSimplifiedLeroy(0, 0)
```

---

`PressureToDepthLeroyParthiot`
*Pressure To Depth from Leroy Parthiot 1998*

---

## Description

Returns the Pressure To Depth from Leroy Parthiot 1998

## Usage

```
PressureToDepthLeroyParthiot(P, latitude, CorrectiveTerm = NA)
```

## Arguments

| | |
|---|---|
| `P,` | pressure in MPa (relative to atmospheric pressure) |
| `latitude,` | latitude in degrees |
| `CorrectiveTerm,` | optional corrective term |

## Value

the depth

## Author(s)

Jose Gama

## Source

C. C. Leroy and F Parthiot, 1998 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://resource.npl.co.uk/acoustics/techguides/soundseawater/

## References

C. C. Leroy and F Parthiot, 1998 Depth-pressure relationship in the oceans and seas (1998) J. Acoust. Soc. Am. 103(3) pp 1346-1352

## Examples

```
PressureToDepthLeroyParthiot(0.1, 0)
```

PressureToDepthSaundersFofonoff

*Pressure To Depth from Saunders and Fofonoff 1976*

## Description

Returns the Pressure To Depth from Saunders and Fofonoff 1992 CHECKVALUE: DEPTH = 9712.653 M FOR P=10000 DECIBARS, LATITUDE=30 DEG ABOVE FOR STANDARD OCEAN: T=O DEG. CELSIUS; S=35 (PSS-78)

## Usage

```
PressureToDepthSaundersFofonoff(P, latitude)
```

## Arguments

| | |
|---|---|
| P, | pressure in MPa (relative to atmospheric pressure) |
| latitude, | latitude in degrees |

## Value

the depth

## Author(s)

Jose Gama

## Source

Unesco, 1983 Algorithms for computation of fundamental properties of seawater, 1983. Unesco Tech. Pap. in Mar. Sci., No. 44, 53 pp.

## References

Saunders P.M., Fofonoff N.P., 1976 Conversion of pressure to depth in the ocean. Deep Sea Research 23:109-111

## Examples

```
PressureToDepthSaundersFofonoff(0.1, 0)
```

---

`ProjectorSensitivityPower`
*Projector Sensitivity Power*

---

## Description

Returns the Projector Sensitivity Power

## Usage

```
ProjectorSensitivityPower(I1, Ir, P)
```

## Arguments

| | |
|---|---|
| `I1` | intensity of source at standard range |
| `Ir` | reference intensity |
| `P` | power (Watt) |

## Value

response Sv (dB/V)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 9.

## Examples

```
ProjectorSensitivityPower( 10000, 15000, 0.7 )
```

---

`ProjectorSensitivityVoltage`
*Projector Sensitivity Voltage*

---

## Description

Returns the Projector Sensitivity Voltage

## Usage

```
ProjectorSensitivityVoltage(I1, Ir, v)
```

### Arguments

| | |
|---|---|
| I1 | intensity of source at standard range |
| Ir | reference intensity |
| v | Voltage |

### Value

response Sv (dB/V)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 9.

### Examples

```
ProjectorSensitivityVoltage( 10000, 15000, 0.7 )
```

---

## PropagationLoss *Propagation loss (PL)*

---

### Description

Returns the Propagation loss (PL)

### Usage

```
PropagationLoss(I0, Ir)
```

### Arguments

| | |
|---|---|
| I0 | intensity of the source to a point one metre from its acoustic centre |
| Ir | is the intensity at the receiver |

### Value

Propagation loss (PL) (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 43.

## Examples

```
PropagationLoss( 1000, 500 )
```

---

RangeResolutionCHIRP *Sonar Range Resolution CHIRP*

---

## Description

Returns the Sonar Range Resolution CHIRP

## Usage

```
RangeResolutionCHIRP(SonarBandwidth, Cw)
```

## Arguments

| | |
|---|---|
| SonarBandwidth, | Sonar Bandwidth |
| Cw, | Velocity of sound |

## Value

the Sonar Range Resolution

## Author(s)

Jose Gama

## Examples

```
RangeResolutionCHIRP(1, 343)
```

---

RangeResolutionMonotonic
*Sonar Range Resolution for monotonic acoustic systems*

---

## Description

Returns the Sonar Range Resolution for monotonic acoustic systems

## Usage

```
RangeResolutionMonotonic(SonarPulseDuration, Cw)
```

### Arguments

| | |
|---|---|
| SonarPulseDuration, | Sonar Pulse Duration |
| Cw, | Velocity of sound |

### Value

the Sonar Range Resolution

### Author(s)

Jose Gama

### Examples

```
RangeResolutionMonotonic(1, 343)
```

---

## SLdirectionalProjector

*SL of a directional projector*

---

### Description

Returns the SL of a directional projector

### Usage

```
SLdirectionalProjector(P, DIt)
```

### Arguments

| | |
|---|---|
| P, | power output (watts) |
| DIt, | transmit directivity index (dB) |

### Value

SL of a directional projector

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 4.

### Examples

```
SLdirectionalProjector( 700, 0.7 )
```

## SLomnidirectionalProjector *SL of an omnidirectional projector*

### Description

Returns the SL of an omnidirectional projector

### Usage

```
SLomnidirectionalProjector(P)
```

### Arguments

| | |
|---|---|
| P, | omnidirectional power output (watts) |

### Value

source level (SL)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 4.

### Examples

```
SLomnidirectionalProjector( 1000 )
```

## SonarEquation *sonar equation*

### Description

Returns the sonar equation EL = SL - 2PL + TS

### Usage

```
SonarEquation(SL, PL, TS)
```

### Arguments

| | |
|---|---|
| SL | source level |
| PL | propagation loss |
| TS | target strength |

### Value

EL echo level

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 68.

---

## SourceLevel *source level (SL)*

---

### Description

Returns the source level (SL)

### Usage

```
SourceLevel(I1, Ir)
```

### Arguments

| | |
|---|---|
| I1, | intensity of source at standard range |
| Ir, | reference intensity |

### Value

source level (SL)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 4.

### Examples

```
SourceLevel( 1000, 1100)
```

SourceLevelToAvoidCavitation
*source level to avoid cavitation*

## Description

Returns the source level to avoid cavitation

## Usage

```
SourceLevelToAvoidCavitation(f, DIt)
```

## Arguments

| | |
|---|---|
| f, | frequency (Hz) |
| DIt, | transmit directivity index (dB) |

## Value

source level SL (dB)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 5.

## Examples

```
SourceLevelToAvoidCavitation( 20000, 0.7 )
```

SpeedAlgorithmParameterRanges
*Data on Speed of Sound Algorithm Parameter Ranges*

## Description

Data on Speed of Sound Algorithm Parameter Ranges

## Usage

```
SpeedAlgorithmParameterRanges
```

### Format

dataframe with 10 rows and 10 columns:

**Reference** Reference

**TemperatureRangeMin** Temperature Range (C) Min

**TemperatureRangeMax** Temperature Range (C) Min

**SalinityRangeMin** Salinity Range (ppt) min

**SalinityRangeMax** Salinity Range (ppt) max

**PressureOrDepthRangeMin** Pressure or Depth Range min

**PressureOrDepthRangeMax** Pressure or Depth Range max

**PressureOrDepthRangeUnits** Pressure or Depth Range units

**StandardError** Standard Error

**NumberOfTerms** Number of Terms

### Author(s)

Jose Gama

### References

Paul C. Etter, 2013 Underwater Acoustic Modeling and Simulation, Fourth Edition pp. 28. CRC Press

---

## SpeedOfSound *Speed of sound*

---

### Description

Returns the speed of sound from wavelength and frequency

### Usage

```
SpeedOfSound(lambda, f)
```

### Arguments

| | |
|---|---|
| lambda | numeric, wavelength (meters) |
| f | numeric, frequency (Hz) |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 1.

### Examples

```
SpeedOfSound( 5,  70)
```

---

## SpeedOfSoundAir *speed of sound in humid air at sea level air density and known atmospheric pressure*

---

### Description

Returns the speed of sound in humid air at sea level air density and known atmospheric pressure

### Usage

```
SpeedOfSoundAir(temperatureC, Hr, pressurekPa)
```

### Arguments

| | |
|---|---|
| temperatureC | numeric, temperature in degrees Celsius in the range -30 C to 43 C |
| Hr | numeric, relative humidity, accurate to within 0.1% for temperatures |
| pressurekPa | numeric, atmospheric pressure in kPa |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### References

Kleeman L. & Kuc R., 2008 Springer Handbook of Robotics, Bruno Siciliano, Oussama Khatib (Eds.) Springer-Verlag Berlin Heidelberg, pp.496 eq (21.8).

### Examples

```
#Speed of sound (Humid air, at sea level air density)
#temperature 20 C, 90\% relative humidity, 101 kPa atmosphere pressure
SpeedOfSoundAir(20, 0.9, 101)
```

## SpeedOfSoundDryAir *Speed of sound in dry air at sea level air density and one atmosphere pressure*

### Description

Returns the speed of sound in dry air at sea level air density and one atmosphere pressure

### Usage

```
SpeedOfSoundDryAir(temperatureC)
```

### Arguments

| | |
|---|---|
| temperatureC | numeric, temperature in degrees Celsius accurate to within 1% |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### References

Kleeman L. & Kuc R., 2008 Springer Handbook of Robotics, Bruno Siciliano, Oussama Khatib (Eds.) Springer-Verlag Berlin Heidelberg, pp.496 eq (21.6).

### Examples

```
#Speed of sound (dry air, at sea level air density, one atmosphere pressure)
#temperature 20 C
SpeedOfSoundDryAir(20)
```

## SpeedOfSoundFreshWaterGrossoMader *speed of sound (m/s) in fresh water from Grosso and Mader*

### Description

Returns the speed of sound (m/s) Range of validity: 0-95C, D = 0, error +-0.015

### Usage

```
SpeedOfSoundFreshWaterGrossoMader(temperatureC)
```

### Arguments

| | |
|---|---|
| temperatureC, | temperatureC in Celsius |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://support.echoview.com/WebHelp/Reference/Algorithms/Sonar_calculator_algorithms.htm

### References

Del Grosso, VA and Mader C.W., 1972 Speed of sound in pure water. J. acoust. Soc. Am., 52, 1442-6.

### Examples

```
SpeedOfSoundFreshWaterGrossoMader(25)
```

---

## SpeedOfSoundHumidAir *Speed of sound in Humid air at sea level air density and one atmosphere pressure*

---

### Description

Returns the speed of sound in Humid air at sea level air density and one atmosphere pressure

### Usage

```
SpeedOfSoundHumidAir(temperatureC, Hr)
```

### Arguments

| | |
|---|---|
| temperatureC | numeric, temperature in degrees Celsius in the range -30 C to 43 C |
| Hr | numeric, relative humidity, accurate to within 0.1% for temperatures |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### References

Kleeman L. & Kuc R., 2008 Springer Handbook of Robotics, Bruno Siciliano, Oussama Khatib (Eds.) Springer-Verlag Berlin Heidelberg, pp.496 eq (21.7).

### Examples

```
#Speed of sound (Humid air, at sea level air density, one atmosphere pressure)
#temperature 20 C, 90\% relative humidity
SpeedOfSoundHumidAir(20, 0.9)
```

---

## SpeedOfSoundKinslerEtal

*Speed of sound (m/s) from Kinsler et al*

---

### Description

Returns the speed of sound (m/s) from Kinsler et al accurate to within 0.05% for 0<=T<=100 C and 0<=P<=200 bar

### Usage

```
SpeedOfSoundKinslerEtal(PressureBar, temperatureC)
```

### Arguments

| | |
|---|---|
| PressureBar, | Pressure in bars (1 bar = 100 kPa) |
| temperatureC, | temperatureC in Celsius |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### References

L. Kinsler, A. Frey, A. Coppens, J. Sanders, 1982 Fundamentals of Acoustics, Third Edition New York: John Wiley & Sons. pp. 121 (5.6.8)

### Examples

```
SpeedOfSoundKinslerEtal(1, 20)
```

`SpeedOfSoundPureWaterBelogolskiiSekoyanEtal` *speed of sound (m/s) from Belogolskii, Sekoyan et al*

## Description

Returns the speed of sound (m/s) Range of validity: 0-40C, 0.1 - 60 MPa

## Usage

```
SpeedOfSoundPureWaterBelogolskiiSekoyanEtal(temperatureC, pressureMegaPascals)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperatureC in Celsius |
| `pressureMegaPascals,` | pressure in mega Pascals |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://resource.npl.co.uk/acoustics/techguides/soundpurewater/content.html#LUBBERS

## References

Belogolskii, Sekoyan et al, 1999 Pressure dependence of the sound velocity in distilled water, Measurement Techniques, Vol 42, No 4, pp 406-413.

## Examples

```
SpeedOfSoundPureWaterBelogolskiiSekoyanEtal(25, 1)
```

SpeedOfSoundPureWaterBilaniukWong112 *speed of sound (m/s) from Bilaniuk and Wong 112 point equation*

## Description

Returns returns the speed of sound (m/s) Range of validity: 0-100 OC at atmospheric pressure

## Usage

```
SpeedOfSoundPureWaterBilaniukWong112(temperatureC)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperatureC in Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://resource.npl.co.uk/acoustics/techguides/soundpurewater/content.html#LUBBERS

## References

Bilaniuk and Wong 1993 Speed of sound in pure water as a function of temperature, J. Acoust. Soc. Am. 93(3) pp 1609-1612 Bilaniuk and Wong 1996 Erratum: Speed of sound in pure water as a function of temperature [J. Acoust. Soc. Am. 93, 1609-1612 (1993)], J. Acoust. Soc. Am. 99(5), p 3257.

## Examples

```
SpeedOfSoundPureWaterBilaniukWong112(20)
```

`SpeedOfSoundPureWaterBilaniukWong148` *speed of sound (m/s) from Bilaniuk and Wong 148 point equation*

## Description

Returns returns the speed of sound (m/s) Range of validity: 0-100 OC at atmospheric pressure

## Usage

```
SpeedOfSoundPureWaterBilaniukWong148(temperatureC)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperatureC in Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://resource.npl.co.uk/acoustics/techguides/soundpurewater/content.html#LUBBERS

## References

Bilaniuk and Wong 1993 Speed of sound in pure water as a function of temperature, J. Acoust. Soc. Am. 93(3) pp 1609-1612 Bilaniuk and Wong 1996 Erratum: Speed of sound in pure water as a function of temperature [J. Acoust. Soc. Am. 93, 1609-1612 (1993)], J. Acoust. Soc. Am. 99(5), p 3257.

## Examples

```
SpeedOfSoundPureWaterBilaniukWong148(20)
```

SpeedOfSoundPureWaterBilaniukWong36 *speed of sound (m/s) from Bilaniuk and Wong 36 point equation*

## Description

Returns returns the speed of sound (m/s) Range of validity: 0-100 OC at atmospheric pressure

## Usage

```
SpeedOfSoundPureWaterBilaniukWong36(temperatureC)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperatureC in Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://resource.npl.co.uk/acoustics/techguides/soundpurewater/content.html#LUBBERS

## References

Bilaniuk and Wong 1993 Speed of sound in pure water as a function of temperature, J. Acoust. Soc. Am. 93(3) pp 1609-1612 Bilaniuk and Wong 1996 Erratum: Speed of sound in pure water as a function of temperature [J. Acoust. Soc. Am. 93, 1609-1612 (1993)], J. Acoust. Soc. Am. 99(5), p 3257.

## Examples

```
SpeedOfSoundPureWaterBilaniukWong36(20)
```

SpeedOfSoundPureWaterLubbersandGraaffSEa *speed of sound (m/s) from Lubbers and Graaff's simplified equations a and b*

## Description

Returns returns the speed of sound (m/s) temperature interval 15-35 C at atmospheric pressure, maximum error 0.18 m/s Lubbers and Graaff's simplified equation a)

## Usage

```
SpeedOfSoundPureWaterLubbersandGraaffSEa(temperatureC)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperatureC in Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://resource.npl.co.uk/acoustics/techguides/soundpurewater/content.html#LUBBERS

## References

J. Lubbers and R. Graaff, 1998 A simple and accurate formula for the sound velocity in water, Ultrasound Med. Biol. Vol 24, No 7, pp 1065-1068.

## Examples

```
SpeedOfSoundPureWaterLubbersandGraaffSEa(20)
```

SpeedOfSoundPureWaterLubbersandGraaffSEb *speed of sound (m/s) from Lubbers and Graaff's simplified equations a and b*

## Description

Returns returns the speed of sound (m/s) temperature interval 10-40C at atmospheric pressure, maximum error 0.18 m/s Lubbers and Graaff's simplified equation b)

## Usage

```
SpeedOfSoundPureWaterLubbersandGraaffSEb(temperatureC)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperatureC in Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://resource.npl.co.uk/acoustics/techguides/soundpurewater/content.html#LUBBERS

## References

J. Lubbers and R. Graaff, 1998 A simple and accurate formula for the sound velocity in water, Ultrasound Med. Biol. Vol 24, No 7, pp 1065-1068.

## Examples

```
SpeedOfSoundPureWaterLubbersandGraaffSEb(20)
```

SpeedOfSoundPureWaterMarczak *speed of sound (m/s) from Marczak*

## Description

Returns returns the speed of sound (m/s) Range of validity: 0-95C at atmospheric pressure

## Usage

```
SpeedOfSoundPureWaterMarczak(temperatureC)
```

## Arguments

| | |
|---|---|
| temperatureC, | temperatureC in Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

National Physical Laboratory, 2015 Underwater Acoustics Technical Guides - Speed of Sound in Pure Water http://resource.npl.co.uk/acoustics/techguides/soundpurewater/content.html#LUBBERS

## References

Marczak, 1997 Water as a standard in the measurements of speed of sound in liquids J. Acoust. Soc. Am. 102(5) pp 2776-2779.

## Examples

```
SpeedOfSoundPureWaterMarczak(20)
```

`SpeedOfSoundSeaWaterChenAndMillero`
*speed of sound (m/s) in sea water from Chen and Millero 1977*

## Description

Returns the speed of sound (m/s) Range of validity: temperature 0 to 40 C, salinity 0 to 40 parts per thousand, pressure 0 to 1000 bar

## Usage

```
SpeedOfSoundSeaWaterChenAndMillero(S, temperatureC, P)
```

## Arguments

| | |
|---|---|
| `S,` | salinity in parts per thousand |
| `temperatureC,` | temperature in degrees Celsius |
| `P,` | pressure in kg/cm^2 |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

C-T. Chen and F.J. Millero, 1977 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://resource.npl.co.uk/acoustics/techguides/soundseawater/

## References

C-T. Chen and F.J. Millero, 1977 Speed of sound in seawater at high pressures J. Acoust. Soc. Am. 62(5) pp 1129-1135

## Examples

```
SpeedOfSoundSeaWaterChenAndMillero(30, 0, 1.019716)
```

`SpeedOfSoundSeaWaterCoppens` *speed of sound (m/s) in sea water from Coppens 1981*

## Description

Returns the speed of sound (m/s) Range of validity: temperature 0 to 35 C salinity 0 to 45 parts per thousand and depth 0 to 4000 m

## Usage

```
SpeedOfSoundSeaWaterCoppens(D, S, temperatureC)
```

## Arguments

| | |
|---|---|
| `D,` | depth in meters |
| `S,` | salinity in parts per thousand |
| `temperatureC,` | temperature in degrees Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

A.B. Coppens, 1981 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://resource.npl.co.uk/acoustics/techguides/soundseawater/

## References

A.B. Coppens, 1981 Simple equations for the speed of sound in Neptunian waters J. Acoust. Soc. Am. 69(3), pp 862-863

## Examples

```
SpeedOfSoundSeaWaterCoppens(0, 35, 25)
```

SpeedOfSoundSeaWaterDelGrosso

*speed of sound (m/s) in sea water from Del Grosso 1974*

## Description

Returns the speed of sound (m/s) Range of validity: temperature 0 to 30 C, salinity 30 to 40 parts per thousand pressure 0 to 1000 kg/cm^2 , where 100 kPa=1.019716 kg/cm^2

## Usage

```
SpeedOfSoundSeaWaterDelGrosso(S, temperatureC, P)
```

## Arguments

| | |
|---|---|
| S, | salinity in parts per thousand |
| temperatureC, | temperature in degrees Celsius |
| P, | pressure in kg/cm^2 |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

V.A. Del Grosso, 1974 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://resource.npl.co.uk/acoustics/techguides/soundseawater/

## References

V.A. Del Grosso, 1974 New equation for the speed of sound in natural waters (with comparisons to other equations). J. Acoust. Soc. Am 56(4) pp 1084-1091.

## Examples

```
SpeedOfSoundSeaWaterDelGrosso(30, 0, 1.019716)
```

SpeedOfSoundSeaWaterFryeAndPugh
*Calculation of speed of sound in sea water from Frye and Pugh 1971*

## Description

Returns the speed of sound in sea water from Frye and Pugh 1971

## Usage

```
SpeedOfSoundSeaWaterFryeAndPugh(temperatureC, S, P)
```

## Arguments

| | |
|---|---|
| temperatureC, | temperature from -3C to 30C |
| S, | salinity from 33.1 to -36.6 per 1000 |
| P, | hydrostatic pressure from 1.033 to 984.3 kg/cm^2 |

## Value

the speed of sound

## Author(s)

Jose Gama

## Source

Frye, H.W. and Pugh, J.D. 1971 A new equation for the speed of sound in seawater J. Acoust. Soc. Am., 50, 384-6.

## References

Frye, H.W. and Pugh, J.D. 1971 A new equation for the speed of sound in seawater J. Acoust. Soc. Am., 50, 384-6.

## Examples

```
SpeedOfSoundSeaWaterFryeAndPugh(0, 30, 1.033)
```

SpeedOfSoundSeaWaterLeroy68 *speed of sound (m/s) in sea water from Leroy 1968*

## Description

Returns the speed of sound (m/s)

## Usage

```
SpeedOfSoundSeaWaterLeroy68(D, latitude)
```

## Arguments

| | |
|---|---|
| D, | depth in meters |
| latitude, | latitude in degrees |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

Lurton, X, 2002 An Introduction to Underwater Acoustics, 1st ed. London, Praxis Publishing LTD, p37.

## References

Lurton, X, 2002 An Introduction to Underwater Acoustics, 1st ed. London, Praxis Publishing LTD, p37.

## Examples

```
SpeedOfSoundSeaWaterLeroy68(25, 0)
```

`SpeedOfSoundSeaWaterLeroy69` *speed of sound (m/s) in sea water from Leroy 1969*

## Description

Returns the speed of sound (m/s) Range of validity: -2:23 C, Error +-0.1

## Usage

```
SpeedOfSoundSeaWaterLeroy69(D, S, temperatureC)
```

## Arguments

| | |
|---|---|
| `D,` | depth in meters |
| `S,` | salinity in parts per thousand |
| `temperatureC,` | temperatureC in Celsius |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

Leroy C.C. 1969 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://support.echoview.com/WebHelp/Reference/Algorithms/Sonar_calculator_algorithms.htm

## References

Leroy C.C. 1969 Development of simple equations for accurate and more realistic calculation of the speed of sound in sea water. J. acoust. Soc. Am., 46, 216-26.

## Examples

```
SpeedOfSoundSeaWaterLeroy69(0, 35, 25)
```

SpeedOfSoundSeaWaterLeroyEtAl2008
*Calculation of speed of sound in sea water from Leroy et Al 2008*

## Description

Returns the speed of sound in sea water from Leroy et Al 2008

## Usage

```
SpeedOfSoundSeaWaterLeroyEtAl2008(temperatureC, S, D, L)
```

## Arguments

| | |
|---|---|
| temperatureC, | temperature in degrees C 1990 universal temperature scale |
| S, | salinity in % |
| D, | depth in meters |
| L, | latitude in degrees |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

Leroy, C.C., Robinson, S.P., and Goldsmith, M.J. 2008 A new equation for the accurate calculation of sound speed in all oceans J. Acoust. Soc. Am., 124, 2774-82.

## Examples

```
SpeedOfSoundSeaWaterLeroyEtAl2008(0, 30, 0, 0)
```

---

`SpeedOfSoundSeaWaterLovett1`
*Calculation of speed of sound in sea water from Lovett 1978*

---

## Description

Returns the speed of sound in sea water from Lovett 1978 Check value: at T=2C, S=34.7; P=6000 dbar; C = 1559.462 m/s.

## Usage

```
SpeedOfSoundSeaWaterLovett1(temperatureC, S, P)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperature in degrees C T48 |
| `S,` | salinity in % |
| `P,` | pressure in decibars (0 at surface) |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

Lovett, J.R. 1978 Merged seawater sound-speed equations J. Acoust. Soc. Am., 63, 1713-18.

## Examples

```
SpeedOfSoundSeaWaterLovett1(2, 34.7, 6000)
```

---

`SpeedOfSoundSeaWaterLovett2`
*Calculation of speed of sound in sea water from Lovett 1978b*

---

## Description

Returns the speed of sound in sea water from Lovett 1978b Check value: at T=2C, S=34.7; P=6000 dbar; C = 1559.393 m/s.

### Usage

```
SpeedOfSoundSeaWaterLovett2(temperatureC, S, P)
```

### Arguments

| | |
|---|---|
| temperatureC, | temperature in degrees C T48 |
| S, | salinity in % |
| P, | pressure in decibars (0 at surface) |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### Source

Lovett, J.R. 1978 Merged seawater sound-speed equations J. Acoust. Soc. Am., 63, 1713-18.

### Examples

```
SpeedOfSoundSeaWaterLovett2(2, 34.7, 6000)
```

---

## SpeedOfSoundSeaWaterLovett3

*Calculation of speed of sound in sea water from Lovett 1978c*

---

### Description

Returns the speed of sound in sea water from Lovett 1978c Check value: at T=2C, S=34.7; P=6000 dbar; C = 1559.499 m/s.

### Usage

```
SpeedOfSoundSeaWaterLovett3(temperatureC, S, P)
```

### Arguments

| | |
|---|---|
| temperatureC, | temperature in degrees C T48 |
| S, | salinity in % |
| P, | pressure in decibars (0 at surface) |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### Source

Lovett, J.R. 1978 Merged seawater sound-speed equations J. Acoust. Soc. Am., 63, 1713-18.

### Examples

```
SpeedOfSoundSeaWaterLovett3(2, 34.7, 6000)
```

---

## SpeedOfSoundSeaWaterMackenzie

*speed of sound (m/s) in sea water from Mackenzie 1981*

---

### Description

Returns the speed of sound (m/s)

### Usage

```
SpeedOfSoundSeaWaterMackenzie(D, S, temperatureC)
```

### Arguments

| | |
|---|---|
| D, | depth in meters |
| S, | salinity in parts per thousand |
| temperatureC, | temperatureC in Celsius |

### Value

the speed of sound (m/s)

### Author(s)

Jose Gama

### Source

Mackenzie K.V., 1981 Underwater Acoustics Technical Guides - Speed of Sound in Sea Water http://support.echoview.com/WebHelp/Reference/Algorithms/Sonar_calculator_algorithms.htm

### References

Mackenzie K.V., 1981 Nine-term equation for sound speed in the ocean. J. acoust. Soc. Am., 70, 807-12.

## Examples

```
SpeedOfSoundSeaWaterMackenzie(0, 35, 25)
```

---

`SpeedOfSoundSeaWaterMedwin`
*speed of sound (m/s) in sea water from Medwin 1975*

---

## Description

Returns the speed of sound (m/s) (approximation) Range of validity: limited to 1000 meters in depth

## Usage

```
SpeedOfSoundSeaWaterMedwin(temperatureC, D, S)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperature in degrees Celsius |
| `D,` | depth in meters |
| `S,` | salinity in parts per thousand |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

X Lurton, 2002 An Introduction to Underwater Acoustics, 1st ed. London, Praxis Publishing LTD

## References

Medwin H, 1975 Speed of sound in water: A simple equation for realistic parameters Journal of the Acoustical Society of America, 58, 1318-1319, 1975

## Examples

```
SpeedOfSoundSeaWaterMedwin(0, 1, 30)
```

`SpeedOfSoundSeaWaterSkone` *speed of sound (m/s) in sea water from Skone et al 2002*

## Description

Returns the speed of sound (m/s) modelled using empirical formulae

## Usage

```
SpeedOfSoundSeaWaterSkone(temperatureC, D, S)
```

## Arguments

| | |
|---|---|
| `temperatureC,` | temperature in degrees Celsius |
| `D,` | depth in meters |
| `S,` | salinity in parts per thousand |

## Value

the speed of sound (m/s)

## Author(s)

Jose Gama

## Source

de Jong, C.D., Lachapelle, G., Skone, S. and Elema, I. A., 2002 Hydrography. Delft University Press (The Netherlands). pp.194

## References

de Jong, C.D., Lachapelle, G., Skone, S. and Elema, I. A., 2002 Hydrography. Delft University Press (The Netherlands). pp.194

## Examples

```
SpeedOfSoundSeaWaterSkone(0, 1, 30)
```

SpeedOfSoundSeaWaterWilson *Calculation of speed of sound in sea water from Wilson 1960*

## Description

Returns the speed of sound in sea water from Wilson 1960

## Usage

```
SpeedOfSoundSeaWaterWilson(temperatureC, S, P)
```

## Arguments

| | |
|---|---|
| temperatureC, | temperature from -4C to 30C |
| S, | salinity from 0 to 37 per 1000 |
| P, | hydrostatic pressure from 0.1 MPa to 100 MPa |

## Value

the speed of sound

## Author(s)

Jose Gama

## Source

N. N. Andreyev Acoustics Institute, 2015 The speed of sound in sea water http://www.akin.ru/spravka_eng/s_i_svel_e.htm

## References

Wilson W D, 1960 Equation for the speed of sound in sea water J. Acoust. Soc. Amer., vol.32, N 10, p. 1357

## Examples

```
SpeedOfSoundSeaWaterWilson(0, 30, 0.1)
```

## TargetStrength *Target Strength (TS)*

### Description

Returns the Target Strength (TS), the echo returned by an underwater target

### Usage

```
TargetStrength(Ir, Ii)
```

### Arguments

| | |
|---|---|
| Ir | reflected intensity referred to 1 m from the acoustic centre of the target |
| Ii | incident intensity |

### Value

Target Strength (TS)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 67.

### Examples

```
TargetStrength( 900, 1000 )
```

## TargetStrengthCircularPlateNormal *target strength Circular Plate normal*

### Description

Returns the target strength Circular Plate normal

### Usage

```
TargetStrengthCircularPlateNormal(r, lambda)
```

### Arguments

| | |
|---|---|
| r | radius (meters) |
| lambda | wavelength |

### Value

Target Strength (TS) (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 70.

### Examples

```
TargetStrengthCircularPlateNormal( 10, 500 )
```

---

## TargetStrengthConvexSurface

*target strength Convex surface*

---

### Description

Returns the target strength Convex surface

### Usage

```
TargetStrengthConvexSurface(r1, r2)
```

### Arguments

| | |
|---|---|
| r1 | principal radii (meters) |
| r2 | principal radii (meters) |

### Value

Target Strength (TS) (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 70.

## Examples

```
TargetStrengthConvexSurface( 100, 50 )
```

---

`TargetStrengthCylinderNormal`
*target strength Cylinder normal*

---

## Description

Returns the target strength Cylinder normal

## Usage

```
TargetStrengthCylinderNormal(r, L, lambda)
```

## Arguments

| | |
|---|---|
| `r` | radius (meters) |
| `L` | length (meters) |
| `lambda` | wavelength |

## Value

Target Strength (TS) (dB)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 70.

## Examples

```
TargetStrengthCylinderNormal( 10, 5, 500 )
```

`TargetStrengthCylinderThetaToNormal` *target strength Cylinder, theta to normal*

## Description

Returns the target strength Cylinder, theta to normal

## Usage

```
TargetStrengthCylinderThetaToNormal(r, L, lambda, theta)
```

## Arguments

| | |
|---|---|
| `r` | radius (meters) |
| `L` | length (meters) |
| `lambda` | wavelength |
| `theta` | angle to normal |

## Value

Target Strength (TS) (dB)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 70.

## Examples

```
TargetStrengthCylinderThetaToNormal( 10, 5, 500, 45 )
```

---

`TargetStrengthPlateAnyShape`
*target strength Plate of any shape*

---

## Description

Returns the target strength Plate of any shape

## Usage

```
TargetStrengthPlateAnyShape(A, lambda)
```

## Arguments

| | |
|---|---|
| `A` | area (meters) |
| `lambda` | wavelength |

## Value

Target Strength (TS) (dB)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 70.

## Examples

```
TargetStrengthPlateAnyShape( 10, 500 )
```

---

`TargetStrengthRectangularPlateNormal`
*target strength Rectangular Plate normal*

---

## Description

Returns the target strength Rectangular Plate normal

## Usage

```
TargetStrengthRectangularPlateNormal(A, B, lambda)
```

### Arguments

| | |
|---|---|
| A | side, A>=B (meters) |
| B | side (meters) |
| lambda | wavelength |

### Value

Target Strength (TS) (dB)

### Author(s)

Jose Gama

### References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 70.

### Examples

```
TargetStrengthRectangularPlateNormal( 10, 500, 500 )
```

---

## TargetStrengthRectangularPlateThetaToNormal

*target strength Rectangular Plate, theta to normal*

---

### Description

Returns the target strength Rectangular Plate, theta to normal

### Usage

```
TargetStrengthRectangularPlateThetaToNormal(A, B, lambda, theta)
```

### Arguments

| | |
|---|---|
| A | side, A>=B (meters) |
| B | side (meters) |
| lambda | wavelength |
| theta | angle to normal |

### Value

Target Strength (TS) (dB)

### Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 70.

## Examples

```
TargetStrengthRectangularPlateThetaToNormal( 10, 500, 500, 45 )
```

---

`TargetStrengthSphere` *target strength sphere*

---

## Description

Returns the target strength sphere

## Usage

```
TargetStrengthSphere(r)
```

## Arguments

| | |
|---|---|
| `r` | radius (meters) |

## Value

Target Strength (TS) (dB)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 69.

## Examples

```
PeakTS( 900, 1000 )
```

`TransmitDirectivityIndex` *transmit directivity index*

## Description

Returns the transmit directivity index (DIt)

## Usage

```
TransmitDirectivityIndex(Idir, Iomni)
```

## Arguments

| | |
|---|---|
| `Idir,` | intensity along the axis of the beam pattern |
| `Iomni,` | intensity of the equivalent non-directional projector |

## Value

transmit directivity index (DIt)

## Author(s)

Jose Gama

## References

Waite A. D., 2002 Sonar for Practising Engineers, 3rd Edition Chichester: Wiley. pp. 4.

## Examples

```
TransmitDirectivityIndex( 700, 1000 )
```

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