

Important Wave Propagation Formulas PDF



Formulas Examples with Units

List of 16 Important Wave Propagation Formulas

1) Antenna Beamwidth Formula ↻

Formula

$$b = \frac{70 \cdot \lambda}{d}$$

Example with Units

$$40.1517^\circ = \frac{70 \cdot 90_m}{8990_m}$$

Evaluate Formula ↻

2) Critical Frequency of Ionosphere Formula ↻

Formula

$$F_c = 9 \cdot \sqrt{N_{\max}}$$

Example with Units

$$1.3E+9_{\text{Hz}} = 9 \cdot \sqrt{2e10_{1/\text{cm}^3}}$$

Evaluate Formula ↻

3) Electron Density Formula ↻

Formula

$$N_{\max} = \frac{(1 - \eta_r^2) \cdot f_o^2}{81}$$

Example with Units

$$2E+10_{1/\text{cm}^3} = \frac{(1 - 0.905^2) \cdot 3e9_{\text{Hz}}^2}{81}$$

Evaluate Formula ↻

4) Field Strength of Space Wave Formula ↻

Formula

$$E = \frac{4 \cdot \pi \cdot E_0 \cdot h_r \cdot h_t}{\lambda \cdot D_A^2}$$

Example with Units

$$0.002_{\text{V/m}} = \frac{4 \cdot 3.1416 \cdot 9990_{\text{V/m}} \cdot 70_m \cdot 32_m}{90_m \cdot 40000_m^2}$$

Evaluate Formula ↻

5) Height of Layer Formula ↻

Formula

$$h = \frac{P_d}{2 \cdot \sqrt{\left(\frac{F_{\text{muf}}^2}{f_c^2}\right) - 1}}$$

Example with Units

$$1169.9849_m = \frac{21714_m}{2 \cdot \sqrt{\left(\frac{420_{\text{Hz}}^2}{45_{\text{Hz}}^2}\right) - 1}}$$

Evaluate Formula ↻

6) Line of Sight Formula ↻

Formula

$$\text{LOS} = 3577 \cdot \left(\sqrt{h_r} + \sqrt{h_t}\right)$$

Example with Units

$$50161.8968_m = 3577 \cdot \left(\sqrt{70_m} + \sqrt{32_m}\right)$$

Evaluate Formula ↻



7) Maximum Usable Frequency Formula ↻

Formula

$$F_{\text{muf}} = f_c \cdot \sqrt{1 + \left(\frac{P_d}{2 \cdot h} \right)^2}$$

Example with Units

$$419.9999 \text{ Hz} = 45 \text{ Hz} \cdot \sqrt{1 + \left(\frac{21714 \text{ m}}{2 \cdot 1169.985 \text{ m}} \right)^2}$$

Evaluate Formula ↻

8) Maximum Usable Frequency in F-region Formula ↻

Formula

$$F_{\text{muf}} = \frac{f_c}{\cos(\theta_i)}$$

Example with Units

$$420.0435 \text{ Hz} = \frac{45 \text{ Hz}}{\cos(83.85^\circ)}$$

Evaluate Formula ↻

9) Normal of Reflecting Plane Formula ↻

Formula

$$\lambda_n = \frac{\lambda}{\cos(\theta)}$$

Example with Units

$$103.923 \text{ m} = \frac{90 \text{ m}}{\cos(30^\circ)}$$

Evaluate Formula ↻

10) Parallel of Reflecting Plane Formula ↻

Formula

$$\lambda_p = \frac{\lambda}{\sin(\theta)}$$

Example with Units

$$180 \text{ m} = \frac{90 \text{ m}}{\sin(30^\circ)}$$

Evaluate Formula ↻

11) Phase Difference between Radio Waves Formula ↻

Formula

$$\Phi = 4 \cdot \pi \cdot h_r \cdot \frac{h_t}{D_A \cdot \lambda}$$

Example with Units

$$0.448^\circ = 4 \cdot 3.1416 \cdot 70 \text{ m} \cdot \frac{32 \text{ m}}{40000 \text{ m} \cdot 90 \text{ m}}$$

Evaluate Formula ↻

12) Propagation Distance Formula ↻

Formula

$$P_d = 2 \cdot h \cdot \sqrt{\left(\frac{F_{\text{muf}}^2}{f_c^2} \right) - 1}$$

Example with Units

$$21714.0026 \text{ m} = 2 \cdot 1169.985 \text{ m} \cdot \sqrt{\left(\frac{420 \text{ Hz}^2}{45 \text{ Hz}^2} \right) - 1}$$

Evaluate Formula ↻

13) Refractive Index of Ionosphere Formula ↻

Formula

$$\eta_r = \sqrt{1 - \left(\frac{81 \cdot N_{\text{max}}}{f_o^2} \right)}$$

Example with Units

$$0.9055 = \sqrt{1 - \left(\frac{81 \cdot 2e10 \text{ 1/cm}^3}{3e9 \text{ Hz}^2} \right)}$$

Evaluate Formula ↻



14) Skin Depth or Depth of Penetration Formula

Formula

$$\delta = \frac{1}{\sigma} \cdot \sqrt{\pi \cdot \mu_r \cdot [\text{Permeability-vacuum}] \cdot f}$$

Evaluate Formula 

Example with Units

$$0.0065 \text{ m} = \frac{1}{0.96 \text{ mho/m}} \cdot \sqrt{3.1416 \cdot 0.98 \text{ H/m} \cdot 1.3\text{E-}6 \cdot 10 \text{ Hz}}$$

15) Skip Distance Formula

Formula

$$P_d = 2 \cdot h_{\text{ref}} \cdot \sqrt{\left(\frac{F_{\text{muf}}}{f_c} \right)^2 - 1}$$

Example with Units

$$21714.281 \text{ m} = 2 \cdot 1170 \text{ m} \cdot \sqrt{\left(\frac{420 \text{ Hz}}{45 \text{ Hz}} \right)^2 - 1}$$

Evaluate Formula 

16) Wavelength of Plane Formula

Formula

$$\lambda = \lambda_n \cdot \cos(\theta)$$

Example with Units

$$90.0233 \text{ m} = 103.95 \text{ m} \cdot \cos(30^\circ)$$

Evaluate Formula 



Variables used in list of Wave Propagation Formulas above

- **b** Antenna Beamwidth (Degree)
- **d** Antenna Diameter (Meter)
- **D_A** Antenna Distance (Meter)
- **E** Field Strength (Volt per Meter)
- **E₀** Electric Field (Volt per Meter)
- **f** Frequency of Conductor Loop (Hertz)
- **f_c** Critical Frequency (Hertz)
- **F_c** Critical Frequency of Ionosphere (Hertz)
- **F_{muf}** Maximum Usable Frequency (Hertz)
- **f_o** Operating Frequency (Hertz)
- **h** Ionospheric Layer Height (Meter)
- **h_r** Height of Receiving Antenna (Meter)
- **h_{ref}** Reflection Height (Meter)
- **h_t** Height of Transmitting Antenna (Meter)
- **LOS** Line of Sight (Meter)
- **N_{max}** Electron Density (1 per Cubic Centimeter)
- **P_d** Skip Distance (Meter)
- **δ** Skin Depth (Meter)
- **η_r** Refractive Index
- **θ** Theta (Degree)
- **θ_i** Angle of Incidence (Degree)
- **λ** Wavelength (Meter)
- **λ_n** Normal of Reflecting Plane (Meter)
- **λ_p** Parallel of Reflecting (Meter)
- **μ_r** Relative Permeability (Henry per Meter)
- **σ** Conductivity of Antenna (Mho per Meter)
- **Φ** Phase Difference (Degree)

Constants, Functions, Measurements used in list of Wave Propagation Formulas above

- **constant(s): pi**,
3.14159265358979323846264338327950288
Archimedes' constant
- **constant(s): [Permeability-vacuum]**, 1.2566E-6
Permeability of vacuum
- **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: sin**, sin(Angle)
Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- **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: Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement: Frequency** in Hertz (Hz)
Frequency Unit Conversion 
- **Measurement: Wavelength** in Meter (m)
Wavelength Unit Conversion 
- **Measurement: Electric Field Strength** in Volt per Meter (V/m)
Electric Field Strength Unit Conversion 
- **Measurement: Electric Conductivity** in Mho per Meter (mho/m)
Electric Conductivity Unit Conversion 
- **Measurement: Magnetic Permeability** in Henry per Meter (H/m)
Magnetic Permeability Unit Conversion 
- **Measurement: Number Density** in 1 per Cubic Centimeter (1/cm³)
Number Density Unit Conversion 



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