

# Important Hypersonic Equivalence Principle and Blast-Wave Theory Formulas PDF



**Formulas**  
**Examples**  
**with Units**

## List of 16 Important Hypersonic Equivalence Principle and Blast-Wave Theory Formulas

### 1) Cylindrical Blast Wave Formulas ↻

#### 1.1) Boltzmann Constant for Cylindrical Blast Wave Formula ↻

Formula

$$k_{b1} = \frac{y_{sp}}{2 \cdot \frac{4 - y_{sp}}{2 \cdot y_{sp} - 1}}$$

Example

$$0.418 = \frac{0.4 \cdot 2 \cdot \frac{0.4 - 1}{2 \cdot 0.4}}{\frac{4 - 0.4}{2 \cdot 0.4}}$$

Evaluate Formula ↻

#### 1.2) Modified Energy for Cylindrical Blast Wave Formula ↻

Formula

$$E_{\text{mod}} = 0.5 \cdot \rho_{\infty} \cdot V_{\infty}^2 \cdot d \cdot C_D$$

Evaluate Formula ↻

Example with Units

$$14559.5553 \text{ kJ} = 0.5 \cdot 412.2 \text{ kg/m}^3 \cdot 102 \text{ m/s}^2 \cdot 2.425 \text{ m} \cdot 2.8$$

#### 1.3) Modified Pressure Equation for Cylindrical Blast Wave Formula ↻

Formula

$$P = [\text{BoltZ}] \cdot \rho_{\infty} \cdot \sqrt{\frac{\pi}{8}} \cdot d \cdot \sqrt{C_D} \cdot \frac{U_{\infty \text{ bw}}^2}{y}$$

Evaluate Formula ↻

Example with Units

$$1.7\text{E-}23 \text{ Pa} = 1.4\text{E-}23/\text{K} \cdot 412.2 \text{ kg/m}^3 \cdot \sqrt{\frac{3.1416}{8}} \cdot 2.425 \text{ m} \cdot \sqrt{2.8} \cdot \frac{0.0512 \text{ m/s}^2}{2.2 \text{ m}}$$

#### 1.4) Modified Radial Coordinate Equation for Cylindrical Blast Wave Formula ↻

Formula

$$r = 0.792 \cdot d \cdot C_D^{\frac{1}{4}} \cdot \sqrt{\frac{y}{d}}$$

Example with Units

$$2.3664 \text{ m} = 0.792 \cdot 2.425 \text{ m} \cdot 2.8^{\frac{1}{4}} \cdot \sqrt{\frac{2.2 \text{ m}}{2.425 \text{ m}}}$$

Evaluate Formula ↻



## 1.5) Pressure for Cylindrical Blast Wave Formula

Formula

$$P_{\text{cyl}} = k_{b1} \cdot \rho_{\infty} \cdot \frac{\left(\frac{E}{\rho_{\infty}}\right)^{\frac{1}{2}}}{t_{\text{sec}}}$$

Example with Units

$$2224.0504 \text{ Pa} = 0.8 \cdot 412.2 \text{ kg/m}^3 \cdot \frac{\left(\frac{1200 \text{ kJ}}{412.2 \text{ kg/m}^3}\right)^{\frac{1}{2}}}{8 \text{ s}}$$

Evaluate Formula 

## 1.6) Pressure Ratio for Blunt Cylinder Blast Wave Formula

Formula

$$r_{\text{bc}} = 0.8773 \cdot [\text{BoltZ}] \cdot M^2 \cdot \sqrt{C_D} \cdot \left(\frac{y}{d}\right)^{-1}$$

Example with Units

$$6.8\text{E-}22 = 0.8773 \cdot 1.4\text{E-}23 \text{ J/K} \cdot 5.5^2 \cdot \sqrt{2.8} \cdot \left(\frac{2.2 \text{ m}}{2.425 \text{ m}}\right)^{-1}$$

Evaluate Formula 

## 1.7) Radial Coordinate of Cylindrical Blast Wave Formula

Formula

$$r = \left(\frac{E}{\rho_{\infty}}\right)^{\frac{1}{4}} \cdot t_{\text{sec}}^{\frac{1}{2}}$$

Example with Units

$$20.7761 \text{ m} = \left(\frac{1200 \text{ kJ}}{412.2 \text{ kg/m}^3}\right)^{\frac{1}{4}} \cdot 8 \text{ s}^{\frac{1}{2}}$$

Evaluate Formula 

## 1.8) Simplified Pressure Ratio for Blunt Cylinder Blast Wave Formula

Formula

$$r_p = 0.0681 \cdot M^2 \cdot \frac{\sqrt{C_D}}{\frac{y}{d}}$$

Example with Units

$$3.7996 = 0.0681 \cdot 5.5^2 \cdot \frac{\sqrt{2.8}}{\frac{2.2 \text{ m}}{2.425 \text{ m}}}$$

Evaluate Formula 

## 2) Planar and Blunt Slab Blast Wave Formulas

### 2.1) Blunt-Nosed Flat Plate Pressure Ratio (First Approximation) Formula

Formula

$$r_p = 0.121 \cdot M^2 \cdot \left(\frac{C_D}{\frac{y}{d}}\right)^{\frac{2}{3}}$$

Example with Units

$$7.7591 = 0.121 \cdot 5.5^2 \cdot \left(\frac{2.8}{\frac{2.2 \text{ m}}{2.425 \text{ m}}}\right)^{\frac{2}{3}}$$

Evaluate Formula 

### 2.2) Coefficient of Drag Equation using Energy Released from Blast Wave Formula

Formula

$$C_D = \frac{E}{0.5 \cdot \rho_{\infty} \cdot V_{\infty}^2 \cdot d}$$

Example with Units

$$0.2308 = \frac{1200 \text{ kJ}}{0.5 \cdot 412.2 \text{ kg/m}^3 \cdot 102 \text{ m/s}^2 \cdot 2.425 \text{ m}}$$

Evaluate Formula 



## 2.3) Creation Pressure for Planar Blast Wave Formula

Formula

$$P = [\text{BoltZ}] \cdot \rho_{\infty} \cdot \left( \frac{E}{\rho_{\infty}} \right)^{\frac{2}{3}} \cdot t_{\text{sec}}^{-\frac{2}{3}}$$

Evaluate Formula 

Example with Units

$$2.9\text{E-}19 \text{ Pa} = 1.4\text{E-}23 \text{ J/K} \cdot 412.2 \text{ kg/m}^3 \cdot \left( \frac{1200 \text{ kJ}}{412.2 \text{ kg/m}^3} \right)^{\frac{2}{3}} \cdot 8 \text{ s}^{-\frac{2}{3}}$$

## 2.4) Energy for Blast Wave Formula

Formula

$$E = 0.5 \cdot \rho_{\infty} \cdot V_{\infty}^2 \cdot C_D \cdot A$$

Example with Units

$$1200.7881 \text{ kJ} = 0.5 \cdot 412.2 \text{ kg/m}^3 \cdot 102 \text{ m/s}^2 \cdot 2.8 \cdot 0.2 \text{ m}^2$$

Evaluate Formula 

## 2.5) Pressure Ratio for Blunt Slab Blast Wave Formula

Formula

$$r_p = 0.127 \cdot M^2 \cdot C_D^{\frac{2}{3}} \cdot \left( \frac{y}{d} \right)^{-\frac{2}{3}}$$

Example with Units

$$8.1438 = 0.127 \cdot 5.5^2 \cdot 2.8^{\frac{2}{3}} \cdot \left( \frac{2.2 \text{ m}}{2.425 \text{ m}} \right)^{-\frac{2}{3}}$$

Evaluate Formula 

## 2.6) Radial Coordinate for Planar Blast Wave Formula

Formula

$$r = \left( \frac{E}{\rho_{\infty}} \right)^{\frac{1}{3}} \cdot t_{\text{sec}}^{-\frac{2}{3}}$$

Example with Units

$$57.1151 \text{ m} = \left( \frac{1200 \text{ kJ}}{412.2 \text{ kg/m}^3} \right)^{\frac{1}{3}} \cdot 8 \text{ s}^{-\frac{2}{3}}$$

Evaluate Formula 

## 2.7) Radial Coordinate of Blunt Slab Blast Wave Formula

Formula

$$r = 0.794 \cdot d \cdot C_D^{\frac{1}{3}} \cdot \left( \frac{y}{d} \right)^{\frac{2}{3}}$$

Example with Units

$$2.5433 \text{ m} = 0.794 \cdot 2.425 \text{ m} \cdot 2.8^{\frac{1}{3}} \cdot \left( \frac{2.2 \text{ m}}{2.425 \text{ m}} \right)^{\frac{2}{3}}$$

Evaluate Formula 

## 2.8) Time Required for Blast Wave Formula

Formula

$$t_{\text{sec}} = \frac{y}{U_{\infty \text{ bw}}}$$

Example with Units

$$42.9688 \text{ s} = \frac{2.2 \text{ m}}{0.0512 \text{ m/s}}$$








Evaluate Formula 



## Variables used in list of Hypersonic Equivalence Principle and Blast-Wave Theory Formulas above














- **A** Area for Blast Wave (Square Meter)
- **C<sub>D</sub>** Drag Coefficient
- **d** Diameter (Meter)
- **E** Energy for Blast Wave (Kilojoule)
- **E<sub>mod</sub>** Modified Energy for Blast Wave (Kilojoule)
- **k<sub>b1</sub>** Boltzmann Constant
- **M** Mach Number
- **P** Pressure (Pascal)
- **P<sub>cyl</sub>** Pressure for Blast Wave (Pascal)
- **r** Radial Coordinate (Meter)
- **r<sub>bc</sub>** Pressure Ratio for Blunt Cylinder Blast Wave
- **r<sub>p</sub>** Pressure Ratio
- **t<sub>sec</sub>** Time Required for Blast Wave (Second)
- **U<sub>∞ bw</sub>** Freestream Velocity for Blast Wave (Meter per Second)
- **V<sub>∞</sub>** Freestream Velocity (Meter per Second)
- **y** Distance from X-Axis (Meter)
- **γ<sub>sp</sub>** Specific Heat Ratio
- **ρ<sub>∞</sub>** Freestream Density (Kilogram per Cubic Meter)

## Constants, Functions, Measurements used in list of Hypersonic Equivalence Principle and Blast-Wave Theory Formulas above







- **constant(s):** pi, 3.14159265358979323846264338327950288  
Archimedes' constant
- **constant(s):** [Boltz], 1.38064852E-23  
Boltzmann constant
- **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: Area** in Square Meter (m<sup>2</sup>)  
Area Unit Conversion 
- **Measurement: Pressure** in Pascal (Pa)  
Pressure Unit Conversion 
- **Measurement: Speed** in Meter per Second (m/s)  
Speed Unit Conversion 
- **Measurement: Energy** in Kilojoule (KJ)  
Energy Unit Conversion 
- **Measurement: Density** in Kilogram per Cubic Meter (kg/m<sup>3</sup>)  
Density Unit Conversion 



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