Important Hypersonic Flow and Disturbances Formulas PDF

Formulas
Examples
with Units

List of 17
Important Hypersonic Flow and Disturbances Formulas

1) Change in Velocity for Hypersonic Flow in X Direction Formula

Evaluate Formula

Formula

$$u' = v_{fluid} - U_{\infty}$$

Example with Units

$$3.2\,\text{m/s} = 105.2\,\text{m/s} - 102\,\text{m/s}$$

2) Coefficient of Pressure with Slenderness Ratio Formula

Evaluate Formula

Formula

$$C_p = \frac{2}{\gamma} \cdot M^2 \cdot \left(p_- \cdot \gamma \cdot M^2 \cdot \lambda^2 - 1 \right)$$

Example

$$2.0816 = \frac{2}{1.1} \cdot 5.4^2 \cdot \left(0.81 \cdot 1.1 \cdot 5.4^2 \cdot 0.2^2 - 1 \right)$$

3) Coefficient of Pressure with Slenderness Ratio and Similarity Constant Formula

Evaluate Formula

Formula

$$C_p = \frac{2 \cdot \lambda^2}{\gamma \cdot K^2} \cdot \left(\gamma \cdot K^2 \cdot p_- - 1 \right)$$

Example with Units

$$0.0275 = \frac{2 \cdot 0.2^2}{1.1 \cdot 1.396\,\text{rad}^2} \cdot \left(1.1 \cdot 1.396\,\text{rad}^2 \cdot 0.81 - 1 \right)$$

4) Constant G used for Finding Location of Perturbed Shock Formula

Evaluate Formula

Formula

$$g = \frac{gn}{gd}$$

Example

$$6.5 = \frac{13}{2}$$

5) Density Ratio with Similarity Constant having Slenderness Ratio Formula

Evaluate Formula

Formula

$$\rho_{ratio} = \left(\frac{\gamma + 1}{\gamma - 1} \right) \cdot \left(\frac{1}{1 + \frac{2}{(\gamma - 1) \cdot K^2}} \right)$$

Example with Units

$$1.8646 = \left(\frac{1.1 + 1}{1.1 - 1} \right) \cdot \left(\frac{1}{1 + \frac{2}{(1.1 - 1) \cdot 1.396\,\text{rad}^2}} \right)$$

6) Distance from Tip of Leading Edge to Base Formula

Evaluate Formula

Formula

$$y = U_{\infty bw} \cdot t$$

Example with Units

$$0.041\,\text{m} = 0.0512\,\text{m/s} \cdot 0.8\,\text{s}$$

7) Doty and Rasmussen- Normal Force Coefficient Formula

Evaluate Formula

Formula

$$\mu = 2 \cdot \frac{Fn}{\rho_{fluid} \cdot U_{\infty}^{2} \cdot A}$$

Example with Units

$$0.4171 = 2 \cdot \frac{57.3\,\text{N}}{13.9\,\text{kg/m}^3 \cdot 102\,\text{m/s}^2 \cdot 0.0019\,\text{m}^2}$$

8) Inverse of Density for Hypersonic Flow Formula

Evaluate Formula

Formula

$$\epsilon = \frac{1}{\rho \cdot \beta}$$

Example with Units

$$0.0035\,\text{m}^3\text{/kg} = \frac{1}{997\,\text{kg/m}^3 \cdot 0.286\,\text{rad}}$$

9) Inverse of Density for Hypersonic Flow using Mach Number Formula

Evaluate Formula

Formula

$$\epsilon = \frac{2 + (\gamma - 1) \cdot M^{2} \cdot \sin(\theta_d)^{2}}{2 + (\gamma + 1) \cdot M^{2} \cdot \sin(\theta_d)^{2}}$$

Example with Units

$$0.498\,\text{m}^3\text{/kg} = \frac{2 + (1.1 - 1) \cdot 5.4^{2} \cdot \sin(0.191986\,\text{rad})^{2}}{2 + (1.1 + 1) \cdot 5.4^{2} \cdot \sin(0.191986\,\text{rad})^{2}}$$

10) Non Dimensional Change in Hypersonic Disturbance Velocity in x Direction Formula

Evaluate Formula

Formula

$$u_- = \frac{u'}{U_{\infty bw} \cdot \lambda^{2}}$$

Example with Units

$$585.9375 = \frac{1.2\,\text{m/s}}{0.0512\,\text{m/s} \cdot 0.2^{2}}$$

11) Non Dimensional Change in Hypersonic Disturbance Velocity in y Direction Formula

Evaluate Formula

Formula

$$v^{-'} = \frac{v'}{U_{\infty} \cdot \lambda}$$

Example with Units

$$0.2064 = \frac{4.21\,\text{m/s}}{102\,\text{m/s} \cdot 0.2}$$

12) Non Dimensional Pressure Equation with Slenderness Ratio Formula

Evaluate Formula

Formula

$$p_- = \frac{P}{\gamma \cdot M^{2} \cdot \lambda^{2} \cdot p_{\infty}}$$

Example with Units

$$1.0769 = \frac{80\,\text{Pa}}{1.1 \cdot 5.4^{2} \cdot 0.2^{2} \cdot 57.9\,\text{Pa}}$$

13) Non Dimensional Velocity Disturbance in y Direction in Hypersonic Flow Formula

Evaluate Formula

Formula

$$v^{-'} = \left(\frac{2}{\gamma + 1}\right) \cdot \left(1 - \frac{1}{K^2}\right)$$

Example with Units

$$0.4637 = \left(\frac{2}{1.1 + 1}\right) \cdot \left(1 - \frac{1}{1.396\,\text{rad}^2}\right)$$

14) Non Dimensionalised Time Formula

Evaluate Formula

Formula

$$t^- = \frac{t_{hours}}{\frac{L}{U_\infty}}$$

Example with Units

$$1471.7143 = \frac{1010\,\text{s}}{\frac{70\,\text{m}}{102\,\text{m/s}}}$$

15) Rasmussen Closed Form Expression for Shock Wave Angle Formula

Evaluate Formula

Formula

$$K_\beta = K \cdot \sqrt{\frac{\gamma + 1}{2} + \frac{1}{K^2}}$$

Example with Units

$$1.7454 = 1.396\,\text{rad} \cdot \sqrt{\frac{1.1 + 1}{2} + \frac{1}{1.396\,\text{rad}^2}}$$

16) Similarity Constant Equation using Wave Angle Formula

Evaluate Formula

Formula

$$K_\beta = M \cdot \beta \cdot \frac{180}{\pi}$$

Example with Units

$$88.4876 = 5.4 \cdot 0.286\,\text{rad} \cdot \frac{180}{3.1416}$$

17) Similarity Constant Equation with Slenderness Ratio Formula

Evaluate Formula

Formula

$$K = M \cdot \lambda$$

Example with Units

$$1.08\,\text{rad} = 5.4 \cdot 0.2$$

Variables used in list of Hypersonic Flow and Disturbances Formulas above

- **A** Area *(Square Meter)*
- **C_p** Pressure Coefficient
- **Fn** Normal Force *(Newton)*
- **g** Perturbed Shock Location Constant
- **gd** Perturbed Shock Location Constant at Drag Force
- **gn** Perturbed Shock Location Constant at Normal Force
- **K** Hypersonic Similarity Parameter *(Radian)*
- **K_β** Wave Angle Similarity Parameter
- **L** Length *(Meter)*
- **M** Mach Number
- **P** Pressure *(Pascal)*
- **p_-** Non Dimensionalized Pressure
- **p_∞** Free Stream Pressure *(Pascal)*
- **t** Total Time Taken *(Second)*
- **t_{hours}** Time *(Second)*
- **t^-** Non Dimensionalized Time
- **u'** Change in Velocity for Hypersonic Flow *(Meter per Second)*
- **$U_{\infty\ bw}$** Freestream Velocity for Blast Wave *(Meter per Second)*
- **U_∞** Freestream Velocity Normal *(Meter per Second)*
- **$\bar{u}$,** Non Dimensional Disturbance X Velocity
- **v'** Change in Velocity for Hypersonic Flow y direction *(Meter per Second)*
- **v_{fluid}** Fluid Velocity *(Meter per Second)*
- **$v^{-'}$** Non Dimensional Disturbance Y Velocity
- **y** Distance from X-Axis *(Meter)*
- **β** Wave Angle *(Radian)*
- **γ** Specific Heat Ratio
- **ϵ** Inverse of Density *(Cubic Meter per Kilogram)*
- **θ_d** Deflection Angle *(Radian)*

Constants, Functions, Measurements used in list of Hypersonic Flow and Disturbances Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- 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: **Time** in Second (s) *Time Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Pressure** in Pascal (Pa) *Pressure Unit Conversion*
- Measurement: **Speed** in Meter per Second (m/s) *Speed Unit Conversion*
- Measurement: **Force** in Newton (N) *Force Unit Conversion*
- Measurement: **Angle** in Radian (rad) *Angle Unit Conversion*
- Measurement: **Density** in Kilogram per Cubic Meter (kg/m³) *Density Unit Conversion*
- Measurement: **Specific Volume** in Cubic Meter per Kilogram (m³/kg) *Specific Volume Unit Conversion*

- λ Slenderness Ratio
- μ Coefficient of Force
- ρ Density *(Kilogram per Cubic Meter)*
- ρ_{fluid} Density of Fluid *(Kilogram per Cubic Meter)*
- ρ_{ratio} Density Ratio

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