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## Rocket Propulsion Formulas

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## List of 13 Rocket Propulsion Formulas

Rocket Propulsion 1) Acceleration of Rocket 

$$fx \quad a = \frac{F}{m}$$

Open Calculator 

$$ex \quad 13.85474 \text{m/s}^2 = \frac{7607 \text{kN}}{549054 \text{kg}}$$

2) Compressible Area Ratio 

$$fx \quad A_r = \left( \frac{Y+1}{2} \right)^{-\frac{Y+1}{2Y-2}} \cdot \frac{\left( 1 + \frac{Y-1}{2} \cdot M^2 \right)^{\frac{Y+1}{2Y-2}}}{M}$$

Open Calculator 

$$ex \quad 1.115458 = \left( \frac{1.392758+1}{2} \right)^{-\frac{1.392758+1}{2 \cdot 1.392758-2}} \cdot \frac{\left( 1 + \frac{1.392758-1}{2} \cdot (1.4)^2 \right)^{\frac{1.392758+1}{2 \cdot 1.392758-2}}}{1.4}$$

3) Exit Velocity given Mach Number and Exit Temperature 

$$fx \quad C_j = M \cdot \sqrt{Y \cdot \frac{[R]}{M_{\text{molar}}} \cdot T_{\text{exit}}}$$

Open Calculator 

$$ex \quad 118.0019 \text{m/s} = 1.4 \cdot \sqrt{1.392758 \cdot \frac{[R]}{44.01 \text{g/mol}} \cdot 27 \text{K}}$$

4) Exit Velocity given Molar Mass 

$$fx \quad C_j = \sqrt{\left( \frac{2 \cdot T_c \cdot [R] \cdot Y}{M_{\text{molar}}} / (Y-1) \right) \cdot \left( 1 - \left( \frac{P_{\text{exit}}}{P_c} \right)^{1-\frac{1}{Y}} \right)}$$

Open Calculator 

$$ex \quad 93.93211 \text{m/s} = \sqrt{\left( \frac{2 \cdot 14 \text{K} \cdot [R] \cdot 1.392758}{44.01 \text{g/mol}} / (1.392758-1) \right) \cdot \left( 1 - \left( \frac{2.1 \text{MPa}}{20 \text{MPa}} \right)^{1-\frac{1}{1.392758}} \right)}$$





5) Exit Velocity given Molar Specific Heat Capacity 

Open Calculator 

$$fx \quad C_j = \sqrt{2 \cdot T_t \cdot C_{p \text{ molar}} \cdot \left(1 - \left(\frac{P_{\text{exit}}}{P_c}\right)^{1 - \frac{1}{\gamma}}\right)}$$


$$ex \quad 207.4574 \text{m/s} = \sqrt{2 \cdot 375 \text{K} \cdot 122 \text{J/K} \cdot \text{mol} \cdot \left(1 - \left(\frac{2.1 \text{MPa}}{20 \text{MPa}}\right)^{1 - \frac{1}{1.392758}}\right)}$$

6) Mass Flow Rate through Engine 

Open Calculator 

$$fx \quad m_a = M \cdot A \cdot P_t \cdot \sqrt{Y \cdot \frac{M_{\text{molar}}}{T_t \cdot [R]} \cdot \left(1 + (Y - 1) \cdot \frac{M^2}{2}\right)^{-\frac{Y+1}{2Y-2}}}$$


$$ex \quad 460.4282 \text{kg/s} = 1.4 \cdot 50 \text{m}^2 \cdot 0.004 \text{MPa} \cdot \sqrt{1.392758 \cdot \frac{44.01 \text{g/mol}}{375 \text{K} \cdot [R]} \cdot \left(1 + (1.392758 - 1) \cdot \frac{(1.4)^2}{2}\right)^{-\frac{1.392758+1}{2 \cdot 1.392758-2}}}$$

7) Photon Propulsion Thrust 

Open Calculator 

$$fx \quad F = 1000 \cdot \frac{P_e}{[c]}$$

$$ex \quad 0.004163 \text{kN} = 1000 \cdot \frac{1248 \text{kW}}{[c]}$$

8) Power required to produce Exhaust Jet Velocity 

Open Calculator 

$$fx \quad P = \frac{1}{2} \cdot m_a \cdot C_j^2$$

$$ex \quad 77.18752 \text{kW} = \frac{1}{2} \cdot 2.51 \text{kg/s} \cdot (248 \text{m/s})^2$$

9) Power required to produce Exhaust Jet Velocity given Mass of Rocket and Acceleration 

Open Calculator 

$$fx \quad P = \frac{m \cdot a \cdot V_e}{2}$$

$$ex \quad 456263.9 \text{kW} = \frac{549054 \text{kg} \cdot 13.85 \text{m/s}^2 \cdot 120 \text{m/s}}{2}$$



10) Rocket Exit Pressure 

$$P_{\text{exit}} = P_c \cdot \left( \left( 1 + \frac{\gamma - 1}{2} \cdot M^2 \right)^{-\left(\frac{\gamma}{\gamma - 1}\right)} \right)$$

Open Calculator 

$$6.302943 \text{MPa} = 20 \text{MPa} \cdot \left( \left( 1 + \frac{1.392758 - 1}{2} \cdot (1.4)^2 \right)^{-\left(\frac{1.392758}{1.392758 - 1}\right)} \right)$$

11) Rocket Exit Temperature 

$$T_{\text{exit}} = T_c \cdot \left( 1 + \frac{\gamma - 1}{2} \cdot M^2 \right)^{-1}$$

Open Calculator 

$$10.10901 \text{K} = 14 \text{K} \cdot \left( 1 + \frac{1.392758 - 1}{2} \cdot (1.4)^2 \right)^{-1}$$

12) Thrust given Exhaust Velocity and Mass Flow Rate 

$$F = m_a \cdot C_j$$

Open Calculator 

$$0.62248 \text{kN} = 2.51 \text{kg/s} \cdot 248 \text{m/s}$$

13) Thrust given Mass and Acceleration of Rocket 

$$F = m \cdot a$$

Open Calculator 

$$7604.398 \text{kN} = 549054 \text{kg} \cdot 13.85 \text{m/s}^2$$














## Variables Used

- **a** Acceleration (Meter per Square Second)
- **A** Area (Square Meter)
- **A<sub>r</sub>** Area Ratio
- **C<sub>j</sub>** Exit Velocity (Meter per Second)
- **C<sub>p molar</sub>** Molar Specific Heat Capacity at Constant Pressure (Joule Per Kelvin Per Mole)
- **F** Thrust (Kilonewton)
- **m** Mass of Rocket (Kilogram)
- **M** Mach Number
- **m<sub>a</sub>** Mass Flow Rate (Kilogram per Second)
- **M<sub>molar</sub>** Molar Mass (Gram Per Mole)
- **P** Power Required (Kilowatt)
- **P<sub>c</sub>** Chamber Pressure (Megapascal)
- **P<sub>e</sub>** Power in Jet (Kilowatt)
- **P<sub>exit</sub>** Exit Pressure (Megapascal)
- **P<sub>t</sub>** Total Pressure (Megapascal)
- **T<sub>c</sub>** Chamber Temperature (Kelvin)
- **T<sub>exit</sub>** Exit Temperature (Kelvin)
- **T<sub>t</sub>** Total Temperature (Kelvin)
- **V<sub>e</sub>** Effective Exhaust Velocity (Meter per Second)
- **Y** Specific Heat Ratio



## Constants, Functions, Measurements used

- **Constant:** [c], 299792458.0 Meter/Second  
*Light speed in vacuum*
- **Constant:** [R], 8.31446261815324 Joule / Kelvin \* Mole  
*Universal gas constant*
- **Function:** sqrt, sqrt(Number)  
*Square root function*
- **Measurement: Weight** in Kilogram (kg)  
*Weight Unit Conversion* 
- **Measurement: Temperature** in Kelvin (K)  
*Temperature Unit Conversion* 
- **Measurement: Area** in Square Meter (m<sup>2</sup>)  
*Area Unit Conversion* 
- **Measurement: Pressure** in Megapascal (MPa)  
*Pressure Unit Conversion* 
- **Measurement: Speed** in Meter per Second (m/s)  
*Speed Unit Conversion* 
- **Measurement: Acceleration** in Meter per Square Second (m/s<sup>2</sup>)  
*Acceleration Unit Conversion* 
- **Measurement: Power** in Kilowatt (kW)  
*Power Unit Conversion* 
- **Measurement: Force** in Kilonewton (kN)  
*Force Unit Conversion* 
- **Measurement: Mass Flow Rate** in Kilogram per Second (kg/s)  
*Mass Flow Rate Unit Conversion* 
- **Measurement: Molar Mass** in Gram Per Mole (g/mol)  
*Molar Mass Unit Conversion* 
- **Measurement: Molar Specific Heat Capacity at Constant Pressure** in Joule Per Kelvin Per Mole (J/K\*mol)  
*Molar Specific Heat Capacity at Constant Pressure Unit Conversion* 



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- [Thermodynamics and Governing Equations Formulas](#) 

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