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Rocket Propulsion Formulas

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List of 13 Rocket Propulsion Formulas

Rocket Propulsion

1) Acceleration of Rocket

Open Calculator

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

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

2) Compressible Area Ratio

Open Calculator

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

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

3) Exit Velocity given Mach Number and Exit Temperature

Open Calculator

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

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

4) Exit Velocity given Molar Mass

Open Calculator

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

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

5) Exit Velocity given Molar Specific Heat Capacity

Open Calculator

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

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

6) Mass Flow Rate through Engine

Open Calculator

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

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

7) Photon Propulsion Thrust

Open Calculator

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

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

8) Power required to produce Exhaust Jet Velocity

Open Calculator

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

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

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

Open Calculator

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

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

10) Rocket Exit Pressure

Open Calculator

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

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

11) Rocket Exit Temperature

Open Calculator

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

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

12) Thrust given Exhaust Velocity and Mass Flow Rate

Open Calculator

$$F = m_a \cdot C_j$$

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

13) Thrust given Mass and Acceleration of Rocket

Open Calculator

$$F = m \cdot a$$

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

Variables Used

- **a** Acceleration *(Meter per Square Second)*
- **A** Area *(Square Meter)*
- A_r Area Ratio
- C_j Exit Velocity *(Meter per Second)*
- $C_{p\ molar}$ Molar Specific Heat Capacity at Constant Pressure *(Joule Per Kelvin Per Mole)*
- **F** Thrust *(Kilonewton)*
- **m** Mass of Rocket *(Kilogram)*
- **M** Mach Number
- m_a Mass Flow Rate *(Kilogram per Second)*
- M_{molar} Molar Mass *(Gram Per Mole)*
- **P** Power Required *(Kilowatt)*
- P_c Chamber Pressure *(Megapascal)*
- P_e Power in Jet *(Kilowatt)*
- P_{exit} Exit Pressure *(Megapascal)*
- P_t Total Pressure *(Megapascal)*
- T_c Chamber Temperature *(Kelvin)*
- T_{exit} Exit Temperature *(Kelvin)*
- T_t Total Temperature *(Kelvin)*
- V_e 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 (m²)
  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/s²)
  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

Check other formula lists

- **Rocket Propulsion Formulas**
- **Thermodynamics and Governing Equations Formulas**

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