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Air-Standard Cycles Formulas

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List of 18 Air-Standard Cycles Formulas

Air-Standard Cycles

1) Actual Air Fuel Ratio

$$\text{fx } AFR_{\text{actual}} = \frac{m_{\text{air}}}{m_{\text{fuel}}}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

$$\text{ex } 2.142857 = \frac{6\text{kg}}{2.8\text{kg}}$$

2) Air Standard Efficiency for Diesel Engines

$$\text{fx } \eta_{\text{air}} = 100 \cdot \left(1 - \frac{1}{r^{\gamma-1}} \cdot \frac{r_c^\gamma - 1}{\gamma \cdot (r_c - 1)} \right)$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

$$\text{ex } 11.92995 = 100 \cdot \left(1 - \frac{1}{(1.75)^{1.4-1}} \cdot \frac{(1.56)^{1.4} - 1}{1.4 \cdot ((1.56) - 1)} \right)$$

3) Air Standard Efficiency for Petrol engines

$$\text{fx } \eta_{\text{air}} = 100 \cdot \left(1 - \frac{1}{r^{\gamma-1}} \right)$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d_img.jpg\)](#)

$$\text{ex } 20.0562 = 100 \cdot \left(1 - \frac{1}{(1.75)^{1.4-1}} \right)$$


4) Air Standard Efficiency given Relative Efficiency

$$\text{fx } \eta_{\text{air}} = \frac{\eta_{\text{ith}}}{\eta_{\text{rel}}}$$

[Open Calculator !\[\]\(83bbbd261710c59db0214aa27b2edc0d_img.jpg\)](#)

$$\text{ex } 0.506024 = \frac{42}{83}$$



5) Mean Effective Pressure in Diesel Cycle 

$$\text{fx } P_{mean} = P_1 \cdot \frac{\gamma \cdot r^\gamma \cdot (r_c - 1) - r \cdot (r_c^\gamma - 1)}{(\gamma - 1) \cdot (r - 1)}$$

Open Calculator 


$$\text{ex } 75.07223\text{kPa} = 110\text{kPa} \cdot \frac{1.4 \cdot (1.75)^{1.4} \cdot ((1.56) - 1) - (1.75) \cdot ((1.56)^{1.4} - 1)}{(1.4 - 1) \cdot ((1.75) - 1)}$$

6) Mean Effective Pressure in Dual Cycle 

$$\text{fx } P_{mean} = P_1 \cdot \frac{r^\gamma \cdot ((\beta - 1) + \gamma \cdot \beta \cdot (r_c - 1)) - r \cdot (\beta \cdot r_c^\gamma - 1)}{(\gamma - 1) \cdot (r - 1)}$$

Open Calculator 

$$\text{ex } 216.7039\text{kPa} = 110\text{kPa} \cdot \frac{(1.75)^{1.4} \cdot ((1.6 - 1) + 1.4 \cdot 1.6 \cdot ((1.56) - 1)) - (1.75) \cdot (1.6 \cdot (1.56)^{1.4} - 1)}{(1.4 - 1) \cdot ((1.75) - 1)}$$

7) Mean Effective Pressure in Otto Cycle 

$$\text{fx } MEP = P_1 \cdot r \cdot \left(\frac{(r^{\gamma-1} - 1) \cdot (r_p - 1)}{(r - 1) \cdot (\gamma - 1)} \right)$$

Open Calculator 

$$\text{ex } 724.4124\text{kPa} = 110\text{kPa} \cdot (1.75) \cdot \left(\frac{((1.75)^{1.4-1} - 1) \cdot (5.5 - 1)}{((1.75) - 1) \cdot (1.4 - 1)} \right)$$


8) Relative Air-Fuel Ratio 

$$\text{fx } \lambda = \frac{AFR_{actual}}{AFR_{stoich}}$$

Open Calculator 

$$\text{ex } 1.22449 = \frac{18}{14.7}$$




9) Work Output for Diesel Cycle 

$$\text{fx } W_e = P_1 \cdot V_1 \cdot \frac{r^{\gamma-1} \cdot (\gamma \cdot (r_c - 1) - r^{1-\gamma} \cdot (r_c^\gamma - 1))}{\gamma - 1}$$

Open Calculator 


$$\text{ex } 20.91298\text{kJ} = 110\text{kPa} \cdot 0.65\text{m}^3 \cdot \frac{(1.75)^{1.4-1} \cdot (1.4 \cdot ((1.56) - 1) - (1.75)^{1-1.4} \cdot ((1.56)^{1.4} - 1))}{1.4 - 1}$$

10) Work Output for Dual Cycle 

$$\text{fx } W_e = P_1 \cdot V_1 \cdot \frac{r^{\gamma-1} \cdot (\gamma \cdot r_p \cdot (r_c - 1) + (r_p - 1)) - (r_p \cdot r_c^\gamma - 1)}{\gamma - 1}$$

Open Calculator 


$$\text{ex } 316.822\text{kJ} = 110\text{kPa} \cdot 0.65\text{m}^3 \cdot \frac{(1.75)^{1.4-1} \cdot (1.4 \cdot 5.5 \cdot ((1.56) - 1) + (5.5 - 1)) - (5.5 \cdot (1.56)^{1.4} - 1)}{1.4 - 1}$$

11) Work Output for Otto Cycle 

$$\text{fx } W_e = P_1 \cdot V_1 \cdot \frac{(r_p - 1) \cdot (r^{\gamma-1} - 1)}{\gamma - 1}$$

Open Calculator 

$$\text{ex } 201.8006\text{kJ} = 110\text{kPa} \cdot 0.65\text{m}^3 \cdot \frac{(5.5 - 1) \cdot ((1.75)^{1.4-1} - 1)}{1.4 - 1}$$


Thermal Efficiency 12) Thermal Efficiency of Atkinson Cycle 

$$\text{fx } \eta_{\text{atnk}} = 100 \cdot \left(1 - \gamma \cdot \left(\frac{e - r}{e^\gamma - r^\gamma} \right) \right)$$

Open Calculator 


$$\text{ex } 34.03648 = 100 \cdot \left(1 - 1.4 \cdot \left(\frac{(4) - (1.75)}{(4)^{1.4} - (1.75)^{1.4}} \right) \right)$$



13) Thermal Efficiency of Diesel Cycle [Open Calculator !\[\]\(bd1a142de767a21e5362c595f844a4ff_img.jpg\)](#)


$$\text{fx } \eta_{\text{th}} = 100 \cdot \left(1 - \frac{1}{r^{\gamma-1}} \cdot \frac{r_c^\gamma - 1}{\gamma \cdot (r_c - 1)} \right)$$

$$\text{ex } 11.92995 = 100 \cdot \left(1 - \frac{1}{(1.75)^{1.4-1}} \cdot \frac{(1.56)^{1.4} - 1}{1.4 \cdot ((1.56) - 1)} \right)$$

14) Thermal Efficiency of Dual Cycle [Open Calculator !\[\]\(830769b31eeeaca920791081939ff8ba_img.jpg\)](#)


$$\text{fx } \eta_{\text{dual}} = 100 \cdot \left(1 - \frac{1}{r^{\gamma-1}} \cdot \left(\frac{\beta \cdot r_c^\gamma - 1}{\beta - 1 + \beta \cdot \gamma \cdot (r_c - 1)} \right) \right)$$

$$\text{ex } 14.55924 = 100 \cdot \left(1 - \frac{1}{(1.75)^{1.4-1}} \cdot \left(\frac{1.6 \cdot (1.56)^{1.4} - 1}{1.6 - 1 + 1.6 \cdot 1.4 \cdot ((1.56) - 1)} \right) \right)$$

15) Thermal Efficiency of Ericsson Cycle [Open Calculator !\[\]\(47734e4656765d20df4fdbd5b7aff048_img.jpg\)](#)

$$\text{fx } \eta_{\text{ericsson}} = \frac{T_H - T_L}{T_H}$$

$$\text{ex } 0.4 = \frac{200\text{K} - 120\text{K}}{200\text{K}}$$

16) Thermal Efficiency of Lenoir Cycle [Open Calculator !\[\]\(41aea2746216b27a6939d696d8e035da_img.jpg\)](#)

$$\text{fx } \eta_{\text{lenoir}} = 100 \cdot \left(1 - \gamma \cdot \left(\frac{r_p^{\frac{1}{\gamma}} - 1}{r_p - 1} \right) \right)$$


$$\text{ex } 25.97643 = 100 \cdot \left(1 - 1.4 \cdot \left(\frac{(5.5)^{\frac{1}{1.4}} - 1}{(5.5) - 1} \right) \right)$$

17) Thermal Efficiency of Otto Cycle [Open Calculator !\[\]\(179f167ede0522ebb4ea025b3ad78ca7_img.jpg\)](#)

$$\text{fx } \text{OTE} = 1 - \frac{1}{r^{\gamma-1}}$$

$$\text{ex } 0.200562 = 1 - \frac{1}{(1.75)^{1.4-1}}$$



18) Thermal Efficiency of Stirling Cycle given Heat Exchanger Effectiveness [Open Calculator](#) 

$$\text{fx } \eta_{\text{stirling}} = 100 \cdot \left(\frac{R \cdot \ln(r) \cdot (T_f - T_i)}{R \cdot T_f \cdot \ln(r) + C_v \cdot (1 - \epsilon) \cdot (T_f - T_i)} \right)$$

$$\text{ex } 3.575408 = 100 \cdot \left(\frac{8.314 \cdot \ln(1.75) \cdot (345\text{K} - 305\text{K})}{8.314 \cdot 345\text{K} \cdot \ln(1.75) + 100\text{J/K}^*\text{mol} \cdot (1 - 0.1) \cdot (345\text{K} - 305\text{K})} \right)$$



Variables Used







- **AFR_{actual}** Actual Air Fuel Ratio
- **AFR_{stoich}** Stoichiometric Air Fuel Ratio
- **C_v** Molar Specific Heat Capacity at Constant Volume (*Joule Per Kelvin Per Mole*)
- **e** Expansion Ratio
- **m_{air}** Mass of Air (*Kilogram*)
- **m_{fuel}** Mass of Fuel (*Kilogram*)
- **MEP** Mean Effective Pressure (*Kilopascal*)
- **OTE** OTE
- **P₁** Pressure at Start of Isentropic Compression (*Kilopascal*)
- **P_{mean}** Mean Effective Pressure of Dual Cycle (*Kilopascal*)
- **P_{mean}** Mean Effective Pressure in Diesel Cycle (*Kilopascal*)
- **r** Compression Ratio
- **R** Universal Gas Constant
- **r_c** Cutoff Ratio
- **r_p** Pressure Ratio
- **T_f** Final Temperature (*Kelvin*)
- **T_H** Higher Temperature (*Kelvin*)
- **T_i** Initial Temperature (*Kelvin*)
- **T_L** Lower Temperature (*Kelvin*)
- **V₁** Volume at Start of Isentropic Compression (*Cubic Meter*)
- **W_e** Work Output of Engine (*Kilojoule*)
- **β** Explosion Ratio
- **γ** Heat Capacity Ratio
- **ε** Effectiveness of Heat Exchanger
- **η_{air}** Air Standard Efficiency
- **η_{atk}** Thermal Efficiency of Atkinson Cycle
- **η_{dual}** Thermal Efficiency of Dual Cycle
- **η_{ericsson}** Thermal Efficiency of Ericsson Cycle
- **η_{ith}** Indicated Thermal Efficiency
- **η_{lenoir}** Thermal Efficiency of Lenoir Cycle
- **η_{rel}** Relative Efficiency



- η_{stirling} Thermal Efficiency of Stirling Cycle
- η_{th} Thermal Efficiency of Diesel Cycle
- λ Relative Air Fuel Ratio



Constants, Functions, Measurements used

- **Function:** **ln**, $\ln(\text{Number})$
Natural logarithm function (base e)
- **Measurement:** **Weight** in Kilogram (kg)
Weight Unit Conversion 
- **Measurement:** **Temperature** in Kelvin (K)
Temperature Unit Conversion 
- **Measurement:** **Volume** in Cubic Meter (m^3)
Volume Unit Conversion 
- **Measurement:** **Pressure** in Kilopascal (kPa)
Pressure Unit Conversion 
- **Measurement:** **Energy** in Kilojoule (kJ)
Energy Unit Conversion 
- **Measurement:** **Molar Specific Heat Capacity at Constant Volume** in Joule Per Kelvin Per Mole ($\text{J/K}^{\circ}\text{mol}$)
Molar Specific Heat Capacity at Constant Volume Unit Conversion 



Check other formula lists

- [Air-Standard Cycles Formulas](#) 
- [Fuel Injection in IC Engine Formulas](#) 

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