Air-Standard Cycles Formulas

List of 18 Air-Standard Cycles Formulas

Air-Standard Cycles

1) Actual Air Fuel Ratio

Open Calculator

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

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

2) Air Standard Efficiency for Diesel Engines

Open Calculator

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

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

Open Calculator

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

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

4) Air Standard Efficiency given Relative Efficiency

Open Calculator

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

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

5) Mean Effective Pressure in Diesel Cycle

Open Calculator

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

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

6) Mean Effective Pressure in Dual Cycle

Open Calculator

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

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

7) Mean Effective Pressure in Otto Cycle

Open Calculator

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

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

8) Relative Air-Fuel Ratio

Open Calculator

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

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

9) Work Output for Diesel Cycle

Open Calculator

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

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

10) Work Output for Dual Cycle

Open Calculator

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

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

11) Work Output for Otto Cycle

Open Calculator

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

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

Thermal Efficiency

12) Thermal Efficiency of Atkinson Cycle

Open Calculator

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

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

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

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

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

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

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

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

16) Thermal Efficiency of Lenoir Cycle

Open Calculator

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

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

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

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

18) Thermal Efficiency of Stirling Cycle given Heat Exchanger Effectiveness

Open Calculator

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

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

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
- **P_1** 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)*
- **V_1** 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
- **$\eta_{ericsson}$** Thermal Efficiency of Ericsson Cycle
- **η_{ith}** Indicated Thermal Efficiency
- **η_{lenoir}** Thermal Efficiency of Lenoir Cycle
- **η_{rel}** Relative Efficiency

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

Constants, Functions, Measurements used

- Function: **ln**, ln(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 (J/K*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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