Important Air-Standard Cycles Formulas PDF

Formulas
Examples
with Units

List of 18
Important Air-Standard Cycles Formulas

1) Actual Air Fuel Ratio Formula

Evaluate Formula

Formula

$$R_a = \frac{m_a}{m_f}$$

Example with Units

$$15.9936 = \frac{23.9904\,\text{kg}}{1.5\,\text{kg}}$$

2) Air Standard Efficiency for Diesel Engines Formula

Evaluate Formula

Formula

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

Example

$$64.9039 = 100 \cdot \left(1 - \frac{1}{20^{1.4 - 1}} \cdot \frac{1.95^{1.4} - 1}{1.4 \cdot \left(1.95 - 1\right)}\right)$$

3) Air Standard Efficiency for Petrol engines Formula

Evaluate Formula

Formula

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

Example

$$69.8291 = 100 \cdot \left(1 - \frac{1}{20^{1.4 - 1}}\right)$$

4) Air Standard Efficiency given Relative Efficiency Formula

Evaluate Formula

Formula

$$\eta = \frac{\eta_i}{\eta_r}$$

Example

$$0.506 = \frac{42}{83}$$

5) Mean Effective Pressure in Diesel Cycle Formula

Evaluate Formula

Formula

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

Example with Units

$$828.2159\,\text{kPa} = 110\,\text{kPa} \cdot \frac{1.4 \cdot 20^{1.4} \cdot \left(1.95 - 1 \right) - 20 \cdot \left(1.95^{1.4} - 1 \right)}{\left(1.4 - 1 \right) \cdot \left(20 - 1 \right)}$$

6) Mean Effective Pressure in Dual Cycle Formula

Evaluate Formula

Formula

$$P_d = P_1 \cdot \frac{r^{\gamma} \cdot \left(\left(R_p - 1 \right) + \gamma \cdot R_p \cdot \left(r_c - 1 \right) \right) - r \cdot \left(R_p \cdot r_c^{\ \gamma} - 1 \right)}{\left(\gamma - 1 \right) \cdot \left(r - 1 \right)}$$

Example with Units

$$4348.961\,\text{kPa} = 110\,\text{kPa} \cdot \frac{20^{1.4} \cdot \left(\left(3.35 - 1 \right) + 1.4 \cdot 3.35 \cdot \left(1.95 - 1 \right) \right) - 20 \cdot \left(3.35 \cdot 1.95^{1.4} - 1 \right)}{\left(1.4 - 1 \right) \cdot \left(20 - 1 \right)}$$

7) Mean Effective Pressure in Otto Cycle Formula

Evaluate Formula

Formula

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

Example with Units

$$1567.7381\,\text{kPa} = 110\,\text{kPa} \cdot 20 \cdot \left(\frac{\left(20^{1.4 - 1} - 1 \right) \cdot \left(3.34 - 1 \right)}{\left(20 - 1 \right) \cdot \left(1.4 - 1 \right)} \right)$$

8) Relative Air-Fuel Ratio Formula

Evaluate Formula

Formula

$$\Phi = \frac{R_a}{R_i}$$

Example

$$1.088 = \frac{15.9936}{14.7}$$

9) Thermal Efficiency of Atkinson Cycle Formula

Evaluate Formula

Formula

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

Example

$$62.2417 = 100 \cdot \left(1 - 1.4 \cdot \left(\frac{4 - 20}{4^{1.4} - 20^{1.4}} \right) \right)$$

10) Thermal Efficiency of Diesel Cycle Formula

Evaluate Formula

Formula

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

Example

$$0.649 = 1 - \frac{1}{20^{1.4 - 1}} \cdot \frac{1.95^{1.4} - 1}{1.4 \cdot \left(1.95 - 1 \right)}$$

11) Thermal Efficiency of Dual Cycle Formula

Evaluate Formula

Formula

$$\varepsilon_d = 100 \cdot \left(1 - \frac{1}{r^{\gamma - 1}} \cdot \left(\frac{R_p \cdot r_c^{\gamma} - 1}{R_p - 1 + R_p \cdot \gamma \cdot \left(r_c - 1 \right)} \right) \right)$$

Example

$$66.6046 = 100 \cdot \left(1 - \frac{1}{20^{1.4 - 1}} \cdot \left(\frac{3.35 \cdot 1.95^{1.4} - 1}{3.35 - 1 + 3.35 \cdot 1.4 \cdot \left(1.95 - 1 \right)} \right) \right)$$

12) Thermal Efficiency of Ericsson Cycle Formula

Evaluate Formula

Formula

$$\eta_e = \frac{T_H - T_L}{T_H}$$

Example with Units

$$0.52 = \frac{250\,\mathrm{K} - 120\,\mathrm{K}}{250\,\mathrm{K}}$$

13) Thermal Efficiency of Lenoir Cycle Formula

Evaluate Formula

Formula

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

Example

$$18.2442 = 100 \cdot \left(1 - 1.4 \cdot \left(\frac{3.34^{\frac{1}{1.4}} - 1}{3.34 - 1} \right) \right)$$

14) Thermal Efficiency of Otto Cycle Formula

Evaluate Formula

Formula

$$\varepsilon_o = 1 - \frac{1}{r^{\gamma - 1}}$$

Example

$$0.6983 = 1 - \frac{1}{20^{1.4 - 1}}$$

15) Thermal Efficiency of Stirling Cycle given Heat Exchanger Effectiveness Formula

Evaluate Formula

Formula

$$\eta_s = 100 \cdot \left(\frac{[R] \cdot \ln(r) \cdot (T_f - T_i)}{[R] \cdot T_f \cdot \ln(r) + C_v \cdot (1 - \varepsilon) \cdot (T_f - T_i)} \right)$$

Example with Units

$$19.8854 = 100 \cdot \left(\frac{8.3145 \cdot \ln(20) \cdot (423\,\mathrm{K} - 283\,\mathrm{K})}{8.3145 \cdot 423\,\mathrm{K} \cdot \ln(20) + 100\,\mathrm{J/K^{*}mol} \cdot (1 - 0.5) \cdot (423\,\mathrm{K} - 283\,\mathrm{K})} \right)$$

16) Work Output for Diesel Cycle Formula

Evaluate Formula

Formula

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

Example with Units

$$511.4233\,\mathrm{KJ} = 110\,\mathrm{kPa} \cdot 0.65\,\mathrm{m^3} \cdot \frac{20^{1.4 - 1} \cdot \left(1.4 \cdot (1.95 - 1) - 20^{1 - 1.4} \cdot (1.95^{1.4} - 1) \right)}{1.4 - 1}$$

17) Work Output for Dual Cycle Formula

Evaluate Formula

Formula

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

Example with Units

$$2676.2321\,\mathrm{KJ} = 110\,\mathrm{kPa} \cdot 0.65\,\mathrm{m^3} \cdot \frac{20^{1.4 - 1} \cdot \left(1.4 \cdot 3.34 \cdot (1.95 - 1) + (3.34 - 1) \right) - \left(3.34 \cdot 1.95^{1.4} - 1 \right)}{1.4 - 1}$$

18) Work Output for Otto Cycle Formula

Evaluate Formula

Formula

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

Example with Units

$$968.0783\,\mathrm{KJ} = 110\,\mathrm{kPa} \cdot 0.65\,\mathrm{m^3} \cdot \frac{(3.34 - 1) \cdot (20^{1.4 - 1} - 1)}{1.4 - 1}$$

Variables used in list of Air-Standard Cycles Formulas above

- **C_v** Molar Specific Heat Capacity at Constant Volume *(Joule Per Kelvin Per Mole)*
- **e** Expansion Ratio
- **m_a** Mass of Air *(Kilogram)*
- **m_f** Mass of Fuel *(Kilogram)*
- **P_1** Pressure at Start of Isentropic Compression *(Kilopascal)*
- **P_d** Mean Effective Pressure of Dual Cycle *(Kilopascal)*
- **P_D** Mean Effective Pressure of Diesel Cycle *(Kilopascal)*
- **P_O** Mean Effective Pressure of Otto Cycle *(Kilopascal)*
- **r** Compression Ratio
- **R_a** Actual Air Fuel Ratio
- **r_c** Cut-off Ratio
- **R_i** Stoichiometric Air Fuel Ratio
- **r_p** Pressure Ratio
- **R_p** Pressure Ratio in Dual Cycle
- **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_d** Work Output of Diesel Cycle *(Kilojoule)*
- **W_D** Work Output of Dual Cycle *(Kilojoule)*
- **W_o** Work Output of Otto Cycle *(Kilojoule)*
- **γ** Heat Capacity Ratio
- **ε** Effectiveness of Heat Exchanger
- **ε_d** Thermal Efficiency of Dual Cycle
- **ε_o** Thermal Efficiency of Otto Cycle
- **η** Efficiency

Constants, Functions, Measurements used in list of Air-Standard Cycles Formulas above

- constant(s): **[R]**, 8.31446261815324
  Universal gas constant
- Functions: **ln**, ln(Number)
  The natural logarithm, also known as the logarithm to the base e, is the inverse function of the natural exponential function.
- Measurement: **Weight** in Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Temperature** in Kelvin (K)
  Temperature Unit Conversion
- Measurement: **Volume** in Cubic Meter (m³)
  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

- η_a Thermal Efficiency of Atkinson Cycle
- η_d Efficiency of Diesel Cycle
- η_e Thermal Efficiency of Ericsson Cycle
- η_i Indicated Thermal Efficiency
- η_l Thermal Efficiency of Lenoir Cycle
- η_o Efficiency of Otto Cycle
- η_r Relative Efficiency
- η_s Thermal Efficiency of Stirling Cycle
- η_{th} Thermal Efficiency of Diesel Cycle
- Φ Relative Air Fuel Ratio

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