Important Formulas in Radiation Heat Transfer PDF

Formulas
Examples
with Units

List of 33
Important Formulas in Radiation Heat Transfer

1) Absorptivity given Reflectivity and Transmissivity Formula

Evaluate Formula

Formula

$$\alpha = 1 - \rho - \tau$$

Example

$$0.65 = 1 - 0.10 - 0.25$$

2) Area of Surface 1 given Area 2 and Radiation Shape Factor for Both Surfaces Formula

Evaluate Formula

Formula

$$A_1 = A_2 \cdot \left(\frac{F_{21}}{F_{12}} \right)$$

Example with Units

$$34.7458\,\text{m}^2 = 50\,\text{m}^2 \cdot \left(\frac{0.41}{0.59} \right)$$

3) Area of Surface 2 given Area 1 and Radiation Shape Factor for Both Surfaces Formula

Evaluate Formula

Formula

$$A_2 = A_1 \cdot \left(\frac{F_{12}}{F_{21}} \right)$$

Example with Units

$$49.9917\,\text{m}^2 = 34.74\,\text{m}^2 \cdot \left(\frac{0.59}{0.41} \right)$$

4) Emissive Power of Blackbody Formula

Evaluate Formula

Formula

$$E_b = [\text{Stefan-BoltZ}] \cdot \left(T^4 \right)$$

Example with Units

$$324.2963\,\text{W/m}^2 = 5.7\text{E-}8 \cdot \left(275\,\text{K}^4 \right)$$

5) Emissive Power of Non Blackbody given Emissivity Formula

Evaluate Formula

Formula

$$E = \varepsilon \cdot E_b$$

Example with Units

$$308.0755\,\text{W/m}^2 = 0.95 \cdot 324.29\,\text{W/m}^2$$

6) Emissivity of Body Formula

Evaluate Formula

Formula

$$\varepsilon = \frac{E}{E_b}$$

Example with Units

$$0.95 = \frac{308.07\,\text{W/m}^2}{324.29\,\text{W/m}^2}$$

7) Energy of each Quanta Formula

Evaluate Formula

Formula

$$E_q = [hP] \cdot \nu$$

Example with Units

$$5E\text{-}19\,\text{J} = 6.6E\text{-}34 \cdot 7.5E{+}14\,\text{Hz}$$

8) Frequency given Speed of Light and Wavelength Formula

Evaluate Formula

Formula

$$\nu = \frac{[c]}{\lambda}$$

Example with Units

$$7.5E{+}14\,\text{Hz} = \frac{3E{+}8\,\text{m/s}}{400\,\text{nm}}$$

9) Heat Transfer between Concentric Spheres Formula

Evaluate Formula

Formula

$$q = \frac{A_1 \cdot [\text{Stefan-BoltZ}] \cdot \left(\left(T_1^4\right) - \left(T_2^4\right)\right)}{\left(\frac{1}{\varepsilon_1}\right) + \left(\left(\left(\frac{1}{\varepsilon_2}\right) - 1\right) \cdot \left(\left(\frac{r_1}{r_2}\right)^2\right)\right)}$$

Example with Units

$$731.5713\,\text{W} = \frac{34.74\,\text{m}^2 \cdot 5.7E\text{-}8 \cdot \left(\left(202\,\text{K}^4\right) - \left(151\,\text{K}^4\right)\right)}{\left(\frac{1}{0.4}\right) + \left(\left(\left(\frac{1}{0.3}\right) - 1\right) \cdot \left(\left(\frac{10\,\text{m}}{20\,\text{m}}\right)^2\right)\right)}$$

10) Heat Transfer between Small Convex Object in Large Enclosure Formula

Evaluate Formula

Formula

$$q = A_1 \cdot \varepsilon_1 \cdot [\text{Stefan-BoltZ}] \cdot \left(\left(T_1^4\right) - \left(T_2^4\right)\right)$$

Example with Units

$$902.2712\,\text{W} = 34.74\,\text{m}^2 \cdot 0.4 \cdot 5.7E\text{-}8 \cdot \left(\left(202\,\text{K}^4\right) - \left(151\,\text{K}^4\right)\right)$$

11) Heat Transfer between Two Infinite Parallel Planes given Temp and Emissivity of Both Surfaces Formula

Evaluate Formula

Formula

$$q = \frac{A \cdot [\text{Stefan-BoltZ}] \cdot \left(\left(T_1^4\right) - \left(T_2^4\right)\right)}{\left(\frac{1}{\varepsilon_1}\right) + \left(\frac{1}{\varepsilon_2}\right) - 1}$$

Example with Units

$$675.7228\,\text{W} = \frac{50.3\,\text{m}^2 \cdot 5.7E\text{-}8 \cdot \left(\left(202\,\text{K}^4\right) - \left(151\,\text{K}^4\right)\right)}{\left(\frac{1}{0.4}\right) + \left(\frac{1}{0.3}\right) - 1}$$

12) Heat Transfer between Two Long Concentric Cylinder given Temp, Emissivity and Area of Both Surfaces Formula

Evaluate Formula

Formula

$$q = \frac{\left([Stefan\text{-}BoltZ] \cdot A_1 \cdot \left(\left(T_1^4\right) - \left(T_2^4\right)\right)\right)}{\left(\frac{1}{\varepsilon_1}\right) + \left(\left(\frac{A_1}{A_2}\right) \cdot \left(\left(\frac{1}{\varepsilon_2}\right) - 1\right)\right)}$$

Example with Units

$$547.3353\,W = \frac{\left(5.7E\text{-}8 \cdot 34.74\,m^2 \cdot \left(\left(202\,K^4\right) - \left(151\,K^4\right)\right)\right)}{\left(\frac{1}{0.4}\right) + \left(\left(\frac{34.74\,m^2}{50\,m^2}\right) \cdot \left(\left(\frac{1}{0.3}\right) - 1\right)\right)}$$

13) Mass of Particle Given Frequency and Speed of Light Formula

Evaluate Formula

Formula

$$m = [hP] \cdot \frac{\nu}{[c]^2}$$

Example with Units

$$5.5E\text{-}36\,kg = 6.6E\text{-}34 \cdot \frac{7.5E{+}14\,Hz}{3E{+}8\,m/s^2}$$

14) Maximum Wavelength at given Temperature Formula

Evaluate Formula

Formula

$$\lambda_{Max} = \frac{2897.6}{T_R}$$

Example with Units

$$499586.2069\,\mu m = \frac{2897.6}{5800\,K}$$

15) Net Energy Leaving given Radiosity and Irradiation Formula

Evaluate Formula

Formula

$$q = A \cdot (J - G)$$

Example with Units

$$15452.16\,W = 50.3\,m^2 \cdot (308\,W/m^2 - 0.80\,W/m^2)$$

16) Net Heat Exchange between Two Surfaces given Radiosity for Both Surface Formula

Evaluate Formula

Formula

$$q_{1\text{-}2} = \frac{J_1 - J_2}{\frac{1}{A_1 \cdot F_{12}}}$$

Example with Units

$$245.9592\,W = \frac{61\,W/m^2 - 49\,W/m^2}{\frac{1}{34.74\,m^2 \cdot 0.59}}$$

17) Net Heat Exchange given Area 1 and Shape Factor 12 Formula

Evaluate Formula

Formula

$$Q_{1\text{-}2} = A_1 \cdot F_{12} \cdot \left(E_{b1} - E_{b2}\right)$$

Example with Units

$$3176.973\,W = 34.74\,m^2 \cdot 0.59 \cdot (680\,W/m^2 - 525\,W/m^2)$$

18) Net Heat Exchange given Area 2 and Shape Factor 21 Formula

Evaluate Formula

Formula

$$Q_{1\text{-}2} = A_2 \cdot F_{21} \cdot \left(E_{b1} - E_{b2} \right)$$

Example with Units

$$3177.5\,\text{W} = 50\,\text{m}^2 \cdot 0.41 \cdot \left(680\,\text{W/m}^2 - 525\,\text{W/m}^2 \right)$$

19) Net Heat Transfer from Surface given Emissivity, Radiosity and Emissive Power Formula

Evaluate Formula

Formula

$$q = \left(\frac{\left(\varepsilon \cdot A \right) \cdot \left(E_b - J \right)}{1 - \varepsilon} \right)$$

Example with Units

$$15568.353\,\text{W} = \left(\frac{\left(0.95 \cdot 50.3\,\text{m}^2 \right) \cdot \left(324.29\,\text{W/m}^2 - 308\,\text{W/m}^2 \right)}{1 - 0.95} \right)$$

20) Radiation Heat Transfer between Plane 1 and Shield given Temperature and Emissivity of Both Surfaces Formula

Evaluate Formula

Formula

$$q = A \cdot [\text{Stefan-BoltZ}] \cdot \frac{\left(T_{P1}^{\,4} \right) - \left(T_3^{\,4} \right)}{\left(\frac{1}{\varepsilon_1} \right) + \left(\frac{1}{\varepsilon_3} \right) - 1}$$

Example with Units

$$699.4575\,\text{W} = 50.3\,\text{m}^2 \cdot 5.7\text{E-}8 \cdot \frac{\left(452\,\text{K}^{\,4} \right) - \left(450\,\text{K}^{\,4} \right)}{\left(\frac{1}{0.4} \right) + \left(\frac{1}{0.67} \right) - 1}$$

21) Radiation Heat Transfer between Plane 2 and Radiation Shield given Temperature and Emissivity Formula

Evaluate Formula

Formula

$$q = A \cdot [\text{Stefan-BoltZ}] \cdot \frac{\left(T_3^{\,4} \right) - \left(T_{P2}^{\,4} \right)}{\left(\frac{1}{\varepsilon_3} \right) + \left(\frac{1}{\varepsilon_2} \right) - 1}$$

Example with Units

$$1336.2002\,\text{W} = 50.3\,\text{m}^2 \cdot 5.7\text{E-}8 \cdot \frac{\left(450\,\text{K}^{\,4} \right) - \left(445\,\text{K}^{\,4} \right)}{\left(\frac{1}{0.67} \right) + \left(\frac{1}{0.3} \right) - 1}$$

22) Radiation Temperature given Maximum Wavelength Formula

Evaluate Formula

Formula

$$T_R = \frac{2897.6}{\lambda_{Max}}$$

Example with Units

$$5800.0001\,\text{K} = \frac{2897.6}{499586.2\,\mu\text{m}}$$

23) Radiosity given Emissive Power and Irradiation Formula

Evaluate Formula

Formula

$$J = \left(\varepsilon \cdot E_b\right) + \left(\rho \cdot G\right)$$

Example with Units

$$308.1555\,\text{W/m}^2 = \left(0.95 \cdot 324.29\,\text{W/m}^2\right) + \left(0.10 \cdot 0.80\,\text{W/m}^2\right)$$

24) Reflected Radiation given Absorptivity and Transmissivity Formula

Evaluate Formula

Formula

$$\rho = 1 - \alpha - \tau$$

Example

$$0.1 = 1 - 0.65 - 0.25$$

25) Reflectivity given Absorptivity for Blackbody Formula

Evaluate Formula

Formula

$$\rho = 1 - \alpha$$

Example

$$0.35 = 1 - 0.65$$

26) Reflectivity given Emissivity for Blackbody Formula

Evaluate Formula

Formula

$$\rho = 1 - \varepsilon$$

Example

$$0.05 = 1 - 0.95$$

27) Resistance in Radiation Heat Transfer when No Shield is Present and Equal Emissivities Formula

Evaluate Formula

Formula

$$R = \left(\frac{2}{\varepsilon}\right) - 1$$

Example

$$1.1053 = \left(\frac{2}{0.95}\right) - 1$$

28) Shape Factor 12 given Area of Both Surface and Shape Factor 21 Formula

Evaluate Formula

Formula

$$F_{12} = \left(\frac{A_2}{A_1}\right) \cdot F_{21}$$

Example with Units

$$0.5901 = \left(\frac{50\,\text{m}^2}{34.74\,\text{m}^2}\right) \cdot 0.41$$

29) Shape Factor 21 given Area of Both Surface and Shape Factor 12 Formula

Evaluate Formula

Formula

$$F_{21} = F_{12} \cdot \left(\frac{A_1}{A_2} \right)$$

Example with Units

$$0.4099 = 0.59 \cdot \left(\frac{34.74\,\text{m}^2}{50\,\text{m}^2} \right)$$

30) Temperature of Radiation Shield Placed between Two Parallel Infinite Planes with Equal Emissivities Formula

Evaluate Formula

Formula

$$T_3 = \left(0.5 \cdot \left(\left({T_{P1}}^4 \right) + \left({T_{P2}}^4 \right) \right) \right)^{\frac{1}{4}}$$

Example with Units

$$448.541\,\text{K} = \left(0.5 \cdot \left(\left({452\,\text{K}}^4 \right) + \left({445\,\text{K}}^4 \right) \right) \right)^{\frac{1}{4}}$$

31) Total Resistance in Radiation Heat Transfer given Emissivity and Number of Shields Formula

Evaluate Formula

Formula

$$R = (n + 1) \cdot \left(\left(\frac{2}{\varepsilon} \right) - 1 \right)$$

Example

$$3.3158 = (2 + 1) \cdot \left(\left(\frac{2}{0.95} \right) - 1 \right)$$

32) Transmissivity Given Reflectivity and Absorptivity Formula

Evaluate Formula

Formula

$$\tau = 1 - \alpha - \rho$$

Example

$$0.25 = 1 - 0.65 - 0.10$$

33) Wavelength Given Speed of Light and Frequency Formula

Evaluate Formula

Formula

$$\lambda = \frac{[c]}{\nu}$$

Example with Units

$$399.7233\,\text{nm} = \frac{3\text{E+8}\,\text{m/s}}{7.5\text{E+14}\,\text{Hz}}$$

Variables used in list of Important Formulas in Radiation Heat Transfer above

- **A** Area *(Square Meter)*
- A_1 Surface Area of Body 1 *(Square Meter)*
- A_2 Surface Area of Body 2 *(Square Meter)*
- **E** Emissive Power of Non Blackbody *(Watt per Square Meter)*
- E_b Emissive Power of Blackbody *(Watt per Square Meter)*
- E_{b1} Emissive Power of 1st Blackbody *(Watt per Square Meter)*
- E_{b2} Emissive Power of 2nd Blackbody *(Watt per Square Meter)*
- E_q Energy of Each Quanta *(Joule)*
- F_{12} Radiation Shape Factor 12
- F_{21} Radiation Shape Factor 21
- **G** Irradiation *(Watt per Square Meter)*
- **J** Radiosity *(Watt per Square Meter)*
- J_1 Radiosity of 1st Body *(Watt per Square Meter)*
- J_2 Radiosity of 2nd Body *(Watt per Square Meter)*
- **m** Mass of Particle *(Kilogram)*
- **n** Number of Shields
- **q** Heat Transfer *(Watt)*
- $q_{1\text{-}2}$ Radiation Heat Transfer *(Watt)*
- $Q_{1\text{-}2}$ Net Heat Transfer *(Watt)*
- **R** Resistance
- r_1 Radius of Smaller Sphere *(Meter)*
- r_2 Radius of Larger Sphere *(Meter)*
- **T** Temperature of Blackbody *(Kelvin)*
- T_1 Temperature of Surface 1 *(Kelvin)*
- T_2 Temperature of Surface 2 *(Kelvin)*
- T_3 Temperature of Radiation Shield *(Kelvin)*
- T_{P1} Temperature of Plane 1 *(Kelvin)*
- T_{P2} Temperature of Plane 2 *(Kelvin)*

Constants, Functions, Measurements used in list of Important Formulas in Radiation Heat Transfer above

- constant(s): **[c]**, 299792458.0
  Light speed in vacuum
- constant(s): **[hP]**, 6.626070040E-34
  Planck constant
- constant(s): **[Stefan-BoltZ]**, 5.670367E-8
  Stefan-Boltzmann Constant
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- 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: **Energy** in Joule (J)
  Energy Unit Conversion
- Measurement: **Power** in Watt (W)
  Power Unit Conversion
- Measurement: **Frequency** in Hertz (Hz)
  Frequency Unit Conversion
- Measurement: **Wavelength** in Nanometer (nm), Micrometer (µm)
  Wavelength Unit Conversion
- Measurement: **Heat Flux Density** in Watt per Square Meter (W/m²)
  Heat Flux Density Unit Conversion

- T_R Radiation Temperature *(Kelvin)*
- α Absorptivity
- ε Emissivity
- ε_1 Emissivity of Body 1
- ε_2 Emissivity of Body 2
- ε_3 Emissivity of Radiation Shield
- λ Wavelength *(Nanometer)*
- λ_{Max} Maximum Wavelength *(Micrometer)*
- ν Frequency *(Hertz)*
- ρ Reflectivity
- τ Transmissivity

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