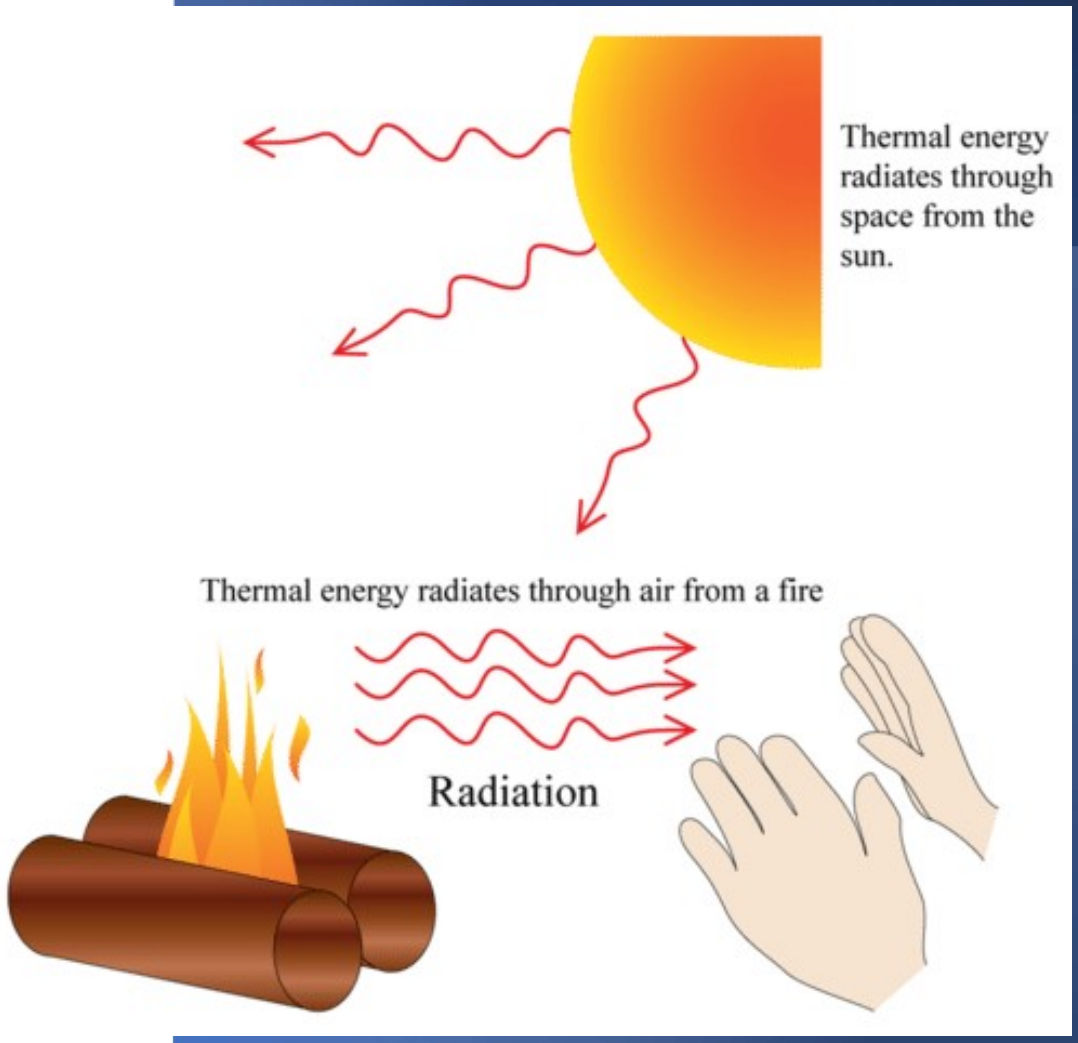
CEN 3311 HEAT TRANSFER

RADIATION
(Thermal Radiation)

Radiation is the transfer of energy by electromagnetic waves

While the transfer of energy by conduction or convection requires of a material medium, radiation does not.


Thermal energy radiates through space from the sun.
Thermal energy radiates through air from a fire
Radiation

Spectrum of Electromagnetic Radiation

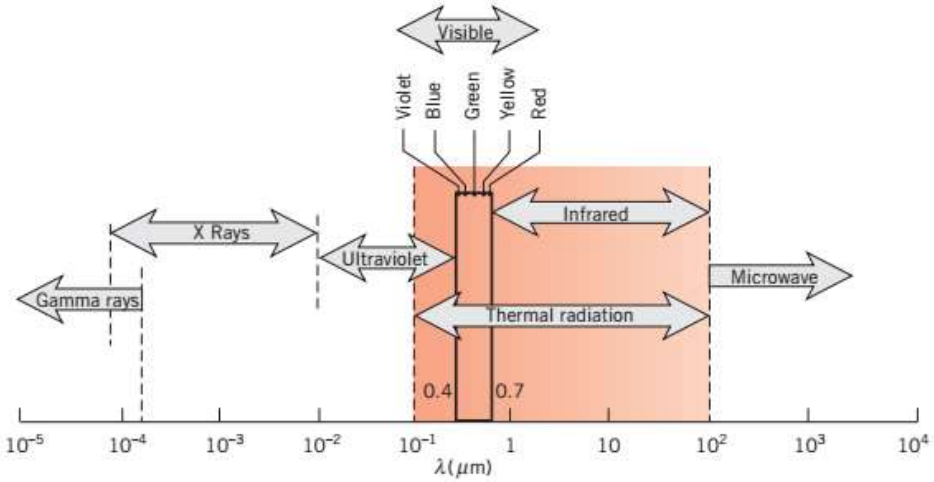
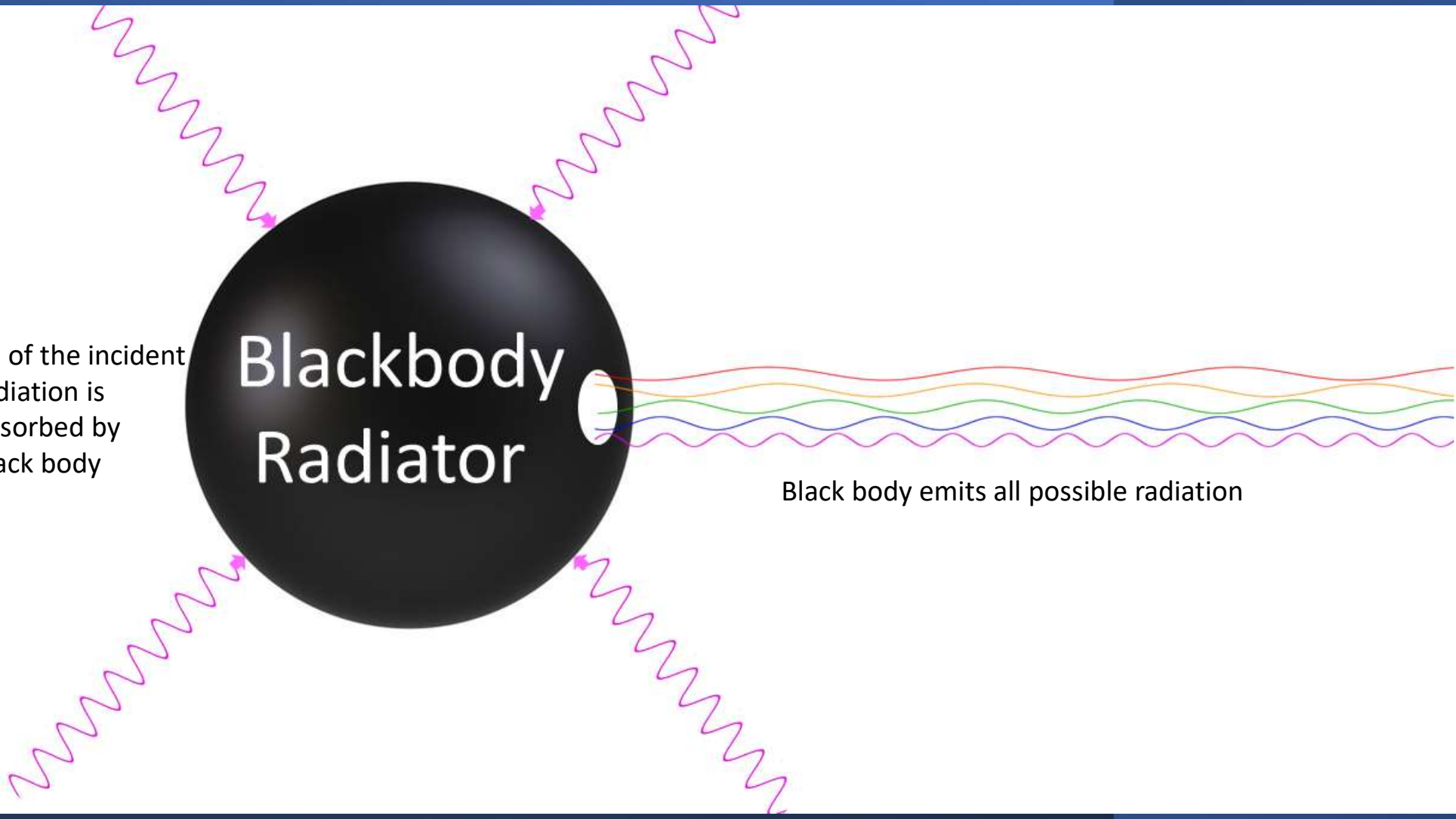


Figure Credit: Bergman, Lavine (2017) Fundamentals of Heat and Mass Transfer, 8th Ed.

All of the incident radiation is absorbed by black body



Black body emits all possible radiation

Stefan-Boltzmann Equation

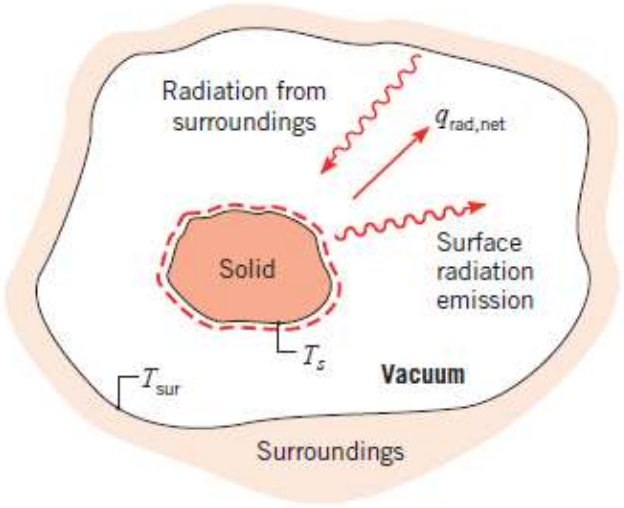
A perfect blackbody is a surface that reflects nothing and emits radiation.

$$Q = \sigma A T^4$$

Absolute temperature (K)

Stefan-Boltzmann constant
5.67×10^{-8} W/m^{2}K^4

In addition to emission, the surface of a body has a capacity for absorbing all or part of the radiation emitted by surrounding surfaces and falling on it.



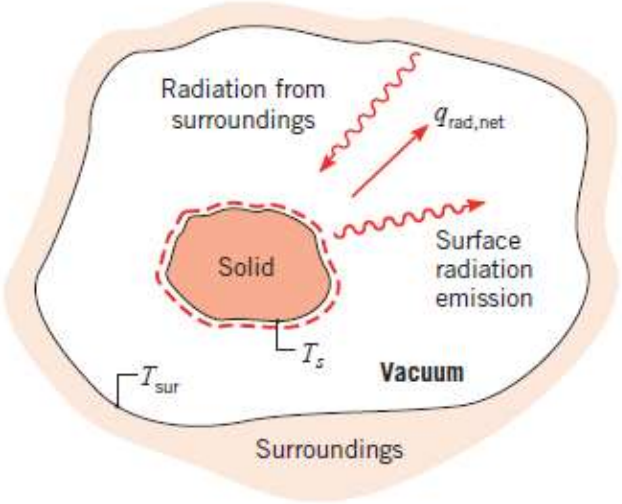
Credit: Bergman, Lavine (2017) Fundamentals of Heat and Mass Transfer, 8th Ed.

RADIATION TO A SMALL OBJECT FROM ITS SURROUNDINGS

Stefan-Boltzmann Equation:

$$q = A\epsilon\sigma(T_s^4 - T_{Sur}^4)$$

Total emissivity of the surface



Credit: Bergman, Lavine (2017) Fundamentals of Heat and Mass Transfer, 8th Ed.

Total Emissivity, ε, of Various Surfaces

Surface	*T(K)*	*T(°F)*	*Emissivity, ε*
Polished aluminum	500	440	0.039
	850	1070	0.057
Polished iron	450	350	0.052
Oxidized iron	373	212	0.74
Polished copper	353	176	0.018
Asbestos board	296	74	0.96
Oil paints, all colors	373	212	0.92–0.96
Water	273	32	0.95

Table Credit: Geankoplis, CJ (1993) Transport Processes and Unit Operations,3rd Ed.

Example:

Ratio X/D= 0.5/0.5 =1

Y/D=1/0.5=2

Shape factor from the graph =F_{12}=0.285 (Fig. 18)

$$q_{12} = \sigma A_1 F_{12}(T_1^4 - T_2^4) = 5.669 * 10^{-8} * 0.5 * 1 * 0.285 * (1273^4 - 773^4) = 18330\ W$$

Fig.18. Radiation shape factor for radiation between parallel rectangles