Radiation problem set (Unified eng.)

The energy balance (heat power eqn.) is:

\[
MC \frac{dT}{dt} = Pin - Pout
\]

In steady state: \(Pin = Pout\)

Adiabatic system everywhere, except in the radiator

* The input power has several parts:

- Dissipated input power: \(P_d = 100\) W

- Solar radiation (from albedo): \(P_{s,r} = \sigma a A r a\)

  where \(\sigma\) is the solar flux:

  \[
  \sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4 = 1384 \text{ W/m}^2
  \]

  \(a\) is the Earth's solar albedo, \(a = 0.3\)

  \(A\) is the radiator area

  \(\alpha\) is the radiator coefficient of absorption

- Direct thermal radiation from the Earth: \(P_{r,e} = \varepsilon E E T^4 (\frac{R_e}{R_{\text{earth}}}^2)\alpha\)

* Output power is through radiation only: \(P_{out} = \varepsilon E E T^4\)

Solve for \(T_r\) \(\Rightarrow\) \(\varepsilon E E T^4 = P_d + \sigma a A a + E E E E T^4 (\frac{R_e}{R_{\text{earth}}}^2)\alpha\)

then \(T^4 = \frac{P_d}{\varepsilon E E r} + \sigma a \left(\frac{a}{E E r}\right)^{\frac{3}{2}} + \left(\frac{E E E E}{E E r}\right) T^4 (\frac{R_e}{R_{\text{earth}}}^2)\alpha\)

\[
T^4 = \frac{100\text{ W}}{(0.1)(5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4)(1\text{ m}^2)} + \frac{1384 \text{ W}}{(5.67 \times 10^{-8} \text{ W/m}^2)} + \left(\frac{0.5}{0.1}\right)(300 \text{ K})^4 (\frac{6378\text{ km}}{6398.5\text{ km}})^2 \times 0.1
\]

then \(T = 410.68\text{ K}\) (without looking to "hot" pots)

\(\therefore Tr = 364.1\text{ K}\)