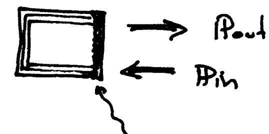
Radiation problem set (Unified eng.)

The energy balance (heat power equ.) is:

$$Mc\frac{dT}{dt} = P_{in} - P_{out}$$



In steady state: $\boxed{P_{in} = P_{out}}$

Adiabatic system everywhere, except in the radiator

* The input power has several parts:

- Dissipated input power: $P_D = 100\,W$
- Solar radiation (from albedo): $P_{S.R.} = S_f\, a\, A_r\, \alpha$

  where
  - S_f is the solar flux: $S_f = \sigma T_{sun}^4 \left(\frac{0.695}{149.6}\right)^2 = 1384\ W/m^2$
  - a is the Earth's solar albedo, $a = 0.3$
  - A_r is the radiator area
  - α is the radiator coefficient of absorption
- Direct thermal radiation from the Earth: $P_{T.R.} = \epsilon_{EARTH}\, \sigma T_E^4 A_r \left(\frac{r_E}{r_{SAT}}\right)^2 \alpha$

* Output power is through radiation only: $P_{out} = \epsilon_r \sigma A_r T_r^4$

Solve for $T_r \Rightarrow$

$$\epsilon_r \sigma A_r T_r^4 = P_D + S_f\, a A_r \alpha + \epsilon_{EARTH}\, \sigma T_E^4 A_r \left(\frac{r_E}{r_{SAT}}\right)^2 \alpha$$

then

$$T_r^4 = \frac{P_D}{\epsilon_r \sigma A_r} + S_f \frac{a}{\sigma}\left(\frac{\alpha}{\epsilon_r}\right) + \left(\frac{\epsilon_{EARTH}}{\epsilon_r}\right) T_E^4 \left(\frac{r_E}{r_{SAT}}\right)^2 \alpha$$

$$= \frac{100\,W}{(0.1)(5.67\times10^{-8}\frac{W}{m^2\cdot K^4})(1\,m^2)} + \frac{1384\frac{W}{m^2}}{(5.67\times10^{-8})}\left(\frac{0.3}{[illegible]}\right) + \left(\frac{0.5}{0.1}\right)(300^4)\left(\frac{6378\,km}{6378+500\,km}\right)^2 0.1$$

then $\boxed{T_r = [illegible]}$ $\boxed{410.68\,K}$

(Without looking to "hot" spots $\boxed{T_r = 364\,K}$)