Today’s Session Summary

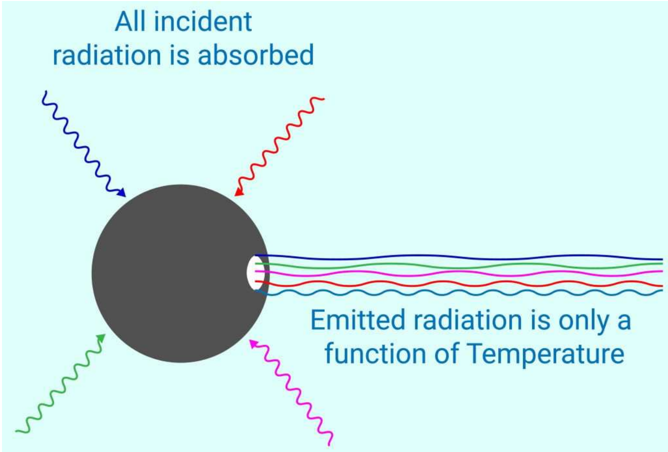
- Radiation
- Solar Panels
- Space systems cooling
- Cooling fin model
- Cell control volume

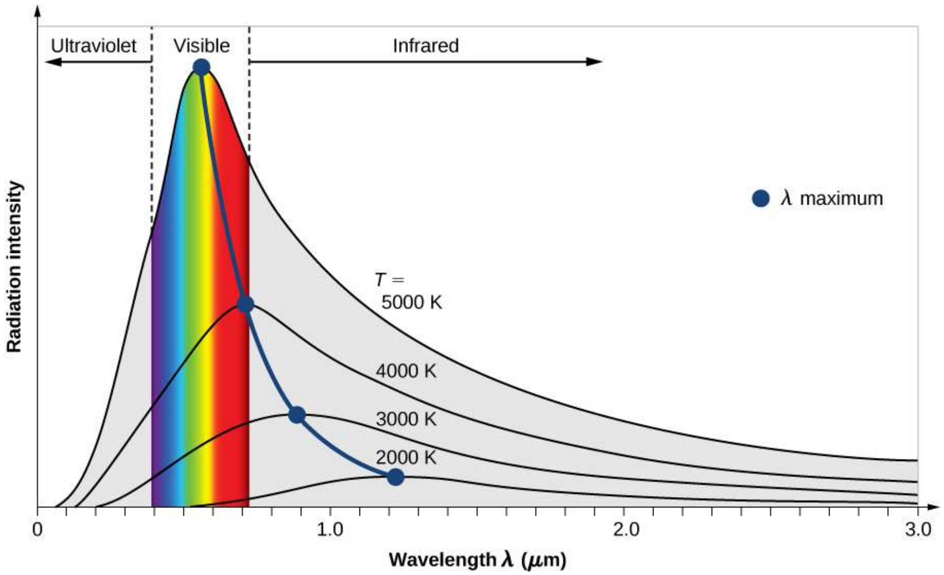
Radiation

Black Body – Boltzman Law

$$P = \dot{E} = A\varepsilon\sigma\,(T^4 - T_\infty^4)$$

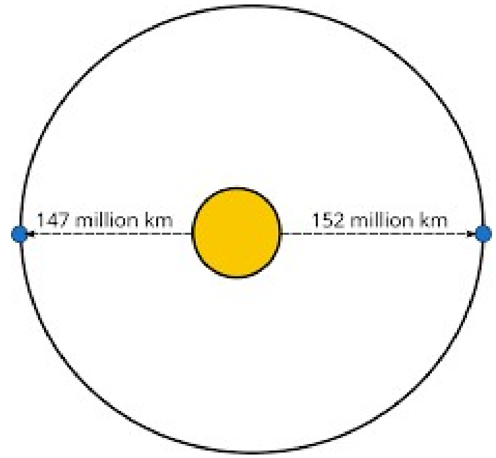
$$\sigma = 5.67\ 10^{-8}\,\frac{w}{m^2K^4}$$

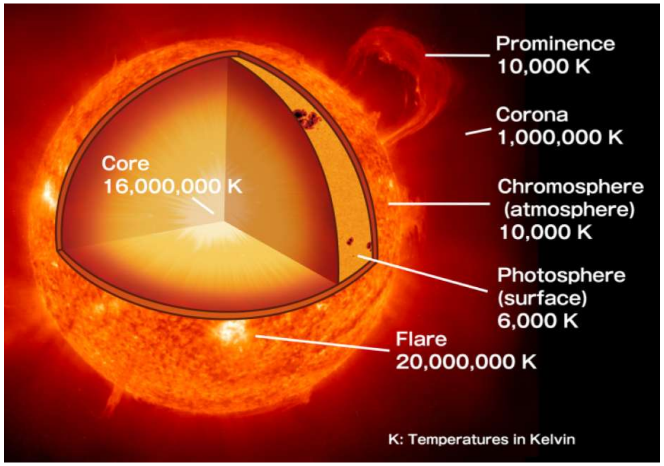




Radiation

$$P = A\varepsilon\sigma\,(T^4 - T_\infty^4)$$





$$R_{sun} = 6.96\ 10^8 m;$$

$$T_{sun} = 5778K$$

$$P_{emitted} = 4\pi R_{sun}^2\ \varepsilon\ \sigma\ (T^4 - T_\infty^4) = 4\pi\left(6.96\ 10^8 m\right)^2 1\ \ 5.67\ \ 10^{-8}\frac{w}{m^2K^4}\left((5778K)^4 - (293K)^4\right) = 3.85\ 10^{26}\ w$$

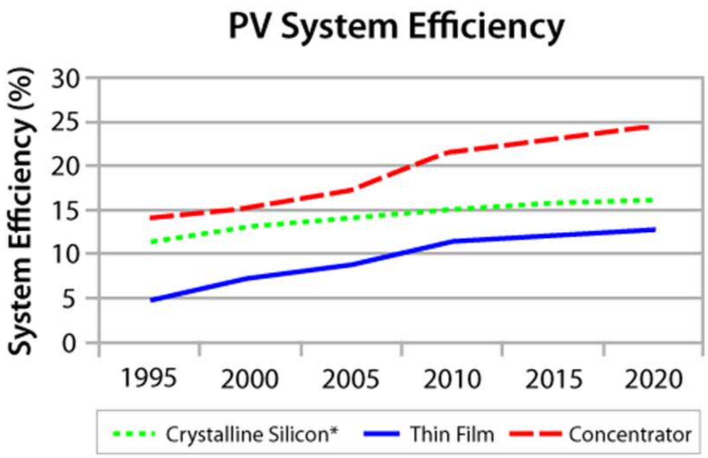
$$P_{received} = \frac{P_{emitted}}{4\pi d_{sun\_earth}^2} =$$

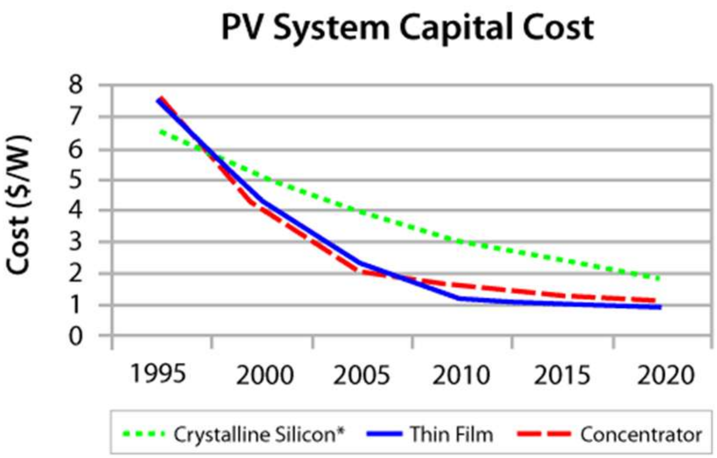
$$d_{sun\ earth} = 150\ 10^9 m$$

Solar panel efficiency

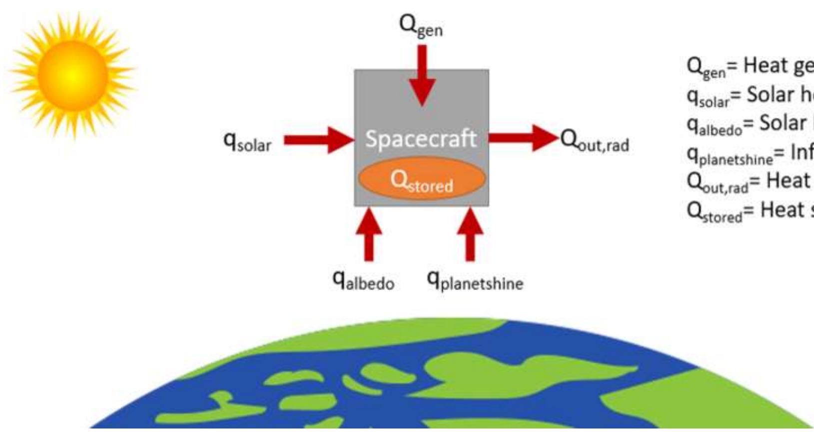
Power generated: 100W / 53.99USD

Efficiency?

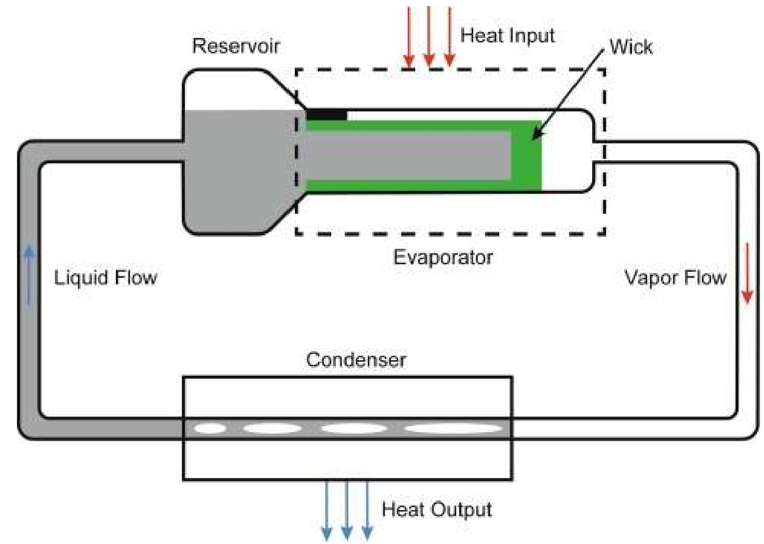


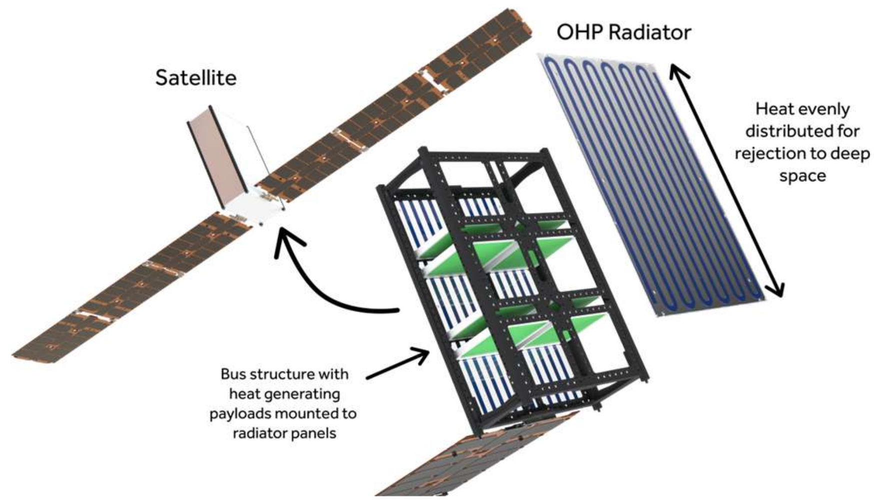


Space systems cooling



Q_{gen}= Heat generated by spacecraft
q_{solar}= Solar heating
q_{albedo}= Solar heating reflected by planet
$q_{planetshine}$= Infrared heating from planet
$Q_{out,rad}$= Heat emitted via radiation
Q_{stored}= Heat stored by the spacecraft

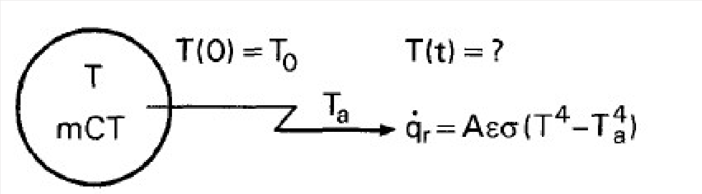




Practice

Sphere cooling

Determine Temperature evolution



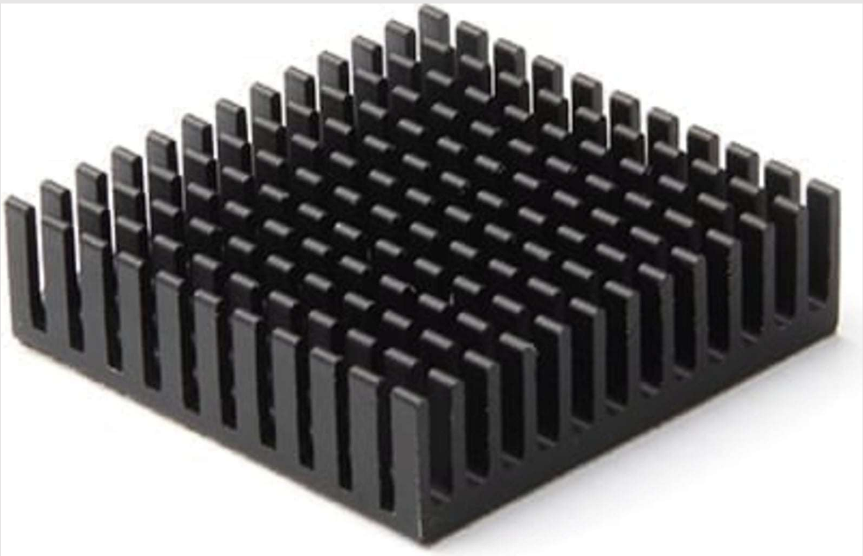
$$A\varepsilon\sigma\,(T^4 - T_\infty^4) = \dot{Q}$$

$$mC\dot{T} = \dot{Q}$$

Practice

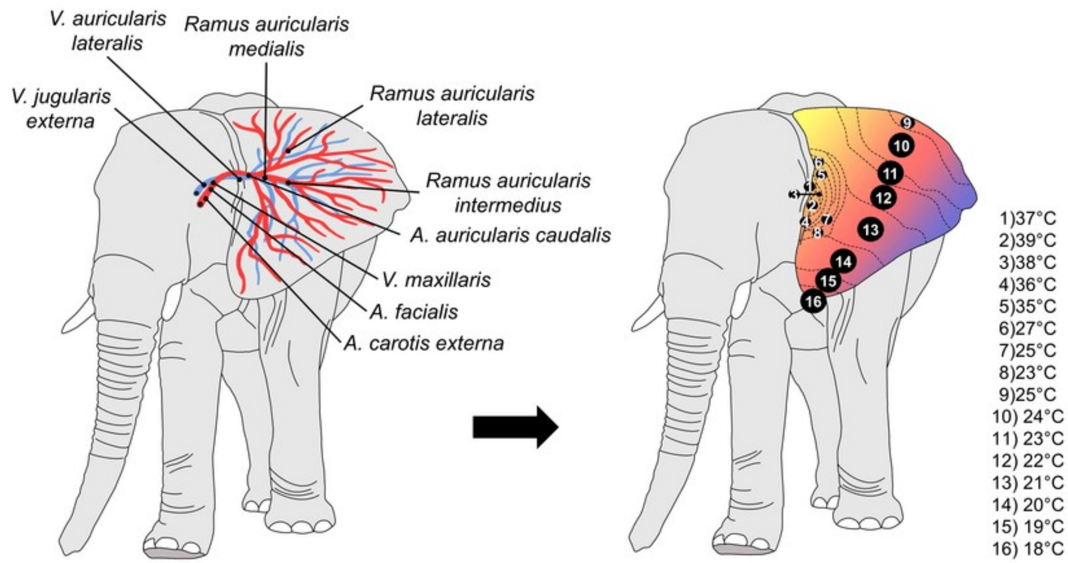
Develop model to evaluate a heat sink thermal behavior.

Analyze heat sink power dissipation capability for a limit temperature of 60C with an environment temperature range from -20C to 45C.

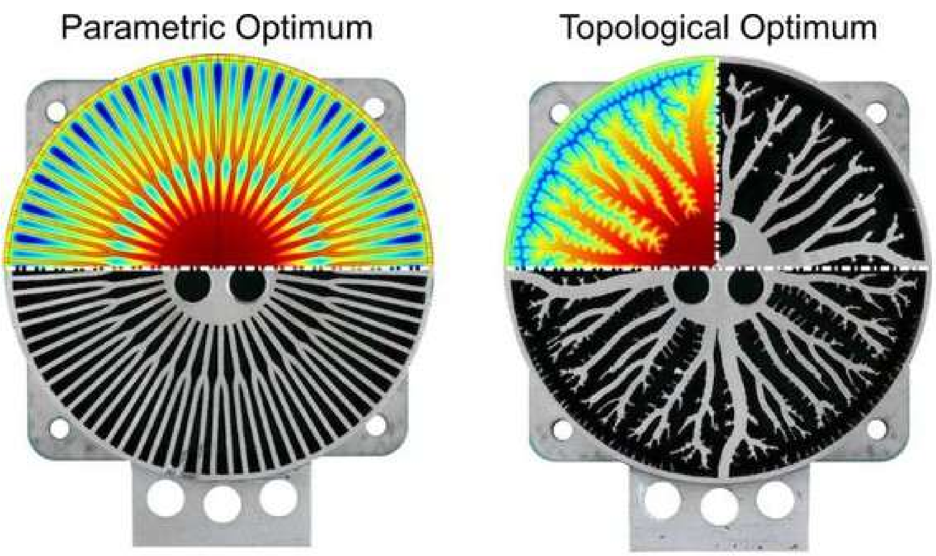


143 Fins. Aluminium Heatsink Cooling Module
Fins: 2.5(L) x 1mm(W) x 10mm(H)
Module: 40mm(L) x 40mm(W) x 11mm(H)

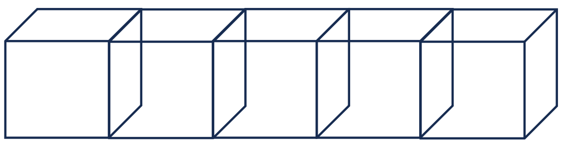
Cooling fin model

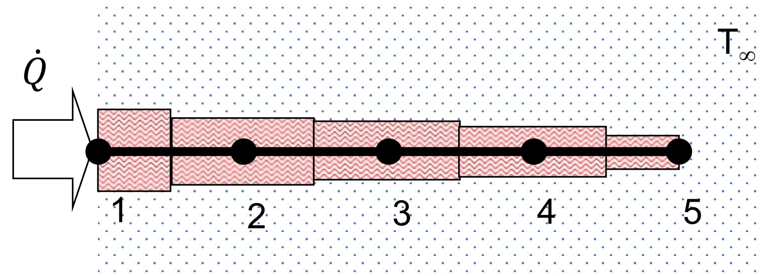


Cooling fin model



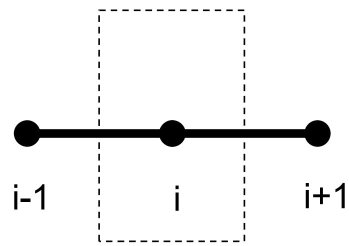
Cooling fin model





Cell Control Volume

$$m_{block} C \dot{T}_{block} = \dot{Q}$$

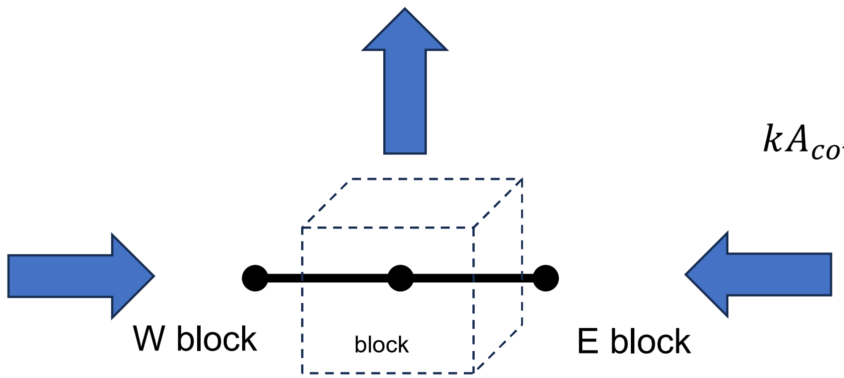


Cell control volume

Heat Balance

$$hA_{convection}(T_{block} - T_{\infty}) = \dot{Q}_{convected}$$

$$kA_{conduction}\frac{T_{E\ block} - T_{block}}{Distance} = \dot{Q}_{E\ conducted}$$



$$kA_{conduction}\frac{T_{W\ block} - T_{block}}{Distance} = \dot{Q}_{W\ conducted}$$

Time variation $\quad m_{block}C\dot{T}_{block} = \dot{Q}$

$$kA_{conduction}\frac{T_{W\ block} - T_{block}}{Distance} + kA_{conduction}\frac{T_{E\ block} - T_{block}}{Distance} + hA_{convection}(T_{block} - T_{\infty}) = m_{block}C\dot{T}_{block}$$

End Session 19