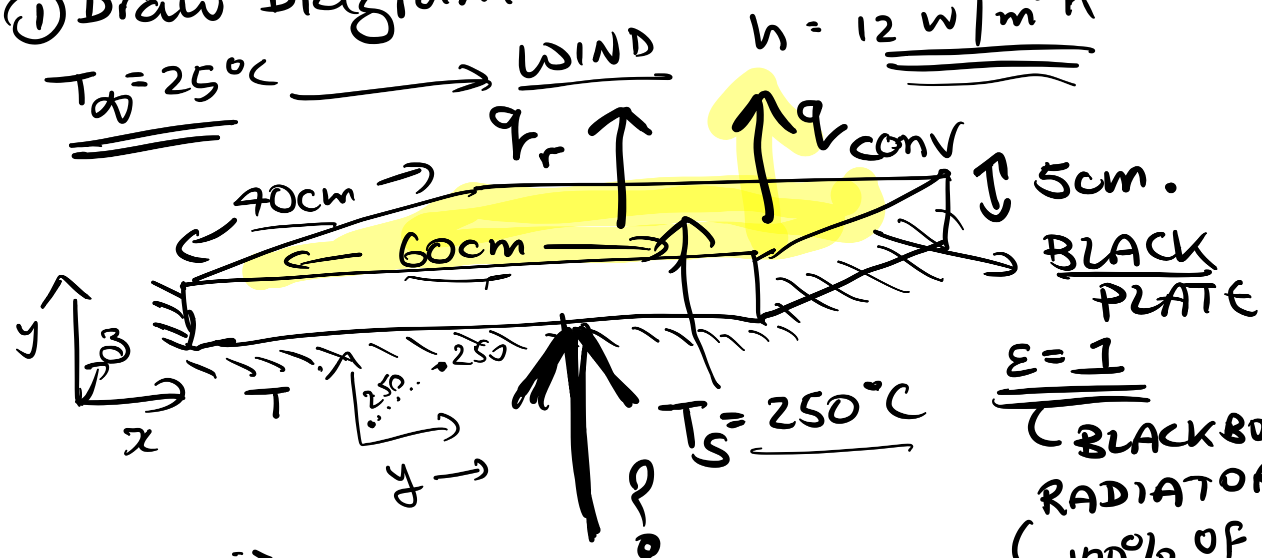
SOLUTION to TUTE 2, ~~Q5~~ Q4

① Draw Diagram



ε = 1
(BLACKBODY RADIATOR
(100% OF ENERGY IS EMITTED TO ATMOS.

② Define
steady state convection and radiation transfer from a black plate to the atmosphere

④ Data
(reference table or data pack)

③ Assumptions

- Black plate implies ε = 1.
- Steady state → we can use equations like
  Fourier's Law
  Newton's Law
  Radiation equation
- 1D conv/rad leaving top of plate only

∴ no heat loss from edges or bottom of plate

④ analysis

(a) q_{conv}?   Newton's Law of Cooling

$$q_{conv} = h A (T_s - T_\infty)$$

Area is related to L×W of the plate, normal to q_{conv}.

$$q_{conv} = 12 \frac{W}{m^2 K} \times 0.4\,m \times 0.6\,m \times (250-25)\,K$$

$= 648\ W \approx 650\,W$

650W from surface to atmosphere.

OR

(+) 650 W

$q_r = \sigma \varepsilon A T_s^4 - \cancel{\sigma \varepsilon A T_\infty^4}$

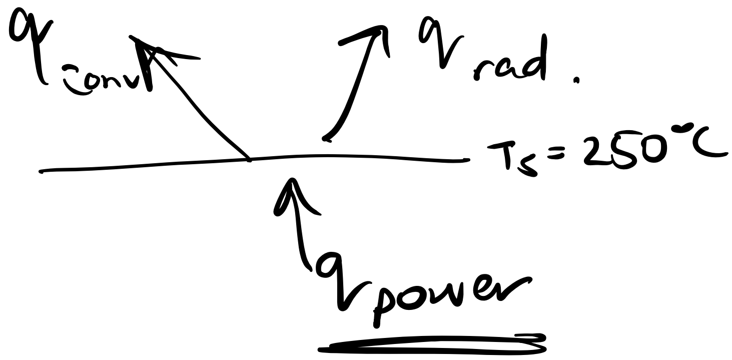
(b) q_r? $q_r = \sigma \varepsilon A (T_s^4 - T_\infty^4)$

$$q_r = 5.67 \times 10^{-8} \frac{W}{m^2 K^4}\ 0.4\,m \times 0.6\,m \times [(250+273)^4 - (25+273)^4]\,K^4$$

$(523)^4\,K^4$

$= \sim \underline{1\,kW}$ from surface to atmosphere.

(c)



EB over surface

$$q_{power} = q_{conv} + q_{rad}.$$

$$q_{power} - q_{conv} - q_{rad} = 0$$

$$q_{power} = 1\,kW + 0.65\,kW$$

$\sim 1.65\,kW$

TO THE SURFACE.

CRITICAL ANALYSIS

The assumption that we only consider heat loss from the surface might lead to

- underestimate of q_{conv}, q_{rad}

- underestimate of q_{power}