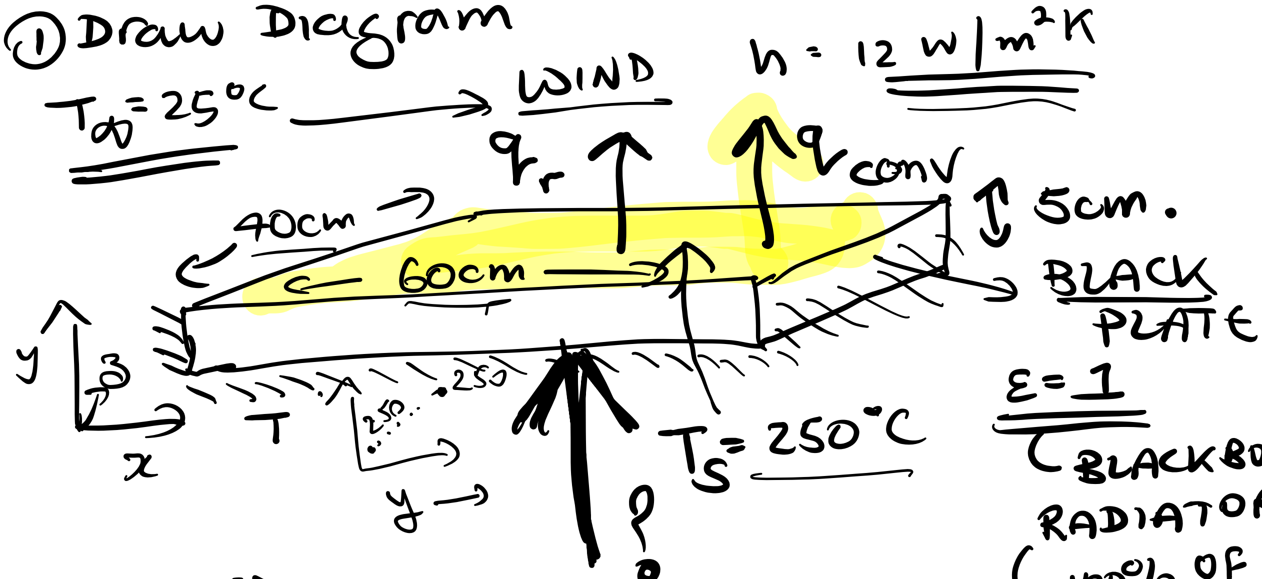
SOLUTION to TUTE 2, ~~Q5~~ Q4

① Draw Diagram



$\varepsilon = 1$

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

② Define

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

③ Assumptions

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

④ Data

(reference table or data pack)

∴ 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}.

$$q_{conv} = \frac{10\,W}{m^2 K} \times 0.4\,m \times 0.6\,m \times (250-25)\,K$$

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

650W from surface to atmosphere.

OR

(+) 650 W

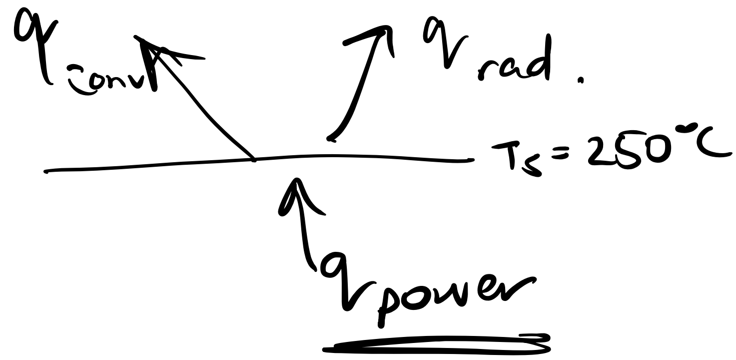
$q_r = \sigma \varepsilon A T_s^4 - \cancel{\sigma \varepsilon A T_\infty^4}$

(b) q_r? $q_r = \sigma \varepsilon A (T_s^4 - T_\infty^4)$, $\varepsilon = 1$

$$q_r = 5.67 \times 10^{-8} \frac{W}{m^2 K^4}\; 0.4\,m \times 0.6\,m \times [\underbrace{(250+273)^4}_{(523)^4 K^4} - (25+273)^4]\,K^4$$

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

(c)



EB over surface

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

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

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

$\sim 1.65\,kW$

TO THE SURFACE.

CRITICAL ANALYSIS

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

- underestimate of q_{com}, q_{rad}
- underestimate of q_{power}