MAE 119 Winter 2015 Quiz 2
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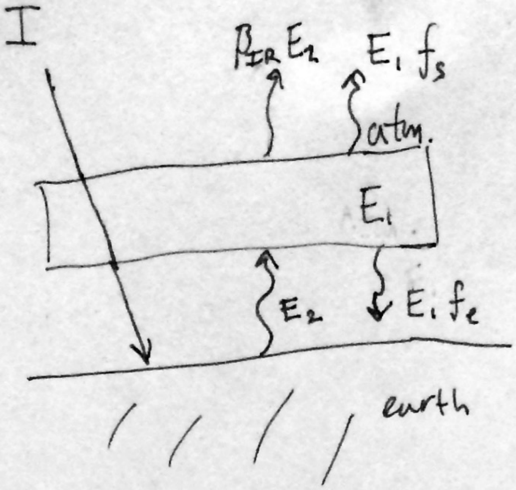
Closed book closed notes.

1. A planet with a surface that perfectly absorbs visible light is surrounded by an atmosphere that is perfectly transparent in the visible part of the spectrum where its star illuminates with an intensity, I. The atmosphere does, however, transmits only 50% of the infra-red radiation emitted by the warm planetary surface which results in the warming of the atmosphere. The warmed atmosphere then re-radiates 50% this energy towards the planets surface and 50% to space.
    a. Draw a diagram like that used in class to discuss this type of problem and label the visible light intensity, IR emissions showing their direcitons and where they are absorbed or lost. 10 pts.
    b. What is the infra-red emissivity E_{surf} of the planet's surface? 10 pts
    c. What is the infra-red emissivity E_{atm} of the atmosphere? 10 pts
    d. If the concentration of IR-absorbing molecules in the atmosphere were to double, what would happen to the IR transmission coefficient. 10 pts
    e. How would this then affect E_{surf} and E_{atm}? 10 pts

2. Suppose that the surface of the tropical ocean is 300 deg K, and water 100 m deep is at 270 deg K. You wish to convert this temperature difference into electricity using an ideal heat engine which can reach the surface hot reservoir and the cold reservoir at 100 m depth. Assuming ideal heat engine efficiency, what is the mass flow rate of water (kG/sec) needed to produce 100kW of electrical power? The specific heat of water is about 4 kJ/kg-deg-C.. One significant figure will suffice. 10 POINTS.

1.



$f_s = 0.5$

$\beta_{vis} = 1$

$f_e = 0.5$

$\beta_{IR} = 0.5$

a) $E_2 \equiv E_{surf.}$ $\qquad E_1 \equiv E_{atm.}$

$$\boxed{E_2 = I + E_1 f_e}$$

b) $E_1 = E_2 - \beta_{IR} E_2$

$$\boxed{E_1 = E_2 (1 - \beta_{IR})}$$

c) $\beta_{IR} = e^{-d(\sigma n)}$

$2n$: $\beta \to e^{-d(\sigma 2n)} = \underbrace{\left[e^{-d(\sigma n)}\right]^2}_{\beta_{IR}} = \boxed{\beta_{IR}^2}$

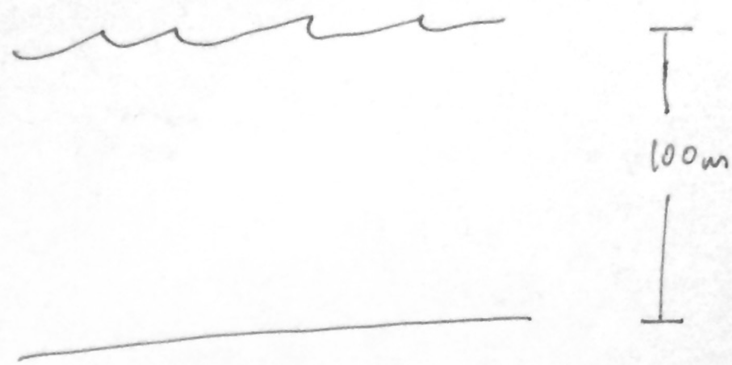
∴ β_{IR} gets squared when the concentration of IR absorbing molecules in the atmosphere doubles.

d) $E_1 \Rightarrow E_2 (1 - \beta_{IR}^2)$ (E_1 would Increase)

and since E_2 is also a function of E_1 ($E_2 = I + \underline{E_1} f_e$) it would increase as well.

2. $T_0 = 300\ K$

$T = 270\ K$



Ideal efficiency: $\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{270}{300} = \frac{30}{300}$

$\underline{\eta = 10\%}$

$\frac{100\ KW}{0.1} = 1\ MW$ required to yield $100\ KW$
(1000 KW)

$C = 4 \frac{KJ}{Kg - °C}$ $\quad \frac{4\ KJ}{Kg\ °C} \cdot 30\,°C = 120 \frac{KJ}{Kg}$

$1000\ KW = 1000 \frac{KJ}{S}$

mass flow rate to produce $1000 \frac{KJ}{S}$ is

$1000 \frac{KJ}{S} \cdot \frac{1}{120} \frac{Kg}{KJ} \simeq \boxed{8 \frac{Kg}{S}}$