MAE 119 Winter 2018 Quiz 2
Prof. G.R. Tynan
Closed book closed notes. Calculators permitted (but not needed).

1. A planet with a surface with an albedo of unity *for all wavelengths of light* is illuminated by visible light from its sun at an intensity per unit area I. The surface is surrounded by an atmosphere that has an albedo of zero for the solar radiation. The atmosphere transmits a fraction β_{vis} of this solar radiation to the planetary surface. The atmosphere then absorbs a fraction (1- β_{vis}) and, as a result, warms to a finite temperature. The atmosphere has a transmission coefficient β_{IR}.
    a. Draw a heat balance diagram like that used in class and label the solar intensity at the top of the atmosphere, at the bottom of the atmosphere, the reflected solar radiation from the surface, and the fraction of this radiation that is transmitted back to space. 10 pts.
    b. Using part (a), find an expression for the amount of solar radiation absorbed by the atmosphere. 10 pts
    c. Assuming heat balance, what is the infra-red emissivity E_{atm} of the atmosphere? 10 pts
    d. What value must the emissivity of the surface have? [Hint: remember it reflects *all* wavelengths of radiation]. 10 pts
    e. If the atmosphere acts as a perfect blackbody emitter, what is the atmospheric temperature? 10 pts

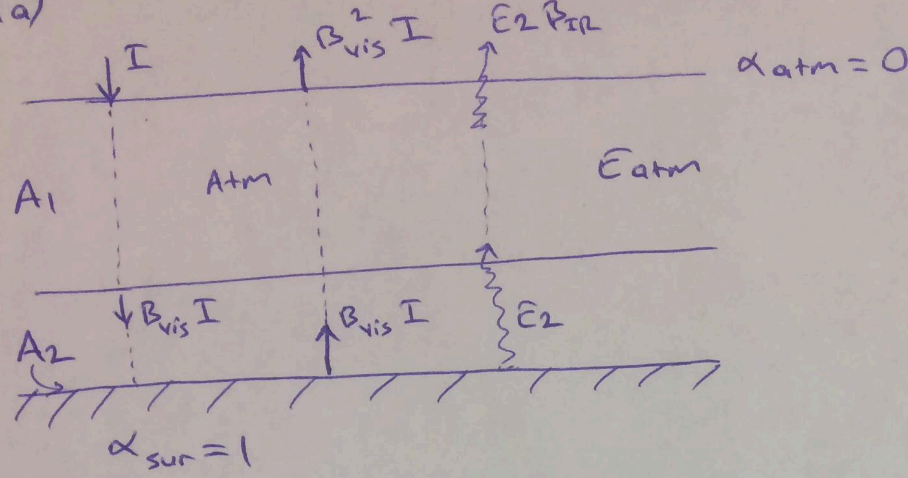
2. Derive the efficiency of an ideal heat engine that extracts heat q_h from a hot reservoir held at temperature T_h, performs work w on the environment, and then rejects an amount of heat q_c to a cold reservoir held at temperature T_c.
    a. Draw a diagram showing the thermal reservoirs, the heat engine, and q_h, q_c and w. (15 points)

    b. Using the first law of thermodynamics, what is the relationship between q_h, q_c and w. (15 points)

    c. If $\frac{q_h}{T_h} = \frac{q_c}{T_c}$ for the ideal engine, use the result from part b to find the efficiency. (15 points).

QUIZ 2

1a)



b) $A_1 = I(1 - B_{vis}) + B_{vis} I (1 - B_{vis})$

$= I(1 - B_{vis}^2)$

c) $E_{atm} = A_1 + E_2 - E_2 B_{IR}$

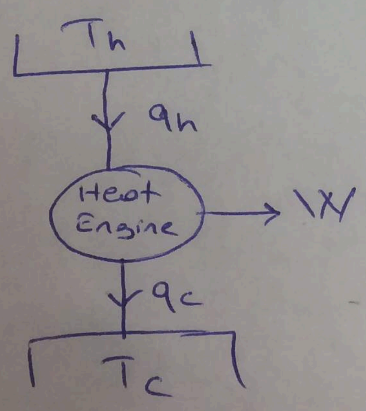
Since $E_2 = 0$

$E_{atm} = A_1 = I(1 - B_{vis}^2)$

d) Emissivity values can range from 0 to 1. A blackbody has an emissivity of 1, while a perfect reflector or whitebody has an emissivity of 0. As the surface reflects all wavelengths of radiation, its emmissivity value is 0.

e) $E_{atm} = \sigma T^4 \rightarrow T^4 = \frac{E_{atm}}{\sigma} \rightarrow T = \sqrt[4]{\frac{(1 - B_{vis}^2) I}{\sigma}}$

2) a)



b) $q_h = W + q_c$

c) $\eta = \frac{W}{q_h} = \frac{q_h - q_c}{q_h} = 1 - \frac{q_c}{q_h}$