

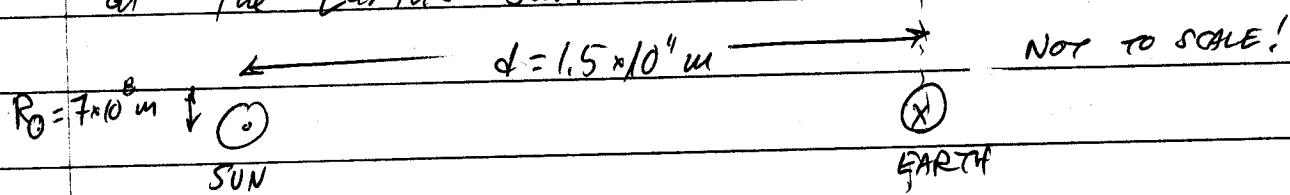
# HELP-SHEET (Zita 16 Nov 04)

## Problem 1

Use the Stefan-Boltzmann law to estimate the intensity of the solar radiation emitted by the sun, assuming that it is a perfect radiator and that its surface temperature is 6000 K. Then find the solar intensity at the Earth's surface, remembering that the solar energy will be spread over a spherical surface whose radius is equal to the mean distance from the sun to the Earth ( $1.495 \times 10^{11}$  m). The sun's radius is about  $6.96 \times 10^8$  m.

~~(This is an overestimate)~~

If  $T_\odot = T_{\text{sun}} = 6000$  K, find the solar intensity  $S = I = F$  at the Earth's surface.



Sun radiates  $F_\odot = \sigma T_\odot^4 = \text{Power} / \text{Intensity}$ , Sun radiates into a sphere of radius =  $d$

Intensity of radiation at the Sun's surface is  $F_\odot =$

Power emitted by sun =  $P_\odot = F_\odot A_\odot =$

where Area of the Sun's Surface =  $A_\odot = 4\pi R_\odot^2 =$

Intensity of Solar radiation at the Earth's surface =  $\frac{P_\odot}{A} =$

where Area of sphere to Earth's radius =  $A = 4\pi d^2 =$

Problem 2 - Now consider the effects of Earth's atmosphere.

## TWO-LAYER MODEL

$$\text{Earth radiates } \frac{\text{Power}}{\text{area}} = E = \sigma T_S^4$$

$$\text{Atmosphere radiates } \frac{\text{power}}{\text{area}} = A = \sigma T_E^4$$

$$\text{Atmosphere absorbs } \frac{\text{power}}{\text{area}} = aE$$

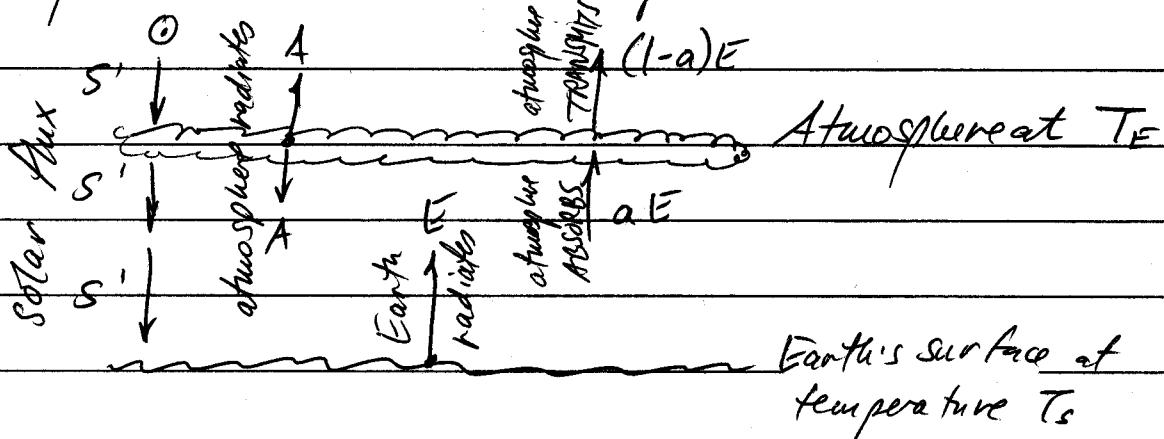
### Problem 2

In the two-layer model, consider the case in which the atmosphere absorbs a fraction

$a < 1$  of the Earth's radiation. In this case, the radiation leaving the top of the atmosphere will include a fraction of the radiation from the Earth's surface that has not been absorbed by the atmosphere. What value of absorptivity  $a$  would the atmosphere have to have for the surface temperature to have the observed value of 288 K?

(Some fraction of what Earth radiates. The rest gets through.)

Atmosphere transmits  $(1-a)E$  of Earth's radiation



Thermal Equilibrium: Heat in = Heat out ( $T = \text{const}$ )

$$\text{Power in} = \text{Power out}$$

$$\text{Flux in} = \text{Flux out}$$

$$\downarrow S' = \uparrow A + (1-a)E \uparrow$$

TOP OF  
ATMOSPHERE:

EARTH'S SURFACE:

$$\downarrow S' + A \uparrow = E \uparrow$$

Solve both equations for  $A$ :

ATMOSPHERE

$$S' = A + (1-a)E$$

$$A =$$

equate

EARTH'S SURFACE

$$S' + A = E$$

$$A =$$

$$A = A$$

Solve for  $a$ , assuming Earth's temperature is  $T_s = 288\text{K}$