NTNU ENGLISH

Department of Physics

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EXAMINATION IN : MNFFY 221/SIF 4082 Energy and Environmental Physics

Friday 6. December 2002

DURATION: 09.00-15.00

Permitted aids: Mathematical tables,

B1 – Calculator, no memory , reference NTNU.

Number of pages: 3

Grades to be announced in week 2 , 2003

Problem 1.

a) Show that the power through a cross section A in a wind field with wind speed u_0 is

$$P_0 = A \rho u_0^3/2 \qquad (2.1)$$

The Betz criterion states that the power of a wind turbine of cross section A is limited by

$$P = C_T P_0, \quad C_T < C_{TB} = 16/27 \qquad (2.2)$$

C_T is called the power coefficient. Derive this condition, and discuss the assumptions you make.

b) Derive an expression for the axial force (thrust) on the turbine, and find the particular form corresponding to maximal power from the turbine according to the Betz criterion.

c) Describe briefly how large wind turbines are constructed today. Discuss the shape of the power function $P(u_0)$, and the principles of control used to obtain this shape.

d) A special type of wind systems is called drag machines. Derive the limiting power coefficient for this machine (corresponding to equation 2.2).

Problem 2

a) Show that the energy received from the sun at earth is on average equal to the solar constant S given by

$$\frac{r_s^2 s T_s^4}{d_{se}^2} = S \approx 1400 \quad [W/m^2]$$

Surface suntemperatur T_s, r_s sun radius (r_s =6.96x10^8 m), d_{se} sun earth distance (d_{se}=1.49x10^{11} m) and σ Stefan-Booltzmann's constant (σ=5.672x10^{-8} W/m^{2}K^4).

b)
Balance the incoming solar radiation with the total radiation emitted from the earth (assume that the earth behaves like a black body). Also assume that a fraction a of the incoming radiation is reflected back to space. Show that an estimate of the temperature of the earth T_e can be found by

$$T_e^4 = \frac{(1-a) r_s^2 T_s^4}{4 d_{se}^2} [K^4]$$

c)
What is the temperature on earth calculated using information given in a) and b) above assuming earth albedo to be 34%? The global average temperature on earth is measured to be 288 K. Explain why our estimate is to low?

d) A doubling of the amount of CO_2 in the atmosphere is estimated to give a radiative forcing of 4.6 W/m^2 corresponding to an expected temperature increase of 1.37 K. What is meant with radiative forcing?

Problem 3

a) What is meant by fission absorption cross section?

b) Explain the function of a moderator in a nuclear fission reactor.

c) The multiplication factor k is given by

$$k = hepf\,(1-l_f)(1-l_s)$$

What does this factor describe and which processes are involved (described by the factors in the equation above) ?

d) Discuss the main arguments for and against nuclear energy ?

Problem 4

a) What are the three main heat transfer mechanisms, and how can each of them be expressed by a simple model (equation) ?

b) A commonly used expression for heat transport is U-value, for a typical insulated wall one can find a U- value of 0.3 $Wm^{-2}K^{-1}$. How do you define the U-value for a wall made out of bricks on the outside and wood on the inside with an isolation layer and an air layer between? (You are not supposed to calculate any numbers, just show how the value can be found and clearly explain the parameters needed to find the value)

c) Direct gain passive solar heating of a house can be of great value. Explain how this can be done in practice. Calculate the solar irradiance required to maintain room temperature 20^oC above ambient. A typical value for thermal resistivity for windows can be 0.07 m^2KW^{-1} ? Make your own assumptions for the other factors needed for calculating the value?

d) A solar collection will be more efficient with a selective surface. Explain why

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Please note:

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