Foundations of Physics 2B/3C 2019-2020

Thermodynamics – Weekly Problem, Th. 1

Publication: 11th Oct Completion: 21st Oct

a) The first part of the problem gives you chance to look at the properties of functions which may be either exact or inexact differentials.

i) A gas has equation of state given by

$$pV = RT + \frac{aT^2}{V},$$

where a is some constant. Determine the total derivative of the pressure, dp.

ii) Show that the following function is in fact exact,

$$z = x^9y^3 + 5x^{-3}y^4.$$

iii) Determine whether the differentials given below are exact or inexact.

$$da = \frac{4}{3}b^3\exp(5c)db + \frac{5b^4}{3}\exp(5c)\,dc,$$

$$dI = 12p^2T\sin T\,dp - 4p^3T\cos T\,dT.$$

[6 marks]

b) Two bodies having temperature independent heat capacities C_1 and C_2 are initially at temperatures T_1 and T_2. They are brought into contact through a diathermal wall and allowed to reach an equilibrium state.

i) Show that the final temperature is in general given by

$$T_f = \frac{C_1T_1 + C_2T_2}{C_1 + C_2}.$$

ii) If $C_1 \gg C_2$, show that the final temperature can be approximated by

$$T_f \approx T_1 + \frac{C_2}{C_1}(T_2 - T_1).$$

Hence explain why the material of heat capacity C_2 would be appropriate to use to make a thermometer.

[4 *marks*]