METÓDY RIEŠENIA FYZIKÁLNYCH ÚLOH 3 leto22 – Príklady 3

Cvičenie 16.3.2022

Príklad 1

Consider a (non-relativistic) particle of mass m in the 1d potential

$$V(x) = \begin{cases} \infty & x < 0 \\ cx & x \geq 0. \end{cases} .$$

(a) Use the uncertainty principle to estimate the groundstate energy and characteristic length scale.

(b) Use the variational principle, with xe^{-ax} as the trial function, to estimate the groundstate energy and characteristic length scale. (You'll get a fair amount of partial credit for clearly setting up the calculation.)

Príklad 2

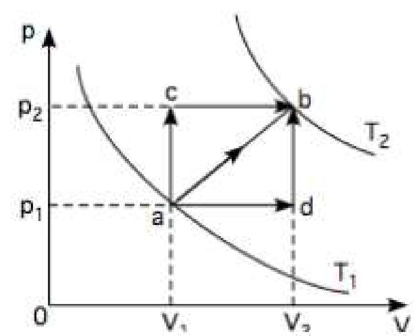
As it falls vertically under the influence of gravity, the hail stone grows by accretion of microdroplets of water from the atmosphere. The droplets have negligible velocity and their collisions with the hail stone are almost completely inelastic. Suppose that the mass $m(t)$ of the hail stone grows linearly with its velocity $v = v(t)$:

$$\frac{dm}{dt} = kv\,, \quad k = \text{const}\,.$$

Find the function $v(t)$ in the limit of large time t where it becomes independent of the initial conditions, $m(0)$ and $v(0)$.

Príklad 3

A classical ideal gas is taken from state a to state b in the figure using three different paths: acb, adb, and ab. The pressure $p_2 = 2p_1$ and the volume $V_2 = 2\,V_1$.

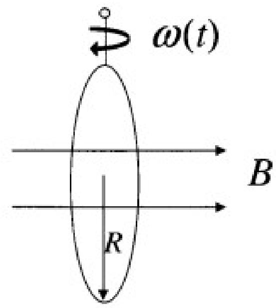


(a) The heat capacity $C_V = \frac{5}{2}Nk$. Starting from the First Law of Thermodynamics derive a value for C_p . No credit will be given for this part if you just state the answer.

(b) Compute the heat supplied to the gas along each of the three paths, acb, adb, and ab, in terms of N, k, and T_1.

(c) What is the heat capacity C_{ab} of the gas for the process ab?

Príklad 4



Calculate the spin frequency decay time, τ, of a thin ring of mass M and radius R that hangs on a string and spins with an angular frequency $\omega(t)$ in a horizontal magnetic field B. The ring has conductivity σ, and a small cross-sectional area $\pi r^2 \ll \pi R^2$.

Assume initially $\omega(0) = \omega_0$ and that the energy lost to Joule heating per period is small compared to the rotation kinetic energy at all times. You can assume the string does not exert any torque. (Hint: use $\langle \sin^2\theta(t) \rangle = ½$ over a period.)