2024 OPhO Clarifications

Theory Problem Clarifications

T1 - Penned Particles

This problem's last update: 8/31 16:15 GMT

We have been made aware that a valid potential should be proportional to (2z^2-r^2), and that (z^2-r^2) is unphysical. This does not change anything in the problem except some numerical coefficients.

You may solve the problem by consistently choosing either of:

1) $V = V_0(z^2 - r^2)/2d^2$

2) $V = V_0(2z^2 - r^2)/2d^2$

(a) In the potential function, r and z are coordinates. r^2 = x^2 + y^2.

(b) You may answer using any of r_0, z_0, and d.

(c)

(d) You may use whatever quantities you deem necessary in the expressions for gamma. The formula for power from an accelerating charge should have an extra factor of pi in the denominator; we won't penalize you if you use the formula as given in the original pdf. **The formula for power is now correct in the new pdf.**

(e) The expression for zeta is meant to contain kappa. You may use any constant quantity in your expression.

(f) You are supposed to find the energy in terms of the radius of the orbit. The first task is to solve for the energy, the second task is to solve for T_m. When it says $\hbar(w_z + w_m)$, it is supposed to be ω_z and ω_m. **We've fixed this in the problem pdf.**

T2 - Bouncy Bubble

The ideal gas is monatomic. "To the lowest order" means the lowest-order nonzero correction.

(a) T_0 is the temperature at the bubble's equilibrium radius.

(c) κ is the thermal conductance per unit area of the bubble's surface. The bubble starts at radius R_0. You should express future answers in terms of R_f instead of T_c or P_c (when possible).

(d) The oscillations begin around radius R_0.

(e) When expanding to the lowest order in α' and δ_0, you may neglect the cross term. You may not use R_f' in your answer.

T3 - Stellar Shaping

- The particles are monatomic

(a) The angular momentum is measured from the center of the sphere. Assume that there is an infinite expanse of gas at the same temperature outside the sphere.

(b) of The cloud -> next time use context from other parts of the problem (part (e))

(c) Assume that radiation pressure is negligible. The model you find should work under the limit $r^2 >> k_b T/Gm\rho$ (solution should approach a closed form) Only the cloud remains at thermal equilibrium.

(d) Choose R' such that the enclosed mass is still equal to M, and assume that the exterior gas mentioned in part (a) confines the cloud. Assume that the work done by the exterior gas is small.

(h) k here is NOT the Boltzmann constant, assume constant temperature here

T4 - Hot Solids

- T is the temperature of the solid, and beta is the thermodynamic temperature $\beta=1/(k_B T)$ with k_B the Boltzmann constant.
- The integral is a line integral along the closed curve from -A to A and back.
- (a) asks to find the speed up to a dimensionless constant (meaning we don't care if you have a factor of 2 in front or not, for example). 4.1 (b) asks to find the value of this dimensionless constant (it could be 1). If you think you solved 4.1 (a) exactly, don't worry about this part (we will give you the correct credit).
- (c) Even if you already know the correct energy levels, please complete the derivation using the given WKB approximation.

- (d) Don't worry too much about ω_{av}—this statement simply means that you can treat $\beta\hbar\omega$ as **large** for the entire problem (any relevant value of omega). (This previously said small, this was an error—we are finding heat capacity in the low temperature limit.)
- Both ends are fixed
- Assume the oscillations of the entire chain act like a single quantum harmonic oscillator (meaning the energy contributions for the entire chain from each frequency are that of a quantum harmonic oscillator of that frequency).
- We are deriving the first order relativistic correction, so even though the mass energy is significant enough to need a relativistic correction we want the answer to first order in $\hbar\omega/mc^2$

Experimental Problem Clarifications

You may add new code if you feel it is necessary - make sure to add a screenshot and explain what you did.
Mu is the atomic magnetic moment. You do not have to experimentally determine this value - it is given in the delta energy expression in the code, please do not change this value.
Use B=0 for all part except e)

- d) use the absolute value of M