End Semester Remote Examination 2021

PH100: Mechanics and Thermodynamics

Time: 60 Minutes **Marks: 45**

- **All questions are compulsory and their marks is indicated in square bracket.**
- **<u>All questions needs to be answered sequentially</u> without fail. Non-compliance of instruction will invite deduction in marks.**
- **In case you feel any question/s is/are incorrect or have insufficient instruction then write in the answer book with your justification without wasting any time**
- **Submission Time: 5:40 PM -5:55 PM (Only PDF files, no other form of submission is allowed)**
- **Submission Link:** https://forms.gle/gfnZU5KnAMN7W9AG7
- **File Name: 20205XYYY_Name_PHY100**

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1. Answer the following questions briefly (**<u>not more than 10 lines</u>**) otherwise marks will be deducted.

   (a) What are the conditions for a well behaved wavefunction? Is Ae^{-x} is a well-behaved wavefunction? Justify.

   (b) What do you understand from group and phase velocities? Is it possible to have phase velocity greater than speed of light? Justify.

   (c) Write down the time-dependent and time-independent form of Schrodinger equation for a particle. How the steady state wavefunction of a particle is connected with space-and time-dependent form of its wavefucntion. Justify.

   (d) The atoms in a solid possess a certain minimum zero-point energy even at *0 K*, while no such restriction holds for the molecules in an ideal gas. Use the uncertainty principle to explain these statements.

   (e) Find the variation of atmospheric pressure with elevation in the earth's atmosphere. Assume that at all elevations, $T = 0$ degree centigrade and $g = 9.8\ m/s^2$. **[4*5=20 Marks]**

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2. Solve either (I) or (II)

   (I). (a) One mole of a gas with $\gamma = 4/3$ goes over the cycle ABCA as in Figure where one of AB or AC is isothermal and the other adiabatic. (You figure out which.) Write down the *(P, V, T)* coordinates of A, B and C (some of which are already given). What is the work done in each part of the cycle and the heat absorbed or rejected in the full cycle?

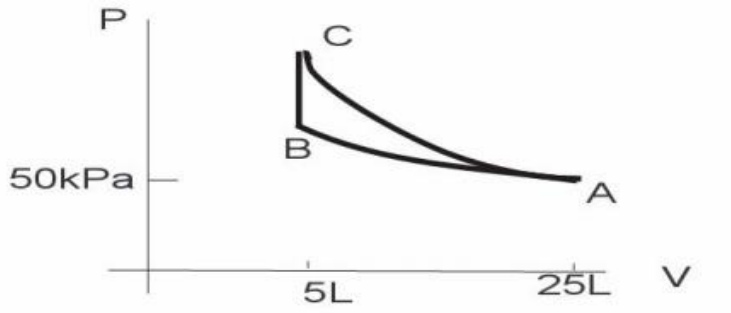

FIG. The gas goes in a loop ABCA, where either AB or AC is isothermal and the other is adiabatic.

(b) A camper is trying to boil water. The *55 g* aluminum pan has specific heat $c = .92J/(gC^0)$, and holds *2000 g* of water. Both at 5^oC. (i) What will be the temperature after *5 minutes* if the pan is on a *2300 Watt* heater? (ii) Next day she starts out doing the same except now rain at 15^oC is falling at the rate of *0.5g/s*. What will be the final temperature after *5 mins* of heating? Assume that the pan and water are at the same temperature at the end. **[5*2=10 Marks]**

OR

(II). (a) Consider a string fixed at $x = 0$ *and* $x = L$ whose displacement obeys

$$\frac{\partial^2\psi(x,t)}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2\psi(x,t)}{\partial t^2}$$

Assuming $\psi(x, t) = F(t)\,\psi(x)$, find the equation obeyed by F and by $\psi(x)$ and verify that a string that starts out at rest in a state $\psi(x,0) = A\sin\frac{n\pi x}{L}$ evolves into $\psi(x,t) = A\sin\frac{n\pi x}{L}\cos\frac{n\pi vt}{L}$.

(b) An electron of energy $E = 200eV$ coming in from $x = -\infty$ approaches a barrier of height $V_0 = 100eV$ that starts at $x = 0$ and extends to ∞. Compute the reflection and transmission amplitudes. Now consider a barrier $V_0 = 400eV$. Show that reflection coefficient has modulus *1*. We know the wave function falls exponentially in the barrier region now. At what x does ψ drop to *1/e* of the value at $x = 0$?

[5*2=10 Marks]

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3. (a) Find the energy functions in a box using $e^{\pm ikx}$ instead of *sin kx* and *cos kx*. *For n=2, 4, 6*, plot the wavefunction and probability density for particle in a box problem.

(b) Two blocks of masses M_1 and M_2 ($M_2 > M_1$) are stacked on top of each other and start at rest on the surface of a frictionless table. The masses are connected via an ideal pulley (massless string and nearly massless pulley wheel), and the coefficient of static friction (assumed equal to the coefficient of kinetic friction) between the block surfaces is μ_S. The pulley is accelerated to the right by a force ***F***, resulting in an acceleration of the pulley wheel of ***a***. Assume that gravity acts with constant acceleration *g* downward.

(i) Draw force diagrams for each of the blocks and the pulley wheel, clearly indicating all horizontal and vertical forces acting on them.

(ii) If the blocks do not slip relative to each other, what are their accelerations?

(iii) Assume that the blocks do slip relative to each other. Determine each block's horizontal acceleration as a function of the parameters specified above *(i.e., M_1, M_2, μ_S, g, **a** and **F**)*. Which block has a higher acceleration? Be sure to work in an inertial reference frame!

(d) What is the minimum force ***F*** required to cause one block to slip relative to the other? Assume that the mass of the pulley is negligible compared to those of the blocks.

[5+10=15 Marks]

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