NAME AND SURNAME
…………………………………
UNIVERSITY
…………………………………

Selected issues:			

GENERAL PHYSICS COMPETITION FOR ENGINEERING STUDENTS "ION I. AGARBICEANU"

XI Edition 2023 13 May 2023

Theoretical test, Physical Section 2

Each contestant participates in the contest with 3 of the 6 subjects of their choice. On the first competition sheet, the candidate will specify under his signature the numbers of the subjects he has chosen.

1. Consider a particle of mass m in a one-dimensional potential pit with walls inside the pit $V=0$ for $|x|<L$. The wave function of the particle in the potential pit is of the form $\psi(x)=A\sin kx+B\cos kx$.

a) Apply to the wave function the boundary conditions and show that $k=\frac{n\pi}{2L}$, $n=1,2,3,\ldots$, with $A=0$ for *odd n* and $B=0$ for n even are obtained.

b) The probability density of locating the particle at a point x in space is equal to $|\psi(x)|^2$. Use this to norm the wave function, i.e. determine the norming constants A or B.

c) Use the result obtained in point c) to calculate the mean value and uncertainty of x as a function of n. Show that for very large values of n the results tend to the classical values obtained for a particle moving back and forth in a pit at constant velocity: $\langle x\rangle=0$, $\langle x^2\rangle^{1/2}=L/\sqrt{3}$.

d) The Schrödinger equation can be written as $\left(\frac{\hat{p}^2}{2m}+V\right)\psi=E\psi$, where $\hat{p}=-i\hbar\frac{\partial}{\partial x}$ for the one-dimensional case. Show that in the n state the particle has energy $E_n=\frac{\pi^2\hbar^2}{8mL^2}n^2$.

e) The first transition in the Lyman series of hydrogen has a wavelength equal to 121.6 nm. Using the one-dimensional potential pit model, estimate a characteristic size of the hydrogen atom.

2. An electron microscope can distinguish two points apart d separately if this distance satisfies the condition $d \geq \frac{\lambda}{2A}$, where λ is the de Broglie wavelength of electrons and A is a constant of the apparatus, called a numerical aperture. Knowing the acceleration voltage of electrons $U = 100\text{kV}$ and that $A = 0{,}15$, determine the minimum value of d. The electron is thought to move relativistically. They know each other: $m_{oe} = 9{,}1 \times 10^{-31}$ kg , $c \cong 3 \cdot 10^{8}$ m/s and .$h = 6{,}626 \times 10^{-34}$Js

3. Knowing that the surface temperature of the human body is, calculate the strength of radiation emitted by the body. It is assumed that the human body behaves like a gray body with the emissivity factor and that the average surface area of the human body is . How long does it take for a human body equivalent to a mass of water () placed in a vacuum in outer space (at ~0 K) to reach temperature? It is considered that body temperature is uniform and that there are no metabolic reactions to increase temperature. The Stefan-Boltzmann constant is known $\theta = 36\ ^{0}C\varepsilon = 0.6S = 1.5\ m^2\tau m = 75$ kg$c = 4200$ J/kg $\cdot\ KT_0 = 273\ K\sigma = 5{,}67 \times 10^{-8}\ Wm^{-2}K^{-4}$.

4. Two balls with initial velocities v01 and v02 are thrown vertically upwards from the surface of a lens converging with focal length f. Determine:

a. Minimum speed (vlim) for which the balls produce real images in the lens
b. The time interval for which the two balls simultaneously produce real images in the lens knowing that *v01=nvlim* and *v02=(n+1)vlim*
c. The time interval for which only one of the balls produces a real image

5. Two monochromatic waves of equal frequencies propagate in parallel directions perpendicular to an inhomogeneous plate of thickness L. In the portion traversed by the first wave, the refractive index n1(z)=n0 and the second wave enters an area where the refractive index is What is the thickness of the wafer so that, at the exit of the plate, the two waves cancel each other out.$n_2(z) = \left(1 + \left(\frac{z}{L}\right)^2\right)$

6. In an enclosure, we insert N01 radioactive nuclei with l1 activity. The decay product is in turn radioactive with l2 activity. Knowing that the final product is stable, find the decay law for the intermediate product and determine the time for which its activity is maximum.