VIT
Vellore Institute of Technology

## Continuous Assessment Test II – December 2022

| | | | | | |
|---|---|---|---|---|---|
| Programme | : | B.Tech. | Semester | : | Fall 2022-2023 |
| Course | : | Engineering Physics | Code & | : | BPHY101L |
| | | | Slot | : | D2+TD2 |
| Faculty | : | Caroline Ponraj, C Justin Raj, M G Shalini, Ramkumar. M C, Kartikeyan. S, Rajasekarakumar. V, Gopinath M, Rishab Antosh B, Uthiram C | Class number | : | CH2022231700409, CH2022231700383, CH2022231700394, CH2022231700366, CH2022231700388, CH2022231700417, CH2022231700360, CH2022231700380, CH2022231700562. |
| Time | : | 90 minutes | Max. Marks | : | 50 |

**Answer any FIVE Questions only (5 × 10 = 50)**

*Physical Constants:* h = $6.626 \times 10^{-34}$ J.s; $m_e = 9.109 \times 10^{-31}$ kg; e = $1.602 \times 10^{-19}$ C;
$m_p = 1.67 \times 10^{-27}$ kg; c = $3 \times 10^8 m.s^{-1}$; 1 eV = $1.6 \times 10^{-19}$ J, $k_B = 1.3807 \times 10^{-23}$ J. $K^{-1}$

| Q.No | Questions | Marks |
|---|---|---|
| 1 | (i) An body of mass $10^4$ kg and a proton moving with a speed of 850 km/ hour and $49.57 \times 10^3$ m/s respectively. Calculate the energy and wavelength associated with them. Comparing the wavelength, explain why the wave nature of matter is not more apparent in daily observations?<br>(ii) Would the effects in Compton scattering due to the photon nature of light be more significant at the visible region of the electromagnetic spectrum? Explain. | 10 |
| 2 | (i) At what angle of scattering, Compton shift was observed to be a maximum? If the scattered wavelength is 13.5 pm, calculate the incident X-ray photon wavelength and the momentum of the recoil electron at the same angle.<br>(ii)What would you expect if Davisson- Germer in their experiment used protons instead of electrons? | 10 |
| 3 | (i) The position and momentum of deuteron ($_1H^2$) moving with velocity of $8.35 \times 10^5$ m/s are measured simultaneously. If its position is measured within 0.5 Å, what is the percentage of uncertainty in the momentum?<br>(ii) Calculate the uncertainty in energy of an unstable elementary particle that has an average life time of $7.2 \times 10^{-9}$ s. | 10 |
| 4 | (i) $\|\psi\|^2$ exhibited 2 and 4 nodes in a 1D box of width L, find the corresponding value of Energy state and energy. Explain with neat sketch of $\psi$, $\|\psi\|^2$ *and* $E$.<br>(ii) Objects in nano-scale tend to show a quite change in physical properties compared to its bulk counterparts. Explain why? | 10 |

| | | |
|---|---|---|
| 5 | (i)Calculate the probability of a 0.42 eV electron to tunnel through a barrier of energy 8 eV and thickness 0.1 nm.<br>(ii) Below is the figure that shows the morphology of graphite. Identify and briefly explain the principle behind getting this image.<br>  | 10 |
| 6 | (i)In a laser system, the two energy levels involved in laser transition are at 20.66 eV and 18.70 eV. Calculate the ratio of the population of upper energy level to lower energy level at room temperature.<br>(ii)A laser operating at a temperature of, 1000 K emits a radiation of wavelength 750 nm. What is the ratio between stimulated and spontaneous emission rate. | 10 |

# VIT
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## Continuous Assessment Test (CAT - II), December 2022

| | | | | | |
|---|---|---|---|---|---|
| Programme | : | B.Tech | Semester | : | Fall 2022-2023 |
| Course Title | : | Engineering Physics | Course Code | : | BPHY101L |
| School | : | School of Advanced Sciences | Slot | : | E1+TE1 |
| Duration | : | 90 mins | Max. Marks | : | 50 |
| Class No | : | 5879, 5830, 5771, 5801, 5765, 5852, 5868, 5875, 5815 | | | |

**Part – A (5 x 10 = 50)**

**Answer ALL Questions**

| Sl. No | Questions | Max Marks |
|---|---|---|
| 1 | (a) Discuss how did classical physics laws fail to explain blackbody radiation spectrum curve? How did Planck's radiation law overcome the shortcomings of classical physics laws? (3+2)<br>(b) A photon of initial energy 90 keV is scattered at an angle of 60° in Compton scattering experiment. Find the energy of the scattered photon. | 5<br>5 |
| 2 | Arrive at Schrodinger's time-independent and time-dependent equation considering classical wave equations and de-Broglie concept of matter waves. | 10 |
| 3 | (a) Explain in brief the experimental verification of matter waves.<br>(b) An electron beam is accelerated through a potential difference of 200 V. Calculate the wavelength of the associated matter waves of this electron beam. | 5<br>5 |
| 4 | (a) Explain how the three–dimensional analysis of conducting surfaces can be analyzed by quantum tunneling with neat sketch?<br>(b) Explain the concepts of quantum well, quantum wire and quantum dot with suitable diagrams. | 5<br>5 |
| 5 | (a) Consider a particle trapped in an infinite potential well, obtain the expressions for its energy eigen values and eigen functions.<br>(b) An electron is confined in a 1-D box of length 5 angstroms. Find its energy eigen values for the first three quantum states. | 5<br>5 |

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## Continuous Assessment Test (CAT - II), December 2022

| | | | | | |
|---|---|---|---|---|---|
| Programme | : | B.Tech | Semester | : | Fall 2022-2023 |
| Course Title | : | Engineering Physics | Course Code | : | BPHY101L |
| School | : | School of Advanced Sciences | Slot | : | E2+TE2 |
| Duration | : | 90 mins | Max. Marks | : | 50 |
| Class No | : | 5877, 5819, 5862, 5872, 5804, 5881, 5776, 5753 | | | |

**Part – A (5 x 10 = 50)**

**Answer ALL Questions**

| Sl. No | Questions | Max Marks |
|---|---|---|
| 1 | Discuss in detail the experiment that gave the experimental proof of the wave nature of matter with suitable diagrams. | 10 |
| 2 | Write three conditions for acceptable wave functions and explain the significance of probability density. From the time-dependent Schrodinger wave equation, deduce the time-independent wave equation for matter waves. (3+2+5 marks) | 10 |
| 3 | (a) What is an ultraviolet catastrophe? Write down the Planks formula for black body radiation and show under what conditions it reduces to Rayleigh-Jeans law. (2+1+2 marks)<br>(b) An electron has a speed of 400 m/s with an accuracy of 0.007 %. Calculate the certainty with which we can locate the position of the electron. | 5<br>5 |
| 4 | Write the energy eigenvalues for the first three states of the particle trapped in the 1-D box of dimension L and plot the corresponding wavefunction and probability density states for those states. Explain why the particles are never at rest inside the 1-D box. (3+2+2+3 marks) | 10 |
| 5 | (a) Explain how quantum confinement leads to various nanomaterials citing one example of each.<br>(b) A 1-eV electron got trapped inside the surface of a metal. If the potential barrier is 4.0 eV and the width of the barrier is 2 Å. Calculate the probability of its transmission. | 5<br>5 |

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# Continuous Assessment Test 2

| | | | |
|---|---|---|---|
| Program | : B.Tech | Semester | : FS 22-23 |
| Course | : Engineering Physics | Code | : BPHY101L |
| Faculty | : Dr. Sanjit Das | Cls. Nb.(Slot) | : CH2022231700337 (D1) |
| Time & Date | : 90 mins 14 Dec 22 | Max Marks | : 50 |

## (ATTEMPT ANY FIVE) 50 Marks (Each question carry 10 marks)

Q1. (a) Compare the uncertainties in the velocities of an electron and a proton confined in a 1.00 nm box. (b) An x-ray photon of initial frequency $3.0 \times 10^{19}$ Hz collides with an electron and is scattered through 90 deg. Find its new frequency. (Marks 5+5)

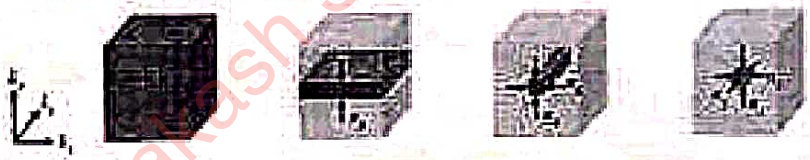
Q2. (a) Find the probability that an electron trapped in a 1D box $L$ wide can be found between $0.55L$ to $0.65L$ for the ground state. (b) (a)Check whether this is a valid wavefunction or not $\Psi(x,t) = 5\, e^{i(kx^4 - \omega t)}$ for 1D Schroedinger's equation. Justify your answer with proper calculation. (Marks 5+5)

Q3. The lowest energy possible for a certain particle trapped in a 1D box is 1.00 eV. (a) What are the next two higher energies the particle can have? (b) If the particle is an electron, how wide is the box? (Marks 5+5 )

Q4. A hypothetical laser operating at 540 nm has a output of powe 1.0mW witha 1 mm beam diameter. If the energy density for this system is $u(\nu) = 6.23 \times 10^{32}\ J - s/m^3$ fine the following (a) The ratio of stimulated emmission to spontaneous radiation. (b) The effective blackbody temperature of the system. (Marks 5+5)

Q5. (a) An electron with initial kinetic energy 32 eV encounters a square barrier with height 41 eV and width 0.25 nm. What is the probability that the electron will tunnel through the barrier? (b) A proton with the same kinetic energy encounters the same barrier. What is the probability that the proton will tunnel through the barrier?(Marks 5+5)

Q6. (a)Briefly discuss the dimensionality and the application of the following.



(b) In a 1D box if the both ends are kept at $-L/2$ to $+L/2$ then what will be the wavefunction of the particle in the first excited state and second excited state? (5+5 Marks)

# Continuous Assessment Test-2 (CAT - 2), December 2022

| | | | | |
|---|---|---|---|---|
| Programme | : B.Tech | Semester | : | Fall 2022-23 |
| Course Title | : Engineering Physics | Course Code | : | BPHY101L |
| School | : School of Advanced Sciences | Slot | : | D2+TD2 |
| Duration | : 90 min. | Max. Marks | : | 50 |
| Class Nos. | : VL2022230105799, 5812, 5827, 6279, & 6315 | | | |

**Answer ALL Five Questions (5 Qs x 10 Mark = 50 Marks)**

| Sl. | Questions | Ma Mar |
|---|---|---|
| 1 | (a) Draw black body spectral distribution curves as a function of frequency at temperatures $T_3>T_2>T_1$. And, write down three important observations from the curves. [Marks: 5]<br>(b) Differentiate the *quantization hypothesis of Planck's* with that of Einstein's. [Marks: 5] | 10 |
| 2 | State the *hypothesis which* connects the wave-characteristics and particle-characteristics *of an electron. To support* this hypothesis, describe an *experiment, with figures* and equations that can conclusively validate this *hypothesis.* [Marks: 3 + 7 = 10] | 10 |
| 3 | (a) Compare with proper justification the mechanical wave equation and the electron wave equation. [Marks: 5]<br>(b) The decay energy of a short-lived nuclear excited state has an uncertainty of 2.0 eV due to its short lifetime. What is the smallest lifetime it can have? [Marks: 5] | 10 |
| 4 | (a) Derive an eigen wavefunction for motion of a particle in a confinement length L. [Marks: 6]<br>(b) Show that a motion confined free subatomic particle has wider energy levels separation at higher quantum states. [Marks: 4] | 10 |
| 5 | (a) Write down four important parameters of materials which influence physical, chemical, optical and mechanical properties of nanomaterials. [Marks: 5]<br>(b) Calculate the specific surface area of 50 nm & 10 Å diameter spherical particles. Write your observations on the results. [Marks: 2+2+1] | 10 |

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**Continuous Assessment Test II – December 2022**

| | | | |
|---|---|---|---|
| Programme | : B.Tech. | Semester | : Fall 2022-2023 |
| Course | : Engineering Physics | Code & | : BPHY1011L |
| | | Slot | : D1+TD1 |
| Faculty | : Caroline Ponraj, G Vinitha, N Punithavelan | Class number | : CH2022231700339, CH2022231700560, CH2022231700355 |
| Time | : 90 minutes | Max. Marks | : 50 |

**Answer any FIVE Questions only (5 x 10 = 50)**

*Physical Constants:* $h = 6.626 \times 10^{-34}$ J.s; $m_e = 9.109 \times 10^{-31}$ kg; $e = 1.602 \times 10^{-19}$ C;

$m_p = 1.67 \times 10^{-27}$ kg; $c = 3 \times 10^8 m.s^{-1}$; 1 eV $= 1.6 \times 10^{-19}$ J, $k_B = 1.3807 \times 10^{-23}$ J.K$^{-1}$

| Q.No | Questions | Marks |
|---|---|---|
| 1 | (i) In Compton scattering experiment, why at zero degree angle, only one peak is observed while at 90 degrees two peaks are observed? Explain with necessary diagram.<br>(ii) A beam of X- rays with wavelength 12.5 pm is Compton scattered by the electrons in a sample. At what angle from the incident beam should you look to find X-rays with a wavelength of 13.71pm? Calculate the energy of the recoil electron at that angle. | 10 |
| 2 | (i) Compare the observations when a beam of 4.5 KeV electrons is directed at normal incidence onto (a) a single crystal and (b) an amorphous solid. If an intensity maximum occurs at an angle of 2.5° for n=1 when electrons fall on the crystal, calculate the spacing between lattice planes.<br>(ii) For a proton of energy 3 MeV trapped in a sodium nucleus of diameter $3.7 \times 10^{-15}$ m, the position and momentum measurements were simultaneously done. Compute the percentage of uncertainty in momentum of that proton. | 10 |
| 3 | The wave function of a certain particle confined with a least energy in a 1D box is $\varphi = \sqrt{P} \cos(y)$ for $-\pi/4 < y < \pi/2$. Find the value of P. Find the probability of the particle between $y = 0$ and $y = \pi/4$. | 10 |
| 4 | (i) How can you explain the changes in the concept of chemical reactivity when a particle is reduced to smaller dimensions? Explain with an example.<br>(ii) An electron is confined in a one dimensional box of side 5.5Å. How much energy is required to excite the electron from the ground state to the fourth excited state? | 10 |
| 5 | (i) A beam of proton with kinetic energy of 5 eV is made to incident on a barrier of width 0.30 nm and height 8.50 eV. Calculate the probability of the protons to tunnel through it.<br>(ii)Your friend who is interested in studying the morphology of a wood sample feels that the Scanning Tunneling Microscope is a good choice to study the sample. What is your suggestion? Comment. | 10 |
| 6 | (i) In a precision photonics experiment, the minimum required temporal coherence length of the illuminating light source is 3.5 m. If you were asked to find a suitable light source operating in the red region of the visible spectrum (660nm), what would be the maximum emission frequency width of your light source?<br>(ii) For the 5mW He-Ne laser emitting a wavelength of 632.8 nm, calculate the corresponding energy and momentum of the emitted photon. | 10 |

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(Deemed to be University under section 3 of UGC Act, 1956)

## Continuous Assessment Test (CAT - II), December 2022

| | | | | | |
|---|---|---|---|---|---|
| Programme | : B.Tech | | Semester | : | Fall 2022-2023 |
| Course Title | : Engineering Physics | | Course Code | : | BPHY101L |
| School | : School of Advanced Sciences | | Slot | : | C1+TC1 |
| Duration | : 90 mins | | Max. Marks | : | 50 |
| Class No | : 5670, 5703, 5690, 5885, 5724, 5742, 5750, 5716, 5729 | | | | |

**Part – A (5 x 10 = 50)**

**Answer ALL Questions**

| Sl. No | Questions | Max Marks |
|---|---|---|
| 1 | What are the implications and properties of wave function? Obtain the one dimensional steady-state wave equation in quantum mechanics? [4+6] | 10 |
| 2 | How matter waves are different from the electromagnetic wave? Demonstrate the wave nature of electrons with a suitable experiment. [3+7] | 10 |
| 3 | (a) Why visible light does not show Compton effect? Experimentally verify the Compton's wavelength shift according to the scattering angle. [5]<br>(b) Determine the minimum uncertainties in the position of the following objects. If their speeds are known with the precision of $1 \times 10^{-3}$ m/s.<br>a) an electron<br>b) a bowling ball of mass 6.0kg [5] | 5<br>5 |
| 4 | Show that a particle bound to a one-dimensional box can only have certain discrete values of energy. Explain the normalized wave function with necessary diagram. [7+3] | 10 |
| 5 | (a) How the structure of nanomaterials varies based on the dimension? Discuss the same with necessary diagrams. [5]<br>(b) The normalized wavefunctions for the various levels in the potential well are $\Psi_z = \sqrt{2}/Lz \sin(n\pi z/L_z)$. Find out the probability of finding the electron between 0.1 and 0.2 nm from one side of the well. Given n=1 and $L_z$=1. [5] | 5<br>5 |

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**Continuous Assessment Test (CAT - II), December 2022**

| | | | | | |
|---|---|---|---|---|---|
| Programme | : | B.Tech | Semester | : | Fall 2022-2023 |
| Course Title | : | Engineering Physics | Course Code | : | BPHY101L |
| School | : | School of Advanced Sciences | Slot | : | C2+TC2 |
| Duration | : | 90 mins | Max. Marks | : | 50 |
| Class No | : | 5693, 5887, 5673, 5720, 5726, 5746, 5705, 5768, 5733 | | | |

**Part – A (5 x 10 = 50)**

**Answer ALL Questions**

| Sl. No | Questions | Max Marks |
|---|---|---|
| 1 | Define ultraviolet Catastrophe. Describe how Planck obtained the correct formula for the spectral distribution of radiation from a black body to solve this problem with the key assumptions that were considered. | 10 |
| 2 | Elaborate on the de Broglie concept of matter waves and describe an experiment to establish the existence of matter waves. | 10 |
| 3 | (a) Arrive at the time-dependent Schrödinger waveequation and give the significance of the Hamiltonian operator.<br>(b) X-rays of wavelength 10 pm are scattered from a target. Find the maximum kinetic energy of the recoil electron in eV. | 5<br>5 |
| 4 | Discuss quantum Tunneling and explain the working of an instrument developed based on the above principle. | 10 |
| 5 | (a) Prove that the energy levels of a particle confined in a one-dimensional box of infinite potential are discrete.<br>(b) A particle is moving in a one-dimensional box of width10Å. Calculate the probability of finding the particle within an interval of 1Å at the center of the box, when it is in its state of least energy. | 5<br>5 |

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**Continuous Assessment Test (CAT - II), December 2022**

| | | | | | |
|---|---|---|---|---|---|
| Programme | : | B.Tech | Semester | : | Fall 2022-2023 |
| Course Title | : | Engineering Physics | Course Code | : | BPHY101L |
| School | : | School of Advanced Sciences | Slot | : | B1+TB1 |
| Duration | : | 90 mins | Max. Marks | : | 50 |
| Class No | : | 2684, 5663, 5675, 5683, 5707 | | | |

**Part – A (5 x 10 = 50)**

**Answer ALL Questions**

| Sl. No | Questions | Max Marks |
|---|---|---|
| 1 | What is the de-Broglie hypothesis for the matter waves (**1+1 marks**)? Identify (**1 mark**) and explain the experiment and its results (**2 marks**), which proved the de-Broglie hypothesis with the help of appropriate diagrams (**3 marks**) and formulas (**1+1 marks**). | 10 |
| 2 | Write the time-dependent Schrodinger wave equation (SWE) and define its components (**2 marks**). Starting from the plane-wave expression $\psi(x,t) = A \exp[i(kx - \omega t)]$, verify the time-dependent Schrodinger wave equation (**7 marks**). Explain why verifying the SWE with the plane wave function is sufficient (**1 mark**). | 10 |
| 3 | (a) Describe Heisenberg's uncertainty principle (**2 marks**). Then, examine the consequences by considering a macroscopic object (Example: Cricket ball) if the Planck constant becomes h=6.63 J. sec (**3 marks**).<br>(b) In Compton scattering, an X-ray beam of wavelength 0.01nm is scattered from a nickel target,<br>(i) Estimate the wavelength of the scattered X-ray at 60 degrees. (**1 mark**)<br>(ii) Estimate the wavelength present in the back scattered X-rays. (**2 mark**)<br>(iii) Estimate the maximum kinetic energy of the recoiled electron. (**2 mark**) | 5<br>5 |
| 4 | An electron is bound within a potential well with potential $U(x) = \begin{cases} 0, 0 \le x \le \frac{L}{2} \\ \infty, \text{ elsewhere} \end{cases}$. Stating the reason, start with the appropriate Schrodinger wave equation (**1mark**), and evaluate the eigenfunction and eigenvalues for the system (**6 marks**). Plot the wave function and probability density with energy value for the first excited state (**1+1+1 marks**). | |
| 5 | (a) Define quantum confinement (**1 mark**), and classify the nanostructure based on this principle, discuss the effect on the density of states if the dimensions of a material are reduced to the nanoscale. Draw the appropriate energy band diagrams (**2+2 marks**).<br>(b) An electron in an infinitely deep square well of length L/2, has associated matter wave function as $\Psi(x) = A\cos\left(\frac{2\pi x}{L}\right)$ for $-\frac{L}{4} \le x \le \frac{L}{4}$, and zero outside. Explain why outside the matter wave function should be zero (**2 marks**), and Calculate the normalization constant A (**3 marks**). | |

## Continuous Assessment Test II – May 2023

| | | | | |
|---|---|---|---|---|
| Programme | : B.Tech. | Semester | : | Winter 2022-2023 |
| Course | : Engineering Physics | Code & | : | BPHY101L |
| | | Slot | : | E2+TE2 |
| Faculty | : Dr. M. Gopinath<br>Dr. C. Justin Raj<br>Dr. S. Karthikeyan<br>Dr. M.G. Shalini<br>Prof. B. Rishab Antosh | Class number | : | CH2022232300031<br>CH2022232300032<br>CH2022232300046<br>CH2022232300043<br>CH2022232300044 |
| Time | : 90 minutes | Max. Marks | : | 50 |

**Answer ANY FIVE Questions (5 × 10 = 50)**

*Physical Constants:* $h = 6.626 \times 10^{-34}$ J.s; $m_e = 9.109 \times 10^{-31}$ kg; $e = 1.602 \times 10^{-19}$ C; $m_p = 1.67 \times 10^{-27}$ kg; $c = 3 \times 10^{8} m.s^{-1}$; $1\ eV = 1.6 \times 10^{-19}$ J, $k_B = 1.3807 \times 10^{-23}$ J. $K^{-1}$

| Qn. No. | Questions | Marks |
|---|---|---|
| 1 | (a) In a Compton scattering experiment, the scattered photon has an energy of 80 keV and the recoiling electron has an energy of 50 keV. Find the wavelength of the incident photon and the angle at which the photon is scattered.<br>(b) In Compton scattering experiment, why at an angle 0°, only one peak is observed while at 90° two peaks are observed? Explain with necessary diagram. | 10 |
| 2 | (a) Consider a bullet of mass 20 g and an electron travelling with the same velocity of 5000 km/h. Discuss their wave-particle duality supported with necessary calculations.<br>(b) If the accuracy in the velocity for the above-mentioned bullet and an electron is 0.085%, calculate the uncertainty in the position for both the particles. | 10 |
| 3 | (a) Pictorially depict the wavefunction and energy levels of a free-particle confined in a 1-D potentialwell for the following cases: i) *Infinite potential well of width L* ii) *Infinite potential well of width L/2*<br>(b) If an exciton in a semiconductor material is created with an uncertainty of about $10^{-6}$ seconds, what will be its uncertainty in the energy? Also calculate the uncertainty in the frequency of the emitted radiation. | |
| 4 | (a) Discuss the zero-point energy of a free particle confined in a 1-D box of infinite potential and calculate the difference in its energy between the ground and third energy states in terms of the width of the box.<br>(b) Discuss the requirement of the nature of material (crystalline/amorphous) required for proving the wave nature of electron. Explain with an example of the experiment done in the lab. | 10 |
| 5 | Consider an electron moving in a one-dimensional infinite potential well of width 100Å.<br>(a) Calculate the probability of finding the electron within an interval of 10Å about the centre of the box when it is in its lowest state of energy.<br>(b) Calculate the energy required to excite the electron from its ground state to the 2nd excited state. | 10 |
| 6 | (a) Consider a material with energy band gap of 1.3 eV. Now, since the light produced by the optical source available is not being absorbed by the material, requiring the material to be replaced with another material of bang gap 1.35 eV. Suggest a solution to tune the band gap of the existing material for the purpose explaining in detail the phenomenon.<br>(b) Calculate the probability for an electron of 0.4 eV to be found on the other side of the barrier of height 5eV and thickness 0.2 nm | 10 |

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Vellore Institute of Technology

## Continuous Assessment Test II – May 2023

| | | | | | |
|---|---|---|---|---|---|
| Programme | : | B.Tech. | Semester | : | Win22-23 |
| Course | : | Engineering Physics | Code | : | BPHY101L |
| Faculty | : | Caroline Ponraj, R.D. Eithiraj, N. Manikandan, M.C. Ramkumar, M.G. Shalini | Slot/ Class Numbers | : | E1/CH2022232300022, CH2022232300024, CH2022232300028, CH2022232300040, CH2022232300042 |
| Time | : | 1½ Hours | Max. Marks | : | 50 |

**Answer any FIVE Questions (5 x 10 = 50)**

1. (a) If the frequency of the incident photon is $8 \times 10^{18}$ Hz in Compton experiment, then calculate the wavelength of the scattered photon at 45° and 90°. 10

   (b) A non-relativistic particle is moving three times as fast as an electron. The ratio of their de Broglie wavelength of particle to electron is $1.813 \times 10^{-4}$. Identify the particle.

2. (a) Consider that you are given a source of electrons and a grating element made of glass slide as used in the lab. It is to prove the wave nature of such radiation. Is it possible to prove it? Give appropriate reasons. 10

   (b) Consider that you have been given a condition that the uncertainty in the location of a particle's position is about equal to half its de Broglie wavelength. Calculate its corresponding uncertainty in velocity.

3. (a) Calculate the probability of finding the particlein the ground state between $x = 0.2L$ and $x = 0.8L$, if it is confined in a 1-D box of length L. 10

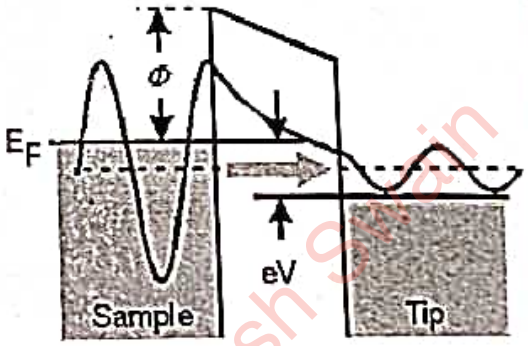
   (b) How do you prove the particle nature of radiation based on your understanding of this subject? Use only conceptual approach.

4. (a) A hydrogen atom is $5.3 \times 10^{-11}$ m in radius. Use the uncertainty principle to estimate the minimum energy an electron can have in this atom. 10

   (b) Show that for a free particle, the uncertainty relation can also be written as $\Delta\lambda\Delta x \geq \lambda^2/4\pi$

5. (a) A particle moving with kinetic energy equal to its rest mass energy has a de Broglie wavelength of $2 \times 10^{-6}$ Å. If the kinetic energy reduces to 70% of initial, what will be the new de Broglie wavelength? 10

   (b) Consider the image given below. Give your understanding of the same explaining the phenomenon involved.




6. (a) Consider a particular application in which you are using a material with energy band gap of 1.3 eV. There arises a situation wherein the optical absorption and emission of the material needs to be tuned around 1.4 eV. How will you achieve this without changing the material? Briefly write down what happens during that process. 10

   (b) A 4 eV, 0.1 nm barrier is placed in the path of an electron with 2 eV energy. Calculate the transition probability for the electron to be on the other side of barrier.

# VIT

Vellore Institute of Technology
CHENNAI

Reg. Number: 23BAJ1038

## Continuous Assessment Test (CAT) – II- APRIL 2024

| | | | | | |
|---|---|---|---|---|---|
| Programme | : | B.Tech | Semester | : | Win 23-24 |
| Course Code & Course Title | : | BPHY101L<br>Engineering Physics | Class Number | : | CH2023240500308<br>CH2023240500320<br>CH2023240500288<br>CH2023240500280<br>CH2023240500284<br>CH2023240500312<br>CH2023240500316<br>CH2023240500276<br>CH2023240500324 |
| Faculty | : | Caroline P.<br>Karthikeyan S<br>Parasuraman E<br>Punithavelan N.<br>Rajasekarakumar V<br>Sanjit Das<br>Shalini M G<br>Swaathi P<br>Uthiram C | Slot | : | F1+TF1 |
| Duration | : | 90 minutes | Max. Mark | | 50 |

**General Instructions:**

- Write only your registration number on the question paper in the box provided and do not write other information.
- Only non-programmable calculator without storage is permitted

Section A - **Answer all questions** (2×15=30)

| Q. No | Sub Sec. | Questions | Marks |
|---|---|---|---|
| 1. | a) | A subatomic particle Muon (mass = $1.88 \times 10^{-28}$ kg) is confined in a 1-dimensional box of length 10 nm. Calculate the energies corresponding to the quantum numbers n= 1 to 3. Depict with appropriate neat figures the correlation of energy, wave function, and probability density function. | 7 |
| | b) | How do you prove the particle nature of radiation based on your understanding of this subject? Use only a conceptual approach. | 3 |
| | c) | Explain the physical phenomena involved in the confinement of particles in space and its influence on electronic and optical property variations of a substance at the sub-10 nm level. | 5 |
| 2. | a) | If Davisson and Germer had used 90 volts to accelerate their electron beam instead of 54 volts, at which scattering angle φ would they have found a peak in the distribution of scattered electrons (the intensity)? | 8 |
| | b) | An electron is in a certain energy state in a one-dimensional, infinite potential well between x = 0 and x = L = 180 pm. The electron's probability density is zero at x = 0.200L, and x = 0.300L; it is not zero at intermediate values of x. The electron then jumps to the next lower energy level by emitting light. What is the change in the electron's | 7 |

| | | | |
|---|---|---|---|
| | | energy? | |
| Section B - **Answer any two questions** (2×10 = 20) | | | |
| 3. | | Beams of an electron (mass = $9.1 \times 10^{-31}$ kg) and a proton (mass = $1.6 \times 10^{-27}$ kg) having a kinetic energy of 4 eV are made to incident on a barrier of width 1.5 nm and height U= 8.0 eV. Calculate the de Broglie wavelengths and tunneling probability of the electron and proton that penetrates through it. Comment on your observations. (4+4+2) | 10 |
| 4. | a) | Describe the differences between the types of emissions responsible for the glowing of a 60 W bulb and the production of He-Ne laser in the laser cavity. | 5 |
| | b) | Given an emission wavelength of 7000 Å and the coefficient of spontaneous emission of $10^8$ /s, what is the coefficient of stimulated emission? Also, calculate the corresponding frequency of laser light. | 5 |
| 5. | a) | X-rays with an energy of 200 keV undergoes Compton scattering with a target. If the scattered X-rays make an angle 30° relative to the incident X-rays, calculate the energy of the incident photon and recoil electron at this angle. | 6 |
| | b) | What will be the uncertainty in position of an electron moving at a speed of 200 m/s with an accuracy of 0.01 percent? | 4 |

**********All the best **********

Reg. No: Name:

# VIT

Vellore Institute of Technology

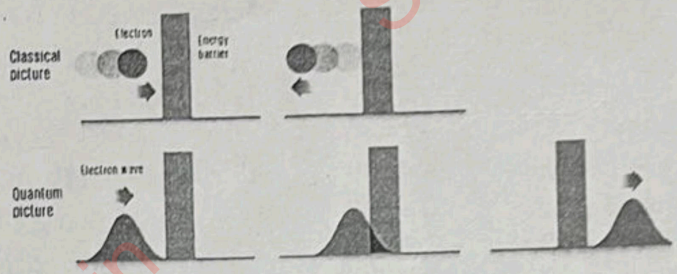
(Deemed to be University under section 3 of UGC Act, 1956)

## Continuous Assessment Test II – October 2023

| | | | | |
|---|---|---|---|---|
| Programme | : B.Tech. | Semester | : | Fall Semester 2023-2024 |
| Course | : Engineering Physics | Code & | : | BPHY101L |
| | | Slot | : | D2+TD2 |
| Faculty | : Dr. Justin Raj C<br>Dr. Karthikeyan S<br>Dr. Ramkumar M C<br>Dr. Rajasekarakumar V<br>Dr. Parasuraman E<br>Dr. Divya Bharathi K<br>Prof. Rishab Antosh B | Class number | : | CH2023241700061<br>CH2023241700069<br>CH2023241700063<br>CH2023241700067<br>CH2023241700071<br>CH2023241700059<br>CH2023241700065 |
| Time | : 90 minutes | Max. Marks | : | 50 |

**Answer any FIVE Questions only (5 × 10 = 50)**

| Q. No | Questions | Marks |
|---|---|---|
| 1 | (a) You have been asked a question about the wave-particle duality of EM radiation. To justify your answer, you have been asked to use graphite as a target element. What will be your answer to that? How will you justify your answer (Without any derivation)?<br>(b) A muon has a position uncertainty of $10^{-7}$ m. Calculate its minimum energy using uncertainty principle. (ii) If another muon was in the ground state of a 1D box of length $10^{-7}$ m, what will be its corresponding energy? (iii) Can you comment on the difference between the two results? Given mass of muon is $1.88\times10^{-28}$ Kg. | 5 + 5 |
| 2 | (a) Through what angle must a 100 keV photon be scattered by an electron so that its wavelength increases by 5% in a Compton scattering experiment.<br>(b) Explain the significance of double peaks in Compton experiment and indicate when do you observe a maximum wavelength shift. | 6+4 |
| 3 | For a given wave function, $\Psi(x) = A\cos(\frac{n\pi}{L}x)$. Normalize the wave function and find the probability amplitude, A for limit: x=0 and x= L/2. | 10 |
| 4 | (a) Find the kinetic energy of an electron whose de Broglie is same as that of a 70 keV X-ray.<br>(b) A gold ball of 4 mm diameter is broken into very small pieces of 4 nm diameter. Explain the possible changes in their physical properties compared to its bulk form. | 7+3 |

| | | |
|---|---|---|
| 5 | A beams of electron and proton with kinetic energy of 6 eV are made to incident on a barrier of width L=0.40 nm and height U=9.50 eV. Calculate the deBroglie wavelengths and tunneling probability of the electrons and protons to tunnel through it. | 10 |
| 6 | (a) If you are given the following image, what will be your explanation to the science enthusiasts? How will you convince them about the scientific phenomenon related to this?   (b) An electron is confined to a 1D box of length L. When the electron makes a transition from its third excited state to the second state, it emits a photon of energy 0.9 eV. (i) What is the ground state energy in eV of the electron in the box? (ii) Sketch the wave function of the electron in the second excited state. | 4 + 6 |

VIT
Vellore Institute of Technology
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CHENNAI

| Reg. Number: | BB 1169 |
|---|---|

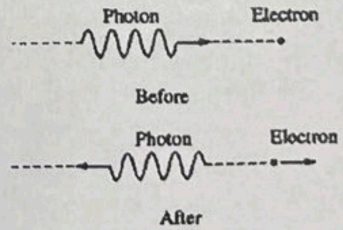
## Continuous Assessment Test (CAT) – II - 2024

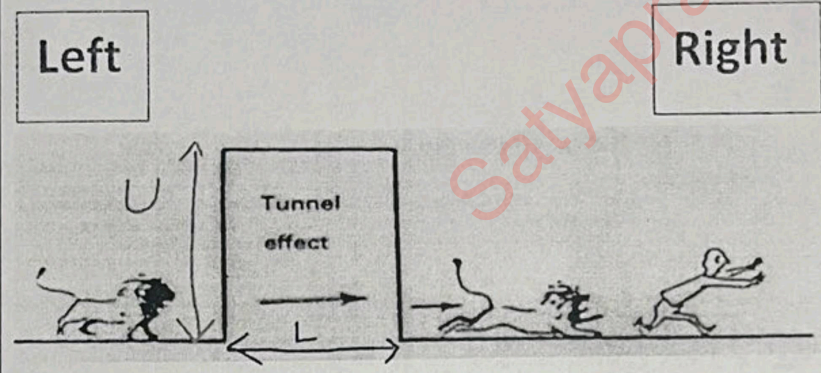
| | | | | | |
|---|---|---|---|---|---|
| Programme | : | **B.Tech.** | Semester | : | **Winter Semester 2023-2024** |
| Course Code & Course Title | : | **BPHY101L & Engineering Physics** | Class Number | : | **CH2023240500278 CH2023240500310 CH2023240500282 CH2023240500286 CH2023240500314 CH2023240500318 CH2023240500290 CH2023240500326 CH2023240500322** |
| Faculty | : | **Dr.R. Navamathavan Dr. Sanjit Das Dr.N. Punithavelan Dr.RajasekarakumarVadapoo Dr.S. Karthikeyan Dr.K. Divya Bharathi Dr.E. Parasuraman Dr.C.Uthiram Prof. B. Rishab Antosh** | Slot | : | **F2+TF2** |
| Duration | : | **1½ Hours** | Max. Mark | | **50** |

**General Instructions:**

- Write only your registration number on the question paper in the box provided and do not write other information.
- Only non-programmable calculator without storage is permitted

**Section-A (Answer all Questions (2× 15 = 30))**

| Q. No | Sub Sec. | Description | Marks |
|---|---|---|---|
| 1 | a | A photon strikes an electron of mass $m_0$ which is at rest; after the collision the photon gains a wavelength by an amount of $\Delta\lambda$ and reversed in direction as shown in figure.<br>$\lambda = 3.0 \times 10^{-11}$ m<br>  <br><br>i) Find the Compton shift ($\Delta\lambda$).<br>ii) Find the energy in Joules of the scattered photon.<br>iii) Determine the magnitude of the momentum acquired by the electron | 7 |
| | b | Consider a quantum particle confined in a region of $0 \leq x \leq a$, where the wave function is $\Psi(x,t) = (e^{-iwt})\sin(\pi x/a)$. Find the potential $V(x)$. | 8 |

| | | | |
|---|---|---|---|
| 2 | a | A beam of subatomic particles electrons and neutrons have the kinetic energy of 12 eV.<br>  <br><br>They fall on a barrier like above of width L=0.50 nm and height U=10 eV. Calculate the probability of the electrons and neutrons to pass from left to right by adopting the mechanism of quantum physics. | 7 |
| | b | Your friend who is interested in studying the morphology of a gold sample feels that the Scanning tunnelling microscope is a good choice to study the sample. What is your suggestion? Comment. | 3 |
| | c | Explain the physical significance and confinement of quantum particle in space inside matter with neat sketches. Explain the variation of physical properties of a matter at sub-10 nm level. | 5 |
| **Section-B (Answer any TWO Questions (2×10 = 20))** | | | |
| 3 | a | The position and momentum of deuteron ($_1H^2$) moving with frequency $10^{-7}$ Hertz are measured simultaneously. If its position is sighted within 0.5Å, what is the percentage of uncertainty in the momentum? | 5 |
| | b | An electron is moving in a one-dimensional infinite well of width 100Å. (i) Calculate the probability of finding the electron within an interval of 10Å at the centres of the box when it is in state of least energy. (ii) What would be the energy of the electron if it is set free out of the potential well? | 5 |
| 4 | a | A laser emits light of wavelength 550 nm. Find the ratio of the population between the two states at 300K. | 3 |
| | b | At what temperature would the population ratio reach 0.5, and what implication does this have for population inversion? | 4 |
| | c | Why is it difficult to achieve laser action at higher frequency range? Justify your answer with an expression. | 3 |
| 5 | | A proton is confined in an infinite potential well of width 10 fm (The nuclear potential that binds protons and neutrons in the nucleus of an atom is often approximated by an infinite square well potential). Calculate the energy and wavelength of the photon emitted when the proton undergoes a transition from the first excited state to the ground state and in what region of the electromagnetic spectrum does this wavelength belong? | 10 |

**********All the best **********

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VIT-C 26 (Satya Helpzz)
VIT-C 27 (Satya Helpzz)
VIT-C 28 (Satya Helpzz)

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