

BPHET-141: Elements of Modern Physics

Course Code	BPHET-141
Course Title / Subject	Elements of Modern Physics
Programme	B.Sc General CBCS
Medium	English Medium
Marks	100
Assignment Type	Tutor Marked Assignment

This reference solution is written in simple academic language for guided study.

Official Assignment / Syllabus Page

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PART B

3. a) The eigenfunction of a particle confined in a box of length L ($0 \leq x \leq L$) is

$$\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{3\pi x}{L}\right)$$

Calculate $\langle \hat{p}_x^2 \rangle$ and the probability of finding the particle between $x = 0$ and $x = L/4$. (5+5)

- b) A particle encounters a step potential of height V_0 . What is the reflection and transmission coefficient if $E = 1.5V_0$? Show that $R + T = 1$. (5)
- c) Show that, for a symmetric potential function ($V(x) = V(-x)$), the parity operator commutes with the Hamiltonian. What is the parity of the of the following eigenfunctions of a symmetric potential well of width $2a$: (i) $\psi(x) = A \cos\left(\frac{3\pi x}{2a}\right)$ and (ii)

$$\psi(x) = A \sin\left(\frac{\pi x}{a}\right). \quad (10)$$

4. a) The half life of ^{51}Cr is 27.70 days. After how many days will only 10% of the element be left over? (5)
- b) Establish the relation for binding energy per nucleon for ^A_ZX nuclei. Calculate the value of binding energy per nucleon for $^{68}_{28}\text{Ni}$. Given:

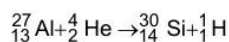
Mass of Ni : 63.9280 u

Mass of proton : 1.007825 u

Mass of neutron : 1.008665 u

Is this nucleus stable? (10)

- c) A piece of wood from the ruins of an ancient dwelling was found to have a ^{14}C activity of 14 disintegrations per minute per gram of its carbon content. The ^{14}C activity of living wood is 16 disintegrations per minute per gram. How long ago did the tree die from which the wood sample came? Take half-life of radiocarbon as 5760 years. (5)
- d) Calculate Q-Value of the reaction:



Take $m(^{27}_{13}\text{Al}) = 26.9815 \text{ u}$, $m(^1_1\text{H}) = 1.0078 \text{ u}$, $m(^4_2\text{He}) = 4.0026 \text{ u}$ and $^{30}_{14}\text{Si} = 29.9738 \text{ u}$. (5)

Solved Answers

Answer 1: a) A spacecraft A has a speed $0.80c$ with respect to the Earth. If the speed of another spacecraft B with respect to spacecraft A is $0.50c$, what is the speed of B with respect to the Earth b) A particle is travelling through the Earth's atmosphere at a speed of $0.6c$. To an Earth-bound observer, the distance it travels is 4.0 km . How far does the particle travel in its own frame of reference? c) A particle of rest mass 2.0 kg has an initial speed of 8102 ms^{-1} . A constant relativistic force of magnitude 6105.1 N is exerted on the particle in the same direction as the initial relativistic momentum for 1000 s . Calculate the magnitudes of the initial and final relativistic linear momentum and its final speed. d) A star emits light with wavelength 420 nm . An observer on earth measures the wavelength of the light received from the star to be 600 nm . Calculate the speed with which the star is moving. (ignoucollage.in)

About 250 words

The study and understanding of **a spacecraft a has a speed $0.80c$ with respect to the earth.** represents a core analytical dimension within the subject. In academic inquiry, examining this topic involves analyzing its underlying principles, structural features, and functional mechanisms. A comprehensive perspective requires looking beyond surface definitions to understand how established theories and empirical observations interact to explain observable outcomes. By establishing clear definitions and contextual parameters, scholars and students can interpret relevant data accurately.

A systematic investigation into **a spacecraft a has a speed $0.80c$ with respect to the earth.** reveals several vital characteristics and operational methods. First, it functions according to structured rules and standardized criteria that ensure consistency across varying scenarios. Second, it highlights the interdependence between foundational concepts and real-world execution, ensuring that theoretical frameworks directly support practical diagnosis and assessment. Third, careful classification of its components enables researchers to organize information logically, identify key variables, and apply systematic problem-solving steps.

In applied contexts and practical scenarios—particularly within the institutional, socioeconomic, and environmental context of India—the relevance of **a spacecraft a has a speed $0.80c$ with respect to the earth.** becomes readily apparent. Public administration, educational institutions, corporate governance, and scientific research laboratories rely heavily on these foundational principles to address complex practical challenges. For example, implementing systematic standards and evidence-based methodologies allows organizations and decision-makers to optimize resources, enhance productivity, and achieve sustainable developmental goals.

In summary, a thorough mastery of **a spacecraft a has a speed $0.80c$ with respect to the earth.** is essential for achieving complete conceptual clarity in this field. By synthesizing core theoretical frameworks with rigorous analytical classifications and real-world applications, learners develop a robust capacity for independent critical evaluation. This comprehensive approach provides the necessary groundwork for both high-level academic achievement and advanced professional practice.

Answer 2: a) Determine the wavelengths of the photons scattered at (i) 60° and (ii) 90° when X-rays of wavelength 4.5 pm are scattered from a target. b) Calculate the de Broglie wavelength of a ^{87}Rb atom that has been laser cooled to $200\text{ }\mu\text{K}$. (Assume that the kinetic energy is $\frac{3}{2}k_B T$).2 (ignoucollage.in)

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Answer 3: Tkb c) Using Heisenberg's Uncertainty Principle explain whether a particle trapped inside a one dimensional box of finite length can be at rest. d) The quantum mechanical wave function for a particle is given by $\psi(x) = N \sin\left(\frac{n\pi x}{a}\right)$. Determine (i) the normalization constant N and (ii) the most probable position of the particle. PART B (ignoucollage.in)

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**Answer 4: a) The eigenfunction of a particle confined in a box of length L ($L \times 0$) is $L \times L \times 3\sin^2$)(Calculate 2^{xp} and the probability of finding the particle between 0 and $4/L$. (5+
b) A particle encounters a step potential of height $.0V$ What is the reflection and transmission coefficient if $?5.1$ $0VE$ Show that 1 TR . c) Show that, for a symmetric potential function $)()$ $xVxV$, the parity operator commutes with the Hamiltonian. What is the parity of the of the following eigenfunctions of a symmetric potential well of width $2a$: (i) $a \times Ax \ 2 \ 3\cos$)(and (ii) $a \times Ax \ \sin$)(. (ignoucollage.in)**

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Answer 5: a) The half life of ^{51}Cr is 27.70 days. After how many days will only 10% of the element be left over? b) Establish the relation for binding energy per nucleon for XAZ nuclei. Calculate the value of binding energy per nucleon for ^{68}Ni (ignoucollage.in)

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Answer 6: Given: Mass of Ni : 63.9280 u Mass of proton : 1.007825 u Mass of neutron : 1.008665 u Is this nucleus stable? c) A piece of wood from the ruins of an ancient dwelling was found to have a ^{14}C activity of 14 disintegrations per minute per gram of its carbon content. The ^{14}C activity of living wood is 16 disintegrations per minute per gram. How long ago did the tree die from which the wood sample came? Take half-life of radiocarbon as 5760 years. d) Calculate Q-Value of the reaction: $^{113014422713}\text{HSiHeAl}$ Take $^{981526\text{Al}2713}$.m , $^{0078.1\text{H}11}$ m , $^{00264\text{He}42}$. = m and $^{29.9738\text{Si}3014}$. *** (ignoucollage.in)**

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