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Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Third Semester M.Sc Degree Examination, November 2025

MPH3E05(6) - Experimental Techniques

(2022 Admission onwards)

Time: 3 hours Max. Weightage : 30

Section A
(8 Short questions, each answerable within 7.5 minutes)
(Answer all questions, each carrying weightage 1)

1. What is a gas ballast in a rotary pump? Discuss the uses in detail.
2. How do oil molecules in a diffusion pump achieve supersonic velocities?
3. Briefly explain the term "energy straggling".
4. Explain the ion implantation technique. What are the applications of the ion implantation technique?
5. With a suitable diagram, discuss the operation of a butterfly valve
6. What is sputtering yield, and explain its significance?
7. Explain any one of the electrical/electronic conductivity methods to determine the thickness of a thin film.
8. What are the applications of PIXE, and discuss its limitations?

Total weightage 8x1=8

Section B
(4 Essay questions, each answerable within 30 minutes)
Answer ANY TWO questions, each carrying a weightage of 5)

9. Discuss the instrumentation and operations of
   (a) the Turbo molecular pump, and (b) the Diffusion pump.
10. With the help of neat diagrams, explain the working principles of
    (a) Van de Graaff accelerator, (b) Tandem Van de Graaff accelerator,
    (c) Linear accelerator
11. With the help of the necessary theory, discuss how the quartz crystal oscillator is used in thin-film thickness measurement.
12. Discuss Neutron activation analysis with the principles of its operation, experimental arrangement, and applications

Total weightage 2x5=10

Section C

(7 Problem questions, each answerable within 15 minutes)
Answer ANY FOUR questions, each carries a weightage 3.

13. A powder X-ray diffraction experiment is performed on a material known to have a Simple Cubic crystal structure with a lattice constant (a) of 0.38 nm. The incident X-ray beam has a wavelength (λ) of 0.154 nm (Cu Kα radiation). A high-intensity diffraction peak is observed at a Bragg angle (θ) of 19.6^0 from the (100) plane of the crystal. Determine the order of diffraction (n) corresponding to this peak..
14. If I and V are the current and voltage across the relevant terminals of a four-probe setup. Prove that the thickness t and resistivity ρ of the thin film are related as $t = \frac{\rho}{\pi} ln\, 2\left(\frac{I}{V}\right)$.
15. Obtain the mathematical basis and nuclear reaction kinematics for the characterization of a material.
16. How will you determine the thickness of a thin film using the interference of light from a uniform thin film? Obtain the mathematical formula for this.
17. A hollow cylindrical thin film deposition chamber is 125cm high 35 cm base diameter. How long does it take for a single-stage rotary pump (pumping speed 175 litres per minute) to reach a pressure of 10^{-3} Torr from atmospheric?
18. A proton accelerator consists of 180 drift tubes. The RF electric field has a frequency of 450 MHz. The average potential when the protons cross the accelerating gap is $3x10^3$ kV. If the protons are injected into the machine at 2MeV energy, calculate the final energy and the length of the last drift tube.
19. A beam of alpha particles with an initial kinetic energy (KE) of 2.5 MeV is directed at a thick target made of Gold (Au). For a head-on collision (where the impact parameter b=0), the α-particle is scattered directly back (θ=180°). At the point of closest approach, all initial kinetic energy is momentarily converted into electrostatic potential energy. Calculate the distance of closest approach between the α-particle and the Gold nucleus in femtometers (fm).

(Total weightage 4x3=12)

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Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Third Semester M.Sc Degree Examination, November 2025

MPH3C09: Quantum Mechanics- II

(2022 Admission onwards)

Time: 3 hours

Max. Weightage: 30

SECTION A

Short answer questions. Answer *all* questions. Each carries 1 weightage

1. Explain how the nth-order correction to the energy is obtained in non-degenerate perturbation theory.
2. Differentiate between the weak-field Zeeman effect and the strong-field Zeeman effect.
3. Describe the connection formulae for WKB approximation.
4. Sketch the time dependence of the transition probability for constant perturbation.
5. How does the differential scattering cross section depend on the scattering amplitude?
6. Show that the order of Dirac's matrices has to be even.
7. Express Dirac's equation in the covariant form.
8. What is golden Fermi rule? Explain.

(8 × 1 = 8 weightage)

SECTION B

Essay questions. Answer any *two* questions. Each carries 5 weightage

9. Discuss the method of time-independent perturbation theory in the case of degenerate states and apply it to find the energy states and wave functions to illustrate Zeeman effect in hydrogen atom.
10. Describe the method of WKB approximation. Apply it to find the wave function and energy inside a potential well with two vertical walls.
11. Find the non-relativistic limit of Dirac equation and hence show that the positive energy Dirac particles are electrons.
12. For a square well potential show that the scattering cross section is independent of energy and scattering angle.

(2 × 5 = 10 weightage)

SECTION C

Problems. Answer any *four* questions. Each carries 3 weightage

13. Give the expression for the correction to the ground-state energy of a harmonic oscillator under a linear perturbation term $H' = \alpha x$.

14. Derive the relativistic correction to the hydrogen atom energy levels starting from the kinetic energy expansion.

15. Using time-independent perturbation theory, find the first-order correction to the energy of n=2 state of hydrogen atom in the presence of electric field.

16. Optimize the trial function $e^{-\alpha r}$ and evaluate the ground state energy of the hydrogen atom.

17. Apply time-dependent perturbation theory in the case of harmonic perturbation to find the transition probabilities.

18. Derive Optical theorem.

19. Show that the Dirac particles have spin ½.

(4 × 3 = 12 weightage)

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Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Third Semester M.Sc Degree Examination, November 2025

MPH3C10 – Nuclear and Particle Physics

(2022 Admission onwards)

Time: 3 hours Max. Weightage: 30

Section A

(Answer ALL questions, each carries weightage 1)

1. A neutron-proton bound state is stable, while a proton-proton or neutron-neutron system is not stable. Justify.
2. Show that nuclear matter density is independent of mass number of the nucleus.
3. Mention the drawbacks of the single particle nuclear shell model.
4. Comment on the collective motion of nucleons in a nucleus.
5. Electrons are not integral parts of a nucleus. But during a beta decay, electrons are found to be emitted from the nucleus. Explain.
6. Differentiate nuclear fission and nuclear fusion. Which produces more power?
7. What is the principle of a scintillation detector?
8. What are resonance particles? Give examples.

(Total weightage 8 x 1 = 8)

Section B

(Answer ANY TWO questions, each carries weightage 5)

9. Define binding energy of a nucleus. Draw the binding energy curve. Discuss the various terms in the semi-empirical mass formula.
10. Obtain an expression for the rate of probability of beta decay using Fermi's theory.
11. What are the important features of nuclear fission process? Explain the working of a nuclear fission reactor with natural uranium fuel.
12. With a neat diagram, explain the principle and working of a Lithium drifted Germanium Li(Ge) detector.

(Total weightage 2 x 5 = 10)

Section C

(Answer ANY FOUR questions, each carries weightage 3)

13. Show that the electric quadrupole moment of a spherically symmetric charge distribution vanishes.
14. Show that the nucleon-nucleon interaction is strongly spin dependent.
15. Predict the ground state spin and parity of the following nuclei using the single particle shell model : (a) ${}^{13}_{6}C$ (b) ${}^{17}_{8}O$ (c) ${}^{27}_{13}Al$ (d) ${}^{40}_{20}Ca$
16. The radioactive nuclide C^{11} decays according to the scheme $C^{11} \rightarrow B^{11} + e^{+} + \nu$. The maximum energy of the emitted positron is 0.960 MeV. If the atomic masses of C^{11} and B^{11} are 11.011434 u and 11.009305 u respectively, calculate the Q-value of the decay.
17. A GM tube operates at 1KV and has a wire of diameter 0.20 mm. The radius of the cathode is 20 mm and the tube has a guaranteed life time of 10^9 counts. What is the maximum radial field and how long will the count last if it is used on the average of 30 hours per week at 3000 counts/minute?
18. Check whether the following reactions are allowed or forbidden:
    - (a) $p + p \rightarrow K^{+} + \Sigma^{+}$
    - (b) $p + \pi^{-} \rightarrow \Sigma^{0} + \eta^{0}$
    - (c) $\pi^{-} \rightarrow e^{-} + \nu_e + \pi^{0}$
    - (d) $\pi^{-} + p + n \rightarrow n + K^{+} + K^{-}$
19. Explain the strange behavior of elementary particles. Calculate the strangeness of K^{+} and Ω^{-}.

(Total weightage 4 x 3 = 12)

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Name: ....

FAROOK COLLEGE (AUTONOMOUS), KOZHIKODE

Third Semester M.Sc Degree Examination, November 2025

MPH3C11 — Solid State Physics

(2022 Admission onwards)

Time: 3 hours Max. Weightage: 30

Section A

(Answer all questions, each answerable within 7.5 minutes carries weightage 1)

1. Give the crystal structure of diamond.
2. Distinguish between ionic and covalent bonding in solids.
3. Explain how lattice vibrations are quantized.
4. What are the basic assumptions of Debye theory of heat capacity of solids?
5. Briefly discuss Hall effect.
6. Distinguish between soft superconductors and hard superconductors.
7. Discuss the basic concept of ferroelectric domains.
8. Distinguish between paramagnetic and ferromagnetic materials.

Total weightage 8x1=8

Section B

(Answer ANY TWO questions, each answerable within 30 minutes carries weightage 5)

9. Discuss the fundamental types of lattices in three dimensions. Explain the structure of the three Bravais lattices of cubic crystals in detail.
10. Discuss the formation of allowed and forbidden energy bands in solids on the basis of the Kronig Penny model.
11. Explain Meissner effect. Derive the London equations for superconductors and hence explain the phenomenon of penetration of magnetic field lines into superconductors.
12. Derive Curie-Weiss law for ferromagnetism.

Total weightage 2x5=10

Section C

(Answer ANY FOUR questions, each answerable within 15 minutes and carries weightage 3)

13. Find the reciprocal lattice vectors for a space lattice defined by the following primitive vectors, a = 2i-2j+2k, b=2i+2j-2k, c=-2i+2j+2k (in Å).
14. A beam of X-rays of wavelength 0.922 Å is incident on a crystal at a glancing angle of 8° 42' when the first order Bragg reflection occurs. Calculate the glancing angle for the third order reflection.
15. Calculate the specific heat per kmol of diamond at 20 K. Given the Debye temperature of diamond = 1850 K. What is the highest lattice frequency?
16. Prove that the Fermi level in an intrinsic semiconductor lies in the middle of the energy gap if the effective masses of electrons and holes are equal.
17. The mobility of holes is 0.025 m^2/Vs. What would be the resistivity of p-type silicon if the Hall coefficient of the sample is 2.25×10^{-5} m^3/C.
18. The magnetic field intensity in a piece of ferric oxide is 10^6 A/m. If the susceptibility of the material at room temperature is 1.5×10^{-3}, calculate the flux density and magnetization of material.
19. A superconducting specimen has T_c= 3.7 K in the absence of the magnetic field and a critical field of 0.03T at 0 K. Find the critical field for the specimen at 2 K.

Total weightage 4x3=12