[This question paper contains 4 printed pages.]

Sr. No. of Question Paper	:	**5810**	**Your Roll No................**
			L
Name of the Department	:	Physics	
Name of the Course	:	B.Sc. Hons.–(Physics)_NEP: UGCF-2022	
Name of the Paper	:	Physics of Detectors	
Semester	:	IV/VI- Semester (GE Paper)	
Unique Paper Code	:	2224002009	
Question Paper Set No	:	2	

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately upon receipt of this question paper.
2. Attempt **five** questions in total.
3. Question No. **1** is **compulsory**.
4. All questions carry equal marks (18 marks each).
5. Use of a non-programmable calculator is allowed.

1. Answer any six of the following: **[6x3 = 18]**

(a) Why are high-Z materials preferred for gamma-ray shielding?

(b) Why does radiative loss (bremsstrahlung) become dominant at high energies while ionisation energy loss predominates for electrons at low energies?

(c) A NaI(Tl) scintillation detector is used to measure a 1 MeV gamma-ray source, and the observed Full Width at Half Maximum (FWHM) of the energy peak is 80 keV. Calculate the energy resolution of the detector in percentage terms.

(d) Why is pulse mode preferred for low count rates, whereas current mode detector operation is better suited for high radiation intensities?

(e) How does the 'Gas Multiplication' process work in a Proportional Counter?

(f) What is shot noise, and what is its origin in radiation detectors?

(g) What is Transistor-Transistor-Logic (TTL) standardization? Why are NIM signals not recommended to be connected to the TTL inputs?

2. (a) Derive the expression of specific energy loss (Bethe-Block formula) for heavy charged particles in the detector material. **10**

(b) What is neutron moderation? How does neutron energy influence interaction types? **4**

(c) Calculate the energy of a 1 MeV gamma-ray photon after Compton Scattering through 90°. **4**

3. (a) Define the terms intrinsic efficiency and extrinsic (absolute) efficiency of a radiation detector. A radioactive source emits 10^6 particles per second. A detector placed near the source records 2 x 10^5 counts per second, while only 5 x 10^5 particles per second actually impinge on the detector. Calculate the intrinsic and extrinsic efficiency of the detector for this situation. **6**

(b) Define the Fano factor. What does it indicate about the performance of a radiation detector? Explain why the Fano factor for semiconductor detectors is typically less than one. **6**

(c) Define dead-time and response time in radiation detectors. Explain why gas detectors generally exhibit longer dead-time compared to scintillation detectors. **6**

4. (a) Explain the construction, working, and applications of a Geiger-Müller counter. **8**

(b) What is the fundamental principle behind the operation of bubble and cloud chambers for particle detection? **6**

(c) Discuss the role of polyatomic and electronegative gases in the operation of gaseous detectors. **4**

5. (a) Compare a typical inorganic scintillator, such as NaI(Tl), with a typical organic scintillator, such as a plastic scintillator, based on: mechanism of scintillation, density, response time, light yield, gamma-ray detection efficiency, and cost. **6**

(b) Explain the basic working principle of a semiconductor detector. Why do semiconductor detectors provide better energy resolution compared to gas-filled detectors? **6**

(c) Explain the principles of detection of slow (thermal) neutrons and fast neutrons. Describe the types of detectors used for each and the underlying interaction mechanisms involved. **6**

6. (a) Differentiate between Analog and Digital signal processing in the context of high-energy physics. Under what conditions is a Digital Pulse Processing system preferred? **6**

(b) Describe the sequence of NIM modules required to process a raw photomultiplier tube (PMT) pulse into a logic signal suitable for counting by a scaler. Illustrate the signal flow and briefly explain the function of each module involved. **6**

(c) Discuss the applications of radiation detectors in particle physics experiments. Illustrate your answer with suitable examples, and identify the types of detectors used in these experiments along with their specific roles. **6**