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1. Three measurements are made with a detector system and set of known sources to determine the system's dead time characteristics. For the purposes of this question assume that the detector system can be adequately represented by either a paralyzable dead time model or, alternatively, by a non paralyzable model. Three measurements are made with different source configurations. The Table shows the expected true count rate in the absence of dead time effects and the actual number of counts recorded in a 10 second interval.

A. Is the system best represented by a paralyzable or a nonparalyzable dead time model?

Expected count rate (no dead time) [counts per second]	Actual counts recorded in 10 sec
40000	245000
80000	299000
120000	274000

B. Based on the data, estimate the dead time per event. Please express your answer in microseconds.

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2. Suppose you set up a 1.5”x1.5” cylindrical NaI(Tl) detector so that its front face is 10 cm from a 1-microCurie ^{137}Cs point source. In this configuration, the detector’s intrinsic photopeak efficiency for 662-keV gamma rays is known to be 15%. How many 662-keV photopeak events do you expect to count in 1 minute of live time? You may assume a background count rate of zero.

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3. A. Explain the difference between intrinsic photopeak efficiency and absolute photopeak efficiency.

B. For any given setup, which is larger?

4. Express the geometric factor *G* in term of *w* and *d* for a detector with a square face of width *w* located a distance *d* from a point source. You may assume that $w << d$. Recall that in this class $G = \frac{\Omega}{4\pi}$ where Ω is the solid angle subtended by the detector.

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5. Gamma rays of energy 6.13 MeV are incident on a gamma detector.

A. At what energies do we expect to find the photopeak, first escape peak, second escape peak, and Compton edge?

B. Why does the Compton continuum have a high energy end point (the Compton edge)?

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6. A 10-stage photomultiplier tube (PMT) has a quantum efficiency (QE) of 30% for photons produced by the attached scintillator. Voltage is distributed to the PMT dynodes such that each of the 10 stages has the same multiplication factor (δ) of 4. If a radiation event causes a pulse of 100 photons (produced by the scintillator) to strike the photocathode, on average how many electrons do we expect to be collected at the anode? Assume that the dynode collection efficiency (α) is 1.

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7. In a counting experiment, a 10-minute measurement resulted in a statistical uncertainty of 2.8%. How much additional time must be allocated to reduce the statistical uncertainty to 1.0%?

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8. The background count from a detector was measured to be 845 over a 30-min period. A source-to-be measured increases the total counting rate to about 80 counts per minute. Estimate the time the source should be counted to determine the counting rate due to the source alone (i.e. after correction for background) to with a fractional standard deviation of 3%.

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9 (Bonus Question): In a given counter gas operated at a pressure of 0.5 atm, the mobility of a free electron is 0.05 (m/s)(m/V) atm. The threshold filed for the onset of avalanche formation is 2×10^6 (V/m). If this gas is used in a cylindrical tube with anode radius of 0.005 cm and cathode radius of 2 cm, calculate the drift time of an electron from the cathode to the multiplying region for an applied voltage of 1500 V.