EE119 Discussion Section 7

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I. Photomultiplier Tube

Example:

A PMT with 8 dynodes and $\delta = 5$ is used to detect a laser beam at $\lambda = 630nm$. The quantum efficiency of the PMT at this wavelength is ~50%. Assume the laser power incident on the PMT is 3×10^{-9}W.

- **Photoelectric effect**
  What is the maximum possible value of the work function of the photocathode?
- **Quantum efficiency**
  How many photo-electrons are generated at the photocathode per second?
- **Gain**
  What is the anode current?
- **Dark current**
  a) If the cathode dark current is found to be $5x10^4$e/sec at room temperature (300K), what is the minimum detectable power of this PMT?
  b) What would the cathode dark current be if you cool the PMT down to 200K? Does it suggest a way of reducing the dark current? What is the minimum detectable power now? How much improvement in the sensitivity of the PMT you've gained in cooling it down?
- **Shot noise; Poisson statistics; SNR**
  Given the same cathode dark current at 300K, what is the shot noise?
  What is the signal-to-noise ratio?
  Assume the bandwidth is 1Hz, which means that, the integration time is 1 sec.

II. Brief intro to semiconductor and p-n junction