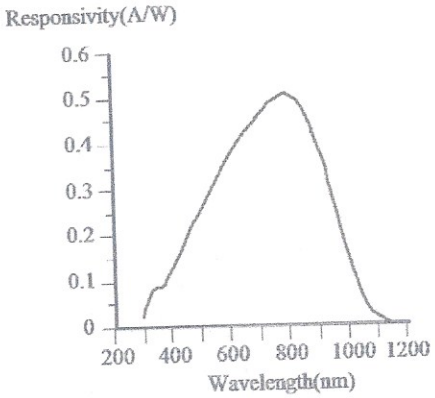
Problem 2.4 (37.5 points) (*Si pin photodiodes*) A Si pin photodiode has the following characteristics and responsivity:

Wavelength range [nm]	Active area diameter [mm]	Rise time [ps]	Junction capacitance [pF]	Dark current [pA]	NEP [W $Hz^{-1/2}$]
400 - 1100	1.25	300	24	40	9×10^{-14}
The reverse operation voltage for the photodiode is 100 V					



(a) Calculate the *i*-layer thickness for this device and the internal electric field for a reverse bias of 100 V ($\varepsilon_r \sim 11$).

(b) Given that for the electric field at point (a) the drift velocity for the charge carriers, is around $\sim 6 \times 10^4$ m/s, calculate the maximum drift time of the carriers across the i – layer.

(c) Compare the drift time of the carriers with the rise time specified for this device. Explain the discrepancy.

(d) What is the optimal load resistance to be used with this photodiode?

(e) What is the quantum efficiency of the device at 400 nm, 800 nm, and 1000 nm?

(f) Calculate the minimum light intensity for the three wavelengths that would produce a photocurrent signal at least equal with the dark current.

(g) This detector is used across the specified wavelength range to detect signals with a bandwidth of 100 MHz. What is the minimum power required for a SNR equal with at least 1?