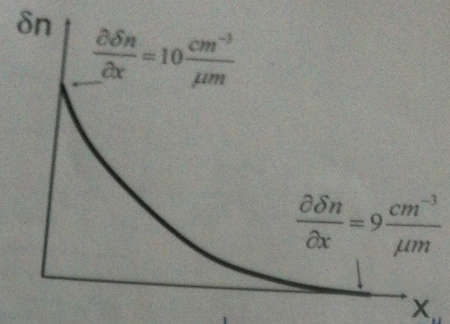
3) For the hypothetical density of electrons in this p-doped semiconductor, calculate the electron diffusion current density at the left and right sides of this semiconductor.



$D = 10\ cm^2/s = 10\ 10^{-4} \frac{m^2}{s}$

15 pts.
+5 pts. Plug in #s
+5+5 each right answer

$$\boxed{J = qD \frac{d\,\delta n}{dx}}$$

$= 1.6 \times 10^{-19} C \quad 10\ 10^{-4} \frac{m^2}{s} \quad \frac{10}{10^{-6} m\ (10^{-2} m)^3}$

$= 1.6 \times 10^{-19-4+1+6+6+1} \frac{C}{s\,m^2}$

$= 1.6 \times 10^{-23+14} \frac{A}{m^2} = 1.6 \times 10^{-9} \frac{A}{m^2}$

$= 1.6 \times 10^{-13} \frac{A}{cm^2}$

RHS $= 0.9 \times 1.6\ 10^{-9} \frac{A}{m^2}$

$= 1.44 \frac{A}{m^2} = 1.44 \times 10^{-13} \frac{A}{cm^2}$

2-D Density of States

In two dimensionsal structures such as the quantum well, the procedure is much the same but this time one of the k-space components is fixed. Instead of a finding the number of k-states enclosed within a sphere. The problem is to calculate the number of k-states lying in an annulus of radius **k** to**k** +d **k** . k-space would be completely filled if each state occupied an area of

$$V_{2D} = \left(\frac{2\pi}{L}\right)^2 \tag{13}$$

And the 'volume' of the annulus is given by

$$v_{s2D}\,\mathrm{d}\mathbf{k} = 2\pi|\mathbf{k}|\,\mathrm{d}\mathbf{k} \tag{14}$$

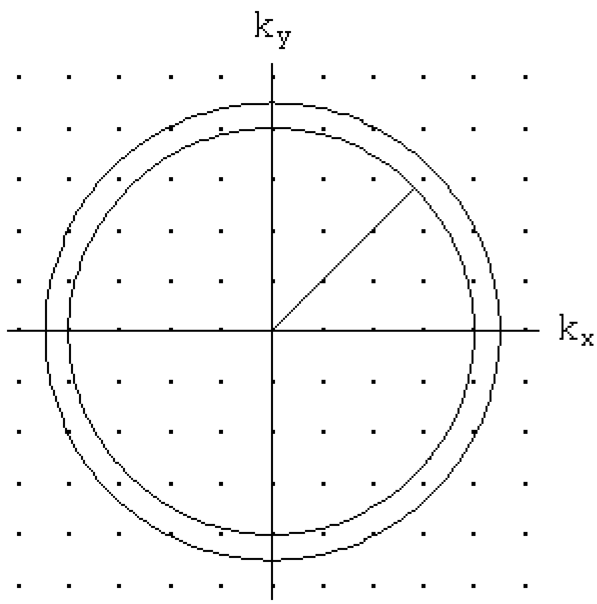


Figure 2 k-space in 2D. The density of states at an energy E is the number of k-states per unit volume contained with the annulus of radius k and thickness dk.

Dividing the 'volume' of the k-state by the area of the annulus gives and remembering to multiply by 2 to account for the electron spin states we get:

$$g(\mathbf{k})_{2D}\,\mathrm{d}\mathbf{k} = 2\times\frac{v_{s2D}}{V_{2D}} = \frac{|\mathbf{k}|\,\mathrm{d}\mathbf{k}L^2}{\pi} \tag{15}$$

Or in terms of energy per unit volume at an energy *E* .

$$g(E)_{2D}\,\mathrm{d}E = \frac{k\,\mathrm{d}k}{\pi} = \sqrt{\frac{2mE}{\hbar^2}}\left(\frac{2mE}{\hbar^2}\right)^{-\frac{1}{2}}\frac{m}{\hbar^2}\,\mathrm{d}E = \frac{m}{\pi\hbar^2}\,\mathrm{d}E \tag{16}$$

It is significant that the 2-d density of states does not depend on energy.

1) Consider a Haynes-Shockley experiment on a p-type silicon bar. If a pulse of electrons I injected at x=0, t=0, and of the maximum of the electron pulse reaches a probe at x= 100μm at t=10 ns, determine electron mobility and diffusion coefficient using whatever method you like. Assume that a voltage of 10 V is maintained between the two ends of the 1 cm long bar.

$$\mathcal{E} = \frac{10V}{1cm} = 10^{3} \frac{V}{m}$$

10pts

$$\boxed{\mu = \frac{x}{\mathcal{E}t}} = \frac{100(10^{-6}m)}{10^{3} V/m \quad 10(10^{-9}s)} = 10^{+2-6-3-1+9} \frac{m^2}{V-s} = \boxed{10 \frac{m^2}{V-s} = 10^{5} \frac{cm^2}{V-s}}$$

5pts

10pts

$$\text{Einstein} \quad \boxed{D = \mu \frac{KT}{q}} = 10 \frac{m^2}{V-s} \frac{1}{30} V$$

$$= \frac{1}{3} m^2/s = 0.3 \ m^2/s = 3\ 10^{-1} \frac{m^2}{s}$$

$$= \boxed{3\ 10^{3} \frac{cm^2}{s}}$$

5pts