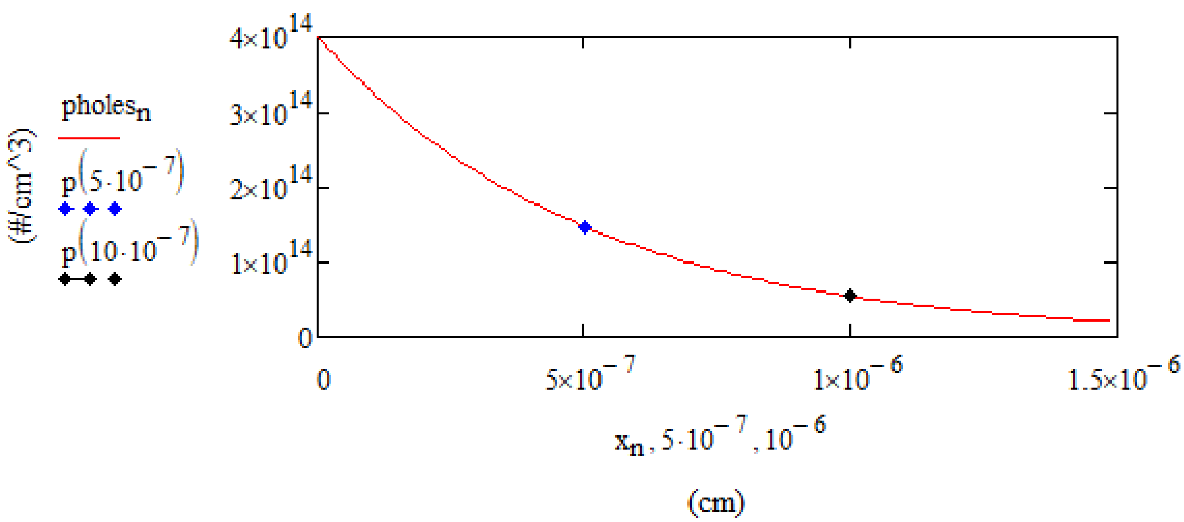
Example

A *p*-type semiconductor has a hole diffusion coefficient of 2.4 cm^2/s and a hole concentration of $p(x) = 4\times 10^{14} e^{-x/5\times 10^{-7}}$ $(\#/cm^3)$ where *x* (cm). First, plot *p*(*x*). Then, find the hole diffusion current density at $x = 0^+$, 5 nm (5×10^{-7} cm), & 10 nm (10×10^{-7} cm).

Given: $p(x) := 4\cdot 10^{14}\cdot \exp\left(\frac{-x}{5\cdot 10^{-7}}\right)$ ($\#/cm^{-3}$) where *x* is in cm.

$n := 0 .. 149$ $\qquad x_n := n\cdot 10^{-8}$ $\qquad pholes_n := p(x_n)$



- From graph, we expect the diffusion current density to flow in the +*x*-direction, i.e., from higher hole concentration to lower.
- Since the slope of *p*(*x*) decreases as *x* increases, we expect the diffusion current density to get smaller as *x* increases.

$$J_{px|diff} = -eD_p \frac{d\,p(x)}{dx} = -1.602\times 10^{-19}\text{ C }(2.4\,\text{cm}^2/\text{s}) \frac{d\left(4\times 10^{14} e^{-x/5\times 10^{-7}}\,\#/\text{cm}^3\right)}{dx}$$

Per (5.34),
$$= -1.6022\times 10^{-19}\text{ C }(2.4\text{ cm}^2/\text{s}) \frac{4\times 10^{14} e^{-x/5\times 10^{-7}}}{-5\times 10^{-7}}\,\#/\text{cm}^4 .$$

$$= 307.6224 e^{-x/5\times 10^{-7}}\text{ A/cm}^2 \text{ w/ } x \text{ in cm}$$

$J_{px|diff}$ (x = 0) = 307.6 A/cm^2,

$J_{px|diff}$ (x = 5×10^{-7} cm) = 307.6224 e^{-1} = 113.2 A/cm^2, and

$J_{px|diff}$ (x = 10×10^{-7} cm) = 307.6224 e^{-2} = 41.6 A/cm^2.