An ideal germanium pn junction diode at 300 K has a reverse-saturation current $I_s = 8$ pA. a) Calculate the small-signal diffusion resistance r_d for an applied forward bias voltage of 30 mV. b) Calculate r_d for an applied reverse bias voltage of -30 mV.

Per (7.10) at 300 K, the thermal voltage is

$$V_t = \frac{k_B T}{e} = \frac{8.617333\times10^{-5}\ \text{eV/K}\,(300\,\text{K})}{e} = 0.025852\ \text{V}.$$

Per (8.67), $g_d = \frac{1}{V_t} I_s e^{V_0/V_t} = \frac{1}{0.025852} 8\times10^{-12} e^{V_0/0.025852} = 3.0945381\times10^{-10} e^{V_0/0.025852}$.

a) w/ $V_0 = 30$ mV, $g_d = 3.0945381\times10^{-10} e^{0.03/0.025852} = 9.87583\times10^{-10}$ S.

$r_d = 1/g_d = 1/9.87583\times10^{-10}$ $\Rightarrow$ <u>$\boldsymbol{r_d = 1.0126\times10^{9}\ \Omega = 1.0126\ \text{G}\Omega}$.</u>

b) w/ $V_0 = -30$ mV, $g_d = 3.0945381\times10^{-10} e^{-0.03/0.025852} = 9.6965675\times10^{-11}$ S.

$r_d = 1/g_d = 1/9.6965675\times10^{-11}$ $\Rightarrow$ <u>$\boldsymbol{r_d = 1.0313\times10^{10}\ \Omega = 10.313\ \text{G}\Omega}$.</u>