1. Suppose you have a metal/oxide/p-type-silicon sandwich which forms a capacitor as shown.

   a) Sketch qualitatively the AC capacitance ($dQ/dV$) as the voltage is scanned from -10V to +10V. (This is the so-called CV curve.)

   b) Identify the key points on the voltage axis and explain what is happening in the silicon in various voltage ranges. (You do not need to calculate any numerical values nor write any formulas.)

   c) Why are modern MOSFET’s made with thinner and thinner gate oxides? (i.e. what are the specific effects of the thinner gate oxides on device performance.)
2. a) Suppose you have an n-type silicon slab doped with $10^{17}$ donors/cm$^3$ as shown. The mobility of the silicon is $1250 \text{cm}^2/\text{V-sec}$. There is an ohmic contact on each end of the sample. What is the end-to-end resistance between the contacts? 

![Diagram of n-type silicon slab](image1.png)

b) Suppose you have the same n-layer mounted on a p-type substrate doped with $10^{17}$ acceptors/cm$^3$. Assume no current flows across the p-n junction. Would you expect to measure the same resistance as in part a) if you apply a low voltage, say $V = 1 \text{mV}$ as shown? Why or why not? 

![Diagram of n-layer on p-type substrate](image2.png)

c) Suppose you apply a higher voltage, say $V = 2 \text{V}$, would you measure the same resistance as in part a) or part b)? Explain. (Assume the temperature remains constant)
3. Suppose you have a bipolar transistor with I-V characteristics shown connected in the circuit on the left.

a) If the base-to-emitter voltage, $V_{BE}$, is 0.7V, what is the base current, $I_B$?

b) Suppose you adjust the values of $V_{BB}$ and/or the base resistor $R_B$ so that the base current is 0.06mA.

   i) Given the I-V characteristic what is the collector current, $I_C$ for $V_{CE} > 10V$?
   ii) What is the emitter current?
   iii) What is the collector voltage, $V_{CE}$?

c) Why is the collector of a bipolar transistor lightly doped?

d) In the IV characteristics plotted above the collector current curves are shown horizontal past a certain collector voltage. In reality the curves have a slight upward (positive) slope. What happens in the bipolar transistor to produce this upward slope.
Expression with R consistent.

Fig. 1 - Graph. The data

Obtaining the graph function and

Therefore, obtaining the function

The function will be shown next.

2.5 The interation at V + end 0.

Reduce the interaction function.

Graph or graphs will follow.

2.6 Further will be lighter.

\[ R = 1.25 \times 10^{-4} \, \text{cm} \]

\[ \frac{V}{W + 0.5 \, \text{cm}} = \frac{0.05}{10} \]

\[ R = \frac{10}{0.05} \, \text{cm} \]

2.7 0.05 cm

\[ A \times \text{cm}^{2} = 1.25 \times 10^{-4} \, \text{cm}^{2} \]

\[ \frac{t}{\text{cm}^{2}} = \frac{8}{1} = \rho \, \text{cm}^{2} \]

\[ 10 \, \text{cm}^{2} \]

\[ \frac{c}{\text{cm}} \]

\[ \text{cm}^{-1} \]

\[ 10 \, \text{cm}^{2} \]

\[ \frac{c}{\text{cm}} \]

\[ \text{cm}^{-1} \]

\[ \text{cm}^{2} \]

\[ \frac{c}{\text{cm}} \]

\[ \text{cm}^{-1} \]

\[ \text{cm}^{2} \]

\[ \frac{c}{\text{cm}} \]

\[ \text{cm}^{-1} \]

\[ \text{cm}^{2} \]

\[ \frac{c}{\text{cm}} \]

\[ \text{cm}^{-1} \]

\[ \text{cm}^{2} \]

\[ \frac{c}{\text{cm}} \]

\[ \text{cm}^{-1} \]
3. (a) $V_{BE} = I_0 R_0 + V_E$