**BJT Lab – Worked out problem**

**(** <http://nanohub.org/tools/bjt> )

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Q1) Simulate the npn BJT transistor as shown in Fig. 1 using [‘BJT Lab’](http://www.nanohub.org/tools/bjt) at nanoHUB and calculate the following characteristics,

1. Early Voltage.
2. βDC parameter while operating at *ibase*=2µA VCC=20V and RLOAD=200kΩ.
3. Output Resistance.
4. Specify the active and saturation region in the output characteristic curve.

10µm

5µm

Collector

Emitter

Base

Emitter

ND = 1e19/cm3

τ = 0.1µs

NA = 1e16/cm3

τ = 1µs

ND = 1e15/cm3

τ = 0.1µs

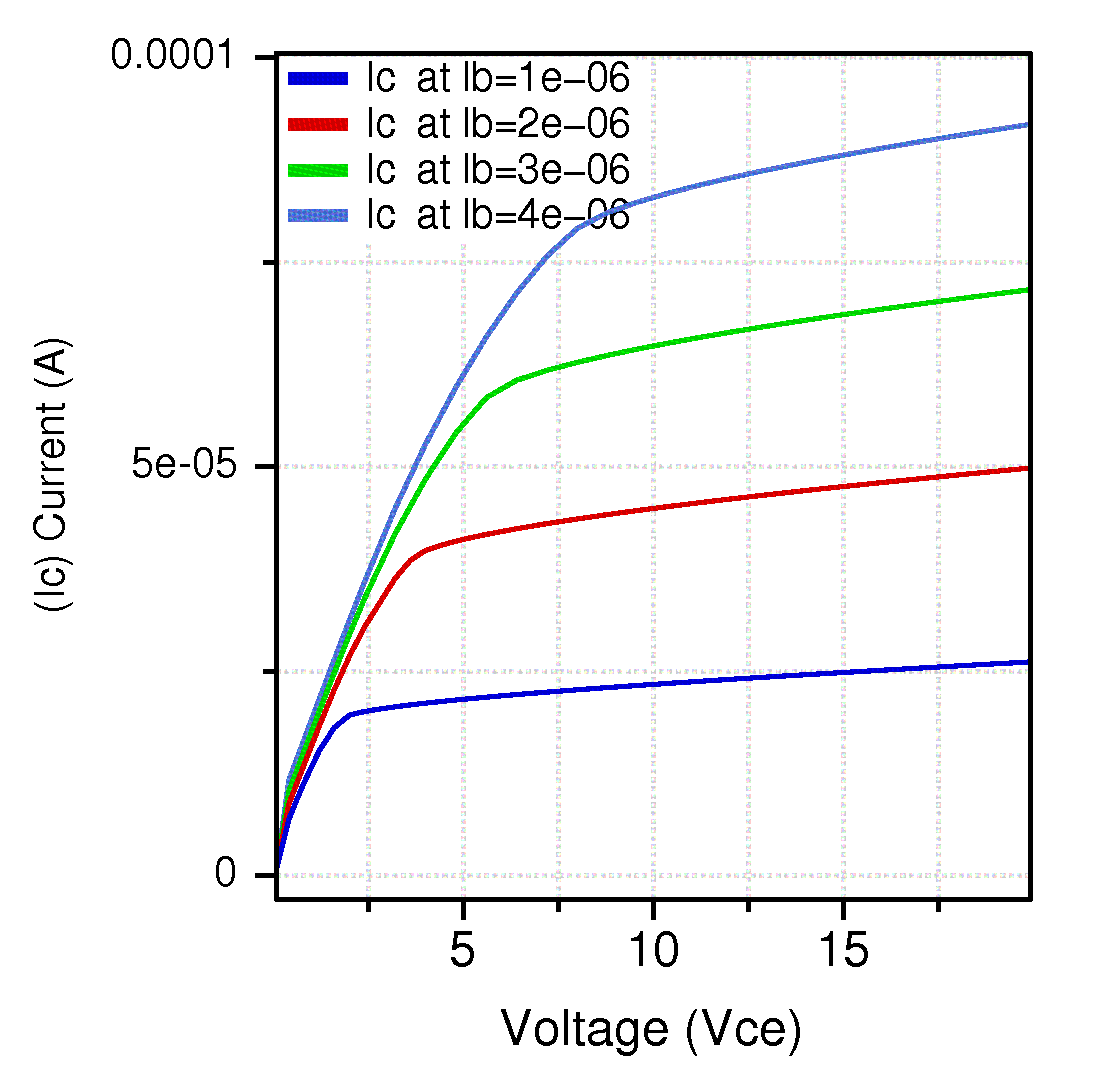
25µm

1µm

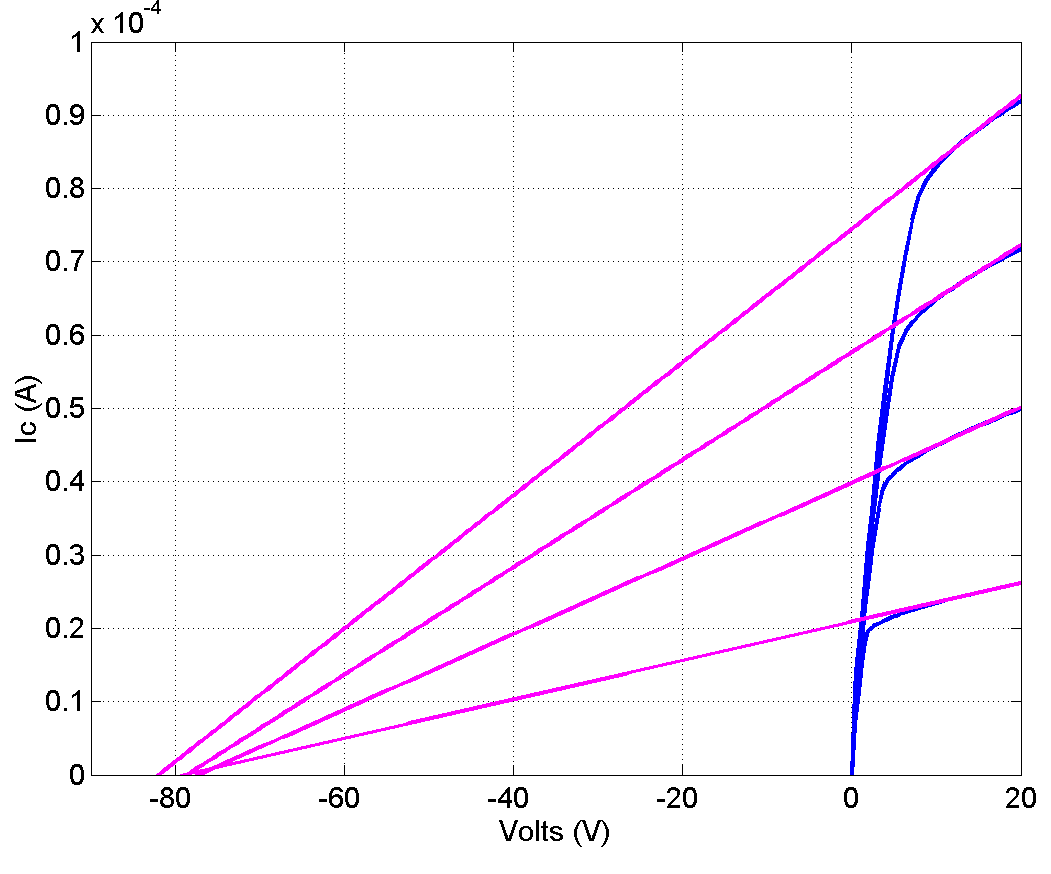
4µm

Answer)

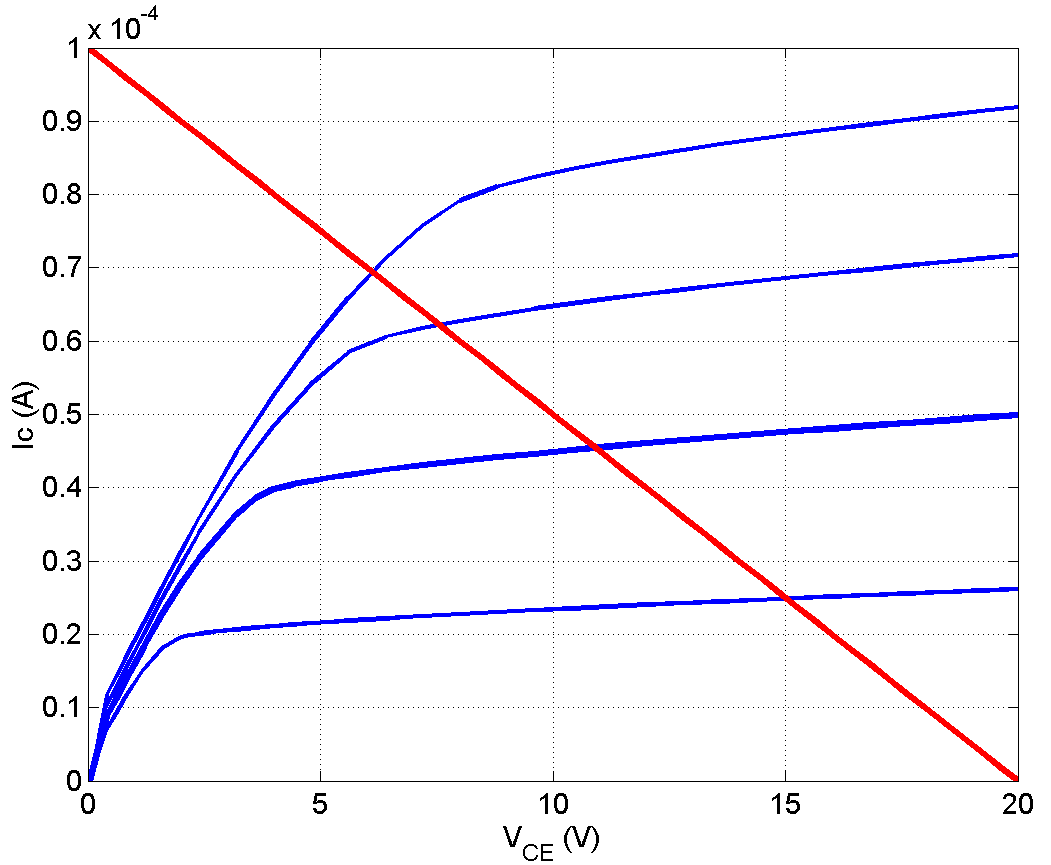
Simulation the above BJT design using BJT lab gives the following output characteristics.



(a) Early voltage can be estimated by extrapolating the linear regimes of the output curves as shown below. Early voltage is found to be **VEarly ~ 80 V**



(c) βDC can be calculated by plotting a load line to obtain the operating point as shown below. **βDC=*ic*/*ib*=** 45.4µA/2µA**= 22.7**

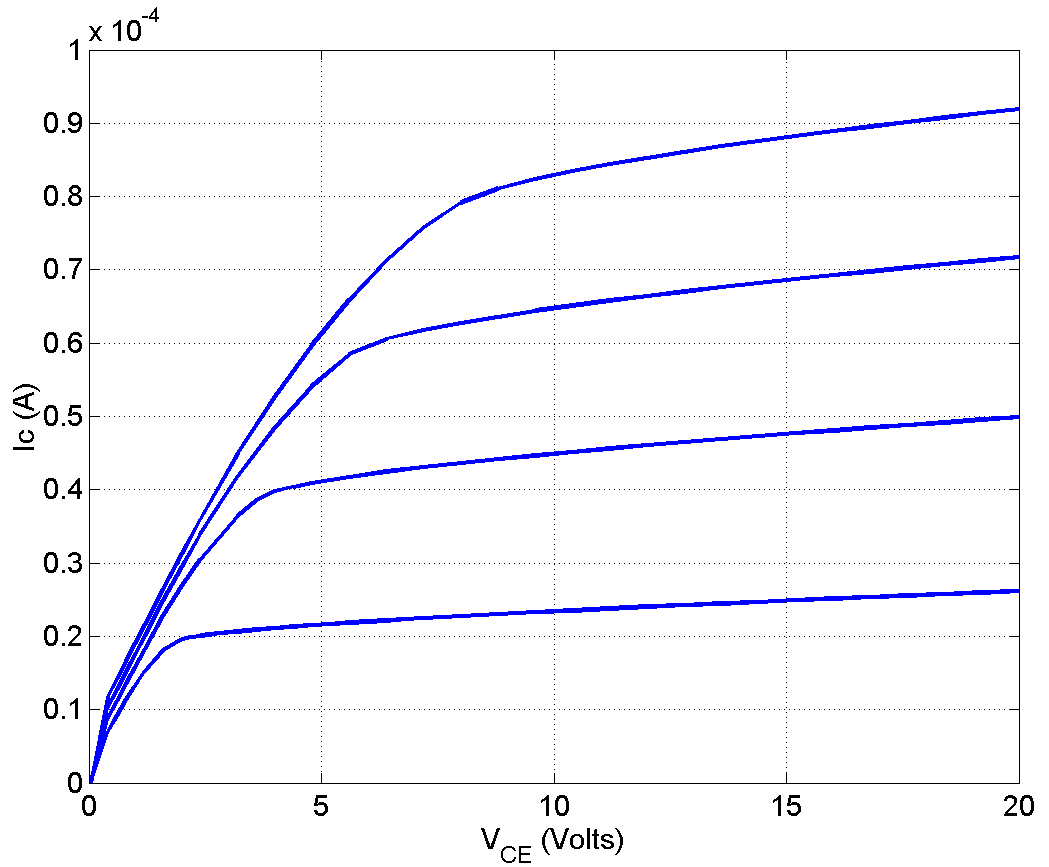


Operating point

(c) Output resistance at the operating point ro= (Vearly+VCE)/ *ic* ~ (80+11)/45.4µA

or **ro ~ 2 MΩ**.

(d) Active and Saturation regions are marked on the Ic-VCE plot below.



Saturation Region

Active Region