PHYS 202L Transistor and Measuring e/k Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. [Fundamental constants](http://hyperphysics.phy-astr.gsu.edu/hbase/tables/funcon.html) are used extensively in the sciences. Can you name the one we already measured in one of the labs this semester?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
In this lab we will measure the ratio of two fundamental constants, namely e/k, using a transistor.  
Record the e (electron charge) and k (Boltzmann constant) values from the above link, in the data table on page 4. These values will be used to calculate the accepted value of e/k.

2. Watch the following video for an introduction of [Transistor](https://www.youtube.com/watch?v=IcrBqCFLHIY), and answer the following questions:

a. Where can you find transistors?

b. What is a transistor?

c. What is a semiconductor?

d. What is doping in semiconductor technology?

d. What is an n-type semiconductor?

e. What is a p-type semiconductor?

f. What is a hole in semiconductor terminology?

g. Number of valence electrons in Silicon\_\_\_\_\_, Phosphorous\_\_\_\_\_\_, and Boron\_\_\_\_\_\_\_.

h. What is Moore’s law?

II. hFE (or β) of a transistor: (<http://www.learningaboutelectronics.com/Articles/What-is-hfe-of-a-transistor>)

hFE of a transistor is the current gain or amplification factor of a transistor.

hFE (which is also referred to as β) is the factor by which the base current is amplified.

A transistor works by feeding a base current into the base of the transistor. The base current (IB) is then amplified by hFE to yield its amplified collector current (IC).   
  
 IC = hFEIB or IC = βIB

So, if 1mA is fed into the base of a transistor and it has a hFE of 100, the collector current will be 100 mA. Every transistor has its own unique hFE. The hFE is normally seen to be a constant value, normally around 10 to 500, but it may change slightly with temperature and with changes in collector-to-emitter voltage.

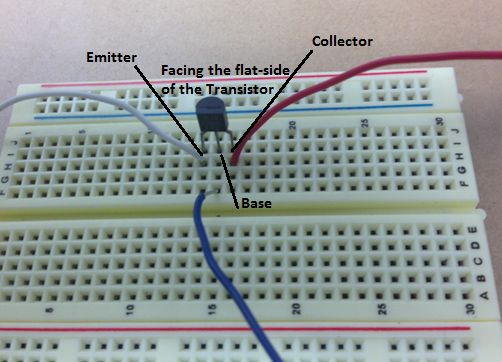
In this activity; emitter (E), base (B), and collector (C) of the transistor are identified and its value is measured for a PNP transistor, as shown below, using the blue digital multimeter (DMM). Its value, hFE = β = 196.

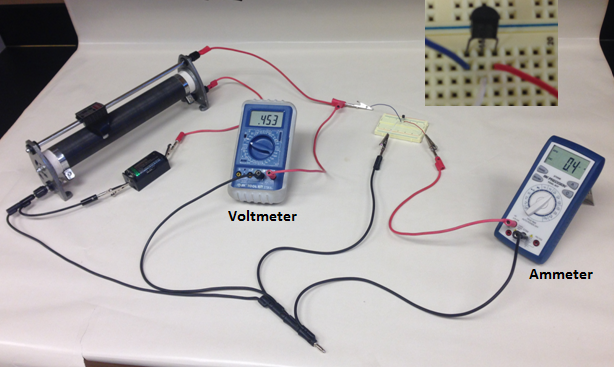
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III. Purpose: Experimentally measure e/k, where e is the electronic charge and k is the Boltzmann’s constant, and compare it with the accepted value.

Apparatus: Temperature sensor, PNP transistor, proto-board, 2-digital-multimeters (A and V), rheostat, D-cell battery w/holder, 3 proto-board wires, 5 alligator clips, 4 red banana plug wires, and 4 black banana plug wires.

The figure below shows how to insert and connect a transistor in a breadboard.



The figure below shows the circuit diagram to measure the emitter-base voltage, V [0.453 V] and collector- current, I [0.4 µA]. Connect similar polarities: + of the battery with + of the meter.  
Circuit set-up video: <https://www.youtube.com/watch?v=g1IKqPv2GGc&t=33s>

Procedure:

1. Set up the above circuit. V: 2V DC, A: DC µA, and slider at the bottom.   
2. Slide up the control in the rheostat until the ammeter reads a very low current, say 0.5 µA.   
3. Record the voltage, V and current, I in the data table.  
4. Increase the current and collect I and V data. [About 30 set of data, evenly spread with the voltage, until the current reaches about 50 µA]. Record the data from the video.  **DATA collection video:** <https://www.youtube.com/watch?v=zGbUn1fzmEU&t=141s>  
 Don’t use the first 5 data points, start with (0.47 V, 0.8 μA) and finish it with (0.582 volt, 50.3 μA)  
5. The current (*I*) and the voltage (*V*) are related by the following equation: (where *k* is the Boltzmann constant, *e* is the electronic charge, and *T* is the temperature in K)  
 or   
6. Plot I *versus* V, fit the data with an appropriate Trendline, and obtain  
*I0* and e/kT from the trendline equation.   
7. Manipulate the above equation and identify the variables for a linear plot.

DATA TABLE

|  |  |
| --- | --- |
| Voltage (V) | Current (µA) |
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8. Calculate the new variables, plot the linear graph, and obtain *I0* and e/kT.  
9. Measure the room temperature, use it with the above slope, and calculate e/k.  
10. Attach your plots, and write a conclusion for part III.

DATA (Include Units):   
  
Magnitude of electron charge = e = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Boltzmann constant = k = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Room temperature = T= 27.00C = \_\_\_\_\_\_\_\_\_K

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *I0*  ( ) | ( ) | e/k ( ) | | % Error |
| Measured | Accepted |
| From I VS. V graph |  |  |  |  |  |
| From linear graph |  |  |  |  |  |