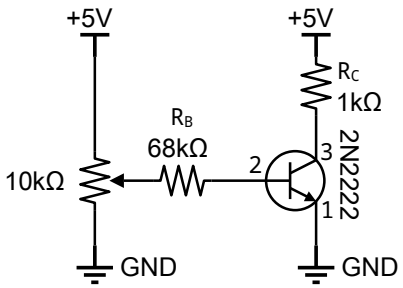
Activity: BJT – Measuring H_{fe}

Required Components

Power Supply: 5 Volt
Potentiometer: 1kΩ
Resistor: Two 1kΩ
Transistor: 1N2222 (or similar NPN BJT)



Procedure

1. Assemble the circuitry shown in the figure to the right.
2. While measuring the voltage across the base resistor, V_{RB}, adjust the potentiometer until the voltage measures within about 0.02 volts of one of the voltages given in the column for ideal V_{RB} in the table, below. Record the exact measured voltage in that row of the table.
3. Without changing the setting of the potentiometer, measure the voltage across the collector resistor, V_{RC}, across the transistor base-emitter, V_{BE}, and across the base-collector, V_{CE}. Record each of the measured voltages in the same row of the table.
4. Repeat steps 2 and 3 in sequence until the all cells of the table contain values. For the column labeled "`max`", turn the potentiometer fully to the side that maximizes the voltage across the base resistor.

V_{CC} [ ] R_B [Ω] [ ] R_C [Ω] [ ]

Ideal	Measured [Volts]				Calculated		
V_{RB}	V_{RB}	V_{RC}	V_{BE}	V_{CE}	I_B [μA]	I_C [mA]	H_{fe}
max							
4.0V							
3.0V							
2.0V							
1.5V							
1.25V							
1.0V							
75mV							
50mV							
25mV							
0V							

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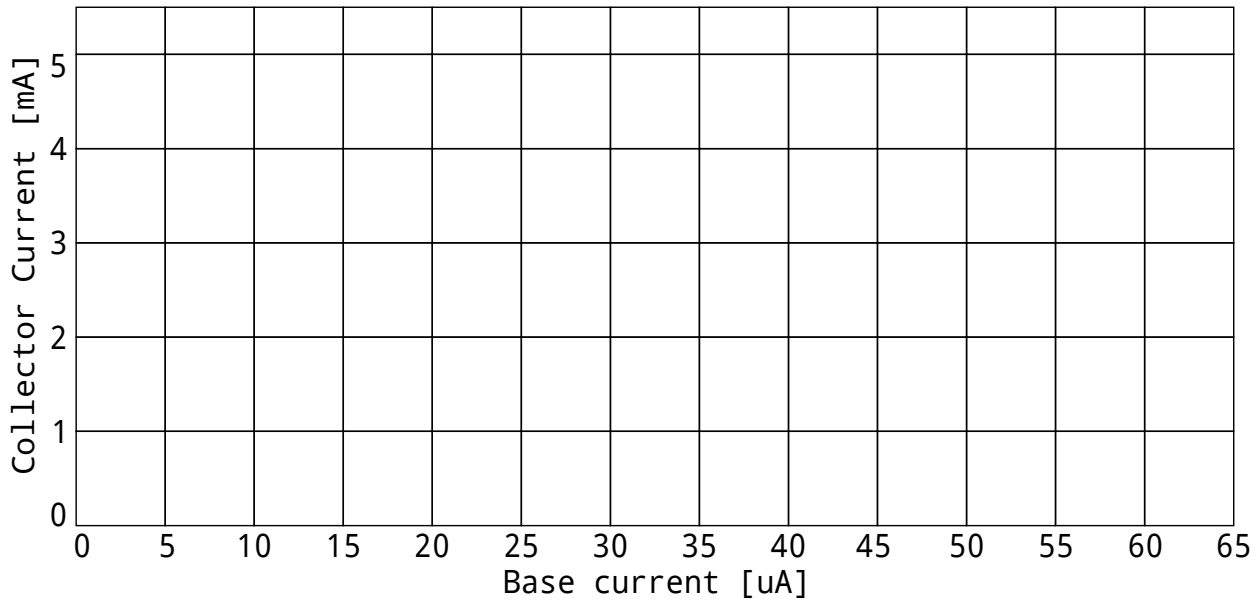
Analysis

1. Plot the points for the calculated transistor base current versus the transistor collector current on the graph, below. Add a title to the graph.
2. The graph should have two approximately linear regions: the points on the right side of the graph should approximate a near horizontal line, while the points on the right approximate another straight line that is sloped upwards to the right. Use a ruler or straight edge to fill in the expected values of the unmeasured points.



3. The region on right (with the near horizontal straight line) is the ***saturation region***. In this region, the transistor collector-emitter resistance is nearly as close to zero as the transistor can get. In our experimental circuit, the current through the circuit will depend on the voltage and the resistance connected to the collector:

$$I_C \approx \frac{V_S}{R_C}$$

Since we are using a 5V supply and a 1kΩ resistor, the ***saturation current*** will be approximately 5mA.

4. In the box below, show your calculations for the slope of the line you drew for the region on the left.

5. The value you have calculated is the ***gain*** , h_{fe}, of the transistor. For every unit of current going into the base, you have h_{fe} times that amount going into the collector.

$$I_C = h_{fe} \times I_B$$

6. Compare your value of h_{fe} to the value obtained by your classmates. One problem with bipolar junction transistors is that it is difficult to accurately set the gain of the transistor during manufacture. Next we will learn how to use these transistors in circuits so that the variation in the gain of the transistor minimally affects the operation of the circuit.