1. (2 points) What does a transistor do? What is an example of a practical use of a transistor in a mechatronic application? What are some indicators that a transistor might be necessary in a certain application?

   A transistor is a current controlled switch or a current amplifier. It is used whenever a high current load needs to be controlled by a computer. (Could also be used to control a high voltage load, such as using a 5V DC computer signal to turn 120V AC devices on and off.)
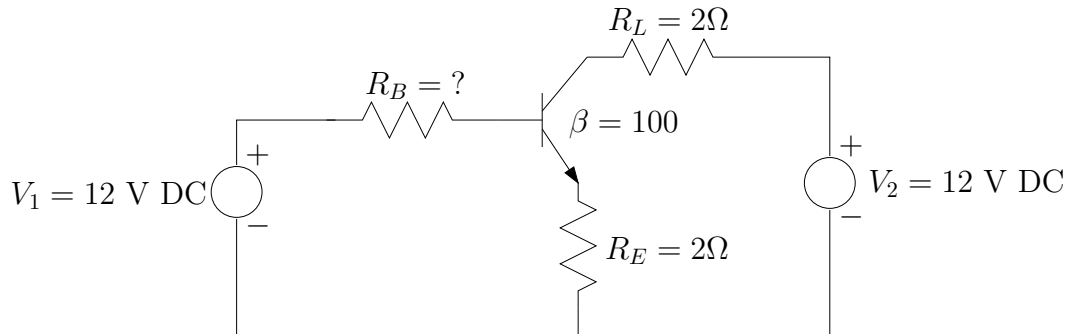
2. (4 points) If the magnification factor for the transistor is $\beta = 100$, what resistance R_B should be used in the above circuit to ensure that the transistor is fully saturated? (Assume the transistor is real NOT ideal).

   KVL for right loop:
   $$12 - R_L i_c - V_{ce} - R_E i_e = 0 \tag{1}$$

   KVL for left loop:
   $$12 - R_b i_b - V_{BE} - R_E i_e = 0 \tag{2}$$

   $$i_c = \beta i_b \tag{3}$$
   $$i_e = i_c + i_b \text{ or } i_e = i_c(1 + \frac{1}{\beta}) \tag{4}$$
   $$V_{ce} = 0.2 \tag{5}$$
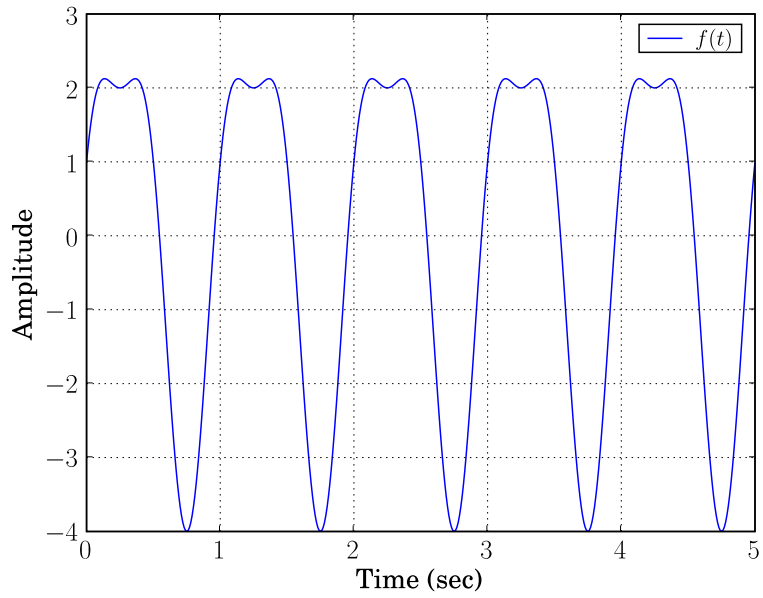 $$V_{be} = 0.7 \tag{6}$$
   $$\beta = 100 \tag{7}$$

   Substituting (4), (5), and (7) into (1) gives
   $$11.8 = R_L i_c + R_E 1.01 i_c \tag{8}$$

   or $i_c = 2.935$ A. Knowing i_c gives $i_e = 2.9647$ A and $i_b = 0.02935$ A. Plugging i_e and i_b into (2) gives
   $$0.02935 R_b = 5.3706 \tag{9}$$

   or $R_b = 182\Omega$.

3. (4 points) In the above graph, $f(t) = 3.0 \sin (2\pi t) + \cos (4\pi t)$. What is the fundamental frequency ω_0? What are the Fourier coefficients a_1, b_1, a_2, and b_2?

$\omega_0 = 2\pi$ rad/sec of 1 Hz

$$\begin{aligned} a_1 &= 0 \\ b_1 &= 3 \\ a_2 &= 1 \\ b_2 &= 0 \end{aligned}$$