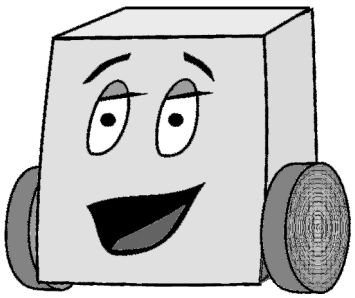


E11: Autonomous Vehicles

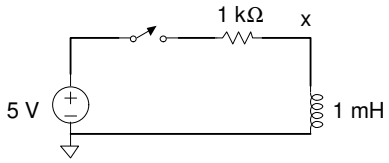
Fall 2011

Harris & Harris

Problem Set 7: First Order Circuits & Transistors

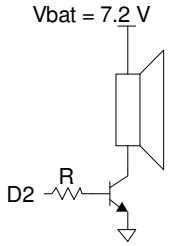
1. LR Circuit

In the following circuit, the switch is closed at time 0. Develop a differential equation for the voltage at node x as a function of time, and plot the voltage from t = -1 μs to 5 μs.



2. Speaker Driver

You have concocted a plan to mount an 8-Ω speaker atop your bot and send it careening around the field blasting out Ride of the Valkyries. The speaker draws too much current to operate off of the microcontroller, so you are planning to drive it with an NPN transistor using the circuit below:



Recall that an NPN transistor has three terminals: base, emitter, and collector. The base to emitter junction forms a diode, which turns on when approximately 0.6 V is applied. The transistor behaves as a switch, allowing a large amount of current to flow from collector to emitter when the transistor is ON. Specifically, the ratio of collector current to base current is called β. This rule applies as long as the transistor is not saturated. If the collector voltage falls to approximately the same as the emitter voltage, the transistor saturates and the collector current ceases to increase with base current. The data sheet for your silicon NPN transistor specifies a value of β between 50 and 200; the exact value depends on manufacturing details and varies from one transistor to another.

The speaker can be modeled as an 8-Ω resistor.

The concept is that when the Arduino pin D2 is 0, no current will be delivered to the speaker. When pin D2 is 1, current will flow through the speaker.

a) What is the maximum power that can be applied to the speaker when D2 = 1?

b) What is the largest value of R that you could choose while ensuring maximum power is applied to the speaker? Your answer should work for all possible values of β within the transistor specifications.

c) Using your value of R from part (b), how much current must the Arduino be able to put out on pin D2? Assume the value of β that gives the worst-case answer.