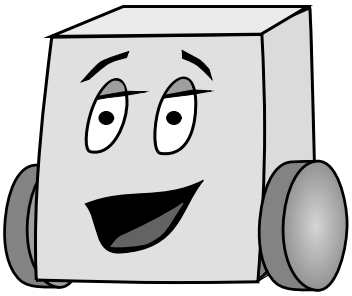


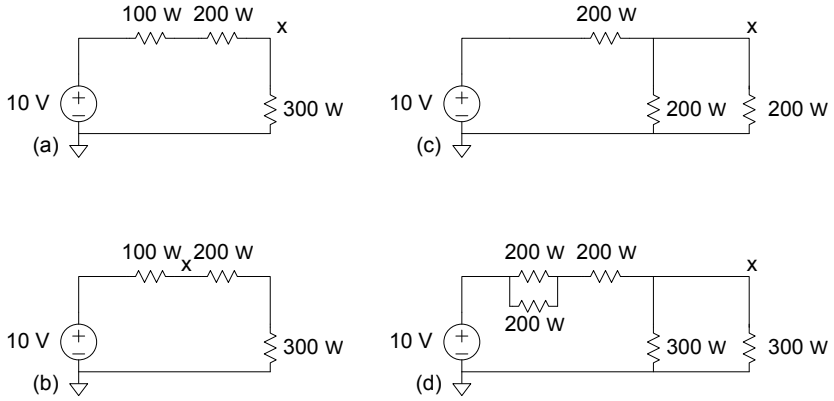
E11: Autonomous Vehicles

Fall 2014

Problem Set 7: Electronics

1. Resistor Circuits

Find the voltage at node *x* in each of the following circuit. (Hint: series and parallel combinations and the voltage divider equation found from applying KCL can make this doable by inspection.)



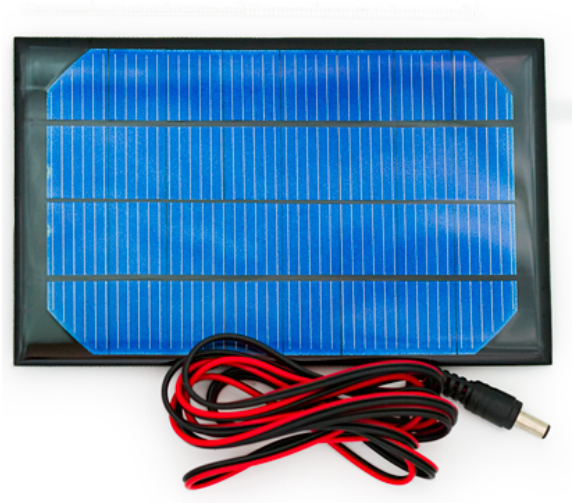
2. Solar Panel

You are considering replacing the pesky battery on your autonomous vehicle with a solar panel so that it can undertake a lengthy foray to raid the Caltech cannon. The solar cell has the nonlinear current-voltage profile given in the following figure. Assume that you can model the rest of your autonomous vehicle as an equivalent resistance, R_{bot}.

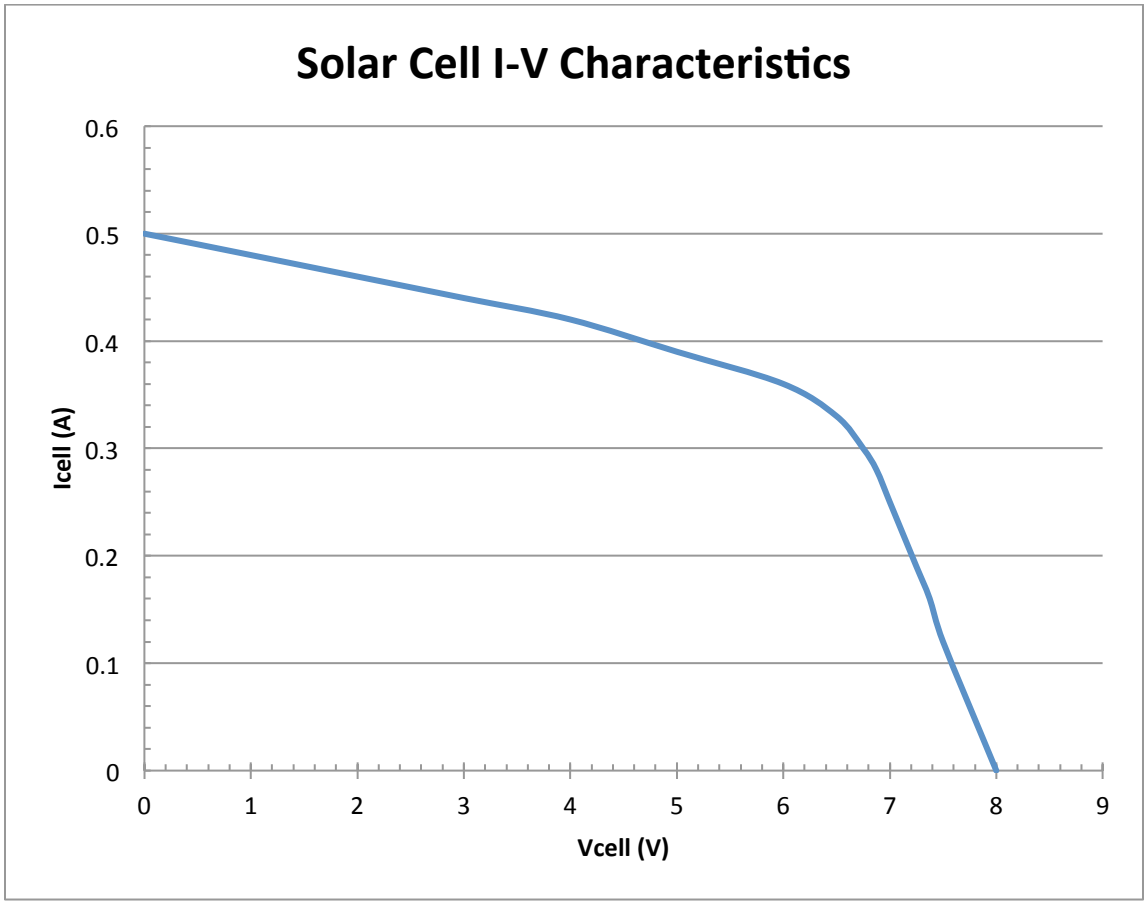
a) If the robot looks like a short circuit ($R_{bot} = 0$), how much current, I_{bot}, will it draw from the solar cell? How much voltage, V_{bot}, will it receive? How much power, P_{bot}, will it obtain from the solar cell?

b) If the robot looks like an open circuit ($R_{bot} = \infty$), determine I_{bot}, V_{bot}, and P_{bot}.

c) What is the equivalent resistance, R_{bot}, that maximizes the power delivered to the robot? What is I_{bot}, V_{bot}, P_{bot}?

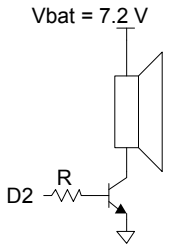


Solar Cell (source: sparkfun.com)



3. 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 hook it up to the battery and 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.

When the Arduino pin D2 is set to 0, no current will be delivered to the speaker. When pin D2 is set to 1, current will flow through the speaker.

a) What is the maximum power that can be applied to the speaker when D2 = 1? You may assume that the transistor saturates at a very low (negligible) collector voltage.

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. Note that D2 will be at 5V, as it is coming from the Arduino pin.

c) The Arduino can put out up to 40 mA. Based on your answer to part (b), will this speaker/transistor pair operate within this limit?

5. Submission

Turn in your assignment on paper at the start of class.