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conductivity sensor implementation

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conductivity measurement circuit

- we use the same voltage divider circuit used earlier for the photoresistor circuit
 $\Delta V / \text{conductivity sensor} + \Delta V / 10\text{k}\Omega \text{ resistor} = 5 \text{ volts}$
- what happens to the electrical resistance of the water as it becomes more salty?
it decreases
- if the resistance of the salt water decreases, then what happens to the voltage drop across the conductivity sensor?
it decreases
- if the voltage drop across the conductivity sensor decreases, then how does this influence the voltage drop across the 10k Ω resistor?
it increases
- so, increasing the salinity of the water causes the analog input read by the Arduino to **increase** or **decrease**?
0 to 1023

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what happens when salt is added to water????

- The ionically bonded NaCl molecules dissociate into Na⁺ and Cl⁻ ions and become mobile
- they are surrounded by polar water molecules (they are hydrated)

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applying voltage to induce electron flow

electrons are really not directly conducting through the water from one electrode to the other (like when electrons move through a copper wire)

reduction occurs at the negatively charged cathode:

$$2 H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$

oxidation occurs at the positively charged anode:

$$2 Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$$

It seems like a Na^+ would accept an electron and be reduced... why not???

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why is H_2O reduced and not Na^+ ???

	Electrode Reduction Half-Reaction	Voltage Output (when electrode is coupled with a 1.0M H^+ ion solution using a platinum electrode)
increasingly inert	$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87 V
	$H_2O_2(aq) + 2H^+ + 2e^- \rightarrow 2H_2O(l)$	+1.78 V
	$Au^+(aq) + 2e^- \rightarrow Au(s)$	+1.52 V
	$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36 V
	$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40 V
	$Cu^2+(aq) + 2e^- \rightarrow Cu(s)$	+0.34 V
	$2H^+ + 2e^- \rightarrow H_2(g)$	0.00 V
	$Ni^2+(aq) + 2e^- \rightarrow Ni(s)$	-0.25 V
	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
	$Al^3+(aq) + 3e^- \rightarrow Al(s)$	-1.66 V
increasingly active	$Na^+(aq) + e^- \rightarrow Na(s)$	-2.71 V
	$Li^+(aq) + e^- \rightarrow Li(s)$	-3.04 V

reactions further down in the table are less likely to occur

half-cell reaction in Table 1 | 1.0M solution of the ions | reference half-cell

- reactions with positive voltages will occur spontaneously
- you must apply external voltage across the electrodes to make a reaction with negative potential occur

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the net reaction of conductivity system

	Possible Half-Reaction	Reference Voltage
1	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
2	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	-1.36 V (direction & sign swapped)
3	$Na^+(aq) + e^- \rightarrow Na(s)$	-2.71 V

the net reaction occurring in the system is...

anode	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	-1.36 V
cathode	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
net reaction	$2Cl^-(aq) + 2H_2O(l) \rightarrow Cl_2(g) + H_2(g) + 2OH^-(aq)$	-2.19 V

- we must apply at least 2.19 V to the conductivity circuit to drive the reaction
- applying 5 V is sufficient, and higher voltages will increase the rate of oxidation & reduction reactions

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system wiring

digital output = 5V when HIGH
(set light permittivity to measure conductivity)

analog input
(measure voltage across 10k resistor)

10 k Ω
