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UNIVERSITY OF ILLINOIS
EXTENSION



College of Agricultural, Consumer and Environmental
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LESSON PLAN

Title: *Exploring Electricity, Advanced DC*

Lesson Level: *Advanced*

Time Frame: *One hour*

Objectives: *The student will explore Advanced Direct Current, with supervision and instruction, and accompanying slide presentation from CD Rom, "Electrifying Experiments".*

Supply List: *One 6-volt battery, One single pull, single throw switch (SPST), One double pull, double throw switch (DPDT), Two single pull, double throw switches (SPDT), Two 6-volt miniature lamps, Two 6-volt miniature bulbs, black wires, red wires & white wires (18/20 AWG).*

(Note Each section of this lesson builds on the previous section. Do not allow students to dismantle their circuit until instructed.)*

Beginning Narrative: Today we are going to:

Electricity Kit Lesson Plan for use with CD Rom, Electrifying Experiments, Lesson Three, Advanced DC.

- 1.) Identify different types of switches and their symbols
- 2.) Define SPST, SPDT, and DPDT
- 3.) Review basic circuits- simple, simple switch, series and parallel circuits.
- 4.) Build a Selector Switch circuit
- 5.) Add an Interlock or safety switch
- 6.) Build a 3-way switch control circuit
- 7.) Build a 3-way and 4-way switch control circuit
- 8.) Look at another application for a DPDT switch

| Slide | Step by Step Guide / (Narrative in bold) | What You Do or Show | What Participants Do |
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| 1. | This is the title slide | | |
| 2. | Objectives listed. | Display slide/read | View the slide |
| 3. | Symbol list for instructor/student reference | Display visual & go over Each symbol | View visual/slide 3 |
| 4. | <p>Picture of a three-way switch “Here is a picture of what a three-way switch looks like. We are going to set up a simple circuit with a battery (power source) and one lamp (light bulb) and use a Single Pull Double Throw (SPDT) (switch) to open and close the circuit. We will see that the switch controls the path of electricity.”</p> <p>*(Note- SPDT switch on slide does not look like the model of switch included with kit—point C is middle of actual switch with lever, points A&B are terminals at opposite ends.)</p> <p>Take battery, SPDT switch and light bulb- Assemble according to schematic. Take a black wire and attach one end to the negative terminal on the battery and the opposite end to the middle of the switch where the lever is (point C). Take another black wire and attach one</p> | <p>Take battery, SPDT switch and light bulb- Assemble according to schematic. Take a black wire and attach one end to the negative terminal on the battery and the opposite end to the middle of the switch where the lever is (point C). Take another black wire and attach one end to one end of the switch</p> | <p>Assembling battery, switch and SPDT switch according to schematic. Take a black wire and attach one end to the negative terminal on the battery and the opposite end to the middle of the switch where the lever is (point C). Take another black wire and attach one end to one end of the switch (point A) and</p> |

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| | <p>end to one end of the switch (point A) and the opposite end underneath the brass screw on the lamp. Take the red wire and attach it under the opposite end of the switch (point B) and attach the opposite end of the red wire to the brass screw on the lamp. Take a white wire and attach it to the silver screw on the lamp and attach the opposite end of the white wire to the positive terminal on the battery.</p> <p>Make sure you have installed a 6-volt light bulb in the lamp.</p> <p>What happens when the switch is moved to position A? (answer : the light bulb comes on.)</p> <p>What happens when the switch is moved to position B? (answer: the light bulb comes on.)</p> <p>Have the students trace the path of electricity.</p> <p>We are using a three way switch to select the path electricity will travel to light the light bulb.</p> | <p>(point A) and the opposite end underneath the brass screw on the lamp. Take the red wire and attach it under the opposite end of the switch (point B) and attach the opposite end of the red wire to the brass screw on the lamp. Take a white wire and attach it to the silver screw on the lamp and attach the opposite end of the white wire to the positive terminal on the battery.</p> | <p>the opposite end underneath the brass screw on the lamp. Take the red wire and attach it under the opposite end of the switch (point B) and attach the opposite end of the red wire to the brass screw on the lamp. Take a white wire and attach it to the silver screw on the lamp and attach the opposite end of the white wire to the positive terminal on the battery.</p> |
| 5. | Visual display of correctly connected student projects. | View slide & help troubleshoot mistakes. | Review projects and troubleshoot mistakes. |
| 6. | <p>Now we will add an additional load (lamp) and allow our SPDT switch to determine which load we want the electricity to flow through (light the bulb).</p> <p>Remove the red wire underneath the 6-volt lamp and attach it to the brass screw on the new lamp. Take a new white wire and attach it to the silver screw on the new lamp. Take the opposite end of the white wire and attach under the silver screw of the first lamp. You will now have two white wires underneath the silver screw on the first lamp.</p> <p>What happens when the switch is moved to position A? (answer: the first lamp lights up)</p> <p>What happens when the switch is moved to position B? (answer: the new lamp lights up)</p> | <p>Remove the red wire underneath the 6-volt lamp and attach it to the brass screw on the new lamp. Take a new white wire and attach it to the silver screw on the new lamp. Take the opposite end of the white wire and attach under the silver screw of the first lamp. You will now have two white wires underneath the silver screw on the first lamp.</p> | <p>Remove the red wire underneath the 6-volt lamp and attach it to the brass screw on the new lamp. Take a new white wire and attach it to the silver screw on the new lamp. Take the opposite end of the white wire and attach under the silver screw of the first lamp. You will now have two white wires underneath the silver screw on the first lamp.</p> |

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| | What happens to the first or second lamp if you remove one of the light bulbs? (answer: the remaining bulb should continue to be lit if the switch is positioned to send electricity to that lamp) Trace the flow of electricity to see why. | | |
| 7. | Visual display of correctly connected student projects. | View slide & help troubleshoot mistakes. | Review projects and troubleshoot mistakes. |
| 8. | <p>We are going to add a safety device into our circuit. The safety device will be a SPST switch that will allow us to break the circuit if needed.</p> <p>Remove the black wire that is attached to the middle of the SPDT switch and attach it to the switch terminal of the SPST switch. Take a new red wire and attach one end to the other terminal on the SPST switch and attach the opposite end of the new red wire to middle (point C) of the SPDT switch.</p> <p>Now the new SPST is a safety-lock for the entire circuit—allowing us to stop the flow of electricity if needed. What needs to happen to light lamp number 2? (answer: the SPST switch needs to be closed and the STDT switch needs to go from point C to point B in a closed position.) This type of an installation is used when the area you are working in is far from the location that controls the electricity. A good example would be a grain bin or a machine shop.</p> | Remove the black wire that is attached to the middle of the SPDT switch and attach it to the switch terminal of the SPST switch. Take a new red wire and attach one end to the other terminal on the SPST switch and attach the opposite end of the new red wire to middle (point C) of the SPDT switch. | Remove the black wire that is attached to the middle of the SPDT switch and attach it to the switch terminal of the SPST switch. Take a new red wire and attach one end to the other terminal on the SPST switch and attach the opposite end of the new red wire to middle (point C) of the SPDT switch |
| 9. | Visual display of correctly connected student projects. Dismantle projects for new steps in lesson. | View slide & help troubleshoot mistakes. Give dismantle direction once troubleshooting is finished. | Review projects and troubleshoot mistakes. Dismantle projects. |
| 10. | <p>Now we will see how 2 three-way switches can turn a light off and on. We will use our 6-volt battery, a 6-volt lamp with bulb, the two outside SPDT switches (that are on the board with three switches). We will only use the outside SPDT switches for this project. You will also need black, red and white wires.</p> <p>Attach one end of the back wire to the negative terminal of the 6-volt battery. Take the opposite end of the black wire and attach it to the middle (point C) of the SPDT switch. Take a new black wire and attach</p> | Attach one end of the back wire to the negative terminal of the 6-volt battery. Take the opposite end of the black wire and attach it to the middle (point C) of the SPDT switch. Take a new black wire and | Attach one end of the back wire to the negative terminal of the 6-volt battery. Take the opposite end of the black wire and attach it to the middle (point C) of the SPDT switch. Take a new black wire and |

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| | <p>one end of it to the top end of the SPDT switch. Take the opposite end of the new black wire and attach it to the top end of the opposite SPDT switch (on the board). Take a red wire and attach one end to the bottom terminal of one SPDT switch and the opposite end of the red wire to the bottom of the other SPDT switch. Take a new black wire and attach it to the middle of the SPDT switch that has presently has no wires connected to it. Take the opposite end of the new black wire and attach it to the brass screw on the lamp. Take a new white wire and attach under the silver screw under the lamp and the opposite end of the white wire to the positive terminal on the battery.</p> <p>As you move the switches back an forth from A to B on the 2 SPDT switches—what happens to the lamp? (answer: they should light up)</p> <p>Examples of 3 way switch locations: basement steps, dining rooms with more than one entry and hallways.</p> | <p>attach one end of it to the top end of the SPDT switch. Take the opposite end of the new black wire and attach it to the top end of the opposite SPDT switch (on the board) Take a red wire and attach one end to the bottom terminal of one SPDT switch and the opposite end of the red wire to the bottom of the other SPDT switch. Take a new black wire and attach it to the middle of the SPDT switch that has presently has no wires connected to it. Take the opposite end of the new black wire and attach it to the brass screw on the lamp. Take a new white wire and attach under the silver screw under the lamp and the opposite end of the white wire to the positive terminal on the battery.</p> | <p>attach one end of it to the top end of the SPDT switch. Take the opposite end of the new black wire and attach it to the top end of the opposite SPDT switch (on the board) Take a red wire and attach one end to the bottom terminal of one SPDT switch and the opposite end of the red wire to the bottom of the other SPDT switch. Take a new black wire and attach it to the middle of the SPDT switch that has presently has no wires connected to it. Take the opposite end of the new black wire and attach it to the brass screw on the lamp. Take a new white wire and attach under the silver screw under the lamp and the opposite end of the white wire to the positive terminal on the battery.</p> |
| 11. | Visual display of correctly connected student projects. | View slide & help troubleshoot mistakes. | Review projects and troubleshoot mistakes. |
| 12. | <p>We will add an additional area of control by adding a 4-way switch. We will now use the top switch on the board of three switches.</p> <p>Remove the black and red wires that go between the SPDT switches.</p> | Remove the black and red wires that go between the SPDT switches. Take a red wire and attach it to a | Remove the black and red wires that go between the SPDT switches. Take a red wire and attach it to a |

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| | <p>Take a red wire and attach it to a top screw on one side of the DPDT switch and attach the opposite end of the red wire to the bottom screw of the opposite side of the DPDT switch. Take a black wire and attach it under the top screw on the DPDT switch that does not have a red wire under it. Take the opposite end of the black wire and attach it to the bottom screw on the opposite side of DPDT switch that does not have a red wire under it</p> | <p>top screw on one side of the DPDT switch and attach the opposite end of the red wire to the bottom screw of the opposite side of the DPDT switch. Take a black wire and attach it under the top screw on the DPDT switch that does not have a red wire under it. Take the opposite end of the black wire and attach it to the bottom screw on the opposite side of DPDT switch that does not have a red wire under it</p> | <p>top screw on one side of the DPDT switch and attach the opposite end of the red wire to the bottom screw of the opposite side of the DPDT switch. Take a black wire and attach it under the top screw on the DPDT switch that does not have a red wire under it. Take the opposite end of the black wire and attach it to the bottom screw on the opposite side of DPDT switch that does not have a red wire under it</p> |
| <p>13.</p> | <p>Visual display of correctly connected student projects.</p> | <p>View slide & help troubleshoot mistakes.</p> | <p>Review projects and troubleshoot mistakes.</p> |
| <p>14.</p> | <p>Now, when we are done with this step, we will have is two 3-way switches and a 4-way switch connected in a circuit that can be turned off or on at any of the 3 locations (switches).</p> <p>Take a new red wire and attach one end to the top of the SPDT switch on the left. Take the opposite end of the red wire and attach it underneath the top terminal of the DPDT switch where the red wire is already attached. Take a new black wire and attach it to the bottom of the SPDT switch on the left and the opposite end to the DPDT switch on the top where there is already a black wire. Take a new red wire and attach one end to the middle terminal on the DPDT switch on the same side as the red wires. Attach the opposite end to the top of the SPDT switch on the right. Take a new black wire and attach it to the middle of the DPDT</p> | <p>Take a new red wire and attach one end to the top of the SPDT switch on the left. Take the opposite end of the red wire and attach it underneath the top terminal of the DPDT switch where the red wire is already attached. Take a new black wire and attach it to the bottom of the SPDT switch on the left and the opposite end to the DPDT switch on the top where there is already a black wire. Take a new red wire and attach one end to the middle terminal</p> | <p>Take a new red wire and attach one end to the top of the SPDT switch on the left. Take the opposite end of the red wire and attach it underneath the top terminal of the DPDT switch where the red wire is already attached. Take a new black wire and attach it to the bottom of the SPDT switch on the left and the opposite end to the DPDT switch on the top where there is already a black wire. Take a new red wire and attach one end to the middle terminal</p> |

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| | <p>switch just below where we have attached two black wires, and attach the opposite end of the new black wire to the SPDT switch on the right. Take a new black wire and attach one end to the middle terminal of the right SPDT switch and attach the opposite end underneath the brass screw of the miniature lamp. Take a new white wire and attach one end underneath the silver screw of the lamp and the opposite end to the positive terminal on the battery.</p> <p>Move each switch individually and see how your actions affect the light bulbs. Also, trace the path of electricity each time you change your switch. If the light is burning, your circuit is complete, if a light is not burning, one of your switches is in the open position, breaking the circuit and shutting off the light bulb.</p> <p>Slide shows visual schematic of a completed circuit, which has a 4-way switch.</p> | <p>on the DPDT switch on the same side as the red wires. Attach the opposite end to the top of the SPDT switch on the right. Take a new black wire and attach it to the middle of the DPDT switch just below where we have attached two black wires, and attach the opposite end of the new black wire to the SPDT switch on the right. Take a new black wire and attach one end to the middle terminal of the right SPDT switch and attach the opposite end underneath the brass screw of the miniature lamp. Take a new white wire and attach one end underneath the silver screw of the lamp and the opposite end to the positive terminal on the battery.</p> | <p>on the DPDT switch on the same side as the red wires. Attach the opposite end to the top of the SPDT switch on the right. Take a new black wire and attach it to the middle of the DPDT switch just below where we have attached two black wires, and attach the opposite end of the new black wire to the SPDT switch on the right. Take a new black wire and attach one end to the middle terminal of the right SPDT switch and attach the opposite end underneath the brass screw of the miniature lamp. Take a new white wire and attach one end underneath the silver screw of the lamp and the opposite end to the positive terminal on the battery.</p> |
| <p>15.</p> | <p>Visual schematic of a completed circuit, which has a 4-way switch. This is the same completed circuit with a different path for the electricity to flow based on the switch settings.</p> <p>Lets trace the path of the electricity with our switches in different positions. We can see that the light bulb can be lit when the switches are in different positions. Some examples of this kind of wiring would be a hallway with many entrances and exits or a garage with more than two entrances. Is there such a thing as a 5-way switch? (answer: no- there are just additional 4-way switches- and you can use as many as you need on a circuit.)</p> | <p>Show visual- trace path of electricity</p> | <p>review visual- trace path of electricity</p> |

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| 16. | Visual picture of what the student's work should look like. This is what your circuit should look like. | Show visual | Review visual, troubleshoot mistakes |
| 17. | This is not part of our lesson, but this is what a double pole, double throw switch can be used for. By moving the double pole switch from one terminal to another, we are flipping the polarity of the battery and causing the motor to run forward or in reverse. | Show visual- | Review visual |
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Summary: **We have learned today how to identify and use various types of switches to perform circuit selection. We used 3-way and 4-way switches to determine the path electricity would take around our circuits.**