

## Switches

This worksheet and all related files are licensed under the Creative Commons Attribution License, version 1.0. To view a copy of this license, visit <http://creativecommons.org/licenses/by/1.0/>, or send a letter to Creative Commons, 559 Nathan Abbott Way, Stanford, California 94305, USA. The terms and conditions of this license allow for free copying, distribution, and/or modification of all licensed works by the general public.

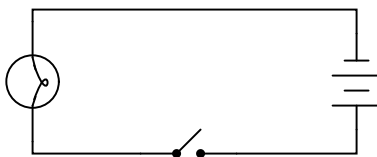
---

Resources and methods for learning about these subjects (list a few here, in preparation for your research):

---

### Question 1

What is the purpose of the *switch* shown in this schematic diagram?



file 00013

---

### Answer 1

This device is known as a *switch*, and its purpose in this circuit is to establish or interrupt the electrical continuity of the circuit in order to control the light bulb.

---

### Notes 1

Beginning students often find the terminology for switches confusing, because the words *open* and *closed* sound similar to the terminology used for doors, but do not mean quite the same thing when used in reference to a switch! In order to help avoid confusion, ask the students how they may think of these terms in a way that is consistent with their meaning in the context of an electrical switch.

One analogy to use for the switch's function that makes sense with the schematic is a drawbridge: when the bridge is down (closed), cars may cross; when the bridge is up (open), cars cannot.

---

### Question 2

How is an electrical switch constructed? What goes on inside the switch that actually "makes" or "breaks" a path for electric current?

file 00154

---

### Answer 2

Switches typically use metal *contacts* that are touched together or moved apart by some sort of actuating lever, shaft, or other mechanical assembly.

---

### Notes 2

An inexpensive type of switch I use for teaching basic electricity/electronics classes is a household light switch. Available from hardware stores for very little cost, these switches are rugged and easy to connect into real circuits, large or small. For this question, you might want to let students disassemble one or two of these switches to observe how they are constructed.

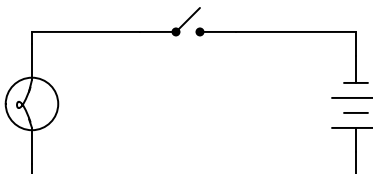
This question is also a good point to start a conversation on the *reliability* of switches. Being that it has moving parts, what could possibly fail in a switch? How about the contacts themselves: what might happen to them over time, especially if "overloaded" with too much electrical current?

---

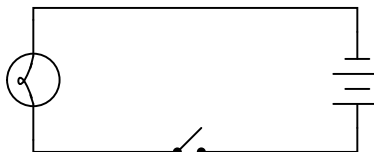
### Question 3

What difference will it make if the switch is located in either of these two alternate locations in the circuit?

Switch on negative side of circuit



Switch on positive side of circuit



file 00014

---

### Answer 3

The choice of switch locations shown in the two alternate diagrams makes no difference at all. In either case, the switch exerts the same control over the light bulb.

---

### Notes 3

This is a difficult concept for some students to master. Make sure they all understand the nature of electrical current and the importance of continuity *throughout* the entire circuit. Perhaps the best way for students to master this concept is to actually build working battery-switch-lamp circuits. Remind them that their "research" of these worksheet questions is not limited to book reading. It is not only valid, but *preferable* for them to experiment on their own, so long as the voltages are low enough that no shock hazard exists.

One analogy to use for the switch's function that makes sense with the schematic is a drawbridge: when the bridge is down (closed), cars may cross; when the bridge is up (open), cars cannot.

---

#### Question 4

Does this switch (in the closed state) have a low resistance or a high resistance between its terminals?



file 00027

---

#### Answer 4

A closed switch is supposed to have *low* resistance between its terminals.

---

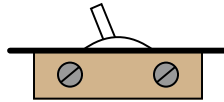
#### Notes 4

Ask the students what it would mean if a closed switch actually measured having high resistance between its terminals. Knowing what the measurements of any electrical component *ought to be* is a very important skill for troubleshooting.

---

### Question 5

How might you use a meter (or a conductivity/continuity tester) to determine whether this electrical switch is in the *open* or *closed* state?



file 00065

---

### Answer 5

Most multimeters have a "resistance" measurement range ("Ohms scale") that may be used to check continuity. Either using a meter or a conductivity/continuity tester, measure between the two screw terminals of this switch: if the resistance is low (good conductivity), then the switch is *closed*. If the measured resistance is infinite (no conductivity), then the switch is *open*.

---

### Notes 5

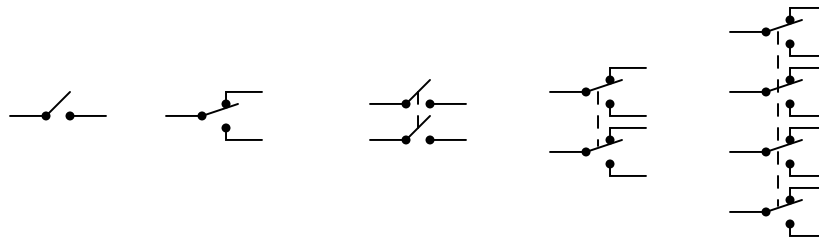
This is another question which lends itself well to experimentation. A vitally important skill for students to develop is how to use their test equipment to diagnose the states of individual components.

An inexpensive source of simple (SPST) switches is a hardware store: use the same type of switch that is used in household light control. These switches are very inexpensive, rugged, and come with heavy-duty screw terminals for wire attachment. When used in small battery-powered projects, they are nearly indestructible!

---

### Question 6

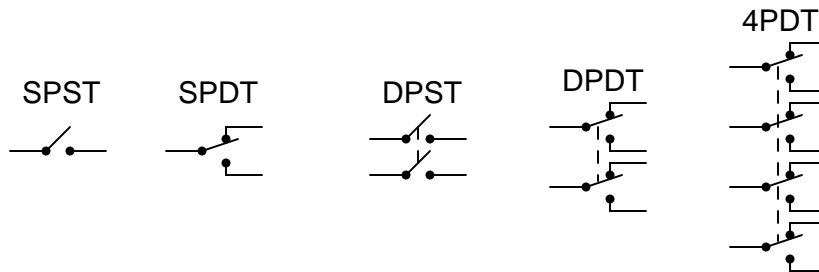
Identify the following types of switches, according to the number of "poles" and "throws" each switch has:



file 00046

---

### Answer 6



---

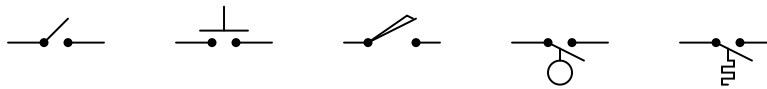
### Notes 6

Switches come in all types and sizes, and it is important for students to recognize certain common switch types, both by name and by schematic symbol.

---

### Question 7

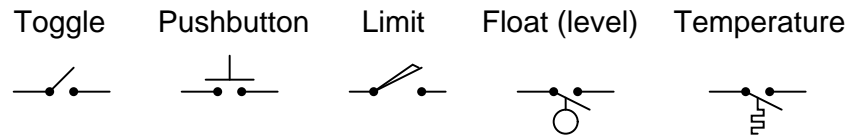
Identify the following types of switches, according to their style of actuation (how each switch is physically operated):



file 00047

---

### Answer 7



---

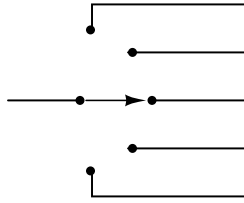
### Notes 7

Students will probably want to know how the temperature switch actually works. Be prepared to explain how bi-metallic elements may be used to actuate small mechanisms like switches, or challenge the students to research this on their own.

---

Question 8

What type of switch is represented by this schematic symbol?



file 00049

---

Answer 8

This is a *selector* switch of the *break-before-make* variety.

---

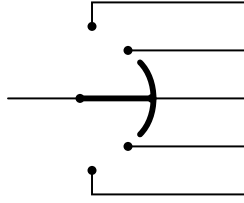
Notes 8

Selector switches are very, very common in electrical and electronic circuits, for selecting different machine functions.

---

Question 9

What type of switch is represented by this schematic symbol?



file 00153

---

Answer 9

This is a *selector* switch of the *make-before-break* variety.

---

Notes 9

Selector switches are very, very common in electrical and electronic circuits, for selecting different machine functions. Make-before-break switches are usually used where it is imperative to maintain continuity through the switch while switching between different positions.

---

Question 10

What positions do the switches have to be in for the light bulb to receive power?



file 00045

---

Answer 10

For the light bulb to be energized, both switches must either be in the "up" position, or in the "down" position.

---

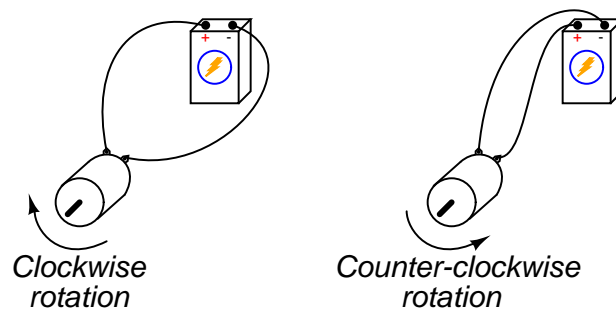
Notes 10

This wiring arrangement ("three-way" switches) is commonly used in residential lighting, for controlling a light bulb in a hallway with switches at either end. Once students relate this circuit to personal experience, it usually makes a lot more sense to them.

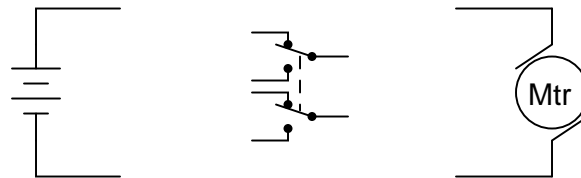
---

### Question 11

Electric motors of the *permanent magnet* design are very simple to reverse: just switch the polarity of the DC power to the motor, and it will spin the other direction:



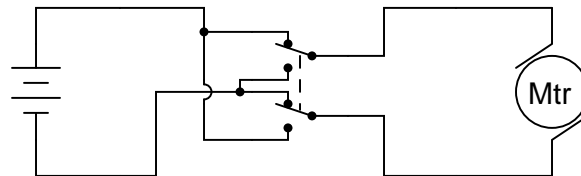
Complete this schematic diagram, showing how a DPDT switch may be placed in this circuit to reverse the motor's direction of rotation without the need to disconnect and re-connect wires:



file 00048

---

### Answer 11



---

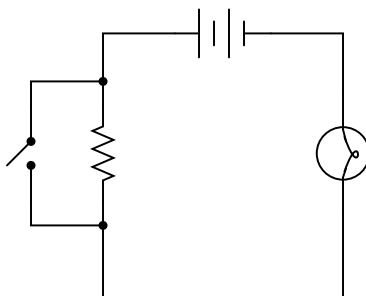
### Notes 11

DPDT switches are often used as polarity-reversal devices. No doubt your students will see (or build!) this switch arrangement some time in their careers.

---

Question 12

What will the light bulb do when the switch is open, and when the switch is closed?



file 00058

---

Answer 12

When the switch is closed, the light bulb will receive full voltage from the battery. When the switch is open, the light bulb will receive less voltage (and correspondingly, less current).

---

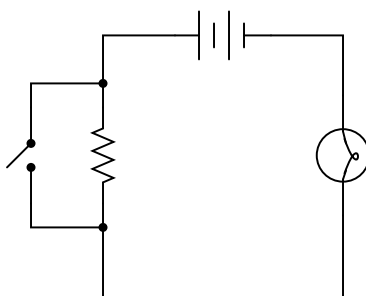
Notes 12

This is another opportunity to review the meanings of "open" and "closed" with regard to switches. Again, students new to electricity often exhibit confusion over these terms, because in the context of doors they hold opposite meanings.

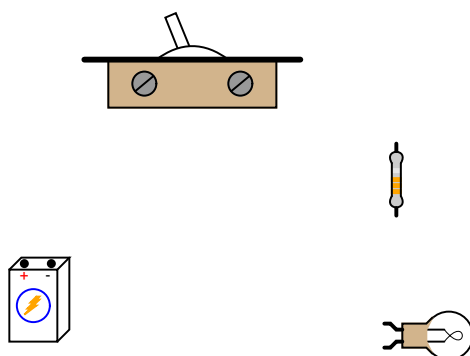
---

### Question 13

Examine this schematic diagram:



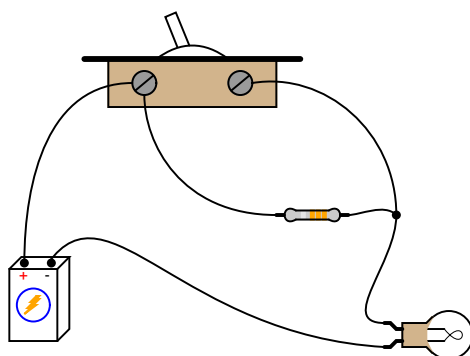
Now, without moving the following components, show how they may be connected together with wires to form the same circuit depicted in the schematic diagram above:



[file 00067](#)

---

### Answer 13



---

### Notes 13

One of the more difficult skills for students to develop is the ability to translate a nice, neat schematic diagram into a messy, real-world circuit, and visa-versa. Developing this skill requires lots of practice.

It is very worthwhile for students to discuss how they solve problems such as these with each other. For those students who have trouble visualizing shapes, a simple hint or "trick" to use when translating schematics to illustrations or visa-versa may be invaluable.

---

#### Question 14

What does the *normal* status of an electrical switch refer to? Specifically, what is the difference between a *normally-open* switch and a *normally-closed* switch?

file 02363

---

#### Answer 14

The "normal" status of a switch refers to the open or closed status of the contacts when there is no actuating force applied to the switch.

---

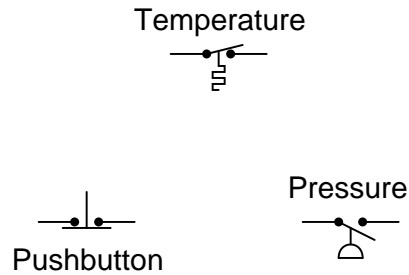
#### Notes 14

An important qualification for an electrical switch to be either "normally-open" or "normally-closed" is that it have a spring to return it to its "normal" state in the absence of an actuating force. Latching switches such as most toggle switches really cannot be defined in terms of "normally-" anything. Discuss this with your students, possibly showing them some examples of momentary contact switches that *are* either N.O. or N.C.

---

### Question 15

Identify the "normal" status of each switch, whether it is *normally-open* (N.O.) or *normally-closed* (N.C.):

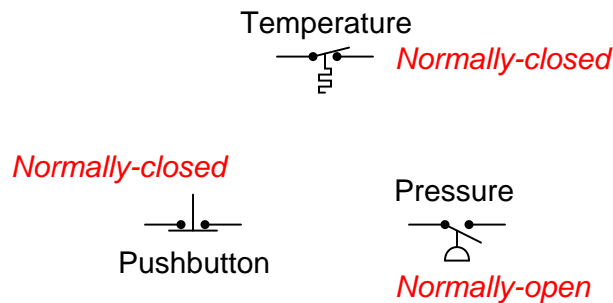


Based on the symbols shown, describe what physical condition results in the switch contacts being open, and what condition results in the switch contacts being closed, for each switch.

[file 02364](#)

---

### Answer 15



- Temperature switch: *cold* = contacts closed, *hot* = contacts open
- Pushbutton switch: *unpressed* = contacts closed, *pressed* = contacts open
- Pressure switch: *no applied pressure* = contacts open, *pressure applied* = contacts closed

---

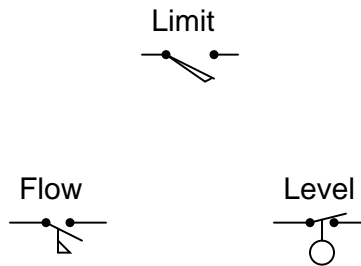
### Notes 15

Discuss with your students the different types of switches shown in this question (not just their normal status, but what physical event actuates each type of switch). There are many, many different types of switches – far more than just the types actuated by a human hand!

---

### Question 16

Identify the "normal" status of each switch, whether it is *normally-open* (N.O.) or *normally-closed* (N.C.):

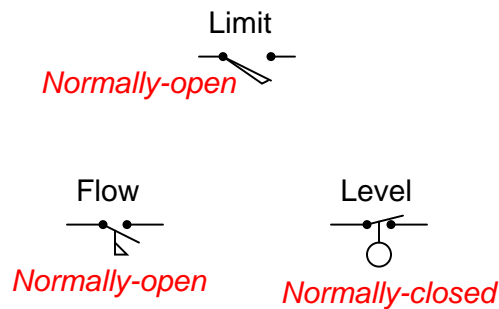


Based on the symbols shown, describe what physical condition results in the switch contacts being open, and what condition results in the switch contacts being closed, for each switch.

file 02365

---

### Answer 16



- Limit switch: *untouched* = contacts open, *mechanical force* = contacts closed
- Flow switch: *no fluid flow* = contacts open, *fluid flow* = contacts closed
- Level switch: *dry (hanging in air)* = contacts closed, *submerged* = contacts open

---

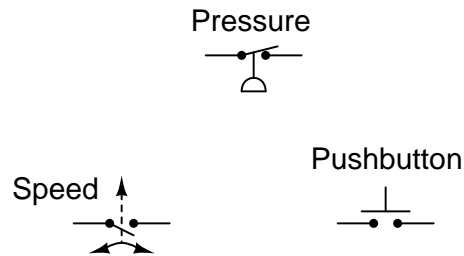
### Notes 16

Discuss with your students the different types of switches shown in this question (not just their normal status, but what physical event actuates each type of switch). There are many, many different types of switches – far more than just the types actuated by a human hand!

---

### Question 17

Identify the "normal" status of each switch, whether it is *normally-open* (N.O.) or *normally-closed* (N.C.):

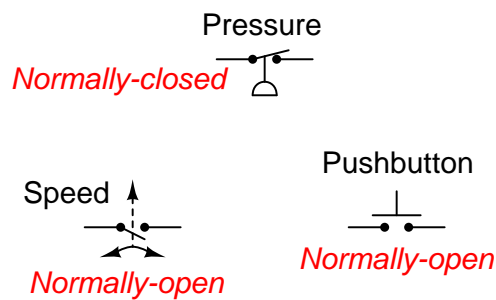


Based on the symbols shown, describe what physical condition results in the switch contacts being open, and what condition results in the switch contacts being closed, for each switch.

file 02366

---

### Answer 17



- Pressure switch: *no applied pressure* = contacts closed, *pressure applied* = contacts open
- Speed switch: *no motion* = contacts open, *motion* = contacts closed
- Pushbutton switch: *unpressed* = contacts open, *pressed* = contacts closed

---

### Notes 17

Discuss with your students the different types of switches shown in this question (not just their normal status, but what physical event actuates each type of switch). There are many, many different types of switches – far more than just the types actuated by a human hand!

---

### Question 18

Find one or two real switches and bring them with you to class for discussion. Identify as much information as you can about your switches prior to discussion:

- Number of poles
- Number of throws
- Voltage rating of contacts
- Current rating of contacts
- Contact status for various actuator positions
- Type (toggle, pushbutton)

file 01153

---

### Answer 18

If possible, find a manufacturer's datasheet for your components (or at least a datasheet for a similar component) to discuss with your classmates.

---

### Notes 18

The purpose of this question is to get students to kinesthetically interact with the subject matter. It may seem silly to have students engage in a "show and tell" exercise, but I have found that activities such as this greatly help some students. For those learners who are kinesthetic in nature, it is a great help to actually *touch* real components while they're learning about their function. Of course, this question also provides an excellent opportunity for them to practice interpreting component markings, poles and throws, use a multimeter, access datasheets, etc.