Performance-based assessments for basic electricity competencies

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The purpose of these assessments is for instructors to accurately measure the learning of their electronics students, in a way that melds theoretical knowledge with hands-on application. In each assessment, students are asked to predict the behavior of a circuit from a schematic diagram and component values, then they build that circuit and measure its real behavior. If the behavior matches the predictions, the student then simulates the circuit on computer and presents the three sets of values to the instructor. If not, then the student then must correct the error(s) and once again compare measurements to predictions. Grades are based on the number of attempts required before all predictions match their respective measurements.

You will notice that no component values are given in this worksheet. The *instructor* chooses component values suitable for the students' parts collections, and ideally chooses different values for each student so that no two students are analyzing and building the exact same circuit. These component values may be hand-written on the assessment sheet, printed on a separate page, or incorporated into the document by editing the graphic image.

This is the procedure I envision for managing such assessments:

1. The instructor hands out individualized assessment sheets to each student.
2. Each student predicts their circuit's behavior at their desks using pencil, paper, and calculator (if appropriate).
3. Each student builds their circuit at their desk, under such conditions that it is impossible for them to verify their predictions using test equipment. Usually this will mean the use of a multimeter only (for measuring component values), but in some cases even the use of a multimeter would not be appropriate.
4. When ready, each student brings their predictions and completed circuit up to the instructor's desk, where any necessary test equipment is already set up to operate and test the circuit. There, the student sets up their circuit and takes measurements to compare with predictions.
5. If any measurement fails to match its corresponding prediction, the student goes back to their own desk with their circuit and their predictions in hand. There, the student tries to figure out where the error is and how to correct it.
6. Students repeat these steps as many times as necessary to achieve correlation between all predictions and measurements. The instructor's task is to count the number of attempts necessary to achieve this, which will become the basis for a percentage grade.
7. (OPTIONAL) As a final verification, each student simulates the same circuit on computer, using circuit simulation software (Spice, Multisim, etc.) and presenting the results to the instructor as a final pass/fail check.

These assessments more closely mimic real-world work conditions than traditional written exams:

- Students cannot pass such assessments only knowing circuit theory or only having hands-on construction and testing skills – they must be proficient at both.
- Students do not receive the "authoritative answers" from the instructor. Rather, they learn to validate their answers through real circuit measurements.
- Just as on the job, the work isn't complete until *all errors* are corrected.
- Students must recognize and correct their own errors, rather than having someone else do it for them.
- Students must be fully prepared on exam days, bringing not only their calculator and notes, but also their tools, breadboard, and circuit components.

Instructors may elect to reveal the assessments before test day, and even use them as preparatory labwork and/or discussion questions. Remember that there is absolutely nothing wrong with "teaching to the test" *so long as the test is valid*. Normally, it is bad to reveal test material in detail prior to test day, lest students merely memorize responses in advance. With performance-based assessments, however, there is no way to pass without truly understanding the subject(s).

Question 1

Competency: **Soldered wire splice** Version:

Description

Strip the ends of a short length of solid copper wire, splicing the ends together so as to form a loop. Use the "Western Union" splice technique, soldering the splice as a final step.

Given conditions

Approximately 6 inches of 22-gauge (or similar) solid copper wire.

25 watt soldering iron

Electrical solder

Needle-nose pliers

Parameters

Parameter	(Check)
Western Union splice well-formed	☐
Even solder coverage of splice	☐
No excess solder on splice *(can still discern shape of splice)*	☐
Solder joint shiny in appearance	☐
Splice stronger than wire	☐

file 01716

Competency: **PCB soldering**	Version:

Description

Solder at least five resistors into a printed circuit board, being careful not to apply excess heat or excess solder. The resistors should lay flat on the board, with the soldered wire ends neatly trimmed.

Given conditions

Five resistors, 1/4 watt each

Printed circuit board with copper pads

25 watt soldering iron

Electrical solder, small-diameter

Needle-nose pliers

Miniature diagonal cutting pliers

Parameters	(Check)
Five resistors soldered in place (flat on board)	☐
Even solder coverage of all pads and leads	☐
No excess solder on pads *(solder has concave profile)*	☐
No cold solder joints	☐
All soldering flux cleaned off	☐
All leads neatly trimmed	☐
No overheated or lifted pads	☐
Good "wetting" of solder on all pads	☐

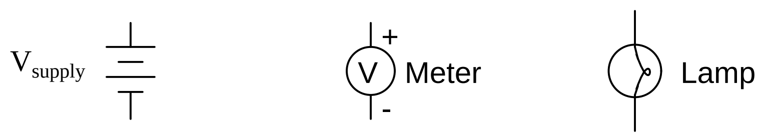
file 01971

Competency: **Voltmeter usage** Version:

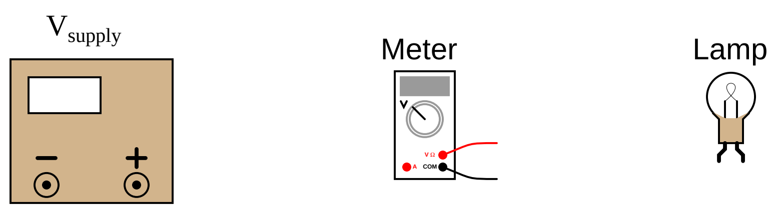
Description

Build a simple one-source, one-lamp circuit and use a multimeter to measure the lamp voltage.

Schematic diagram



Pictorial diagram



Explanation

Should the voltmeter be connected in *series* or in *parallel* with the lamp in order to measure voltage?

What will happen if the meter is connected the wrong way (series vs. parallel)?

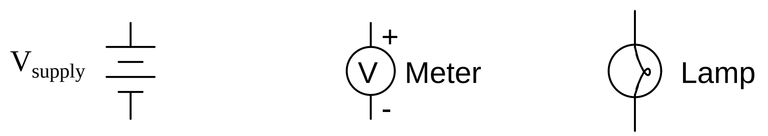
file 01637

Competency: **Voltmeter usage** Version:

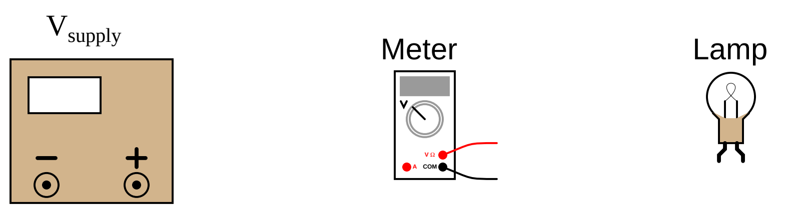
Description

Build a simple one-source, one-lamp circuit and
use two multimeters to measure the lamp voltage.

Schematic diagram



Pictorial diagram



Parameters

Measured

V_{lamp}

(with analog meter)

Measured

V_{lamp}

(with digital meter)

Explanation

Should the voltmeter be connected in *series* or in *parallel* with the lamp in order to measure voltage?

What will happen if the meter is connected the wrong way (series vs. parallel)?

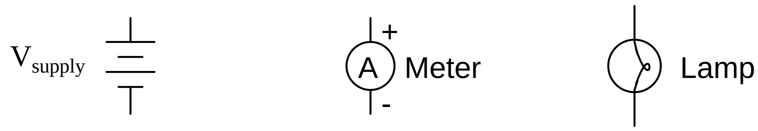
file 01715

Competency: **Ammeter usage**	Version:

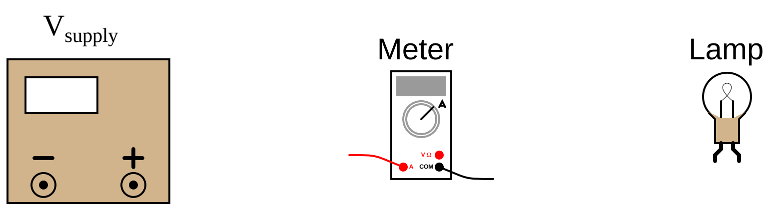
Description

Build a simple one-source, one-lamp circuit and use a multimeter to measure the lamp current.

Schematic diagram



Pictorial diagram



Explanation

Should the ammeter be connected in *series* or in *parallel* with the lamp in order to measure current?

What will happen if the meter is connected the wrong way (series vs. parallel)?

IMPORTANT NOTE: do not actually try to connect the ammeter improperly in the circuit, as the meter may be damaged in the process!

file 01638

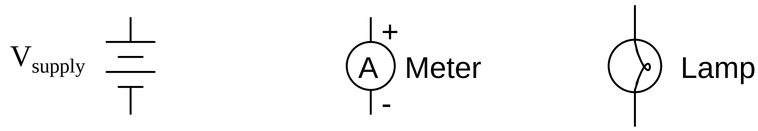
Question 6

Competency: **Ammeter usage** Version:

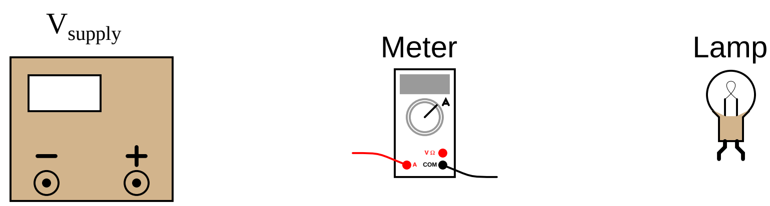
Description

Build a simple one-source, one-lamp circuit and use two multimeters to measure the lamp current.

Schematic diagram



Pictorial diagram



Parameters

	Measured
I_{lamp}	
	(with analog meter)

	Measured
I_{lamp}	
	(with digital meter)

Explanation

Should the ammeter be connected in *series* or in *parallel* with the lamp in order to measure current?

What will happen if the meter is connected the wrong way (series vs. parallel)?

IMPORTANT NOTE: do not actually try to connect the ammeter improperly in the circuit, as the meter may be damaged in the process!

file 01714

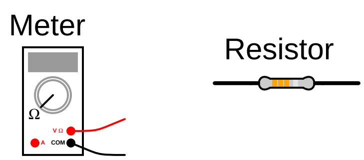
Competency: **Ohmmeter usage** Version:

Description

Interpret the color codes for several resistors, and then compare their rated resistances with the indication given by an ohmmeter.

Schematic diagram

Pictorial diagram



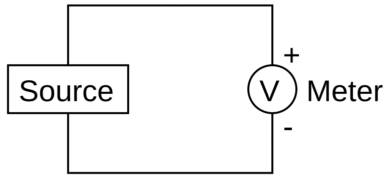
Given conditions and parameters

	Predicted	Measured
Resistor colors: ____ ____ ____ ____		
Resistor colors: ____ ____ ____ ____		
Resistor colors: ____ ____ ____ ____		
Resistor colors: ____ ____ ____ ____		
Resistor colors: ____ ____ ____ ____		
Resistor colors: ____ ____ ____ ____		

file 01639

Competency: **Sources of electricity** Version:

Schematic



Given conditions

(Descriptions of source types; i.e. *photovoltaic*, *chemical*, etc.)

Source 1 =
Source 2 =
Source 3 =

Parameters

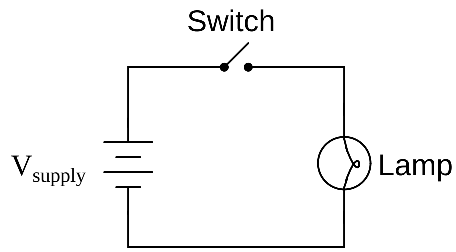
	Predicted	Measured
Greatest voltage produced		
Least voltage produced		

file 01677

Question 9

Competency: **Circuit with switch** Version:

Schematic



Given conditions

V_{supply} = I_{lamp} (nominal) =

Parameters

With switch closed (on)

	Predicted	Measured
V_{lamp}		
I_{lamp}		
V_{switch}		

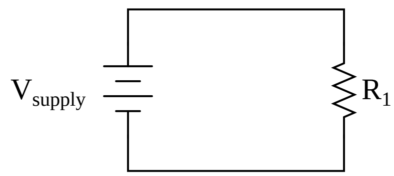
With switch open (off)

	Predicted	Measured
V_{lamp}		
I_{lamp}		
V_{switch}		

file 01640

Competency: **Ohm's Law**	Version:

Schematic



Given conditions

$V_{supply} =$

$R_1 =$

Parameters

	Predicted	Measured
I_{total}		
V_R		

Fault analysis

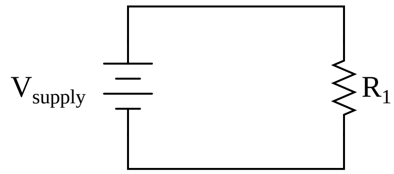
Suppose component R_1 fails ☐ open ☐ shorted ☐ other ______

What will happen in the circuit?

file 01603

Competency: **Ohm's Law** Version:

Schematic



Given conditions

V_{supply} = (see multiple values given below)

R_1 =

Parameters

	Given		Predicted	Measured
V_{supply} =		I_{total}		
V_{supply} =		I_{total}		
V_{supply} =		I_{total}		
V_{supply} =		I_{total}		

Fault analysis

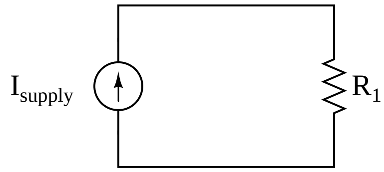
Suppose component ☐ fails ☐ open ☐ other ______ ☐ shorted

What will happen in the circuit?

file 01625

Competency: **Ohm's Law** Version:

Schematic



Given conditions

I_{supply} = (see multiple values given below)

R_1 =

Parameters

	Given		Predicted	Measured
I_{supply} =		V_{R1}		
I_{supply} =		V_{R1}		
I_{supply} =		V_{R1}		
I_{supply} =		V_{R1}		

Fault analysis

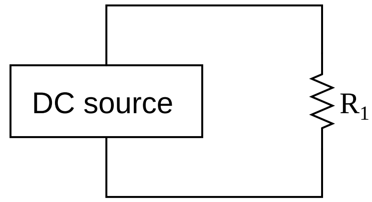
Suppose component ☐ fails ☐ open ☐ other ______
☐ shorted

What will happen in the circuit?

file 01626

Competency: **Ohm's Law** Version:

Schematic



Given conditions

V_{supply} = (see multiple values given below)

I_{supply} = (see multiple values given below)

R_1 =

Parameters

Given			Predicted	Measured
V_{supply} =		I_{R1}		
V_{supply} =		I_{R1}		
I_{supply} =		V_{R1}		
I_{supply} =		V_{R1}		

Fault analysis

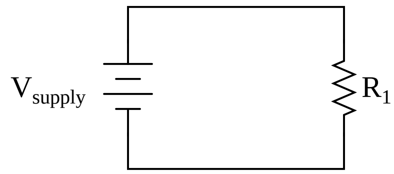
Suppose component ☐ fails ☐ open ☐ shorted ☐ other __________

What will happen in the circuit?

file 01629

Competency: **Current-limiting resistor** Version:

Schematic



Given conditions

V_{supply} = $I_{maximum}$ =

Description

Choose a resistor value such that the circuit current is as close as possible to $I_{maximum}$ without exceeding it.

Parameters

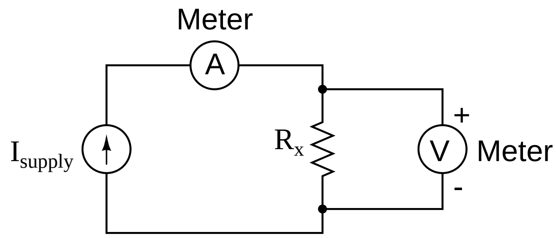
	Predicted	Measured
R_1		
I		

file 01924

Question 15

Competency: **4-wire "Kelvin" resistance measurement** Version:

Schematic



Given conditions

I_{supply} =

Parameters

Measured

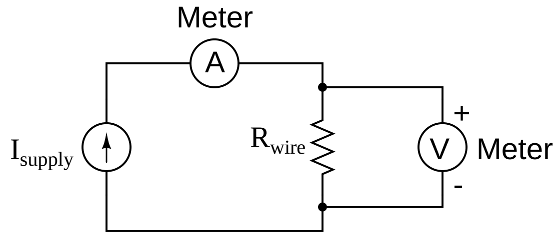
V_{meter} [ ]

	"Kelvin" Measured	Directly Measured (or revealed by instructor)
R_x		

file 01654

Competency: **Determining wire length by resistance** Version:

Schematic



Given conditions

T_{room} =

I_{supply} =

Parameters

Measured

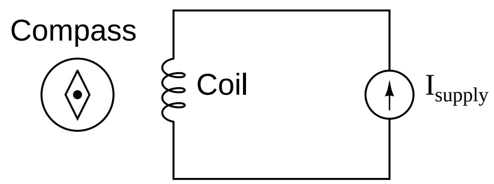
V_{meter} [ ]

	"Kelvin" Measured	Directly Measured (or revealed by instructor)
R_{wire}		

file 01695

Competency: **Electromagnetism** Version:

Schematic



Given conditions

Vary the power supply current, and also switch polarity, noting the effects on the compass needle.

Parameters

Qualitative answers only

	Predicted	Measured
Low current		
Higher current		
Reverse polarity Low current		
Reverse polarity Higher current		

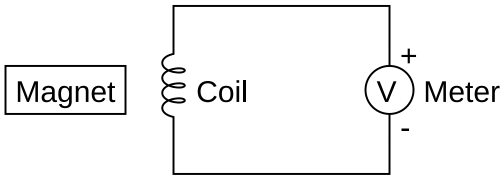
Analysis

Identify the places on the coil where the field is strongest.

file 01645

Competency: **Electromagnetic induction** Version:

Schematic



Given conditions

Set voltmeter to the most sensitive range possible!

Move the magnet slowly toward the coil, and then slowly away

Move the magnet quickly toward the coil, and then quickly away

Parameters

Qualitative answers only

	Predicted	Measured
V_{coil} Slowly, toward		
V_{coil} Slowly, away		
V_{coil} Quickly, toward		
V_{coil} Quickly, away		

Analysis

Does the orientation of the magnet have any effect on the polarity or magnitude of the induced voltage?

Does the direction of approach to the coil have any effect on the magnitude of the induced voltage?

file 01644

Competency: **Series DC voltages** Version:

Description

Connect three DC power sources together to achieve the specified total voltage.

Given conditions

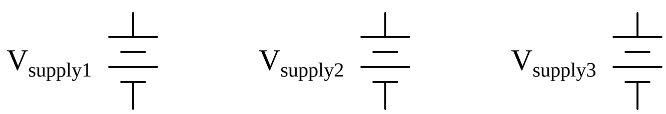
$V_{supply1} =$

$V_{supply2} =$

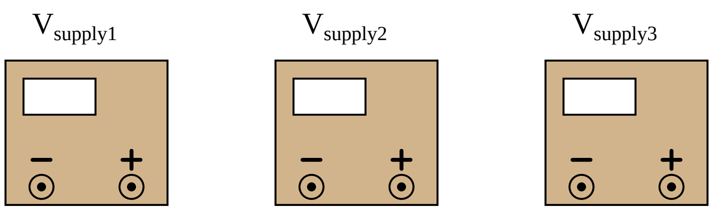
$V_{supply3} =$

$V_{total} =$

Schematic diagram



Pictorial diagram



file 01610

Competency: **Parallel DC currents** Version:

Description

Connect three DC power sources together to achieve the specified total current.

Given conditions

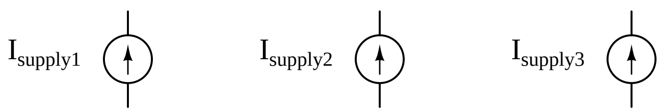
$I_{supply1}$ =

$I_{supply2}$ =

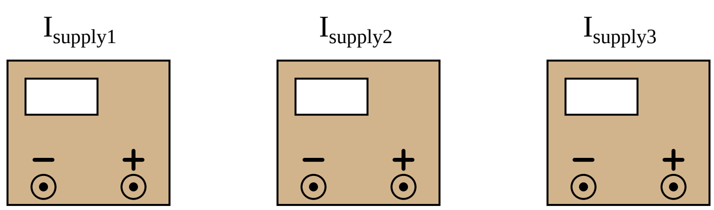
$I_{supply3}$ =

I_{total} =

Schematic diagram



Pictorial diagram

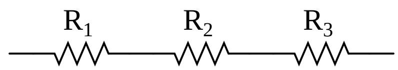


Caution! Consult your instructor to see how to set up each power supply to be a *safe* current source before attempting to connect them together!

file 01678

Competency: **Series resistances** Version:

Schematic



Given conditions

R_1 = R_2 = R_3 =

Parameters

	Predicted	Measured
R_{total}		

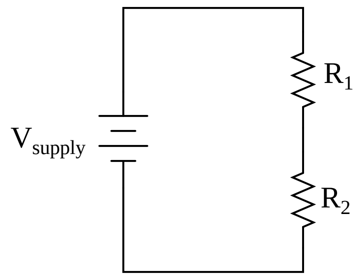
Analysis

Equation used to calculate R_{total} :

file 01634

Competency: **Series DC resistor circuit** Version:

Schematic



Given conditions

V_{supply} = R_1 = R_2 =

Parameters

	Predicted	Measured		Predicted	Measured
I_{supply}			I_{R1}		
V_{R1}			I_{R2}		
V_{R2}					

Analysis

Relationship between resistor voltage drops and total voltage:

Fault analysis

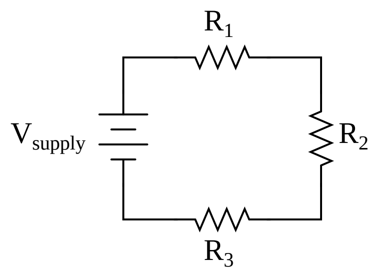
Suppose component ☐ fails ☐ open ☐ shorted ☐ other ________

What will happen in the circuit?

file 01627

Competency: **Series DC resistor circuit** Version:

Schematic



Given conditions

V_{supply} = R_1 = R_2 = R_3 =

Parameters

	Predicted	Measured		Predicted	Measured
I_{supply}			I_{R1}		
V_{R1}			I_{R2}		
V_{R2}			I_{R3}		
V_{R3}					

Analysis

Relationship between resistor voltage drops and total voltage:

Fault analysis

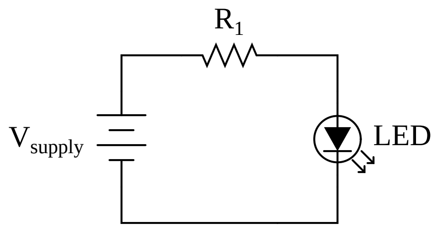
Suppose component ☐ fails ☐ open ☐ shorted ☐ other ____________

What will happen in the circuit?

file 01604

Competency: **Series dropping resistor for LED** Version:

Schematic



Given conditions

V_{supply} =

I_{LED} =

Parameters

Measured

V_{LED} @ I_{LED}

Predicted

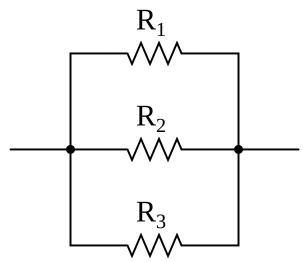
R_1

	Predicted	Measured
I_{total}		
P_{R1}		

file 01636

Competency: **Parallel resistances**	Version:

Schematic



Given conditions

R_1 = R_2 = R_3 =

Parameters

	Predicted	Measured
R_{total}		

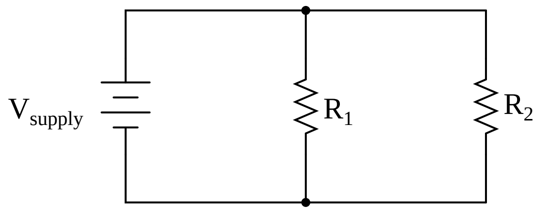
Analysis

Equation used to calculate R_{total} :

file 01635

Competency: **Parallel DC resistor circuit** Version:

Schematic



Given conditions

V_{supply} = R_1 = R_2 =

Parameters

	Predicted	Measured		Predicted	Measured
I_{supply}			I_{R1}		
V_{R1}			I_{R2}		
V_{R2}					

Analysis

Relationship between resistor (branch) currents and total current:

Fault analysis

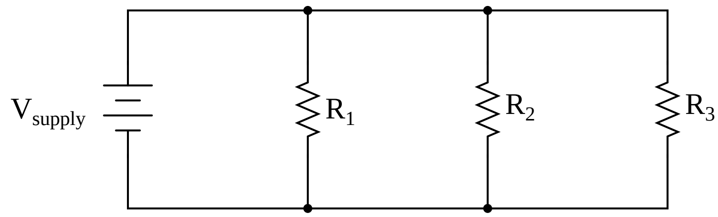
Suppose component ______ fails ☐ open ☐ shorted ☐ other ______

What will happen in the circuit?

file 01628

Competency: **Parallel DC resistor circuit** Version:

Schematic



Given conditions

V_{supply} = R_1 = R_2 = R_3 =

Parameters

	Predicted	Measured		Predicted	Measured
I_{supply}			I_{R1}		
V_{R1}			I_{R2}		
V_{R2}			I_{R3}		
V_{R3}					

Analysis

Relationship between resistor (branch) currents and total current:

Fault analysis

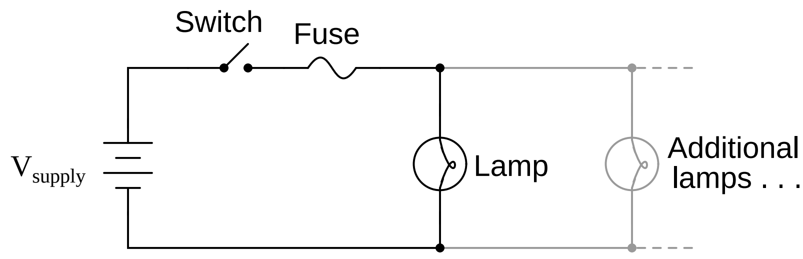
Suppose component ______ fails ☐ open ☐ other ______ ☐ shorted

What will happen in the circuit?

file 01605

Competency: **Parallel loads with fuse protection** Version:

Schematic



Given conditions

V_{supply} =

I_{lamp} (nominal) =

Fuse rating =

Parameters

	Predicted	Tested
Maximum # of lamps		

file 01641

Question 29

(Template)

Competency: Version:

Schematic

Given conditions

Parameters

Predicted	Measured

file 01602

Answer 1

Instructor will certify quality of splice.

Answer 2

Instructor will certify quality of solder joints.

Answer 3

Connect the voltmeter in *parallel* with the component whose voltage is to be measured.

Answer 4

Connect the voltmeter in *parallel* with the component whose voltage is to be measured.

Answer 5

Connect the ammeter in *series* with the component whose current is to be measured.

Answer 6

Connect the ammeter in *series* with the component whose current is to be measured.

Answer 7

The ohmmeter's indication is the "final word" on resistance.

Answer 8

The real-life measurements you take constitute the "final word" on which sources generate the most significant voltages.

Answer 9

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 10

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 11

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 12

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 13

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 14

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 15

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 16

Measure the wire length to check your calculation!

Answer 17

I won't reveal the answer here as to what effect magnitude has on magnetic field strength, but I will suggest a way to test for strength: place the compass at a distance from the coil, where the coil's field has a relatively small effect on the needle position in relation to the ambient magnetic field.

Answer 18

The magnitude of the induced voltage is a direct function of the magnetic flux's rate of change over time ($\frac{d\phi}{dt}$).

Answer 19

Use circuit simulation software to verify schematic diagram. Your real circuit will verify the pictorial diagram.

Answer 20

Use circuit simulation software to verify schematic diagram. Your real circuit will verify the pictorial diagram.

Answer 21

Use circuit simulation software to verify schematic diagram. Your real circuit will verify the pictorial diagram.

Answer 22

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 23

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 24

Note: be careful to choose a resistor with an adequate power rating (Watts)!

Answer 25

Use circuit simulation software to verify schematic diagram. Your real circuit will verify the pictorial diagram.

Answer 26

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 27

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 28

Use circuit simulation software to verify your predicted and measured parameter values.

Answer 29

Here, you would indicate where or how to obtain answers for the requested parameters, but not actually give the figures. My stock answer here is "use circuit simulation software" (Spice, Multisim, etc.).

Notes 1

The purpose of this exercise is to ensure students can solder a good wire splice.

Notes 2

The purpose of this exercise is to ensure students can make good solder joints on a printed circuit board.

Notes 3

The purpose of this exercise is to make absolutely sure students can safely measure voltage with a multimeter.

A good extension of this assessment is to have students demonstrate competency using both digital and analog multimeters!

Notes 4

The purpose of this exercise is to make absolutely sure students can safely measure voltage with a multimeter.

Notes 5

The purpose of this exercise is to make absolutely sure students can safely measure current with a multimeter.

A good extension of this assessment is to have students demonstrate competency using both digital and analog multimeters!

Notes 6

The purpose of this exercise is to make absolutely sure students can safely measure current with a multimeter.

Notes 7

The purpose of this exercise is to make absolutely sure students can accurately measure resistance with a multimeter, and also that they can interpret resistor color codes. Select resistors that span a wide range, from less than 10 ohms to millions of ohms.

I recommend the following resistor color codes for students to try (all 5% tolerance):

- Blk, Brn, Grn, Gld
- Brn, Red, Brn, Gld
- Blu, Gry, Blk, Gld
- Red, Red, Org, Gld
- Brn, Grn, Yel, Gld
- Org, Org, Red, Gld

A good extension of this assessment is to have students demonstrate competency using both digital and analog multimeters!

Notes 8

In this performance assessment, different electricity sources are suggested by way of conversion phenomena. In other words, the instructor will list such things as *photovoltaic* and *piezoelectric*, and students will have to choose the correct components to demonstrate conversion of energy into electrical form. Then, students will demonstrate each conversion for the instructor, ranking them in order of the voltage magnitude generated by each demonstration.

The purpose of this exercise is not only for students to obtain a practical understanding of electricity sources, but also to understand the relative magnitudes of each one. It is important for students to know, for instance, that thermoelectricity is a rather weak effect compared to piezoelectricity. This will help them understand the relative sensitivity of sensors and other electrical devices in the future.

Possible sources to list for student demonstration are:

- Photovoltaic
- Piezoelectric
- Electromagnetic
- Chemical
- Thermoelectric

Of course, your selection of sources for student demonstration depends on the parts and equipment available to them.

Notes 9

Use a variable-voltage, regulated power supply to supply a suitable DC voltage for the incandescent lamp.

Notes 10

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify a standard resistor value, somewhere between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

If using this question as a lab exercise rather than an assessment, I recommend specifying a voltage that is standard for batteries, so students don't necessarily have to have an adjustable power supply available to do this lab.

For example, specify V_{supply} as 6 volts and R_1 as 33 kΩ. The resulting current is sufficient to provide a nice, strong needle deflection on most cheap analog ammeters, too!

Notes 11

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify a standard resistor value, somewhere between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

Notes 12

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify a standard resistor value, somewhere between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

Notes 13

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify a standard resistor value, somewhere between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

An interesting "twist" on this exercise is to specify the value of resistor R_1 in colors. For example: Red, Vio, Red, Gld instead of 2.7 kΩ.

Notes 14

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. If using this question as a lab exercise rather than an assessment, I recommend specifying a voltage that is standard for batteries, so students don't necessarily have to have an adjustable power supply available to do this lab.

In this exercise, the student must both quantitatively and qualitatively analyze the circuit, because the ideal resistor value probably does not exist. As the instructor, it is you task to choose voltage and current specifications that preclude exact solutions with common resistor values.

Notes 15

You will need to provide some low-resistance specimens for your students to measure using this technique. Motor armature coils work well for this purpose, as do large power resistors with the labels scratched off.

Notes 16

You will need to provide some spools of wire for your students to measure using this technique. Your students will need to find wire tables correlating length with resistance (at different temperatures, if the room temperature is significantly different from the standard temperature given in the table).

Notes 17

Old solenoid valve coils work very well for this exercise, as do spools of wire with large steel bolts passed through the center. Students may also wind their own coils using small-gauge magnet wire and a steel bolt. If the coils are hollow, you may experiment with and without ferrous cores, to demonstrate the effects of a ferromagnetic flux path on the field strength produced.

Notes 18

Old solenoid valve coils work very well for this exercise, as do spools of wire with large steel bolts passed through the center. Students may also wind their own coils using small-gauge magnet wire and a steel bolt.

Please note that students will not be able to *predict* the polarity of the induced voltage unless they know the rotation of the coil windings and the polarity of their magnet. This will only be possible if the windings are exposed to view or if the students wind their own coils, and if the magnet has its poles labeled "North" and "South" (or if this is determined experimentally by using the magnet as a compass).

Use magnets that are as strong as possible, and that have their poles on the physical ends. This may seem like a strange request, but I've seen students bring some unusual magnets to class for this experiment, whose poles are *not* located on the ends. One type of magnet that works well is the so-called "cow magnet," used by cattle ranchers to protect cows' multiple stomachs from injury from ingestion of fence staples and other ferromagnetic objects. These are a few inches long, cylindrical in shape (so the cow can swallow it like a big pill), and quite strong.

If students are using analog multimeters to measure the coil's induced voltage, be sure to keep the multimeter far away from the magnet. Analog meter movements are generally quite sensitive to external magnetic fields and may register falsely if positioned too close to a strong magnet.

Notes 19

Use variable-voltage, regulated power supplies to supply any amount of DC voltage below 30 volts.

Notes 20

Use regulated power supplies with adjustable current limits to act as current sources (voltage adjustments set to "full" while current adjustments set the desired output current for each). Keep the currents less than one amp for each supply.

Notes 21

Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

Notes 22

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 23

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 8k2, 10k, 22k, 33k, 39k 47k, 68k, 82k, etc.).

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 24

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. For added challenge, set the power supply voltage high enough (at least 15 volts) that a 1/4 watt resistor will be inadequately rated for the power dissipation.

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 25

Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

Notes 26

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 10k, 22k, 33k, 39k 47k, 68k, etc.).

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 27

Use a variable-voltage, regulated power supply to supply any amount of DC voltage below 30 volts. Specify standard resistor values, all between 1 kΩ and 100 kΩ (1k5, 2k2, 2k7, 3k3, 4k7, 5k1, 6k8, 8k2, 10k, 22k, 33k, 39k 47k, 68k, 82k, etc.).

An extension of this exercise is to incorporate troubleshooting questions. Whether using this exercise as a performance assessment or simply as a concept-building lab, you might want to follow up your students' results by asking them to predict the consequences of certain circuit faults.

Notes 28

Use a variable-voltage, regulated power supply to supply a suitable DC voltage for the incandescent lamp. Set the power supply current limit such that it outputs enough to blow the fuse, but not enough to damage anything else. The fuse needs to be rated for a current value practical for a reasonable number of parallel-connected lamps.

Notes 29

Any relevant notes for the assessment activity go here.