

WORCESTER POLYTECHNIC INSTITUTE

INTERACTIVE QUALIFYING PROJECT

**ASSISTments**

Effectiveness of Problem Set Order between Skill Builder,  
Auto Tutor and BBN

DUC TRAN

SUBMITTED TO THE FACULTY OF WORCESTER POLYTECHNIC INSTITUTE

DATE: May 3<sup>rd</sup>, 2016

## Abstract

This project focuses on two main purposes. First is to develop contents in Skill Builder for ASSISTments system related to Electronics. These contents along with problem sets from Electronix Tutor and AutoTutor are constructed in a way that student will be assigned randomly to either Skill Builder or AutoTutor only or an arbitrary combination of these two sources. A Post Test will be assigned to test student's knowledge about a particular subject. The second purpose is to compare the effectiveness of the order of the problem sets. A study is then conducted using the problem sets from Skill Builder and external sources such as BBN's Electronix Tutor and Auto Tutor. For each problem sets, students will be randomly assigned different order of the problems. Analysis from the collected data will help determine which order of the problem sets is the most efficient method to improve trainees' process of mastering a skill.

## Acknowledgement

We want to dedicate special thanks to Professor Neil Heffernan for leading the project, and to Mrs. Cristina Heffernan and Mr. Eric Vanlnwegen for the meticulous guidance and instructions throughout the project. We would like to thank to Mrs. Whitney from Electronix Tutor for intensively supporting in building electronic templates and giving feedback on the problem sets. We also thank to development teams from ASSISTments and BBN's Electronix Tutor for helping with the system maintenance. Finally, we would like to thank to the teachers and students who spend time using the problem sets; without them, the project would not have been possible.

# Table of Contents

<b>Abstract.....</b>	<b>i</b>
<b>Acknowledgement.....</b>	<b>ii</b>
<b>1. Introduction.....</b>	<b>1</b>
<b>1.1. ASSISTments System .....</b>	<b>1</b>
<b>1.2. iFrame – for outside learning resources .....</b>	<b>1</b>
BBN’s Electronix Tutor .....	1
Auto Tutor .....	2
<b>1.3. Project Goal.....</b>	<b>2</b>
<b>2. Content .....</b>	<b>3</b>
<b>2.1. Template Design Process .....</b>	<b>3</b>
<b>2.2. iFrame – for outside learning resources .....</b>	<b>9</b>
2.2.1. Auto Tutor .....	9
2.2.2. BBN.....	10
<b>2.3. Problem Set Structure .....</b>	<b>11</b>
<b>3. Study.....</b>	<b>12</b>
<b>3.1. Websites for Study.....</b>	<b>12</b>
3.1.1. Website for Students.....	13
3.1.2. Website for Teachers .....	14
<b>3.2. Study.....</b>	<b>14</b>
3.2.1. Group A: Equivalent Resistance (PSAXJFX).....	15
3.2.2. Group B: Ohm’s Law (PSAXHWU).....	17
3.2.3. Group C: Diode (PSAXNK7).....	19
3.2.4. Group D: Transistors (PSAXNMA).....	21
<b>4. Result.....</b>	<b>22</b>
<b>5. Future Plan.....</b>	<b>23</b>
<b>6. Conclusion .....</b>	<b>23</b>
<b>7. References and External Links.....</b>	<b>24</b>
<b>8. Appendix .....</b>	<b>25</b>
<b>8.1. Appendix A (Problem Sets) .....</b>	<b>25</b>
8.1.1. Group A: Equivalent Resistance (PSAXJFX).....	25
8.1.2. Group B: Ohm’s Law (PSAXHWU).....	28
8.1.3. Group C: Diode (PSAXNK7).....	30
8.1.4. Groups D: Transistors (PSAXNMA) .....	36
<b>8.2. Appendix B (Variablized Templates) .....</b>	<b>41</b>



# 1. Introduction

The first purpose of this Interactive Qualifying Project (IQP) is to create a comprehensive set of variablized templates in Skill Builder related to Electronic Content, which involved essential skills such as calculating equivalent resistance, applying Ohm's Law, determining characteristics of diode and understanding behavior of semiconductor devices such as Bipolar Junction Transistor (BJT) and Metal-oxide-semiconductor field-effect transistor (MOSFET). The four different skills, combined with templates provided by Electronix Tutor and AutoTutor, are designed for naval trainees who are in the process of A-school training under the Navy Educational Training Command (NETC) to facilitate training in electronics.

Additionally, we also set up and conduct a study based on these problem sets in order to determine whether different combinations of the problem sets would help student understand a particular skill better. Our skill builders and AutoTutor are constructed in a random order that each student would be randomly assigned to problem set with AutoTutor followed by Skill Builder, problem set with Skill Builder followed by AutoTutor or problem set with either Skill Builder or AutoTutor, respectively. In all cases, a post test in final will give students opportunities to test their understanding about a particular skill. We then compare these four groups and analyze data to determine which tutoring method is more effective for helping trainees learn new electronic content. The methodology, analysis process, and results are discussed later in the body of this report.

## 1.1. ASSISTments System

In 2003, ASSISTments project, an intelligent tutoring system, began as an idea of Neil Heffernan and Ken Koedinger, with the funding from the US Department of Education, the Office of Naval Research and the National Science Foundation. Several thousands of students, mainly located in Maine and Massachusetts, have used ASSISTments. The word "ASSISTments" is a blend of "assistance" and "assessment". While the system effectively helps students to master over a hundred different skills, it gives teachers an effective way of quickly and easily assessing their students' performance. ASSISTments is a full function web-based teaching system that provides tutoring in various areas. Created and supported by WPI, ASSISTments allows teachers to develop and assign tutoring problems, and to access their performance in a timely manner.

## 1.2. iFrame – for outside learning resources

ASSISTments provides the Problem Type, *Externally Run*, for researchers to integrate externally created learning resources into an ASSISTments Problem Set. The contents from external projects that will be supported in this project are from Electronix Tutor, including BBN's Electronix Tutor and Auto Tutor.

### **BBN's Electronix Tutor**

**Integration of Intelligent Tutoring Systems for Electronics**, also known as Electronix Tutor, is a new, collaborative project across multiple institutions that seeks to integrate each of their learning resources into one platform that will deliver electronics content to naval trainees who are in the process of A-school training under the Navy Educational Training Command (NETC). The focus of the project is on building intelligent tutoring systems (ITS) to facilitate training for Auto Tutor (ATT) courses in electronics. The goal is to supplement the existing

individual human tutoring with advanced learning environments (ITS and other adaptive learning technologies) that can help these individuals achieve the instructional objectives. The system integrates many existing ITS technologies which allows students to interact with the electronics material in multiple ways from natural language interaction to simulation, and beyond. The ITS assesses what the students know and provides pedagogically appropriate remediation when needed.

Electronix Tutor will incorporate:

- Selected readings from the Naval A-school curriculum.
- Deep Reasoning question answered in natural language.
- Multiple choice questions.
- Exploring circuits in a simulation environment.
- Constructing mental models of circuits in a simulation environment.
- Answering questions from students through a Point and Query facility.

### **Auto Tutor**

AutoTutor uses conversational agents to promote verbal reasoning, question answering, conceptual understanding, and natural language interaction. In Electronix Tutor, AutoTutor uses two agents (one tutor and one peer) to have a triologue conversation with the human learner. The trainee can observe the tutor agent and peer agent interact and model good behavior, which is sometimes helpful for trainees with low knowledge and skills. The more advanced trainee can attempt to teach the peer agent, with the tutor agent stepping in as needed. This helps students co-construct answers to questions or solutions to problems. There are three levels of questioning in AutoTutor: Answering deep reasoning questions in natural language, answering knowledge component questions in natural language, and asking questions and receiving answers through Point & Query. These constructive and interactive activities encourage deeper comprehension.

### **1.3. Project Goal**

This project focuses on two main purposes. First is to develop content for the ASSISTments system related to Electronics. In particular, we build problem sets for four different skills related to four major topics in Electrical Engineering, namely Equivalent Resistance, Ohm's Law, Diode and Transistor. These contents along with templates from Electronix Tutor and AutoTutor are constructed in a way that student will be assigned randomly to either Skill Builder only or AutoTutor only or randomly ordered combination of the two. A Post Test will be assigned to test student's knowledge about a particular subject.

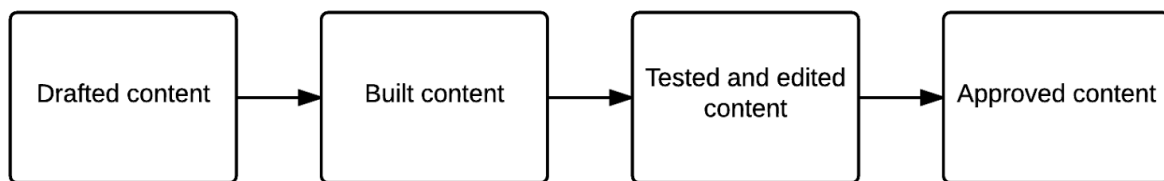
Second is to compare the effectiveness of the order of the problem sets. A study is then conducted using these problem sets from Skill Builder and external sources such as BBN's Electronix Tutor and Auto Tutor. The analysis from the collected data will help determine which order of the problem sets is the more preferable method to accelerate trainees' process of mastering a skill.

## 2. Content

We chose four different topics in electronics to construct our skill builders. In these four skills, some of the problems are simple to review the basic concept while others, built from fundamental concepts, may require more mathematical calculation and may be more challenging for trainees and students. The difference in level of difficulty can introduce the variety of the problem sets as well as the study that we conduct later.

### 2.1. Template Design Process

Throughout the project, to make the progress clear and organized, we keep track of the problem sets and its corresponding status for verification on a document and spreadsheet. Every problem that is used in Skill Builder needs to be ensured the quality before sending out to teachers and students. The process for designing templates is demonstrated in Figure 1 below.



*Figure 1: Template Design Process*

We firstly designed the template by doing research and choosing the most suitable concept for each skills. We reviewed materials from electrical courses and tried out some existing exercises to perceive the important and necessary concept for students. We then started to construct the simple templates before applying to the more challenging problems. For each template, we also included the corresponding hints showing step-by-step to solve the problem and the complete solution. Some templates may have additional appropriate figures for clarity.

The contents we designed are divided into four major topics as following:

- Equivalent Resistance
- Ohm's Law
- Diode
- Transistor

The first main topic, Equivalent Resistance, reviews the basic concept of determining the resistance of a circuit depending on different electrical connection such as series, parallel or the combination of these two types. This topic provides the fundamental knowledge of finding total resistance of a circuit and helps students practice with both simple and complex circuits. All of the templates built in Skill Builder are variablized, which means arbitrary numbers and data from a template will be generated each time students click on the problems. Figure 2 below demonstrates one example of Equivalent Resistance variablized template. All other variablized templates can be found in Appendix B.

Problem #846687 "PRA7QBS - Complex 1 Equivalent Resistance"

Find the equivalent resistance in  $\Omega$  for the circuit below with

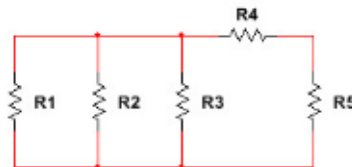
$$R_1 = a \Omega,$$

$$R_2 = b \Omega,$$

$$R_3 = c \Omega,$$

$$R_4 = d \Omega$$

$$R_5 = e \Omega.$$



$$R_{EQ} =$$

Round your answer to 2 decimal place; the units are given, type only the number.

Algebraic Expression:

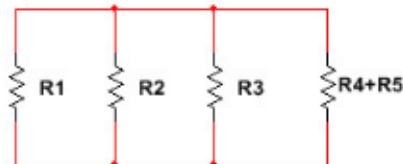
✓  $\text{sprintf}("%.2f", \text{answer})$

✓  $\text{sprintf}("%.2f", \text{answer}) + 0.01$

✓  $\text{sprintf}("%.2f", \text{answer}) - 0.01$

Hints:

- Combine two resistors  $R_4$  and  $R_5$ :



- For parallel resistors:

$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_{45}}$$

- The equivalent resistance is:  $\text{answer} \Omega$ .

Type in:  $\text{rounded\_answer}$

Figure 2: Example of variablized template for Equivalent Resistance topic

In second topic, students and trainees can review one of the most important concept in electronics, the Ohm's Law. Through practicing exercises in this group, students get more understanding of how the current flows, how the voltage drops across resistors in the circuit and to calculate them using Ohm's Law equation ( $V = I \times R$ ). Figure 3 below shows one of the variablized templates for this topic. The entire templates can be found in Appendix B.

Problem #844049 "PRA7MKP - Voltage Divider V1"

Find  $V_1$  for a circuit with voltage source  $V_s = \%v\{x\}V$  connected to three resistors in series,

$$R_1 = \%v\{a\}\Omega,$$

$$R_2 = \%v\{b\}\Omega,$$

$$R_3 = \%v\{c\}\Omega.$$



Assume the voltages are measured in Volts.

$$V_1 =$$

Round your answer to 2 decimal places.

Do not include units (Volts).

**Algebraic Expression:**

✓  $\%v\{\text{answer}\}$

✓  $\%v\{\text{rounded\_answer}\}$

✓  $\%v\{\text{rounded\_answer}\}+0.01$

✓  $\%v\{\text{rounded\_answer}\}-0.01$

**Hints:**

- Because the resistors are in series, the current flowing through each resistor is identical. You will need to:

1. Find the equivalent resistance in the circuit,  $R_{EQ}$
2. Find the current  $I$  in the circuit by applying Ohm's Law.
3. Apply Ohm's Law ( $V = I \times R$ ) to find the voltage across the  $R_1$ .

- 1. To find the equivalent resistance  $R_{EQ}$ , calculate the sum of series resistors.

$$\begin{aligned} R_{EQ} &= R_1 + R_2 + R_3 \\ &= \%v\{a\} + \%v\{b\} + \%v\{c\} \\ &= \%v\{\text{req}\} \Omega. \end{aligned}$$

- 2. The current in the circuit is:  $I = \frac{V_s}{R_{EQ}}$

$$I = \%v\{i\_rounded\}A.$$

- $V_1 = I \times R_1$   
 $= \%v\{i\_rounded\} \times \%v\{a\}$   
 $= \%v\{\text{rounded\_answer}\}V$

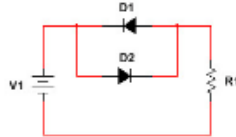
Type in:  $\%v\{\text{rounded\_answer}\}$

Figure 3: Example of variablized template for Ohm's Law topic

The third topic provides essential knowledge to understand behavior and characteristic of diode, a semiconductor electronic component that has two electrodes called anode (positive) and cathode (negative). Throughout this group, students can practice diode in circuit along with resistors and other electronic components. Variablized templates for diode can be found in Figure 4 below and in Appendix B.

**Problem #852653 "PRA7WH8 - Diode - Mixed 4 Current"**

Find the current  $I$  through the resistor in the circuit below, with  $V_1 = \{x\}$ V and  $R_1 = \{a\}$ k $\Omega$ . Use the 0.7 Volt Diode Model.



Assume  $I$  is measured in mA.

$I =$

Round your answer to 2 decimal places.

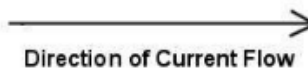
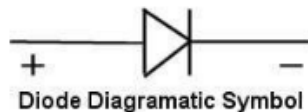
Do not include unit (mA).

**Algebraic Expression:**

- ✓  $\{answer\}$
- ✓  $\{rounded\_answer\}$
- ✓  $\{rounded\_answer\} + 0.01$
- ✓  $\{rounded\_answer\} - 0.01$

**Hints:**

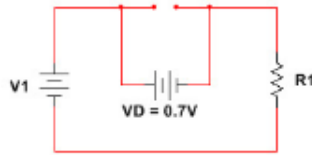
- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.



- The diode  $D_2$  is in forward bias region, replace it with a 0.7V voltage source. However, the diode  $D_1$  is in reversed bias order, thus it is OFF, replace with an open circuit.

To find the current through resistor  $R_1$ :

1. Find the voltage across resistor  $R_1$
2. Find the current through resistor  $R_1$  by using Ohm's Law ( $I = V/R$ )



- 1. Voltage across resistor  $R_1$ :

$$\begin{aligned}
 V &= V1 - 0.7 \\
 &= \%v\{x\} - 0.7 \\
 &= \%v\{v1\}V
 \end{aligned}$$

- 2. The current through resistor  $R_1$ :

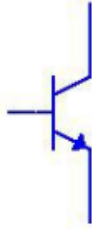
$$\begin{aligned}
 I &= V/R \\
 &= \%v\{v1\}/\%v\{a\} \\
 &= \%v\{rounded\_answer\}mA
 \end{aligned}$$

Type in:  $\%v\{rounded\_answer\}$

*Figure 4: Example of variablized template for Diode topic*

The last topic designed in this project is transistor, namely Bipolar Junction Transistor (BJT) and Metal-oxide-semiconductor Field-effect transistor (MOSFET). Students and trainees can learn and review the basic concept about these semiconductor devices. They are, in fact, are essential components in most contemporary electronic circuits. The development of these powerful devices effectively increases the growth of microelectronics and embedded systems that improve the performance of electronic device but decrease the size of it. Throughout this topic, students and trainees will be able to understand the fundamental concept of these semiconductor devices.

Problem #858589 "PRA74QQ - NPN 1 Symbol"  
Which transistor corresponds to the symbol below?



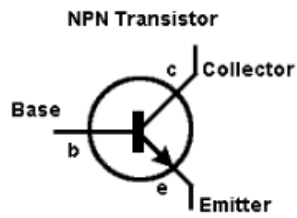
Multiple Choice:

NPN

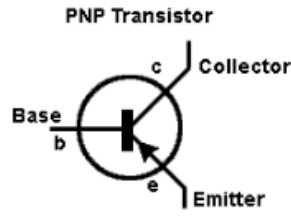
PNP

.

Here's a mnemonic for you:

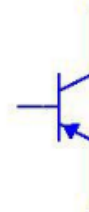


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

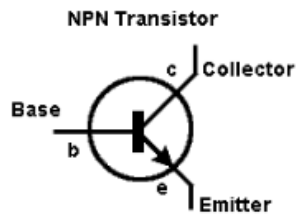
The symbol for pnp transistor is:



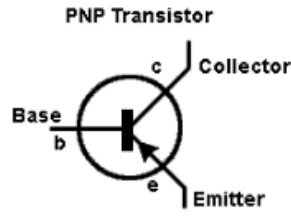
NMOS

.

Here's a mnemonic for you:

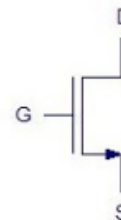


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

The symbol for NMOS transistor is:

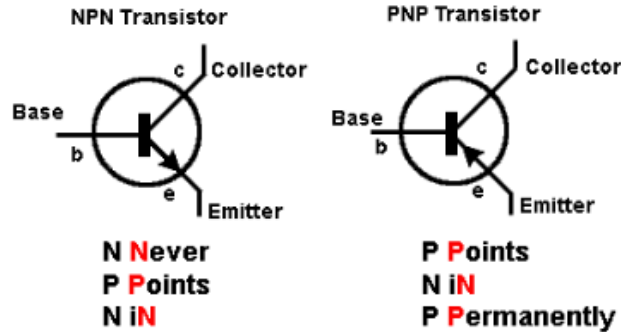




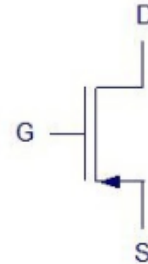
✗ PMOS

.

Here's a mnemonic for you:

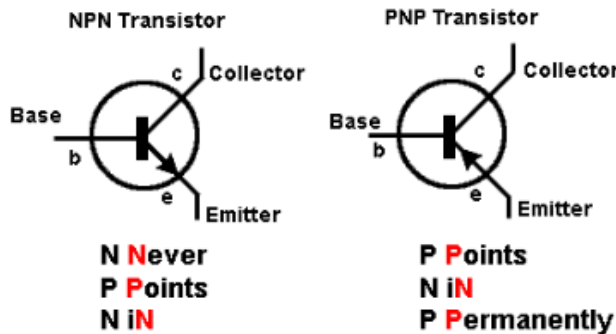


The symbol for PMOS transistor is:



Hints:

- For BJT:



- The answer is NPN.

Figure 5: Example of variablized template for Transistor topic

During the process of building templates, including problems, solutions and hints, we received weekly feedback from our advisor for each building template. We reviewed, went over the templates closely and carefully, focusing on different aspects such as appropriateness of the content, level of difficulty, visualization and grammar. According to the feedback and our weekly discussion, we edited and modified the templates accordingly. This process should be done until the templates are in the best quality and they are approved by our advisors.

## 2.2. iFrame – for outside learning resources

As discussed in the Introduction above, ASSISTments provides the learning resources not only from Skill Builder itself but also from external problem sets. For this project, we collaborate with Electronix Tutor to create electronic groups, including Auto Tutor and BBN.

### 2.2.1. Auto Tutor

Auto Tutor uses conversational agents to promote verbal reasoning, question answering, conceptual understanding, and natural language interaction. They use two agents (one tutor and one peer) to have a dialogue conversation with the student. The trainee can observe the tutor agent and peer agent interact and model good behavior, which is sometimes helpful for trainees with low

knowledge and skills. The more advanced trainee can attempt to teach the peer agent, with the tutor agent stepping in as needed. This helps students co-construct answers to questions or solutions to problems. There are three levels of questioning in Auto Tutor: Answering deep reasoning questions in natural language, answering knowledge component questions in natural language, and asking questions and receiving answers through Point & Query. These constructive and interactive activities encourage deeper comprehension. Figure 6 below demonstrates one of the examples of Auto Tutor problem sets.

The screenshot shows the Auto Tutor interface with the following components:

- Question Panel (Top Left):** "If we increase the rheostat's resistance, what would happen to the reading of the Ammeter?"
- Avatar Panel (Top Right):** Two avatars representing the student and the tutor, each with a green microphone icon.
- Circuit Diagram (Middle Left):** A circuit diagram on a dark blue background. It features a battery labeled 'U' at the bottom. A branch contains a rheostat and a resistor labeled 'R' in parallel. A voltmeter labeled 'V' is connected across the rheostat. An ammeter labeled 'A' is connected in series with the parallel branch.
- Dialogue Panel (Middle Right):**
  - Tutor:** Hello, Mr. Tran. It is time for a quick review question.
  - Tutor:** If we increase the rheostat's resistance, what would happen to the reading of the Ammeter?
  - Tutor:** Let's focus on the main idea.
- Input Area (Bottom Right):** A large text input field and a "Send" button.

Figure 6: Example of conversational dialogue in Auto Tutor

### 2.2.2. BBN

Due to the difficulty level of BBN's problem sets, they are often be used as the Post Test in the final to test students' and trainees' understanding of a skill. It provides opportunities for students to practice their understanding in a specific field by solving a problem. In order to solve for this type of problem, it is necessary that students understand the basic concept of each component and of the overall circuit, which are covered by Auto Tutor and Skill Builder. BBN's question type is multiple choice with hints of showing step by step how to solve the problem. It is useful for students and trainees to test their understanding before moving to another topics. An example of BBN's problem set is shown in Figure 7 below.

**Transistor Circuit Analysis (EU1T1A)**

Analyze the circuit shown below to determine  $V_{CE}$ .  $V_{BE} = 0.7V$ ;  $\beta = 200$

A. 5.3V       B. 6.0V  
 $V_{CE} =$        C. 8.9V       D. 10.6V

Source: Hambley, Electrical Engineering, 5th Edition

**Raytheon**  
BBN Technologies

**Show Steps**

*Figure 7: An example of BBN's problem*

### 2.3. Problem Set Structure

Four major problem sets were created, namely Equivalent Resistance, Ohm's Law, Diode and Transistor, from our Skill Builder templates as well as outside learning resources, BBN and Auto Tutor. In each problem set, templates are carefully chosen from these three sources according to the particular topic of the set.

**Problem Set Settings**

Automatically enter scaffolding on an incorrect response

Problem Set Type: Complete All - Linear Order

Change all Problems in this Problem Set to:

Tutor Mode  Test Mode

**Problems**

Condition Choose One Item or Section - Random Order	Advanced Options	<a href="#">Edit</a>	<a href="#">Delete</a>
Post Test Complete All - Random Order		<a href="#">Edit</a>	<a href="#">Delete</a>

[+ Add existing problems](#)

[+ Write New Problems Using the Builder](#)

[+ New Section](#)

[Show list of problem IDS](#)

Figure 8: Problem Set Settings

Problem sets in our study are set in linear order. Students have to go through Condition part firstly before being able to move on the Post Test part. In the Condition part, students will be assigned randomly into one of the four sub-conditions, which will be discussed in detail in chapter V below. In the Post Test, students are required to complete every problems existing in this part. Different students will practice the Post Test in different orders of problems.

### 3. Study

#### 3.1. Websites for Study

After finishing and summarizing the problem sets design, to start our study, we conducted two separate websites, one for students and one for teachers.

### 3.1.1. Website for Students

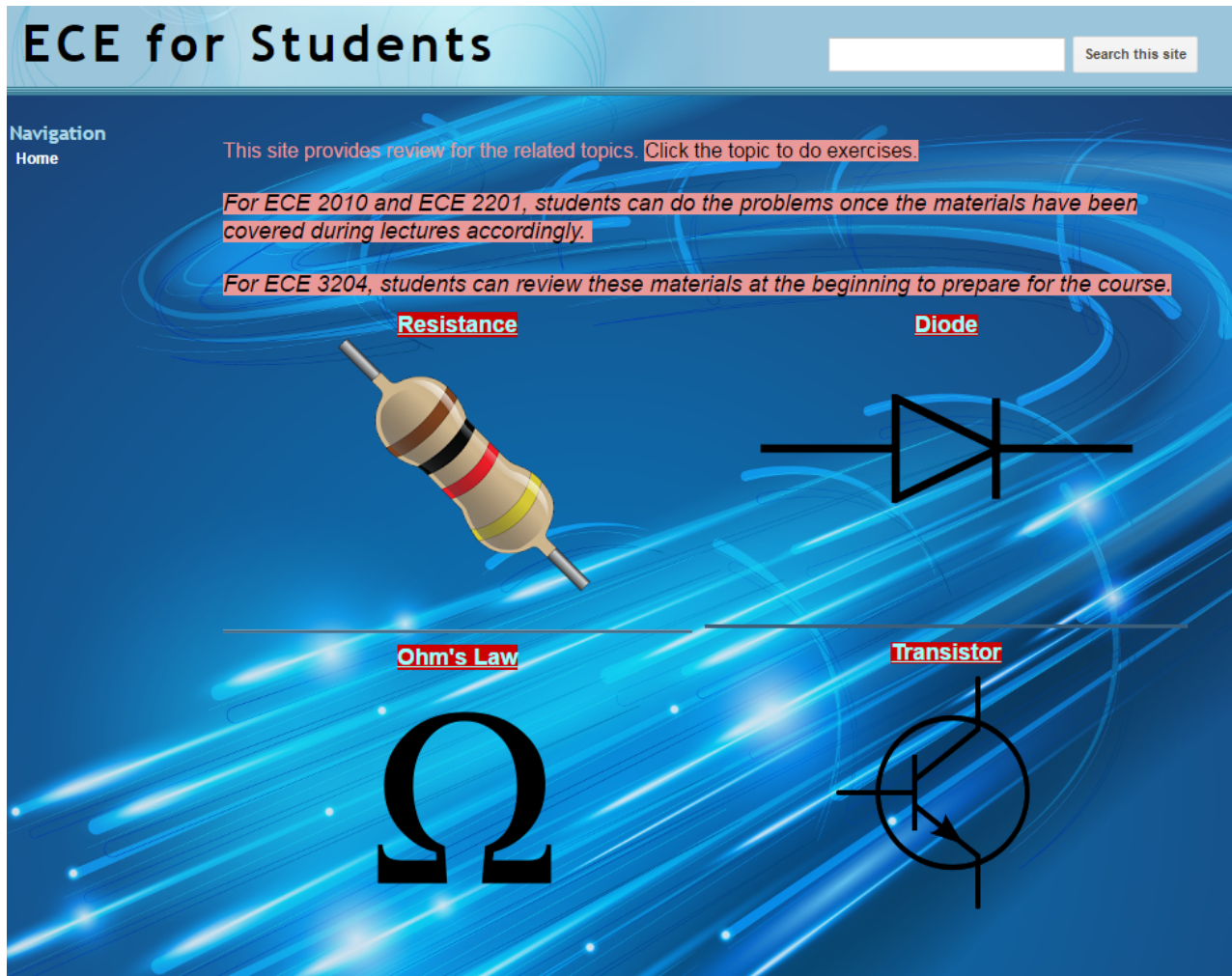


Figure 9: Website for Students

Figure 9 above shows the website that uses for students. From this site, students can choose any topic of their choices among these four groups in order to access to the assignment for practicing and exercising. Notes and instructions are also available in the website, as shown in the pink background colored sentences. The link to the website is [here](#).

### 3.1.2. Website for Teachers

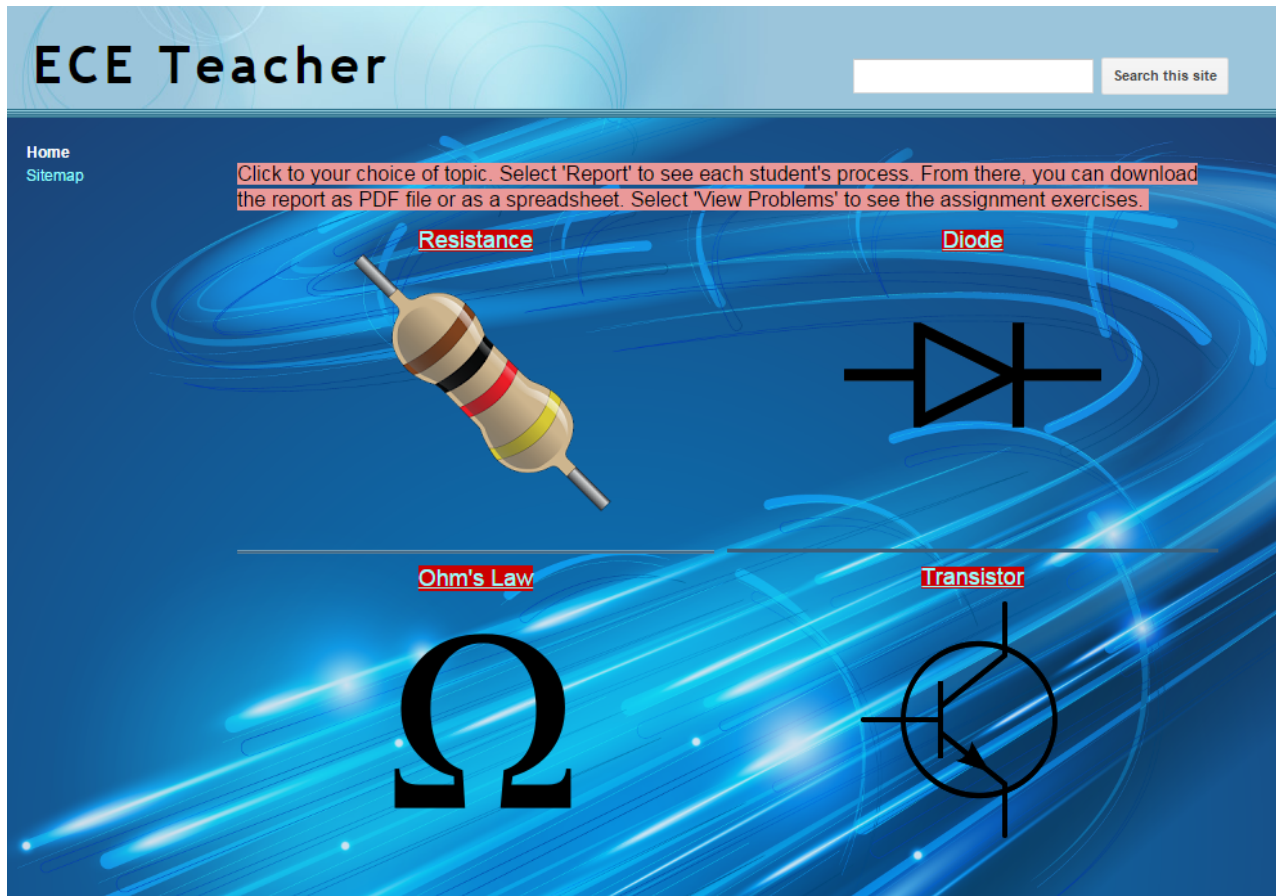


Figure 10: Website for Teachers

Figure 10 above shows the website that uses for teachers. It is similar with the site for Students. Yet, this is designed only for teachers. From here, teachers can get the Share Link from the four topics to assign to the students. They can also get the Report on each student's process. The report can be downloaded as either a PDF file or a spreadsheet for convenience. The link to the website is [here](#).

### 3.2. Study

For our project's study research, we want to investigate the effect of order of templates from Skill Builder, Auto Tutor and BBN on students' works. According to problem set structure discussed above, we divided each problem set into two main parts: Condition and Post Test. For each problem set, in the Condition, there are four sub-conditions, which is also known as the Treatments. Students will be assigned arbitrarily into one of these four Treatments, in which they will be assigned to problem sets from either Skill Builder or Auto Tutor or the combination of these two sources. After completing the problems in the Condition part, no matter which order students are assigned, they are exposed to the Post Test to further evaluate their understanding on the specific skill. Since Auto Tutor problem sets focus more on the conceptual knowledge while problems from Skill Builder and BBN are generated for practicing purpose, either problem sets from BBN or Skill Builders are chosen for the Post Test. The details of each group's problem set



structure are discussed below. All of the problem sets for each study group are included in Appendix A.

### 3.2.1. Group A: Equivalent Resistance (PSAXJFX)

The problem set structure for this group is set up as illustrated in the below block diagram and Figure 11 and 12.

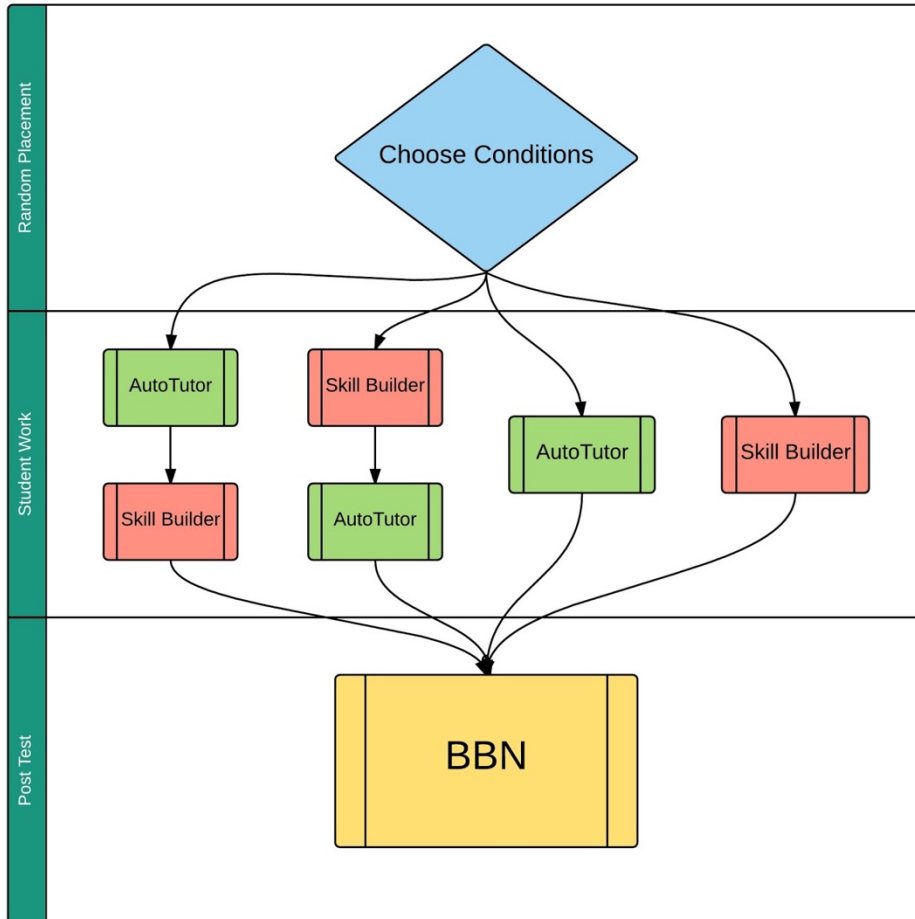


Figure 11: Group A Study

Problem Sets Problems Skills Messages Preferences Need help?

## Group A: Resistance [Edit name](#)

[New Copy](#) - [Details](#) - [View Problems](#) - [Test Drive](#)

### Problem Set Settings

Problem Set Type: Complete All - Linear Order

Change all Problems in this Problem Set to:  
 Tutor Mode  Test Mode

### Problems

- Condition Choose One Item or Section - Random Order [Advanced Options](#) [Edit](#) [Delete](#)
- Post Test Complete All - Random Order [Edit](#) [Delete](#)
- [+ Add existing problems](#)
- [+ Write New Problems Using the Builder](#)
- [+ New Section](#)

[Show list of problem IDS](#)

Group A: Resistance
Condition
Sub-condition AT-SB
AT First
SB Second
Sub-condition SB-AT
SB First
AT Second
AT
SB
Post Test

Figure 12: Group A detailed study

To support for our study, students will be assigned randomly into one of the four sub-conditions. As it is shown above, in the first sub-condition, students will need to complete the problem sets from Auto Tutor first before reaching to Skill Builder. In contrast, for the second sub-condition, students will be assigned to do the Skill Builder followed by the Auto Tutor. In the third and fourth sub-conditions, students will only need to complete the problem sets from either Auto Tutor or Skill Builder only, respectively. For Skill Builder problem sets, students are required to have at least three right in a row in order to move to the next section. The purpose of setting three corrects in a row is to ensure that the trainees and students master the essential skills. The setting for Skill Builder is shown below.

### Problem Set Settings

Problem Set Type: Skill Builder - Random Order

### Variables

Students will get questions in a random order until they demonstrate proficiency.

Completion Count:  correct in a row  
 The number of Problems the student must answer correctly in a row to complete this Problem Set.

Test Out Count:   
 Allows a student to complete the skill Builder by getting this many Problems correct in a row at the beginning of the assignment. For example: if set to 1 and a student gets the first Problem correct, they have completed the Problem Set.  
 A value of 0 disables the setting.

Day Limit:   
 The maximum number of Problems allowed to be answered in a single day. This value is a suggestion: If the student has answered correct 1 or more Problems at the time this limit is reached, The Problem Set will continue until either the student answers a Problem incorrectly or completes the Problem Set - whichever comes first.  
 When set to a value of 0, there is no Day Limit.

Stop On Day Limit:   
 Specifies the Tutor's action when a student reaches the Daily Limit:
 

- Checked: The Tutor stops the Problem Set for the day.
- Unchecked: The Tutor ends the Skill Builder, or, if the parent Problem Set contains addition Problems or Problem Sets, the Tutor allows the student to progress to those items.

[Save Variables](#) [Set to Defaults](#)

After completing the condition, students will be moved to the Post Test, in which they will have to complete all of the problem sets as the final remark for mastering the skills. The results of



students will help us study which order in sub-conditions effectively improve students' skills. The detail of problem sets for this group is available in Appendix A.

### 3.2.2. Group B: Ohm's Law (PSAXHWU)

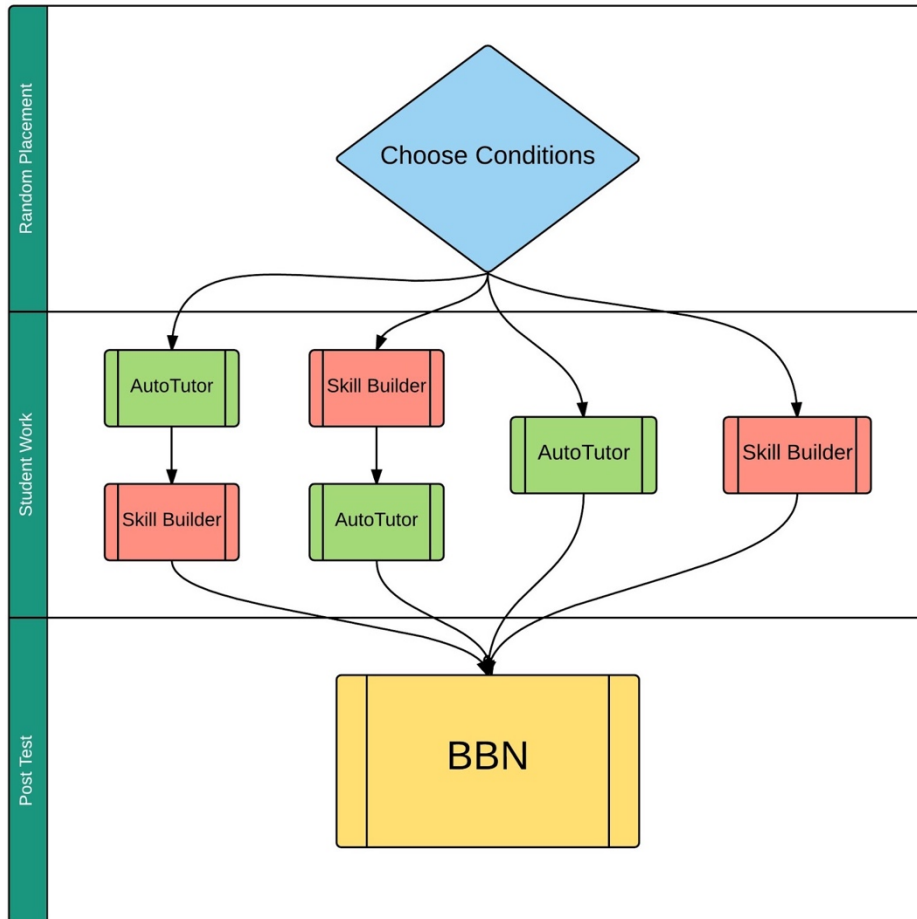


Figure 13: Group B Study

Problem Sets Problems Skills Messages Preferences Need help?

## Group B: Ohm's Law [Edit name](#)

[New Copy](#) - [Details](#) - [View Problems](#) - [Test Drive](#)

### Problem Set Settings

Problem Set Type: Complete All - Linear Order

Change all Problems in this Problem Set to:  
 Tutor Mode  Test Mode

### Problems

- Condition Choose One Item or Section - Random Order [Advanced Options](#) [Edit](#) [Delete](#)
- Post Test Complete All - Random Order [Edit](#) [Delete](#)
- [+ Add existing problems](#)
- [+ Write New Problems Using the Builder](#)
- [+ New Section](#)

[Show list of problem IDs](#)

Group B: Ohm's Law
Condition
Sub-condition AT-SB
AT First
SB Second
Sub-condition SB-AT
SB First
AT Second
AT
SB
Post Test

Figure 14: Group B detailed study

As the same with the study conducted for Group A, in Group B, students will also be randomly assigned to one of the four sub-conditions with different orders and combinations of problem sets. After completing the sub-condition part, they will move to the Post Test, in which students will be tested for mastering the specific skill. Again, results from students will be used for our study to decide which order is the most effective way to assist them understand the material thoroughly. The detail of problem sets for this group is available in Appendix A.

### 3.2.3. Group C: Diode (PSAXNK7)

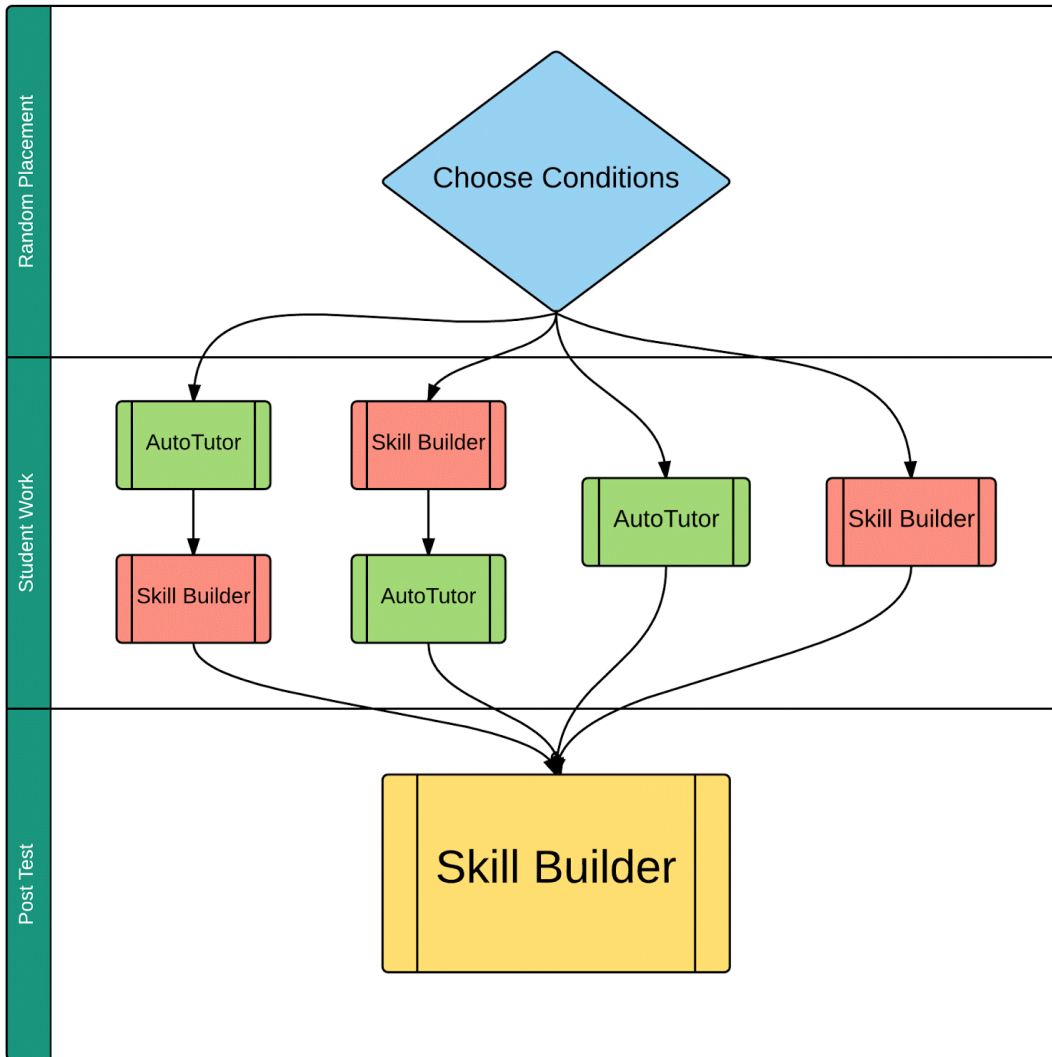


Figure 15: Group C study

Group C: Diode [Edit name](#)  
[New Copy](#) - [Details](#) - [View Problems](#) - [Test Drive](#)

**Problem Set Settings**

Problem Set Type: Complete All - Linear Order

Change all Problems in this Problem Set to:  
 Tutor Mode  Test Mode

**Problems**

Condition Choose One Item or Section - Random Order [Advanced Options](#) [Edit](#) [Delete](#)

Post Test Complete All - Random Order [Edit](#) [Delete](#)

[+ Add existing problems](#)

[+ Write New Problems Using the Builder](#)

[+ New Section](#)

[Show list of problem IDs](#)

Group C: Diode
Condition
Sub-condition AT-...
AT First
SB Second
Sub-condition SB-...
SB First
AT Second
AT [treatment3]
SB [treatment4]
Post Test

Figure 16: Group C detailed study

Similar with two groups above, students will also be arbitrarily assigned to one of the four sub-conditions of different orders and combinations of problem sets. After completing the sub-condition part, they will move to the Post Test, which is problem sets from Skill Builder in this particular group, and students will be tested to master the skill and knowledge in diode. For this particular group, we use our problem sets from Skill Builder to use as Post Test. Again, results from students will be used for our study to decide which order is the most effective way to assist them understand the material thoroughly. The detail of problem sets for this group is available in Appendix A.

### 3.2.4. Group D: Transistors (PSAXNMA)

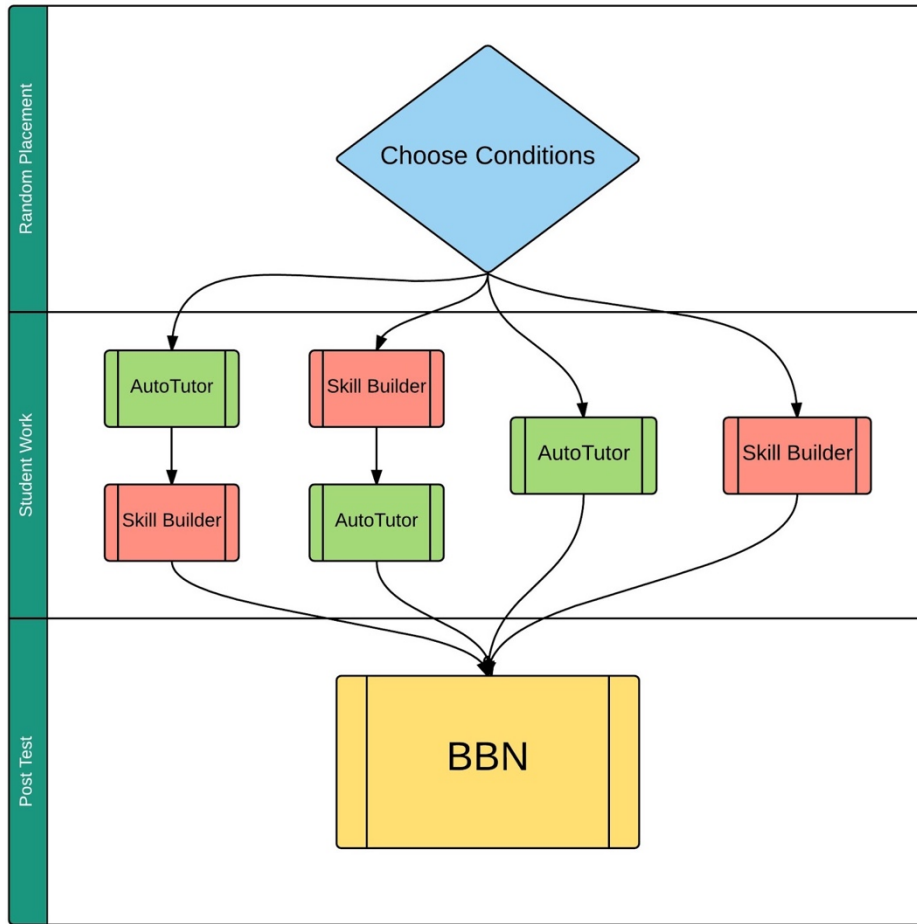


Figure 17: Group D study

### Group D: Transistor [Edit name](#)

[New Copy](#) - [Details](#) - [View Problems](#) - [Test Drive](#)

**Problem Set Settings**

Problem Set Type: Complete All - Linear Order

Change all Problems in this Problem Set to:  
 Tutor Mode  Test Mode

**Problems**

Condition Choose One Item or Section - Random Order [Advanced Options](#) [Edit](#) [Delete](#)

Post Test Complete All - Random Order [Edit](#) [Delete](#)

[+ Add existing problems](#)

[+ Write New Problems Using the Builder](#)

[+ New Section](#)

[Show list of problem IDs](#)

Group D: Transistor
Condition
Sub-condition AT-...
AT First
SB Second
Sub-condition SB-...
SB First
AT Second
AT [treatment3]
SB [treatment4]
Post Test

Figure 18: Group D detailed study

As the same with the study in three groups above, students will also be randomly assigned to one of the four sub-conditions with different orders and combinations of problem sets. After completing the sub-condition part, they will move to the Post Test, in which students will be tested for mastering the specific skill. Results from students will be utilized for our study to decide which order is the most effective way to assist them understand the material thoroughly. Again, the detail of problem sets for this group is available in Appendix A.

## 4. Result

We started conducting the study by giving out the website link to students and asking them to practice the materials with our content. For this time of project, the students we targeted to were from the course ECE 3204 - Microelectronics II. Since this course requires prerequisites from ECE 2010 - Introduction to Electrical and Computer Engineering and ECE 2201 - Microelectronics I, students should know and understand the four major topics that we used for our study. Based on the results that we get from students, we will be able to analyze the effective order of problem sets in helping students master the skills.

However, since the problem sets from Auto Tutor and BBN were still under development, we had to deal with some technical issues in the problem sets, in which either the questions changed unexpectedly every time or it took long time to load the content. Consequently, beginning at the middle of B term 2015 when we finalized the variablized templates and started conducting four major study groups, it was until the end of March 2016 that all technical issues have been fixed by Electronix Tutor and we summarized the problem sets to give out to professors and students at WPI.

The problem sets were given out to Professor Reinhold Ludwig, the instructor of ECE 3204 - Microelectronic II in D term 2016 and his WPI students. Due to limited available time and small class size, we are able to collect only few results from students. Among of those who participated in trying the content, some of them met problem of “*Externally run problem*” from Auto Tutor conversational problem set. This happened due to the overloading error of the problem. Figures below show the example of the error that some students encountered and the recorded result from student who might dropped out after finishing the first problem.

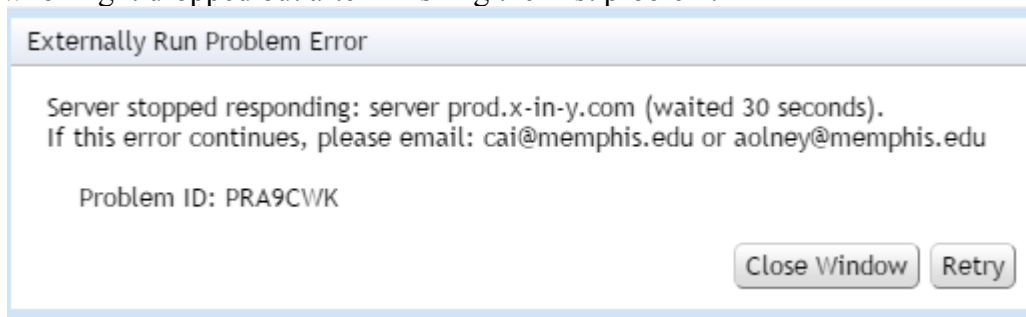


Figure 19: A pop-up loading error problem

Note: These actions are in chronological order. The quantities reported in seconds indicate elapsed time since the previous action.

**Assignment: 1 - Group A: Resistance**

Time	Action	Object ID / Input text
Wed Apr 20 17:42:40 -0400 2016	Started a problem	<a href="#">PRA9CWK</a>
1 mins 25 secs	Answered incorrectly	Externally run problem

Figure 20: The result was recorded

Below is the result from another student who might dropped out after completing the first problem:

**Assignment: 1 - Group A: Resistance**

Time	Action	Object ID / Input text
Thu Mar 17 11:41:54 -0400 2016	Started a problem	<a href="#">PRA8TT5</a>
0 mins 5 secs	Answered correctly	1
Thu Mar 17 11:42:00 -0400 2016	Started a problem	<a href="#">PRA7WDZ</a>
0 mins 23 secs	Asked for a hint	

Figure 21: Another recorded result

However, the biggest constraint we had in our study was time limit. Only until half of D term that we were able to send out the study to teacher and students. As a result, we only had approximately 3 weeks to give out the problem sets, collect and analyze the results. In addition, because the problem sets were sending out at the second half of D term and it was not the requirement for the course, students might focus on their exams and lab reports that they could not spend time on practicing with the problem sets. Due to the small sample size, we do not have enough data and results to determine which order of problem sets is more preferable for students to master the skills. Further study with more participating students should be conducted in the future to have a reasonable conclusion of the most effective order of problem sets.

## 5. Future Plan

The four major groups studied in this project would be used by the Navy Educational Training Command (NETC) to help naval trainees who are in process of A-school with essential electronics background. More electronics topics would be done to cover more necessary materials in the future. To support further study of the effective order in assisting students, the project would be given out to more and more electronic courses in the next academic year. Furthermore, since the Learning Management System (LMS), Blackboard, is going to expire, WPI is going to move to a new LMS called Canvas next academic year (2017 - 2018). ASSISTments can utilize the interface of Canvas platform to collaborate with Professors and instructors to assign more electrical exercises to students, which is useful and more convenient for both teachers and students to manage and record assignments.

## 6. Conclusion

This is a new project funded by the Navy Educational Training Command (NETC) with the purpose of helping naval trainees who are in process of A-school with electronics background.

Since it is still underdevelopment, more and more templates and problem sets from Skill Builder as well as Electronix Tutor will be made to cover different knowledge in electronics. By using ASSISTments educational platform for practicing, naval trainees have opportunities to learn the fundamental but essential materials in electronics anytime and anywhere they want. Throughout this project, they can study the four major topics in Resistance, Ohm's Law, Diode and Semiconductor devices. More topics will be covered to help trainees understand any necessary fields.

For our study, because of the existing technical issues and limited sample size during the time of study, we were not able to collect enough results from students in order to determine the preferable order of the problem sets that is more effective than others in helping students master the skills. Further studies and researches should be conducted in the future. If we could have got more students participating in our study, our conclusions would be more authentic due to large statistical number of results.

## 7. References and External Links

[1]	ECE for Students: <a href="https://sites.google.com/site/eceforstudent/">https://sites.google.com/site/eceforstudent/</a>
[2]	ECE for Teachers: <a href="https://sites.google.com/site/teacherassistment/">https://sites.google.com/site/teacherassistment/</a>
[3]	ASSISTments: <a href="http://www.assistments.org/staticpages/AboutUs.htm">http://www.assistments.org/staticpages/AboutUs.htm</a>
[4]	ASSISTments Teacher Wiki: <a href="http://teacherwiki.assistment.org/">http://teacherwiki.assistment.org/</a>
[5]	ASSISTments TestBed Resource Guide: <a href="http://www.assistmentstestbed.org/home">http://www.assistmentstestbed.org/home</a>

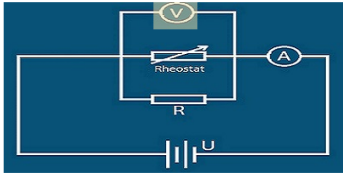
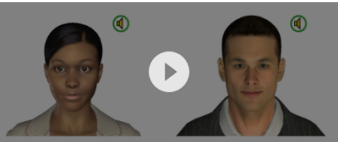
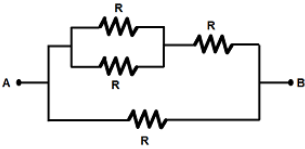



## 8. Appendix

This section includes the templates and problem sets that were built and used throughout the project. Appendix A shows the detail of problem sets using for each of four study groups. Appendix B includes all of the templates that we have built for we have built.

### 8.1. Appendix A (Problem Sets)

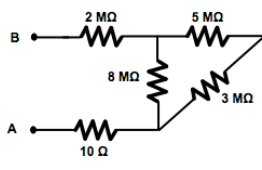
#### 8.1.1. Group A: Equivalent Resistance (PSAXJFX)

PROBLEM ID	DESCRIPTION
PRA9CWK - Auto Tutor	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>If we increase the rheostat's resistance, what would happen to the reading of the Ammeter?</p>  </div> <div style="width: 45%;">  <p><b>Tutor:</b> Hello, Mr. Tran. It is time for a quick review question.</p> <div style="border: 1px solid gray; height: 40px; width: 100%;"></div> <div style="text-align: right; margin-top: 5px;">Send</div> </div> </div>
PRA8RS5 - BBN	<div style="background-color: #1a2b3c; color: white; padding: 10px;"> <p style="text-align: center; color: #007bff; margin: 0;"><b>Equivalent resistance</b></p> <p style="margin: 5px 0;">What is the value of R, if the equivalent resistance between points A and B is equal to <math>3\ \Omega</math>?</p>  <ul style="list-style-type: none"> <li><input type="checkbox"/> A. <math>2\ \Omega</math></li> <li><input type="checkbox"/> B. <math>5\ \Omega</math></li> <li><input type="checkbox"/> C. <math>7\ \Omega</math></li> <li><input type="checkbox"/> D. <math>6\ \Omega</math></li> <li><input type="checkbox"/> E. Cannot be determined</li> </ul> <div style="display: flex; justify-content: space-between; align-items: center; margin-top: 10px;">  <div style="background-color: #007bff; color: white; padding: 5px 10px; border-radius: 5px;">Show Steps</div> </div> </div>

PRA8RS6 - BBN

**Equivalent resistance**

What is the equivalent resistance between points A and B?



The circuit diagram shows a network of resistors between terminals A and B. A 10 Ω resistor is connected in series with terminal A. This is followed by a parallel combination of three branches: a branch with a 2 MΩ resistor in series with an 8 MΩ resistor, a branch with a single 8 MΩ resistor, and a branch with a 5 MΩ resistor in series with a 3 MΩ resistor.

A. 4 MΩ

B. 14 MΩ

C. 16 MΩ

D. 28 MΩ

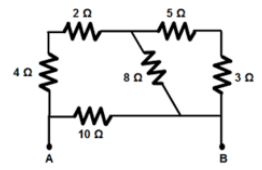
**Raytheon**  
BBN Technologies

[Show Steps](#)

PRA8RS7 - BBN

**Equivalent resistance**

What is the equivalent resistance between points A and B?



The circuit diagram shows a network of resistors between terminals A and B. A 4 Ω resistor is connected in series with terminal A. This is followed by a parallel combination of three branches: a branch with a 2 Ω resistor in series with an 8 Ω resistor, a branch with a single 8 Ω resistor, and a branch with a 5 Ω resistor in series with a 3 Ω resistor. A 10 Ω resistor is connected in series with terminal B.

A. 4 Ω

B. 5 Ω

C. 10 Ω

D. 20 Ω

**Raytheon**  
BBN Technologies

[Show Steps](#)

PSAWEUC (Equivalent Resistance)  
- ASSISTMENTs

Template 1: PRA7MGY

Problem ID: PRA7MGY

[Comment on this problem](#)

Find the equivalent resistance in  $\Omega$  for a circuit with three resistors in series,

$$R_1 = 9\Omega,$$
$$R_2 = 25\Omega,$$
$$R_3 = 19\Omega.$$

$$R_{EQ} =$$

Round your answer to 2 decimal place  
Do not include units ( $\Omega$ )

Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 2

### Template 2: PRA7MGZ

Problem ID: PRA7MGZ

[Comment on this problem](#)

Find the equivalent resistance for the circuit with three resistors in parallel:

$$R_1 = 6\Omega,$$
$$R_2 = 3\Omega,$$
$$R_3 = 3\Omega.$$

$$R_{EQ} =$$

Round your answer to 2 decimal place  
Do not include units ( $\Omega$ )

Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 2

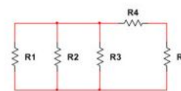
### Template 3: PRA7QBS

Problem ID: PRA7QBS

[Comment on this problem](#)

Find the equivalent resistance in  $\Omega$  for the circuit below with

$$R_1 = 5\Omega,$$
$$R_2 = 18\Omega,$$
$$R_3 = 10\Omega,$$
$$R_4 = 10\Omega$$
$$R_5 = 9\Omega.$$



$$R_{EQ} =$$

Round your answer to 2 decimal place; the units are given, type only the number.

Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 3

### Template 4: PRA7QBU

Problem ID: PRA7QBU

[Comment on this problem](#)

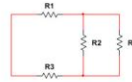
Find the equivalent resistance in  $\Omega$  for a circuit below with

$$R_1 = 1\Omega,$$

$$R_2 = 11\Omega,$$

$$R_3 = 10\Omega,$$

$$R_4 = 6\Omega.$$



$R_{EQ} =$

Round your answer to 2 decimal place; the units are given type only the number.

Type your answer below (mathematical expression):

Submit Answer

100%

Show hint 1 of 3


### 8.1.2. Group B: Ohm's Law (PSAXHWU)

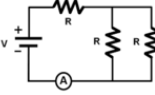
PROBLEM ID	DESCRIPTION
PRA9CWK - Auto Tutor	<div data-bbox="760 1060 1015 1155"> <p>If we increase the rheostat's resistance, what would happen to the reading of the Ammeter?</p> </div> <div data-bbox="717 1209 1058 1381"> </div> <div data-bbox="1068 1037 1409 1184"> </div> <div data-bbox="1078 1203 1344 1241"> <p>Tutor: Hello, Mr. Tran. It is time for a quick review question.</p> </div> <div data-bbox="1338 1415 1382 1436"> <p>Send</p> </div>

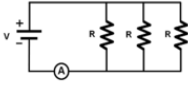
PRA8RTC - BBN

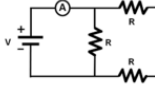
**Current in complex circuits**

In which of the following circuits does the ammeter read the highest current?

A. 

B. 

C. 

D. 

**Show Steps**

PSAWEWS (Ohm's Law) - ASSISTMENTS

### Template 1: PRA7KYE

Problem ID: PRA7KYE

[Comment on this problem](#)

Find voltage  $V$  across a resistor with  $R = 9\Omega$  and the current flowing through it is  $I = 6A$ .

Assume the voltage is measured in Volts.

$V =$

Round your answer to 2 decimal places  
Do not include units (Volts)

Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 2

### Template 2: PRA7KYF

Problem ID: PRA7KYF

[Comment on this problem](#)

Find current  $I$  running through a resistor with  $R = 5\Omega$  and voltage across it,  $V = 9V$ .

Assume the current is measured in Amps.

$I =$

Round your answer to 2 decimal places  
Do not include units (Amps)

Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 2

### Template 3: PRA7K4C

Problem ID: PRA7K4C

[Comment on this problem](#)

Find the resistance of a resistor when the current running through it is,  $I = 8A$  and the voltage across it is,  $V = 4V$ .

Assume the resistor is measured in Ohm ( $\Omega$ ).

R =

Round your answer to 2 decimal places  
Do not include units ( $\Omega$ )

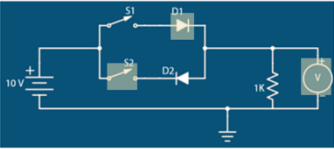


Type your answer below (mathematical expression):

100% ?

Submit Answer

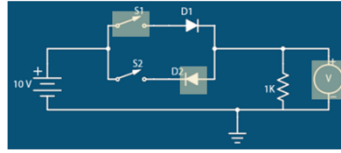
Show hint 1 of 2

### 8.1.3. Group C: Diode (PSAXNK7)

Problem ID	Description
PSAX8AD - Auto Tutor	<div style="border: 1px solid gray; padding: 10px;"> <p data-bbox="662 1052 915 1129"><b>Consider the circuit diagram. D1 and D2 are ideal diodes. What is the voltage across the resistor (R) if only switch S1 is closed?</b></p>  <div style="display: flex; justify-content: space-around; align-items: center;"> <div data-bbox="980 1052 1105 1171">  </div> <div data-bbox="1143 1052 1292 1171">  </div> </div> <p data-bbox="987 1194 1284 1232"><b>Kevin:</b> Hello, Professor and Mr. Tran. My name is Kevin. What are we doing today?</p> <p data-bbox="987 1241 1255 1276"><b>Tutor:</b> Hello, Mr. Tran. In this section, we are going to talk about P-N junction diodes.</p> <div style="border: 1px solid gray; height: 40px; width: 100%; margin-top: 10px;"></div> <div style="text-align: right; margin-top: 5px;"> <input type="button" value="Send"/> </div> </div>

PSAX8AZ - Auto Tutor

Consider the circuit below. D1 and D2 are ideal diodes. What is the voltage across the resistor (R) if only switch S2 is closed?



**Kevin:** Hello, Professor and Mr. Tran. My name is Kevin. What are we doing today?

**Tutor:** Hello, Mr. Tran. In this section, we are going to talk about P-N junction diodes.

**Kevin:** Great! I think P-N junction diodes are difficult. Maybe, Mr. Tran can take the first question and help me out.

Send

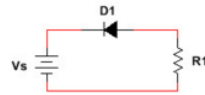
PSAWEW4 (Diode Current) - ASSISTMENTS

Template 1: (PRA7T27)

Problem ID: PRA7T27

[Comment on this problem](#)

Find the current  $I$  through the resistor with  $R_1 = 5k\Omega$  and  $V_s = 4V$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places  
Do not include units (mA)

Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 3

Template 2: (PRA7T26)

Problem ID: PRA7T26

[Comment on this problem](#)

Find the current  $I$  flowing through the resistor with  $R_1 = 2\text{k}\Omega$  and  $V_s = 11\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places  
Do not include units (mA)

Type your answer below (mathematical expression):

100% ?

Submit Answer

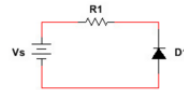
Show hint 1 of 3

### Template 3: (PRA7WQX)

Problem ID: PRA7WQX

[Comment on this problem](#)

Find the current  $I$  through the resistor in the following circuit with  $R_1 = 9\text{k}\Omega$  and  $V_s = 3\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places  
Do not include units (mA)

Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 3

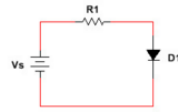
### Template 4: (PRA7WQY)



Problem ID: PRA7WQY

[Comment on this problem](#)

Find the current  $I$  flowing through the resistor with  $R_1 = 9\text{k}\Omega$  and  $V_s = 6\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places.  
Do not include units (mA)

Type your answer below (mathematical expression):

100% ?

Submit Answer

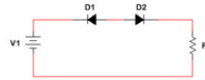
Show hint 1 of 3

### Template 5: (PRA7WH7)

Problem ID: PRA7WH7

[Comment on this problem](#)

Find the current  $I$  through the resistor  $R_1$  in the circuit below, with  $V_1 = 10\text{V}$  and  $R_1 = 5\text{k}\Omega$ . Use the 0.7 Volt Diode Model.



Assume  $I$  is measured in mA.

$I =$

Round your answer to 2 decimal places.  
Do not include unit (mA).

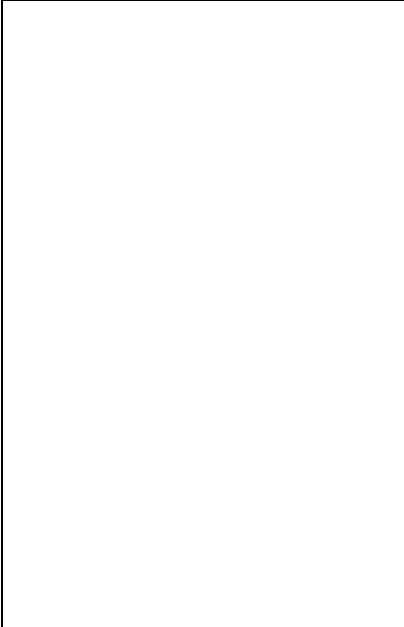
Type your answer below (mathematical expression):

100% ?

Submit Answer

Show hint 1 of 3

### Template 6: (PRA7WH8)



Problem ID: PRA7WH8 [Comment on this problem](#)

Find the current  $I$  through the resistor in the circuit below, with  $V_1 = 9V$  and  $R_1 = 3k\Omega$ . Use the 0.7 Volt Diode Model.

Assume  $I$  is measured in mA.

$I =$

Round your answer to 2 decimal places.  
Do not include unit (mA).

Type your answer below (mathematical expression):

Submit Answer 100% ?

[Show hint 1 of 4](#)

PSAW25V (Diode - Resistor Orientation) - ASSISTMENTS

Template 1: (PRA74HH)

Problem ID: PRA74HH [Comment on this problem](#)

For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).

Select one:

- A. Clockwise and forward-biased
- B. Clockwise and reverse-biased
- C. Counterclockwise and forward-biased
- D. Counterclockwise and reverse-biased

Submit Answer 100% ?

Template 2: (PRA76T9)

Problem ID: PRA76T9

[Comment on this problem](#)

For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).



Select one:

- A. Clockwise and forward-biased
- B. Clockwise and reverse-biased
- C. Counterclockwise and forward-biased
- D. Counterclockwise and reverse-biased

100% ?

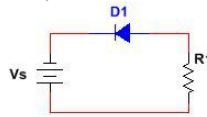
Submit Answer

### Template 3: (PRA76UB)

Problem ID: PRA76UB

[Comment on this problem](#)

For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).



Select one:

- A. Clockwise and forward-biased
- B. Clockwise and reverse-biased
- C. Counterclockwise and forward-biased
- D. Counterclockwise and reverse-biased

100% ?

Submit Answer

### Template 4: (PRA76UA)

Problem ID: PRA76UA [Comment on this problem](#)

For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).

Select one:

- A. Clockwise and forward-biased
- B. Clockwise and reverse-biased
- C. Counterclockwise and forward-biased
- D. Counterclockwise and reverse-biased

100% ?

### 8.1.4. Groups D: Transistors (PSAXNMA)

Problem ID	Description
PSAYMMP - Auto Tutor	<p>Use AutoTutor to help you work through the problem. Once you finish the problem you will see your score.</p> <div style="border: 1px solid gray; padding: 5px;"> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>How will current flow through the transistors shown below if both are turned on?</b></p> <div style="display: flex; justify-content: space-around; align-items: center;"> </div> <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <span>PNP Transistor</span> <span>NPN Transistor</span> </div> </div> <div style="width: 50%;"> <div style="display: flex; justify-content: space-around; align-items: center;"> </div> <p><b>Tutor:</b> Hello, Mr. Tran. Today we will be discussing N-P-N and P-N-P transistors.</p> <p><b>Kevin:</b> Hello, Mr. Tran. Today we will be discussing N-P-N and P-N-P transistors.</p> <p><b>Tutor:</b> That is correct, but they both do their jobs in a different way. Let's start.</p> <p><b>Tutor:</b> How will current flow through the transistors shown below if both are turned on?</p> <div style="border: 1px solid gray; height: 30px; width: 100%;"></div> <div style="text-align: right; margin-top: 5px;"><input type="button" value="Send"/></div> </div> </div> </div>

PRA7GU3 - BBN

**Transistor Circuit Analysis (EU1T1A)**

Analyze the circuit shown below to determine  $V_{CE}$ .  $V_{BE} = 0.7V$ ;  $\beta = 200$

$V_{CE} =$

A. 5.3V     B. 6.0V  
 C. 8.9V     D. 10.6V

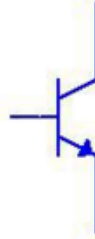
Source: Hambley, Electrical Engineering, 5th Edition

Raytheon  
BBN Technologies




Show Steps



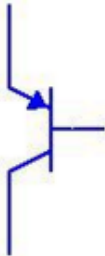
PRA74QQ - ASSISTMENTS

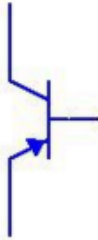
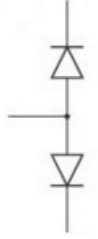
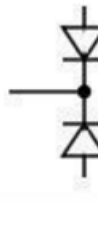
Which transistor corresponds to the symbol below?



- NPN
- PNP
- NMOS
- PMOS

<p>PRA76UC - ASSISTMENTS</p>	<p>Which transistor corresponds to the symbol below?</p>  <ul style="list-style-type: none"> <li><input type="radio"/> NPN</li> <li><input type="radio"/> PNP</li> <li><input type="radio"/> NMOS</li> <li><input type="radio"/> PMOS</li> </ul>
<p>PRA76UD - ASSISTMENTS</p>	<p>Which transistor corresponds to the symbol below?</p>  <ul style="list-style-type: none"> <li><input type="radio"/> NPN</li> <li><input type="radio"/> PNP</li> <li><input type="radio"/> NMOS</li> <li><input type="radio"/> PMOS</li> </ul>
<p>PRA76UE - ASSISTMENTS</p>	<p>Which transistor corresponds to the symbol below?</p>  <ul style="list-style-type: none"> <li><input type="radio"/> NPN</li> <li><input type="radio"/> PNP</li> <li><input type="radio"/> NMOS</li> <li><input type="radio"/> PMOS</li> </ul>

<p>PRA76UF - ASSISTMENTS</p>	<p>Which transistor corresponds to the symbol below?</p>  <ul style="list-style-type: none"><li><input type="radio"/> NPN</li><li><input type="radio"/> PNP</li><li><input type="radio"/> NMOS</li><li><input type="radio"/> PMOS</li></ul>
<p>PRA76UG - ASSISTMENTS</p>	<p>Which transistor corresponds to the symbol below?</p>  <ul style="list-style-type: none"><li><input type="radio"/> NPN</li><li><input type="radio"/> PNP</li><li><input type="radio"/> NMOS</li><li><input type="radio"/> PMOS</li></ul>
<p>PRA76UH - ASSISTMENTS</p>	<p>Which transistor corresponds to the symbol below?</p>  <ul style="list-style-type: none"><li><input type="radio"/> NPN</li><li><input type="radio"/> PNP</li><li><input type="radio"/> NMOS</li><li><input type="radio"/> PMOS</li></ul>

<p>PRA76UJ - ASSISTMENTS</p>	<p>Which transistor corresponds to the symbol below?</p>  <ul style="list-style-type: none"> <li><input type="radio"/> NPN</li> <li><input type="radio"/> PNP</li> <li><input type="radio"/> NMOS</li> <li><input type="radio"/> PMOS</li> </ul>
<p>PRA74RK - ASSISTMENTS</p>	<p>Which transistor corresponds to the diode's orientation below?</p>  <ul style="list-style-type: none"> <li><input type="radio"/> NPN</li> <li><input type="radio"/> PNP</li> <li><input type="radio"/> NMOS</li> <li><input type="radio"/> PMOS</li> </ul>
<p>PRA8BNJ - ASSISTMENTS</p>	<p>Which transistor corresponds to the diode's orientation below?</p>  <ul style="list-style-type: none"> <li><input type="radio"/> NPN</li> <li><input type="radio"/> PNP</li> <li><input type="radio"/> NMOS</li> <li><input type="radio"/> PMOS</li> </ul>



## 8.2. Appendix B (Variablized Templates)

Select All

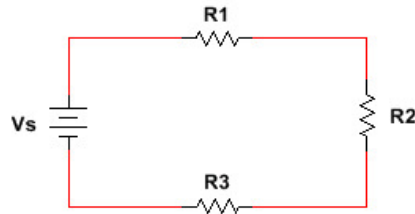
Problem #844049 "PRA7MKP - Voltage Divider V1"

Find  $V_1$  for a circuit with voltage source  $V_s = \text{\%v\{x\}}V$  connected to three resistors in series,

$$R_1 = \text{\%v\{a\}}\Omega,$$

$$R_2 = \text{\%v\{b\}}\Omega,$$

$$R_3 = \text{\%v\{c\}}\Omega.$$



Assume the voltages are measured in Volts.

$$V_1 =$$

Round your answer to 2 decimal places.

Do not include units (Volts).

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

✓  $\text{\%v\{rounded\_answer\}}$

✓  $\text{\%v\{rounded\_answer\}}+0.01$

✓  $\text{\%v\{rounded\_answer\}}-0.01$

**Hints:**

• Because the resistors are in series, the current flowing through each resistor is identical. You will need to:

1. Find the equivalent resistance in the circuit,  $R_{EQ}$
2. Find the current  $I$  in the circuit by applying Ohm's Law.
3. Apply Ohm's Law ( $V = I \times R$ ) to find the voltage across the  $R_1$ .

• 1. To find the equivalent resistance  $R_{EQ}$ , calculate the sum of series resistors.

$$\begin{aligned} R_{EQ} &= R_1 + R_2 + R_3 \\ &= \text{\%v\{a\}} + \text{\%v\{b\}} + \text{\%v\{c\}} \\ &= \text{\%v\{req\}} \Omega. \end{aligned}$$

• 2. The current in the circuit is:  $I = \frac{V_s}{R_{EQ}}$

$$I = \text{\%v\{i\_rounded\}}A.$$

•  $V_1 = I \times R_1$   
 $= \text{\%v\{i\_rounded\}} \times \text{\%v\{a\}}$   
 $= \text{\%v\{rounded\_answer\}}V$

Type in:  $\text{\%v\{rounded\_answer\}}$

Select All

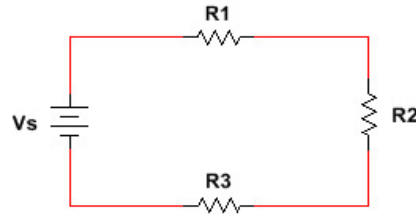
Problem #850910 "PRA7UQZ - Voltage Divider V2"

Find  $V_2$ , voltage across resistor  $R_2$ , for a circuit with voltage source  $V_s = \%v\{x\}$  V connected to three resistors in series,

$$R_1 = \%v\{a\} \Omega,$$

$$R_2 = \%v\{b\} \Omega,$$

$$R_3 = \%v\{c\} \Omega.$$



Assume the voltages are measured in Volts.

$$V_2 =$$

Round your answer to 2 decimal places.

Do not include units (Volts).

**Algebraic Expression:**

✓  $\%v\{\text{answer}\}$

✓  $\%v\{\text{rounded\_answer}\}$

✓  $\%v\{\text{rounded\_answer}\} + 0.01$

✓  $\%v\{\text{rounded\_answer}\} - 0.01$

**Hints:**

- Because the resistors are in series, the current flowing through each resistor is identical. You will need to:

1. Find the equivalent resistance in the circuit,  $R_{EQ}$
2. Find the current  $I$  in the circuit by applying Ohm's Law.
3. Apply Ohm's Law ( $V = I \times R$ ) to find the voltage across the  $R_2$ .

- 1. To find the equivalent resistance  $R_{EQ}$ , calculate the sum of series resistors.

$$\begin{aligned} R_{EQ} &= R_1 + R_2 + R_3 \\ &= \%v\{a\} + \%v\{b\} + \%v\{c\} \\ &= \%v\{\text{req}\} \Omega. \end{aligned}$$

- 2. The current in the circuit is:  $I = \frac{V_s}{R_{EQ}}$

$$I = \%v\{i\_rounded\} \text{A.}$$

- $V_2 = I \times R_2$   
 $= \%v\{i\_rounded\} \times \%v\{b\}$   
 $= \%v\{\text{rounded\_answer}\} \text{V}$

Type in:  $\%v\{\text{rounded\_answer}\}$

Select All

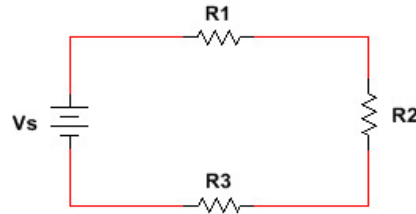
Problem #850911 "PRA7UQ2 - Voltage Divider V3"

Find  $V_3$ , voltage across resistor  $R_3$ , for a circuit with voltage source  $V_s = \%v\{x\}$  V connected to three resistors in series,

$$R_1 = \%v\{a\} \Omega,$$

$$R_2 = \%v\{b\} \Omega,$$

$$R_3 = \%v\{c\} \Omega.$$



Assume the voltages are measured in Volts.

$$V_3 =$$

Round your answer to 2 decimal places.

Do not include units (Volts).

**Algebraic Expression:**

✓  $\%v\{\text{answer}\}$

✓  $\%v\{\text{rounded\_answer}\}$

✓  $\%v\{\text{rounded\_answer}\} + 0.01$

✓  $\%v\{\text{rounded\_answer}\} - 0.01$

**Hints:**

- Because the resistors are in series, the current flowing through each resistor is identical. You will need to:

1. Find the equivalent resistance in the circuit,  $R_{EQ}$
2. Find the current  $I$  in the circuit by applying Ohm's Law.
3. Apply Ohm's Law ( $V = I \times R$ ) to find the voltage across the  $R_3$ .

- 1. To find the equivalent resistance  $R_{EQ}$ , calculate the sum of series resistors.

$$\begin{aligned} R_{EQ} &= R_1 + R_2 + R_3 \\ &= \%v\{a\} + \%v\{b\} + \%v\{c\} \\ &= \%v\{\text{req}\} \Omega. \end{aligned}$$

- 2. The current in the circuit is:  $I = \frac{V_s}{R_{EQ}}$

$$I = \%v\{i\_rounded\} \text{A.}$$

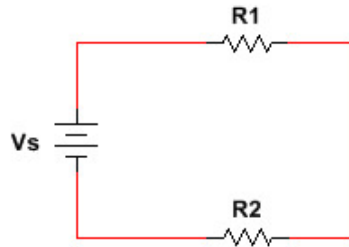
- $V_3 = I \times R_3$   
 $= \%v\{i\_rounded\} \times \%v\{c\}$   
 $= \%v\{\text{rounded\_answer}\} \text{V}$

Type in:  $\%v\{\text{rounded\_answer}\}$

Select All

Problem #850912 "PRA7UQ3 - Voltage Divider V1 of 2"

Find  $V_1$  for a circuit with voltage source  $V_s = \text{\%v\{x\}}V$  connected to two resistors in series,  $R_1 = \text{\%v\{a\}}\Omega$ ,  $R_2 = \text{\%v\{b\}}\Omega$ .



Assume the voltages are measured in Volts.

$V_1 =$

Round your answer to 2 decimal places.

Do not include units (Volt).

**Exact Match (ignore case):**

- ✓  $\text{\%v\{answer\}}$
- ✓  $\text{\%v\{rounded\_answer\}}$
- ✓  $\text{\%v\{rounded\_answer\}}+0.01$
- ✓  $\text{\%v\{rounded\_answer\}}-0.01$

**Hints:**

• Because the resistors are in series, the current flowing through each resistor is identical. You will need to:

1. Find the equivalent resistance in the circuit,  $R_{EQ}$
2. Find the current  $I$  in the circuit by applying Ohm's Law.
3. Apply Ohm's Law ( $V = I \times R$ ) to find the voltage across the  $R_1$ .

• 1. To find the equivalent resistance  $R_{EQ}$ , calculate the sum of series resistors.

$$\begin{aligned} R_{EQ} &= R_1 + R_2 \\ &= \text{\%v\{a\}} + \text{\%v\{b\}} \\ &= \text{\%v\{req\}} \Omega. \end{aligned}$$

• 2. The current in the circuit is:  $I = \frac{V_s}{R_{EQ}}$

$$I = \text{\%v\{i\_rounded\}}A.$$

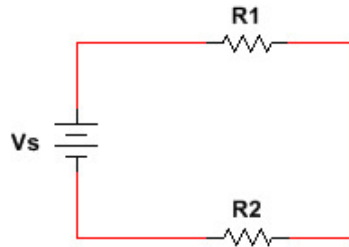
- $V_1 = I \times R_1$   
 $= \text{\%v\{i\_rounded\}} \times \text{\%v\{a\}}$   
 $= \text{\%v\{rounded\_answer\}}V$

Type in:  $\text{\%v\{rounded\_answer\}}$

Select All

Problem #850913 "PRA7UQ4 - Voltage Divider V2 of 2"

Find  $V_2$  for a circuit with voltage source  $V_s = \text{\%v\{x\}}V$  connected to two resistors in series,  $R_1 = \text{\%v\{a\}}\Omega$ ,  $R_2 = \text{\%v\{b\}}\Omega$ .



Assume the voltages are measured in Volts.

$V_2 =$

Round your answer to 2 decimal places.

Do not include units (Volt).

**Exact Match (ignore case):**

- ✓  $\text{\%v\{answer\}}$
- ✓  $\text{\%v\{rounded\_answer\}}$
- ✓  $\text{\%v\{rounded\_answer\}}+0.01$
- ✓  $\text{\%v\{rounded\_answer\}}-0.01$

**Hints:**

• Because the resistors are in series, the current flowing through each resistor is identical. You will need to:

1. Find the equivalent resistance in the circuit,  $R_{EQ}$
2. Find the current  $I$  in the circuit by applying Ohm's Law.
3. Apply Ohm's Law ( $V = I \times R$ ) to find the voltage across the  $R_2$ .

• 1. To find the equivalent resistance  $R_{EQ}$ , calculate the sum of series resistors.

$$\begin{aligned} R_{EQ} &= R_1 + R_2 \\ &= \text{\%v\{a\}} + \text{\%v\{b\}} \\ &= \text{\%v\{req\}} \Omega. \end{aligned}$$

• 2. The current in the circuit is:  $I = \frac{V_s}{R_{EQ}}$

$$I = \text{\%v\{i\_rounded\}}A.$$

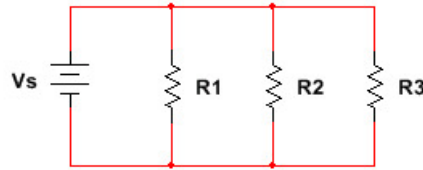
•  $V_2 = I \times R_2$   
 $= \text{\%v\{i\_rounded\}} \times \text{\%v\{b\}}$   
 $= \text{\%v\{rounded\_answer\}}V$

Type in:  $\text{\%v\{rounded\_answer\}}$

Select All

Problem #843968 "PRA7MG3 - Current Division"

Find the current  $I_1$  flowing through  $R_1$  in the circuit with  $V_s = \text{\%v\{x\}}V$ ,  $R_1 = \text{\%v\{a\}}\Omega$ ,  $R_2 = \text{\%v\{b\}}\Omega$  and  $R_3 = \text{\%v\{c\}}\Omega$ .



Assume the current is measured in Amps.

$I_1 =$

Round your answer to 2 decimal places.

Do not include units (Amps).

**Algebraic Expression:**

- ✓  $\text{\%v\{answer\}}$
- ✓  $\text{\%v\{rounded\_answer\}}$
- ✓  $\text{\%v\{rounded\_answer\}}+0.01$
- ✓  $\text{\%v\{rounded\_answer\}}-0.01$

**Hints:**

- To find the current  $I_1$  through resistor  $R_1$ :

1. Find the voltage  $V_1$  across resistor  $R_1$ .
2. Apply Ohm's Law to find the current  $I_1$ .

- 1. Find the voltage across each resistor.

Because resistors and the voltage source are connected in parallel, voltage across each resistor is identical and equal to  $V_s$ .

$$V_1 = V_2 = V_3 = V_s = \text{\%v\{x\}}V$$

- 2. Find current  $I_1$ .

Using Ohm's Law ( $I = \frac{V}{R}$ ) to find the corresponding current.

$$I_1 = \frac{V_1}{R_1}$$

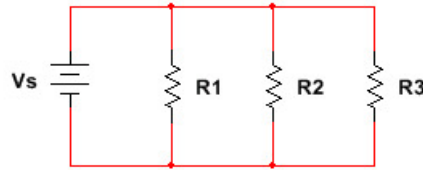
- $I_1 = \text{\%v\{x\}}/\text{\%v\{a\}}$   
 $= \text{\%v\{answer\}}A$

Type in:  $\text{\%v\{rounded\_answer\}}$

Select All

Problem #850915 "PRA7UQ6 - Current Division I2"

Find the current  $I_2$  flowing through  $R_1$  in the circuit with  $V_s = \%v\{x\}V$ ,  $R_1 = \%v\{a\}\Omega$ ,  $R_2 = \%v\{b\}\Omega$  and  $R_3 = \%v\{c\}\Omega$ .



Assume the current is measured in Amps.

$I_2 =$

Round your answer to 2 decimal places.

Do not include units (Amps).

**Algebraic Expression:**

- ✓  $\%v\{\text{answer}\}$
- ✓  $\%v\{\text{rounded\_answer}\}$
- ✓  $\%v\{\text{rounded\_answer}\}+0.01$
- ✓  $\%v\{\text{rounded\_answer}\}-0.01$

**Hints:**

- To find the current  $I_2$  through resistor  $R_2$ :

1. Find the voltage  $V_2$  across resistor  $R_2$ .
2. Apply Ohm's Law to find the current  $I_2$ .

- 1. Find the voltage across each resistor.

Because resistors and the voltage source are connected in parallel, voltage across each resistor is identical and equal to  $V_s$ .

$$V_1 = V_2 = V_3 = V_s = \%v\{x\}V$$

- 2. Find current  $I_2$ .

Using Ohm's Law ( $I = \frac{V}{R}$ ) to find the corresponding current.

$$I_2 = \frac{V_2}{R_2}$$

- $I_2 = \%v\{x\}/\%v\{b\}$   
 $= \%v\{\text{answer}\}A$

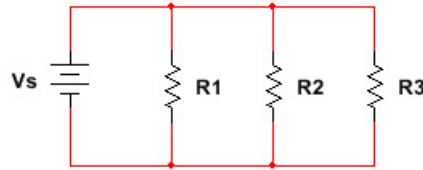
Type in:  $\%v\{\text{rounded\_answer}\}$



Select All

Problem #850916 "PRA7UQ7 - Current Division I3"

Find the current  $I_3$  flowing through  $R_3$  in the circuit with  $V_s = \%v\{x\}V$ ,  $R_1 = \%v\{a\}\Omega$ ,  $R_2 = \%v\{b\}\Omega$  and  $R_3 = \%v\{c\}\Omega$ .



Assume the current is measured in Amps.

$I_3 =$

Round your answer to 2 decimal places.

Do not include units (Amps).

**Algebraic Expression:**

- ✓  $\%v\{\text{answer}\}$
- ✓  $\%v\{\text{rounded\_answer}\}$
- ✓  $\%v\{\text{rounded\_answer}\}+0.01$
- ✓  $\%v\{\text{rounded\_answer}\}-0.01$

**Hints:**

- To find the current  $I_3$  through resistor  $R_3$ :

1. Find the voltage  $V_3$  across resistor  $R_3$ .
2. Apply Ohm's Law to find the current  $I_3$ .

- 1. Find the voltage across each resistor.

Because resistors and the voltage source are connected in parallel, voltage across each resistor is identical and equal to  $V_s$ .

$$V_1 = V_2 = V_3 = V_s = \%v\{x\}V$$

- 2. Find current  $I_3$ .

Using Ohm's Law ( $I = \frac{V}{R}$ ) to find the corresponding current.

$$I_3 = \frac{V_3}{R_3}$$

- $I_3 = \%v\{x\}/\%v\{c\}$   
 $= \%v\{\text{answer}\}A$

Type in:  $\%v\{\text{rounded\_answer}\}$

Select All

Problem #843965 "PRA7MGY - Equivalent Resistance in Series"

Find the equivalent resistance in  $\Omega$  for a circuit with three resistors in series,

$$R_1 = \{a\} \Omega,$$

$$R_2 = \{b\} \Omega,$$

$$R_3 = \{c\} \Omega.$$

$$R_{EQ} =$$

Round your answer to 2 decimal place

Do not include units ( $\Omega$ )

**Algebraic Expression:**

✓  $\{sprintf("%.2f", answer)\}$

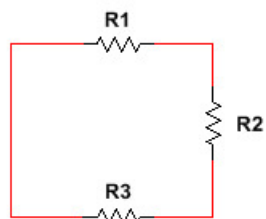
✓  $\{sprintf("%.2f", answer)\} + 0.01$

✓  $\{sprintf("%.2f", answer)\} - 0.01$

**Hints:**

- For series resistors:

$$R_{EQ} = R_1 + R_2 + R_3$$



- The equivalent resistance is:  $\{answer\} \Omega$ .

Type in:  $\{answer\}$

**Select All**

**Problem #843966 "PRA7MGZ - Equivalent Resistance in Parallel"**

Find the equivalent resistance for the circuit with three resistors in parallel:

$$R_1 = \{a\} \Omega,$$

$$R_2 = \{b\} \Omega,$$

$$R_3 = \{c\} \Omega.$$

$$R_{EQ} =$$

Round your answer to 2 decimal place

Do not include units ( $\Omega$ )

**Algebraic Expression:**

✓  $\{sprintf("%.2f", answer)\}$

✓  $\{rounded\_answer\}$

✓  $\{rounded\_answer\} + 0.01$

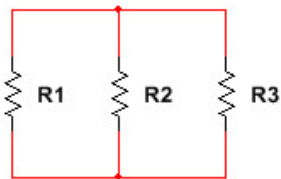
✓  $\{rounded\_answer\} - 0.01$

**Hints:**

- For parallel resistors:

$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$R_{EQ}$$



- The equivalent resistance is:  $\{answer\} \Omega$ .

Type in:  $\{sprintf("%.2f", answer)\}$

Select All

Problem #846687 "PRA7QBS - Complex 1 Equivalent Resistance"

Find the equivalent resistance in  $\Omega$  for the circuit below with

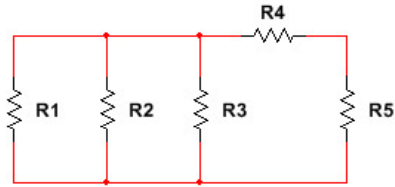
$$R_1 = \{a\}\Omega,$$

$$R_2 = \{b\}\Omega,$$

$$R_3 = \{c\}\Omega,$$

$$R_4 = \{d\}\Omega$$

$$R_5 = \{e\}\Omega.$$



$$R_{EQ} =$$

Round your answer to 2 decimal place; the units are given, type only the number.

**Algebraic Expression:**

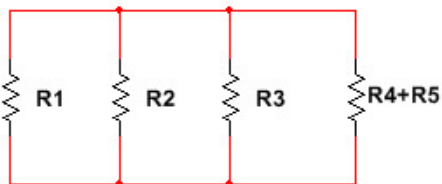
✓  $\{sprintf("%.2f", answer)\}$

✓  $\{sprintf("%.2f", answer)\} + 0.01$

✓  $\{sprintf("%.2f", answer)\} - 0.01$

**Hints:**

- Combine two resistors  $R_4$  and  $R_5$ :



- For parallel resistors:

$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_{45}}$$

- The equivalent resistance is:  $\{answer\}\Omega$ .

Type in:  $\{rounded\_answer\}$

Select All

Problem #846689 "PRA7QBU - Complex 2 Equivalent Resistance"

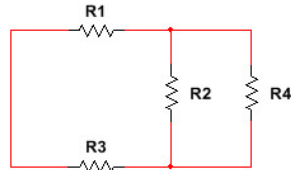
Find the equivalent resistance in  $\Omega$  for a circuit below with

$$R_1 = \{a\} \Omega,$$

$$R_2 = \{b\} \Omega,$$

$$R_3 = \{c\} \Omega,$$

$$R_4 = \{d\} \Omega.$$



$$R_{EQ} =$$

Round your answer to 2 decimal place; the units are given type only the number.

**Algebraic Expression:**

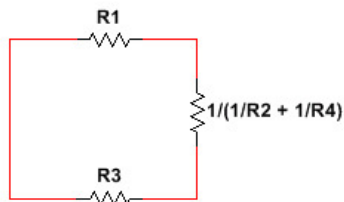
✓  $\{sprintf("%.2f", answer)\}$

✓  $\{sprintf("%.2f", answer)\} + 0.01$

✓  $\{sprintf("%.2f", answer)\} - 0.01$

**Hints:**

- Combine two resistors  $R_2$  and  $R_4$ :



- For series resistors:

$$R_{EQ} = R_1 + R_2 + R_3$$

- The equivalent resistance is:  $\{answer\} \Omega$ .

Type in:  $\{rounded\_answer\}$

Select All

Problem #843967 "PRA7MG2 - Equivalent Capacitance in Series"

Find the equivalent capacitance in  $\mu\text{F}$  for a circuit with three capacitors connected in series,

$$C_1 = \text{\%v\{a\}} \mu\text{F},$$

$$C_2 = \text{\%v\{b\}} \mu\text{F}$$

$$C_3 = \text{\%v\{c\}} \mu\text{F}$$

$$C_{EQ} =$$

Round your answer to 2 decimal places

Do not include units ( $\mu\text{F}$ )

**Algebraic Expression:**

$\text{\%v\{answer\}}$

$\text{\%v\{rounded\_answer\}}$

$\text{\%v\{rounded\_answer\}} + 0.01$

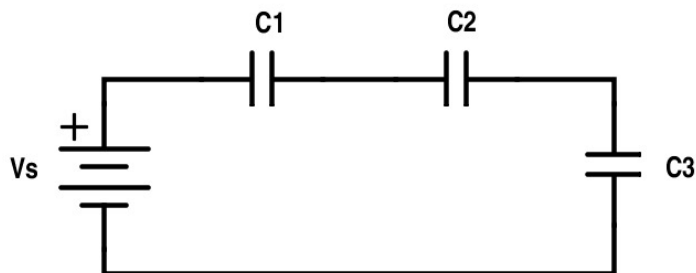
$\text{\%v\{rounded\_answer\}} - 0.01$

$\text{\%v\{rounded\_wanswer\}}$

- Great try! That could be right if the capacitors are in parallel.

**Hints:**

- Circuit Diagram:



- For series capacitors:

$$\frac{1}{C_{EQ}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_{EQ}} = \frac{1}{\text{\%v\{a\}}} + \frac{1}{\text{\%v\{b\}}} + \frac{1}{\text{\%v\{c\}}}$$

- The equivalent capacitance is:  $\text{\%v\{sprintf("%.2f",rounded\_answer)\}} \mu\text{F}$   
Type in:  $\text{\%v\{sprintf("%.2f",rounded\_answer)\}}$

Select All

Problem #843969 "PRA7MG4 - Equivalent Capacitance in Parallel"

Find the equivalent capacitance in  $\mu\text{F}$  for a circuit with three capacitances in parallel,

$$C_1 = \{a\} \mu\text{F},$$

$$C_2 = \{b\} \mu\text{F},$$

$$C_3 = \{c\} \mu\text{F}.$$

$$C_{\text{EQ}} =$$

Round your answer to 2 decimal places.

Do not include units ( $\mu\text{F}$ ).

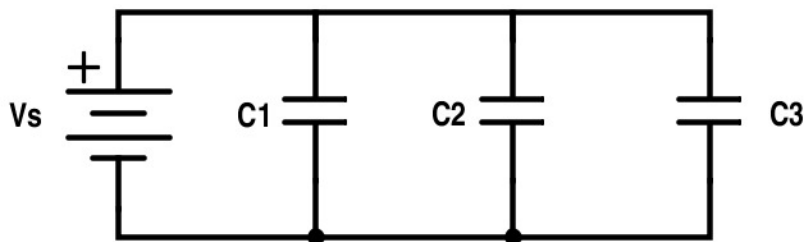
**Algebraic Expression:**

✓  $\{answer\}$

✗  $\{rounded\_wanswer\}$

- Great try! Are you sure? That could be right for series capacitors.

**Hints:**



- For parallel capacitors:

$$C_{\text{EQ}} = C_1 + C_2 + C_3$$

- The equivalent capacitance is:  $\{answer\} \mu\text{F}$

Type in:  $\{answer\}$

**Select All**

**Problem #843452 "PRA7KYE - Voltage - Ohm's Law"**

Find voltage  $V$  across a resistor with  $R = \text{\%v\{y\}} \Omega$  and the current flowing through it is  $I = \text{\%v\{x\}} A$ .

Assume the voltage is measured in Volts.

$V =$

Round your answer to 2 decimal places

Do not include units (Volts)

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

**Hints:**

- Ohm's Law:

$$V = R \times I$$

- The answer is:  $\text{\%v\{answer\}} V$

Type in:  $\text{\%v\{answer\}}$



**Select All**

**Problem #843453 "PRA7KYF - Current - Ohm's Law"**

Find current I running through a resistor with  $R = \{x\}\Omega$  and voltage across it,  $V = \{y\}V$ .

Assume the current is measured in Amps.

I =

Round your answer to 2 decimal places

Do not include units (Amps)

**Algebraic Expression:**

✓  $\{answer\}$

✓  $\{rounded\_answer\}$

✓  $\{rounded\_answer\}+0.01$

✓  $\{rounded\_answer\}-0.01$

**Hints:**

- Ohm's Law:

$$I = \frac{V}{R}$$

- The answer is:  $\{answer\}A$   
Type in:  $\{sprintf("%.2f", rounded\_answer)\}$

**Select All**

**Problem #843574 "PRA7K4C - Resistor - Ohm's Law"**

Find the resistance of a resistor when the current running through it is,  $I = \text{\%v\{x\}}A$  and the voltage across it is,  $V = \text{\%v\{y\}}V$ .

Assume the resistor is measured in Ohm ( $\Omega$ ).

R =

Round your answer to 2 decimal places

Do not include units ( $\Omega$ )

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

✓  $\text{\%v\{rounded\_answer\}}$

✓  $\text{\%v\{rounded\_answer\}}+0.01$

✓  $\text{\%v\{rounded\_answer\}}-0.01$

**Hints:**

- Ohm's Law:

$$R = \frac{V}{I}$$

- The answer is:  $\text{\%v\{rounded\_answer\}}\Omega$   
Type in:  $\text{\%v\{sprintf("\%0.2f", rounded\_answer)\}}$

**Select All**

**Problem #843575 "PRA7K4D - Power - Ohm's Law"**

Find the power a resistor dissipates if the current running through it is,  $I = x$  A and the voltage across it is,  $V = y$  V.

Assume the power is measured in Watts (W).

P =

Round your answer to 2 decimal places.

Do not include units (W).

**Algebraic Expression:**

✓  $x$

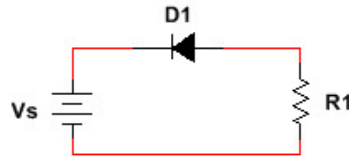
**Hints:**

- Power:  $P = V \times I$
- The answer is:  $x$  W  
Type in:  $x$

Select All

Problem #850265 "PRA7T27 - Diode - Reverse Bias Current"

Find the current  $I$  through the resistor with  $R_1 = \text{\%v\{a\}}\text{k}\Omega$  and  $V_s = \text{\%v\{x\}}\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places

Do not include units (mA)

**Algebraic Expression:**

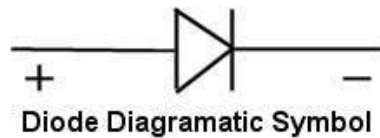
✓  $\text{\%v\{answer\}}$

✗  $\text{\%v\{rwrong\_answer\}}$

- Great try! It could be true if the diode is in forward bias region. However, the diode is operating in **reversed bias region**.

**Hints:**

- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.

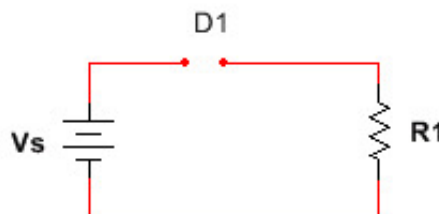


Diode Diagramatic Symbol



Direction of Current Flow

- The diode is operating in negative-bias region. Thus, it is off, creating an open circuit. There is no current flow when there is open circuit.

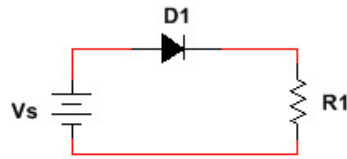


- The answer is: %v{answer}mA.  
Type in: %v{answer}

Select All

Problem #850264 "PRA7T26 - Diode - Forward Bias Current"

Find the current  $I$  flowing through the resistor with  $R_1 = \text{\%v\{a\}}\text{k}\Omega$  and  $V_s = \text{\%v\{x\}}\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places

Do not include units (mA)

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

✓  $\text{\%v\{rounded\_answer\}}$

✓  $\text{\%v\{rounded\_answer\}} + 0.01$

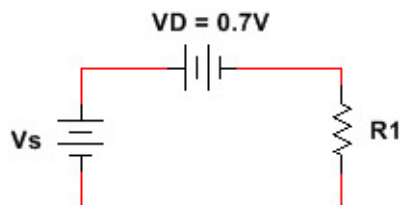
✓  $\text{\%v\{rounded\_answer\}} - 0.01$

✗  $\text{\%v\{wrong\_answer\}}$

- Great try! It could be true if the diode is in reversed bias region. In this case, the diode is operating in **forward bias region** instead.

**Hints:**

- The diode is operating in forward-bias region. Because there will be 0.7 Voltage Drop across the active diode, replace the diode with the 0.7V voltage source.



- The total voltage in the circuit is  $V_s = \text{\%v\{x\}}\text{V}$ . Because there is a 0.7V drop across the diode, the voltage across the resistor  $R_1$  is:

$$V_1 = V_s - 0.7$$

$$= \text{\%v\{x\}} - 0.7$$

$$= \text{\%v\{v1\}}\text{V}$$

- Using Ohm's Law ( $V = I \times R$ ):

$$I = V/R$$

$$= \%v\{v1\}/\%v\{a\}$$

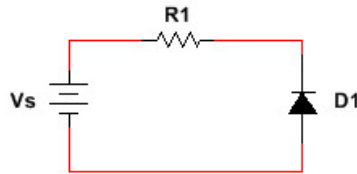
$$= \%v\{rounded\_answer\} \text{ mA}$$

Type in:  $\%v\{rounded\_answer\}$

Select All

Problem #852830 "PRA7WQX - Diode - Reverse Bias Current"

Find the current  $I$  through the resistor in the following circuit with  $R_1 = \text{\%v\{a\}}\text{k}\Omega$  and  $V_s = \text{\%v\{x\}}\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places

Do not include units (mA)

**Algebraic Expression:**

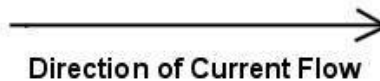
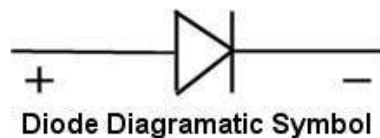
✓  $\text{\%v\{answer\}}$

✗  $\text{\%v\{rwrong\_answer\}}$

- Great try! It could be true if the diode is in forward bias region. However, the diode is operating in **reversed bias region**.

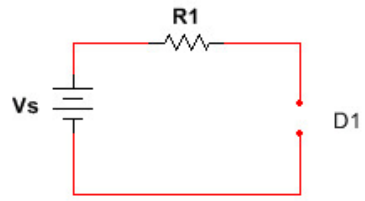
**Hints:**

- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.



- The diode is operating in negative-bias region. Thus, it is off, creating an open circuit. There is no current flow when there is open circuit.



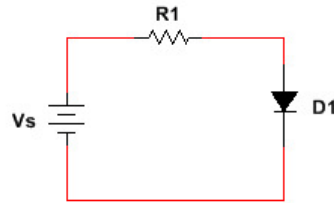


- The answer is: %v{answer}mA.  
Type in: %v{answer}

Select All

Problem #852831 "PRA7WQY - Diode - Forward Bias Current"

Find the current  $I$  flowing through the resistor with  $R_1 = \text{\%v\{a\}}\text{k}\Omega$  and  $V_s = \text{\%v\{x\}}\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places

Do not include units (mA)

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

✓  $\text{\%v\{rounded\_answer\}}$

✓  $\text{\%v\{rounded\_answer\}} + 0.01$

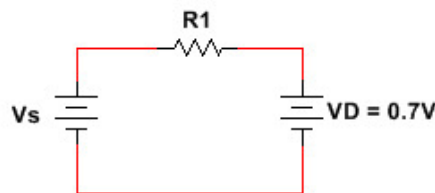
✓  $\text{\%v\{rounded\_answer\}} - 0.01$

✗  $\text{\%v\{wrong\_answer\}}$

- Great try! It could be true if the diode is in reversed bias region. In this case, the diode is operating in **forward bias region** instead.

**Hints:**

- The diode is operating in forward-bias region. Because there will be 0.7 Voltage Drop across the active diode, replace the diode with the 0.7V voltage source.



- The total voltage in the circuit is  $V_s = \text{\%v\{x\}}\text{V}$ . Because there is a 0.7V drop across the diode, the voltage across the resistor  $R_1$  is:

$$V_1 = V_s - 0.7$$

$$= \text{\%v\{x\}} - 0.7$$

$$= \text{\%v\{v1\}}\text{V}$$

- Using Ohm's Law ( $V = I \times R$ ):

$$I = V/R$$

$$= \%v\{v1\}/\%v\{a\}$$

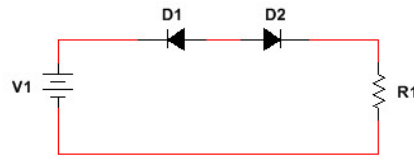
$$= \%v\{rounded\_answer\} \text{ mA}$$

Type in:  $\%v\{rounded\_answer\}$

Select All

Problem #852652 "PRA7WH7 - Diode - Mixed 3 Current"

Find the current  $I$  through the resistor  $R_1$  in the circuit below, with  $V_1 = \{x\}$  V and  $R_1 = \{a\}$  k $\Omega$ . Use the 0.7 Volt Diode Model.



Assume  $I$  is measured in mA.

$I =$

Round your answer to 2 decimal places.

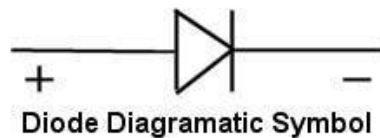
Do not include unit (mA).

**Algebraic Expression:**

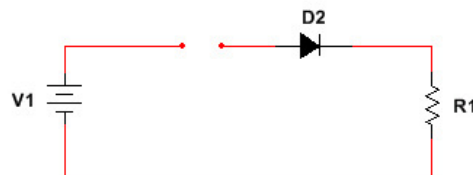
✓  $\{answer\}$

**Hints:**

- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.



- The diode D2 is in forward bias region. However, the diode D1 is in reversed bias order, thus it is OFF, making the circuit open.



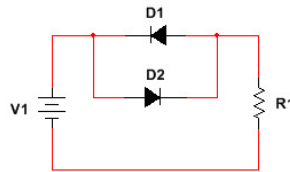
- Because of open circuit, there is no current flowing in the circuit and the current  $I$  is 0mA.

Type in: 0

Select All

Problem #852653 "PRA7WH8 - Diode - Mixed 4 Current"

Find the current  $I$  through the resistor in the circuit below, with  $V_1 = x$  V and  $R_1 = a$  k $\Omega$ . Use the 0.7 Volt Diode Model.



Assume  $I$  is measured in mA.

$I =$

Round your answer to 2 decimal places.  
Do not include unit (mA).

**Algebraic Expression:**

✓  $x$

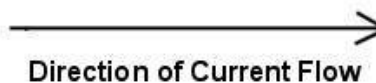
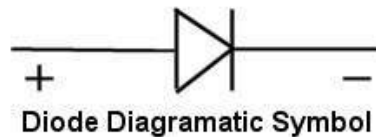
✓  $x$

✓  $x+0.01$

✓  $x-0.01$

**Hints:**

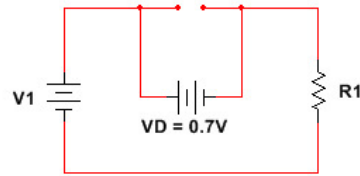
- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.



- The diode  $D_2$  is in forward bias region, replace it with a 0.7V voltage source. However, the diode  $D_1$  is in reversed bias order, thus it is OFF, replace with an open circuit.

To find the current through resistor  $R_1$ :

1. Find the voltage across resistor  $R_1$
2. Find the current through resistor  $R_1$  by using Ohm's Law ( $I = V/R$ )



- 1. Voltage across resistor  $R_1$ :

$$\begin{aligned} V &= V1 - 0.7 \\ &= \%v\{x\} - 0.7 \\ &= \%v\{v1\}V \end{aligned}$$

- 2. The current through resistor  $R_1$ :

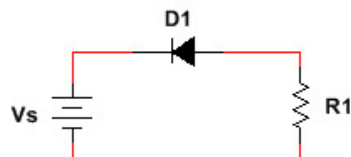
$$\begin{aligned} I &= V/R \\ &= \%v\{v1\}/\%v\{a\} \\ &= \%v\{rounded\_answer\}mA \end{aligned}$$

Type in:  $\%v\{rounded\_answer\}$

Select All

Problem #853012 "PRA7WWT - Diode - Reverse Bias Voltage"

Find the voltage  $V$  across the resistor with  $R_1 = \text{\%v\{a\}}\text{k}\Omega$  and  $V_s = \text{\%v\{x\}}\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the voltage is measured in Volts (V).

$V =$

Round your answer to 2 decimal places

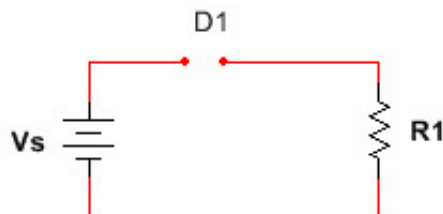
Do not include units (V)

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

**Hints:**

- The diode is operating in negative-bias region. Thus, it is off, creating an open circuit. The voltage therefore, across the resistor  $R_1 = 0\text{V}$ .



- The answer is:  $\text{\%v\{answer\}}\text{V}$ .

Type in:  $\text{\%v\{answer\}}$

Select All

Problem #853013 "PRA7WWU - Diode - Forward Bias Voltage"

Find the voltage  $V$  across the resistor with  $R_1 = \{a\}k\Omega$  and  $V_s = \{x\}V$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in Volts (V).

$V =$

Round your answer to 2 decimal places

Do not include units (V)

**Algebraic Expression:**

✓  $\{answer\}$

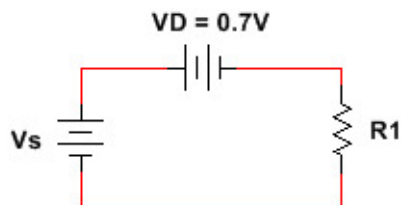
✓  $\{rounded\_answer\}$

✓  $\{rounded\_answer\}+0.01$

✓  $\{rounded\_answer\}-0.01$

**Hints:**

- The diode is operating in forward-bias region. Because there will be 0.7 Voltage Drop across the active diode, replace the diode with the 0.7V voltage source.



- The voltage across the resistor  $R_1$  will be  $V = \{x\} - 0.7 = \{answer\}V$ .

The answer is:  $\{answer\}V$ .

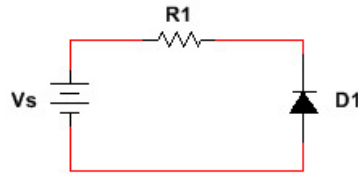
Type in:  $\{rounded\_answer\}$



Select All

Problem #853014 "PRA7WWV - Diode - Reverse Bias Voltage"

Find the voltage  $V$  across the resistor with  $R_1 = \text{\%v\{a\}}\text{k}\Omega$  and  $V_s = \text{\%v\{x\}}\text{V}$ . Use the 0.7 Volt Diode Model.



Assume the voltage is measured in Volts (V).

$V =$

Round your answer to 2 decimal places

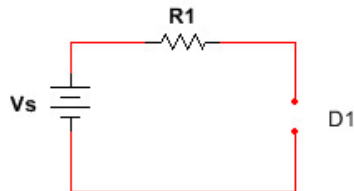
Do not include units (V)

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

**Hints:**

- The diode is operating in negative-bias region. Thus, it is off, creating an open circuit. The voltage therefore, across the resistor  $R_1 = 0\text{V}$ .

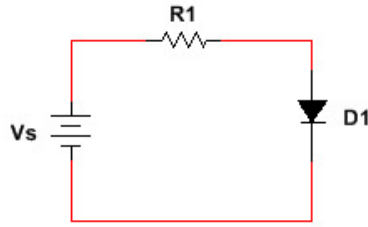


- The answer is:  $\text{\%v\{answer\}}\text{V}$ .  
Type in:  $\text{\%v\{answer\}}$

Select All

Problem #853015 "PRA7WWW - Diode - Forward Bias Voltage"

Find the voltage  $V$  across the resistor with  $R_1 = \{a\}k\Omega$  and  $V_s = \{x\}V$ . Use the 0.7 Volt Diode Model.



Assume the current is measured in Volts (V).

$V =$

Round your answer to 2 decimal places

Do not include units (V)

**Algebraic Expression:**

✓  $\{answer\}$

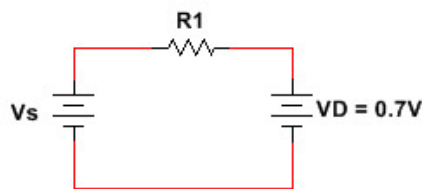
✓  $\{rounded\_answer\}$

✓  $\{rounded\_answer\} + 0.01$

✓  $\{rounded\_answer\} - 0.01$

**Hints:**

- The diode is operating in forward-bias region. Because there will be 0.7 Voltage Drop across the active diode, replace the diode with the 0.7V voltage source.



- The voltage across the resistor  $R_1$  will be  $V = \{x\} - 0.7 = \{answer\}V$ .

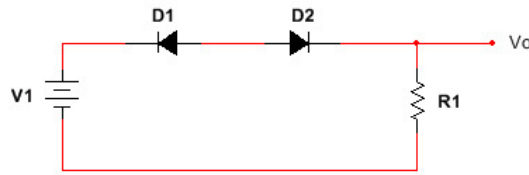
The answer is:  $\{answer\}V$ .

Type in:  $\{rounded\_answer\}$

Select All

Problem #850894 "PRA7UQG - Diode - Mixed 1"

Find the voltage  $V_o$  in the circuit below, with  $V_1 = x$  V and  $R_1 = a$  k $\Omega$ . Use the 0.7 Volt Diode Model.



Assume  $V_o$  is measured in Volts.

$V_o =$

Round your answer to 2 decimal places.

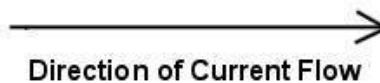
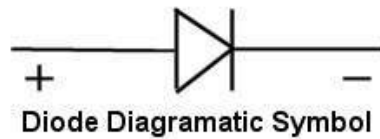
Do not include unit (V).

**Algebraic Expression:**

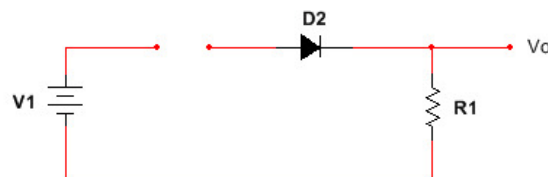
✓  $x$

**Hints:**

- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.



- The diode  $D_2$  is in forward bias region. However, the diode  $D_1$  is in reversed bias order, thus it is OFF, making the circuit open.



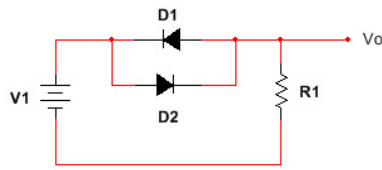
- Because of open circuit, there is no current flowing in the circuit and the voltage  $V_o$  is 0V.

Type in: 0

Select All

Problem #850899 "PRA7UQN - Diode - Mixed 2"

Find the voltage  $V_o$  in the circuit below, with  $V_1 = \{x\}$  V and  $R_1 = \{a\}$  k $\Omega$ . Use the 0.7 Volt Diode Model.



Assume  $V_o$  is measured in Volts.

$V_o =$

Round your answer to 2 decimal places.

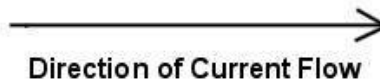
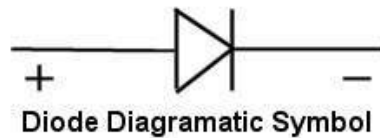
Do not include unit (V).

**Algebraic Expression:**

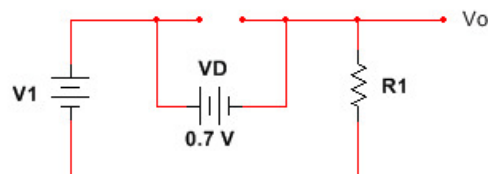
✓  $\{answer\}$

**Hints:**

- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.



- The diode D2 is in forward bias region, replace it with a 0.7V voltage source. However, the diode D1 is in reversed bias order, thus it is OFF, replace with an open circuit.



- $V_o = V_1 - 0.7$   
 $= \{x\} - 0.7$

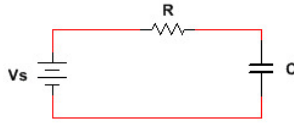
= %v{answer}V

Type in: %v{answer}

Select All

Problem #855376 "PRA7ZC3 - RC Circuit - Initial Current"

Find the initial current, at  $t = 0$ , in the circuit below with  $V_s = \text{\%v\{x\}}V$ ,  $R = \text{\%v\{a\}}k\Omega$  and  $C = \text{\%v\{b\}}\mu F$ .



Assume the current is measured in milliAmps (mA).

$I =$

Round your answer to 2 decimal places.

Do not include units (mA).

**Algebraic Expression:**

✓  $\text{\%v\{answer\}}$

✓  $\text{\%v\{rounded\_answer\}}$

✓  $\text{\%v\{rounded\_answer\}}+0.01$

✓  $\text{\%v\{rounded\_answer\}}-0.01$

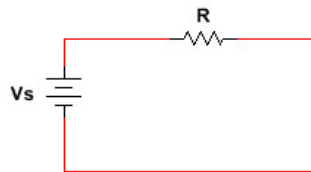
**Hints:**

- Capacitor charging equation for current:

$$I = V_s \frac{e^{-t/\tau}}{R}$$

with time constant  $\tau = RC$

- At  $t = 0$ , the capacitor behaves like a short circuit. Replace the capacitor with a wire, as shown in circuit diagram below.



- Since  $e^{-0/\tau} = 1$  at  $t = 0$ ,

$$I = V_s/R$$

$$= \text{\%v\{x\}}/\text{\%v\{a\}}$$

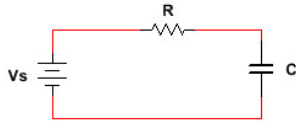
$$= \text{\%v\{rounded\_answer\}}\text{mA}$$

Type in:  $\text{\%v\{rounded\_answer\}}$

Select All

Problem #855377 "PRA7ZC4 - RC Circuit - Final Current"

Find the final current, at  $t = \infty$ , in the circuit below with  $V_s = \%v\{x\}$  V,  $R = \%v\{a\}$  k $\Omega$  and  $C = \%v\{b\}$   $\mu$ F.



Assume the current is measured in milliAmps (mA).

I =

Round your answer to 2 decimal places.

Do not include units (mA).

**Algebraic Expression:**

✓  $\%v\{\text{answer}\}$

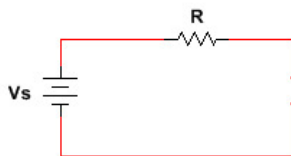
**Hints:**

- Capacitor charging equation for current:

$$I = V_s \frac{e^{-t/\tau}}{R}$$

with time constant  $\tau = RC$

- At  $t = \infty$ , the capacitor behaves like an open circuit. Remove the capacitor as shown in circuit diagram below.



- Find the time constant  $\tau$ .

$$\tau = RC$$

$$= \%v\{a\} \times \%v\{b\}$$

$$= \%v\{ab\} \text{ms}$$

Put  $t = \infty$  in the above equation in hint 1. Since  $e^{-\infty/\%v\{ab\}} = 0$  at  $t = \infty$ ,

$$I = (V_s \times 0)/R$$

$$= \%v\{\text{answer}\} \text{mA}$$

Type in:  $\%v\{\text{answer}\}$

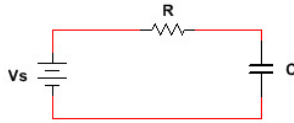




Select All

Problem #855378 "PRA7ZC5 - RC Circuit - Initial Voltage"

Find the initial voltage across the capacitor  $C$ , at  $t = 0$ , in the circuit below with  $V_s = \{x\}$  V,  $R = \{a\}$  k $\Omega$  and  $C = \{b\}$   $\mu$ F.



Assume the voltage is measured in Volts (V).

V =

Round your answer to 2 decimal places.

Do not include units (V).

**Algebraic Expression:**

✓  $\{answer\}$

✓  $\{rounded\_answer\}$

✓  $\{rounded\_answer\} + 0.01$

✓  $\{rounded\_answer\} - 0.01$

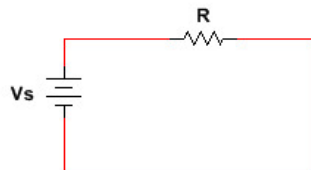
**Hints:**

- Capacitor charging equation for capacitor voltage:

$$V_C = V_S(1 - e^{-t/\tau})$$

with time constant  $\tau = RC$

- At  $t = 0$ , the capacitor behaves like a short circuit. Replace the capacitor with a wire, as shown in circuit diagram below.



- Put  $t = 0$  in the above equation in hint 1. Find the time constant  $\tau$ .

$$\tau = RC$$

$$= \{a\} \times \{b\}$$

$$= \{ab\} \text{ms}$$

Since  $e^{-0/\{ab\}} = 1$  at  $t = 0$ ,

$$V_C = V_S(1 - e^{0/\{ab\}})$$

$$= \%v\{x\} x (1 - 1)$$

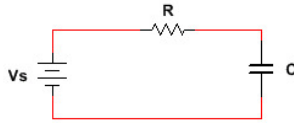
$$= \%v\{answer\}V$$

Type in:  $\%v\{answer\}$

Select All

Problem #855379 "PRA7ZC6 - RC Circuit - Final Voltage"

Find the final voltage across the capacitor C, at  $t = \infty$ , in the circuit below with  $V_s = \%v\{x\}V$ ,  $R = \%v\{a\}k\Omega$  and  $C = \%v\{b\}\mu F$ .



Assume the voltage is measured in Volts (V).

V =

Round your answer to 2 decimal places.

Do not include units (V).

**Algebraic Expression:**

✓  $\%v\{\text{answer}\}$

✓  $\%v\{\text{rounded\_answer}\}$

✓  $\%v\{\text{rounded\_answer}\}+0.01$

✓  $\%v\{\text{rounded\_answer}\}-0.01$

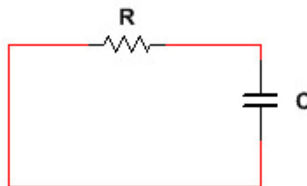
**Hints:**

- Capacitor charging equation for capacitor voltage:

$$V_C = V_S(1 - e^{-t/\tau})$$

with time constant  $\tau = RC$

- At  $t = \infty$ , the capacitor is fully charged, and behaves as a dominant voltage source with a short lifetime. Thus, remove  $V_S$  as in the circuit below.



- Put  $t = \infty$  in the above equation in hint 1. Find the time constant  $\tau$ .

$$\tau = RC$$

$$= \%v\{a\} \times \%v\{b\}$$

$$= \%v\{ab\}ms$$

Since  $e^{-\infty/\%v\{ab\}} = 0$  at  $t = \infty$ ,

$$V_C = V_S(1 - 0)$$

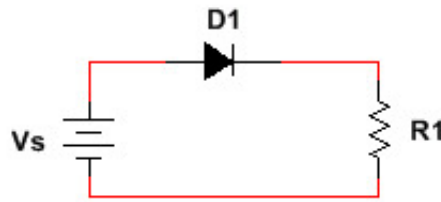
$$= \%v\{x\}V$$

Type in: %v {answer}

Select All

Problem #858397 "PRA74HH - Diode-Resistor 1"

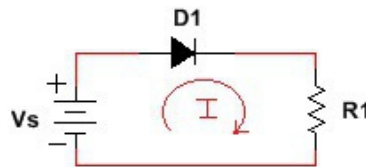
For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).



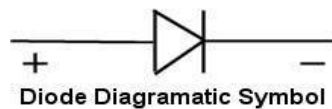
**Multiple Choice:**

- A. Clockwise and forward-biased
- B. Clockwise and reverse-biased

- For **DC voltage source  $V_s$** , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.



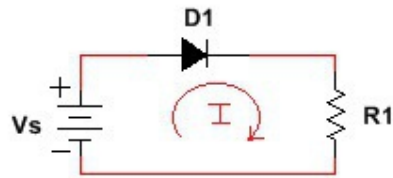
Diode Diagrammatic Symbol



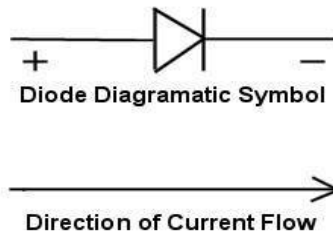
Direction of Current Flow

C. Counterclockwise and forward-biased

- For **DC voltage source  $V_s$** , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.

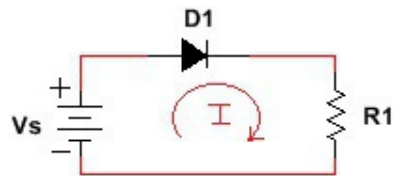


For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

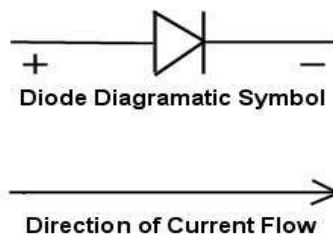


#### ✗ D. Counterclockwise and reverse-biased

- For **DC voltage source  $V_s$** , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



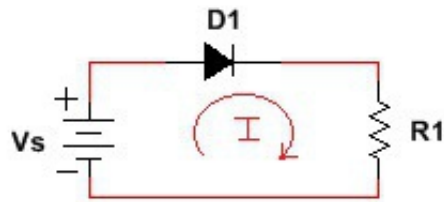
For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.



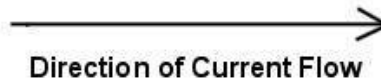
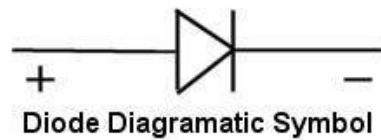
#### Hints:

- For DC voltage source, the current flows from positive to negative terminal. From the voltage

source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.



- The answer is:  
A. Clockwise and forward-biased

Select All

Problem #860621 "PRA76T9 - Diode-Resistor 2"

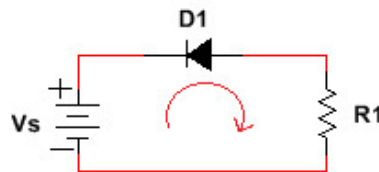
For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).



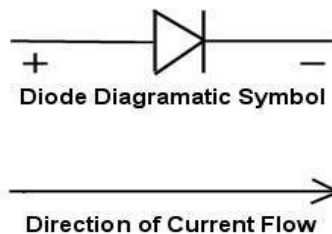
**Multiple Choice:**

A. Clockwise and forward-biased

- For **DC voltage source**  $V_s$ , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

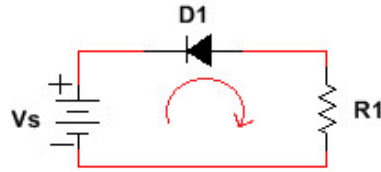


B. Clockwise and reverse-biased

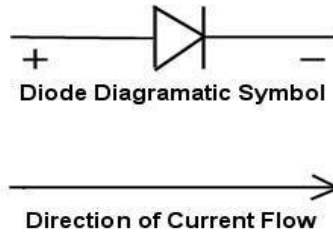
C. Counterclockwise and forward-biased

- For **DC voltage source**  $V_s$ , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



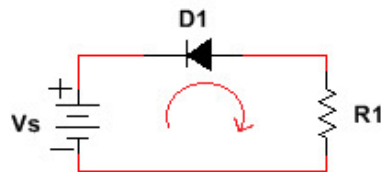


For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

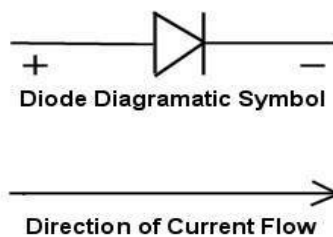


**X** D. Counterclockwise and reverse-biased

- For **DC voltage source  $V_s$** , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.

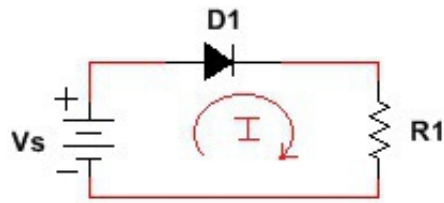


For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

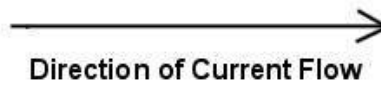
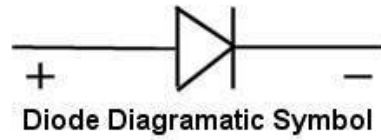


**Hints:**

- For DC voltage source, the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

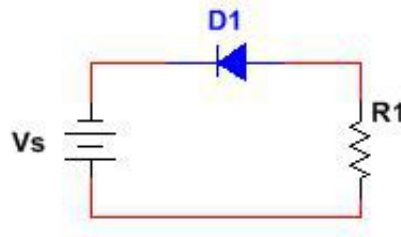


- The answer is:  
A. Clockwise and forward-biased

Select All

Problem #860623 "PRA76UB - Diode-Resistor 3"

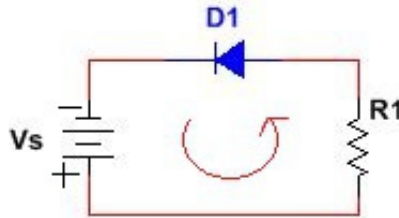
For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).



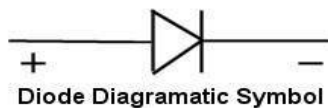
**Multiple Choice:**

A. Clockwise and forward-biased

- For **DC voltage source Vs**, the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in counterclockwise direction.



For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

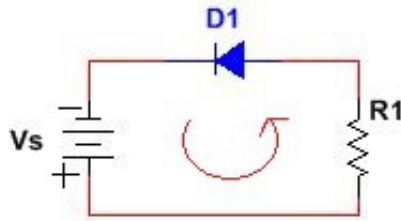


Diode Diagrammatic Symbol

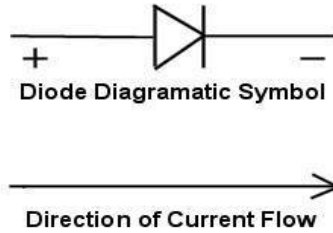


B. Clockwise and reverse-biased

- For **DC voltage source Vs**, the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in counterclockwise direction.

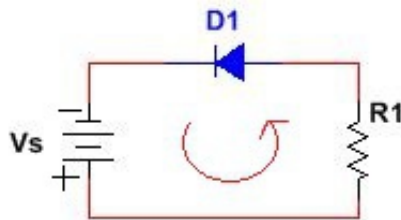


For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

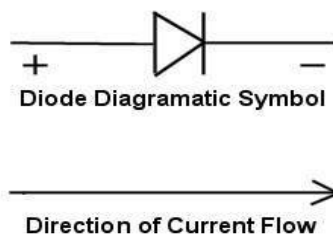


- ✓ C. Counterclockwise and forward-biased
- ✗ D. Counterclockwise and reverse-biased

• For **DC voltage source  $V_s$** , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in counterclockwise direction.

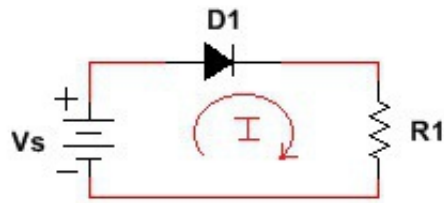


For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

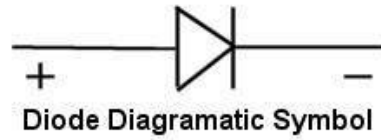


**Hints:**

- For DC voltage source, the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

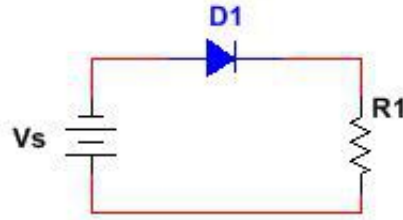


- The answer is:  
A. Clockwise and forward-biased

Select All

Problem #860622 "PRA76UA - Diode-Resistor 4"

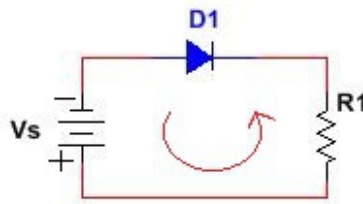
For the circuit given below, indicate the direction of current flowing and the orientation of the diode (forward-biased or reverse-biased).



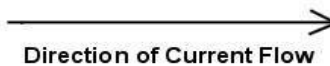
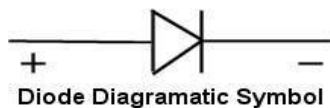
**Multiple Choice:**

A. Clockwise and forward-biased

- For **DC voltage source**  $V_s$ , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in counterclockwise direction.

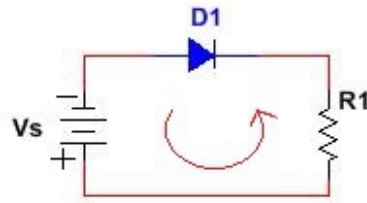


For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

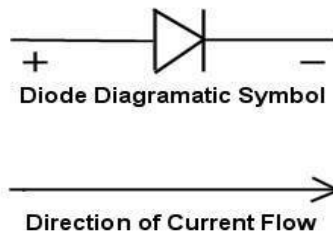


B. Clockwise and reverse-biased

- For **DC voltage source**  $V_s$ , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in counterclockwise direction.

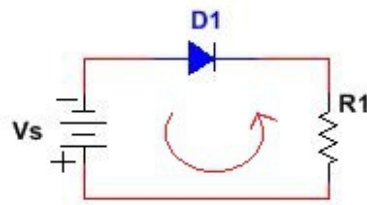


For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.

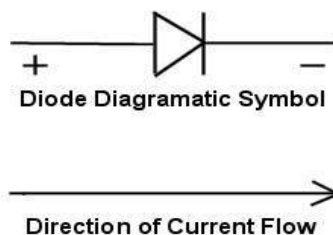


**✗** C. Counterclockwise and forward-biased

- For **DC voltage source  $V_s$** , the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in counterclockwise direction.



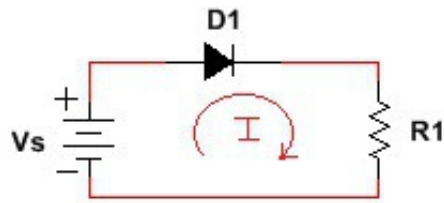
For **diode**, it allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.



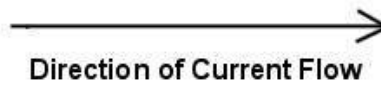
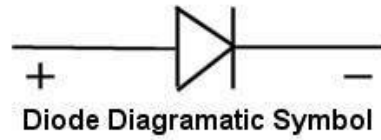
**✓** D. Counterclockwise and reverse-biased

**Hints:**

- For DC voltage source, the current flows from positive to negative terminal. From the voltage source's symbol, the positive terminal corresponds to the longer end line while the shorter end line represents the negative port. Thus, the current flows in clockwise direction.



- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way. The diode is in forward-biased when it is ON (current flowing from anode to cathode). Otherwise, the diode is OFF and is reverse-biased.



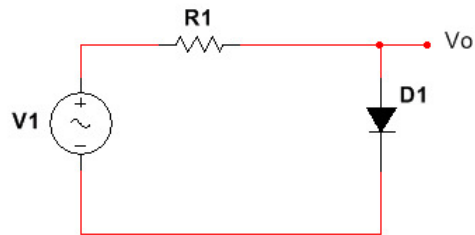
- The answer is:  
A. Clockwise and forward-biased



Select All

Problem #858554 "PRA74PK - Half-wave Rectifier Output Waveform 1"

For the circuit given below, choose the expected waveform of the output  $V_o$  versus time.

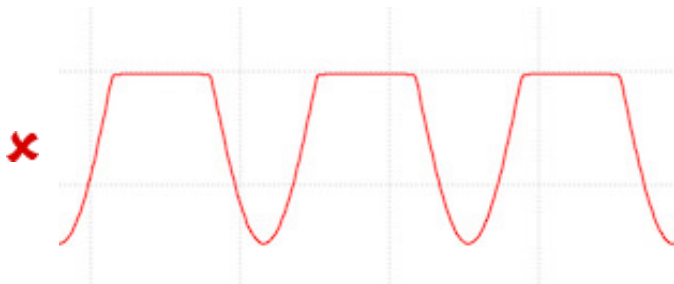
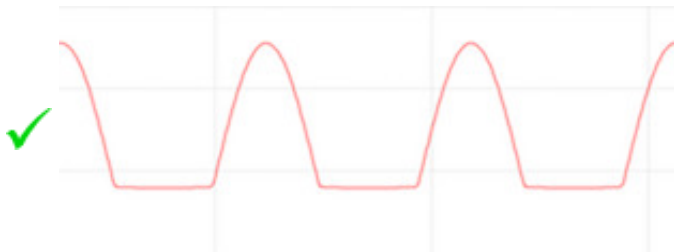


Assume  $V_1$  is a sinusoidal AC voltage source.

Multiple Choice:



- When  $V_1$  is positive (current flows in clockwise direction), the diode is ON. When  $V_1$  is negative (current flows counterclockwise), the diode is OFF, making circuit opened.



- When  $V_1$  is positive (current flows in clockwise direction), the diode is ON. When  $V_1$  is negative (current flows counterclockwise), the diode is OFF, making circuit opened.

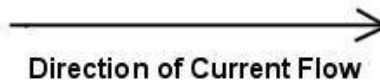
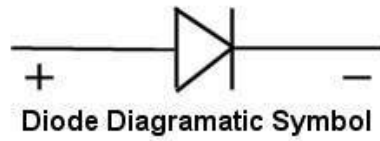
x



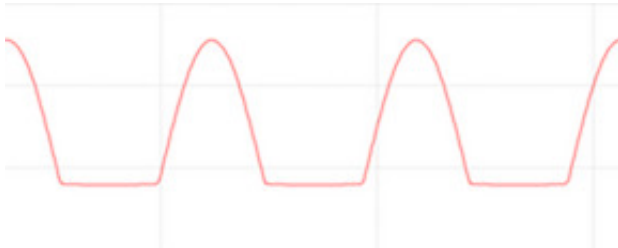
- When  $V_1$  is positive (current flows in clockwise direction), the diode is ON. When  $V_S$  is negative (current flows counterclockwise), the diode is OFF, making circuit opened.

**Hints:**

- Diode allows current to flow in one direction, from anode to cathode, and blocks the reversed way.



- When  $V_S$  is positive (current flows in clockwise direction), the diode is ON. When  $V_S$  is negative (current flows counterclockwise), the diode is OFF.
- The answer is:



Select All

Problem #858589 "PRA74QQ - NPN 1 Symbol"

Which transistor corresponds to the symbol below?

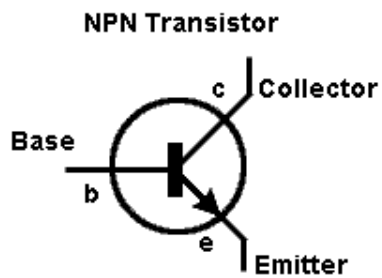


Multiple Choice:

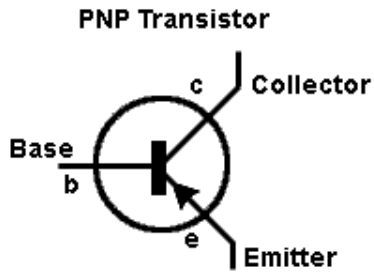
NPN

PNP

Here's a mnemonic for you:

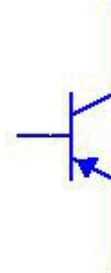


**N** Never  
**P** Points  
**N** iN



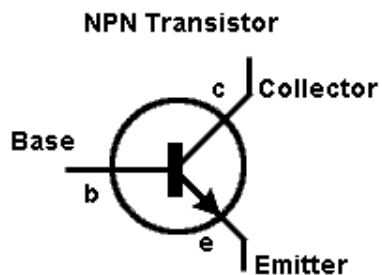
**P** Points  
**N** iN  
**P** Permanently

The symbol for pnp transistor is:

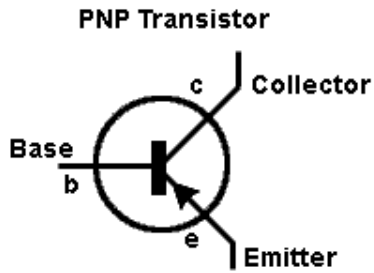


NMOS

Here's a mnemonic for you:

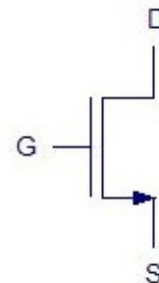


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

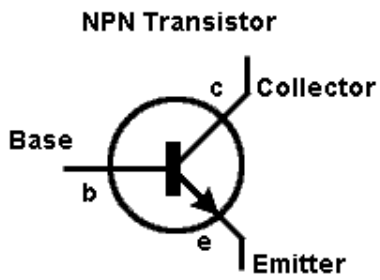
The symbol for NMOS transistor is:



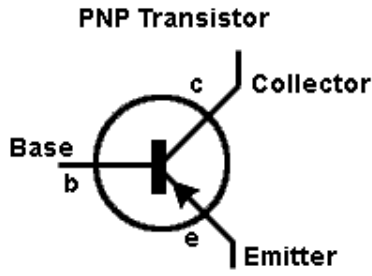
**X** PMOS

•

Here's a mnemonic for you:

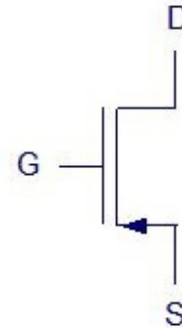


**N** Never  
**P** Points  
**N** iN



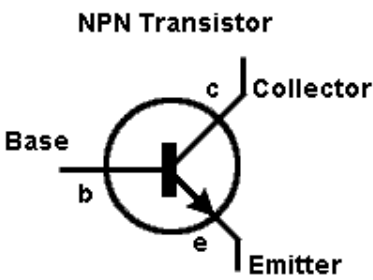
**P** Points  
**N** iN  
**P** Permanently

The symbol for PMOS transistor is:

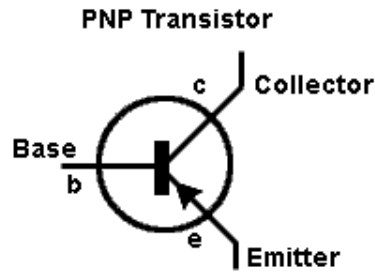


**Hints:**

• For BJT:



**N** Never  
**P** Points  
**N** iN



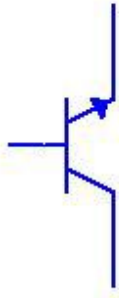
**P** Points  
**N** iN  
**P** Permanently

• The answer is NPN.

Select All

Problem #860624 "PRA76UC - NPN 2 Symbol"

Which transistor corresponds to the symbol below?



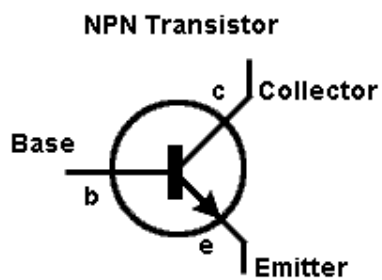
Multiple Choice:

NPN

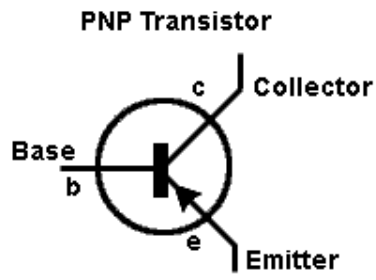
PNP

•

Here's a mnemonic for you:

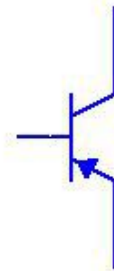


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

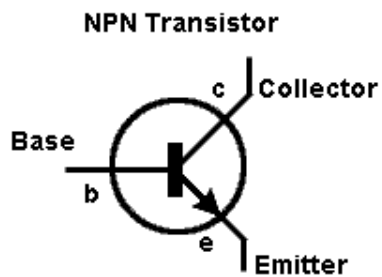
The symbol for pnp transistor is:



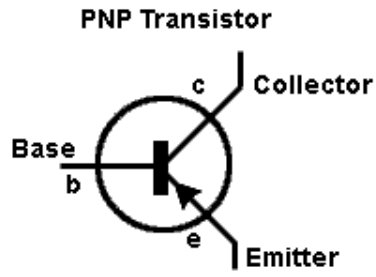
NMOS

•

Here's a mnemonic for you:

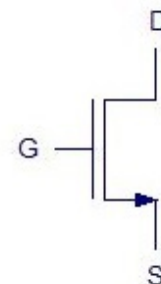


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

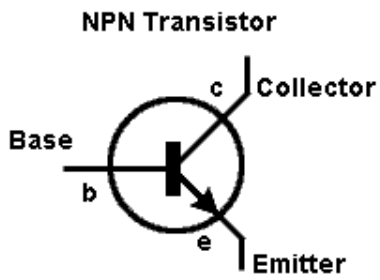
The symbol for NMOS transistor is:



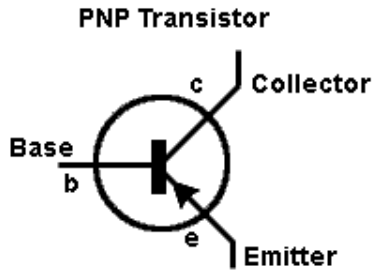
**X** PMOS

•

Here's a mnemonic for you:

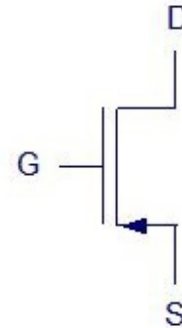


**N** Never  
**P** Points  
**N** iN



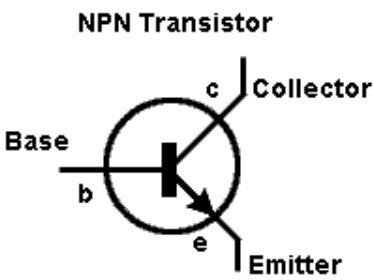
**P** Points  
**N** iN  
**P** Permanently

The symbol for PMOS transistor is:

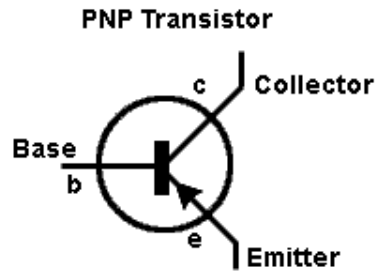


**Hints:**

- For BJT:



**N** Never  
**P** Points  
**N** iN



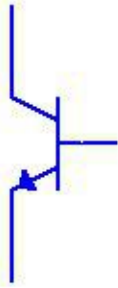
**P** Points  
**N** iN  
**P** Permanently

- The answer is NPN.

Select All

Problem #860625 "PRA76UD - NPN 3 Symbol"

Which transistor corresponds to the symbol below?



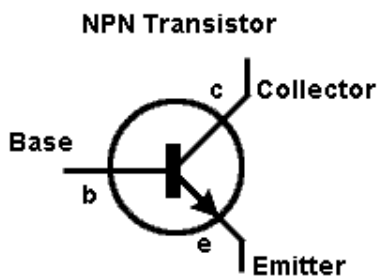
Multiple Choice:

NPN

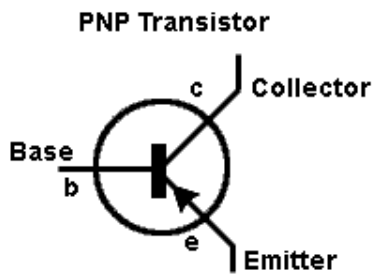
PNP

•

Here's a mnemonic for you:

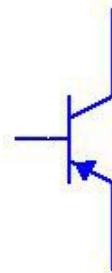


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

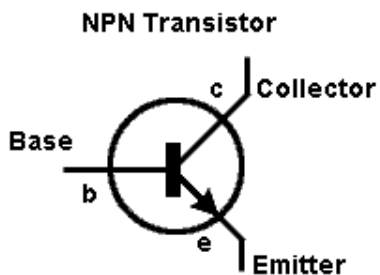
The symbol for pnp transistor is:



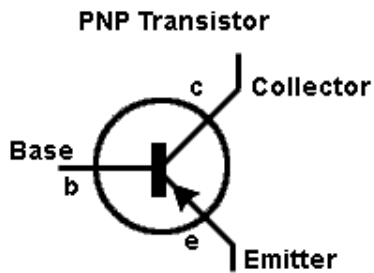
NMOS

•

Here's a mnemonic for you:

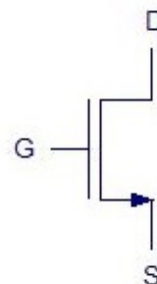


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

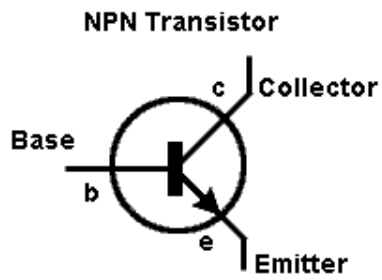
The symbol for NMOS transistor is:



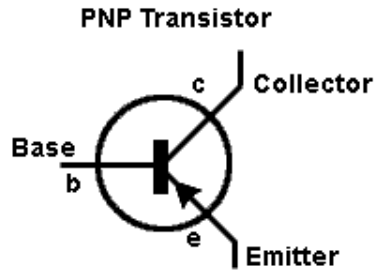
**X** PMOS

- 

Here's a mnemonic for you:

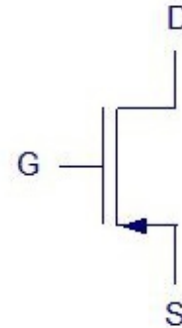


**N** Never  
**P** Points  
**N** i**N**



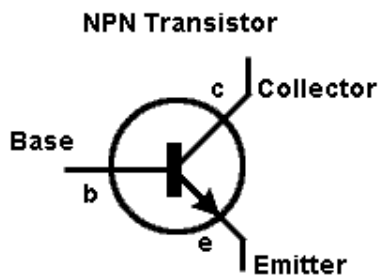
**P** Points  
**N** i**N**  
**P** Permanently

The symbol for PMOS transistor is:

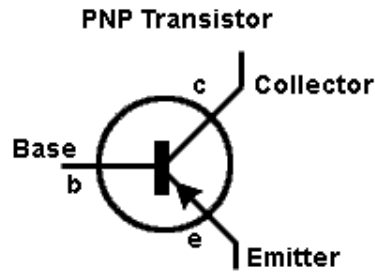


**Hints:**

- For BJT:



**N** Never  
**P** Points  
**N** i**N**



**P** Points  
**N** i**N**  
**P** Permanently

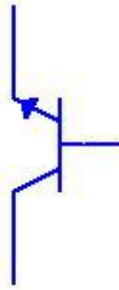
- The answer is NPN.



Select All

Problem #860626 "PRA76UE - NPN 4 Symbol"

Which transistor corresponds to the symbol below?



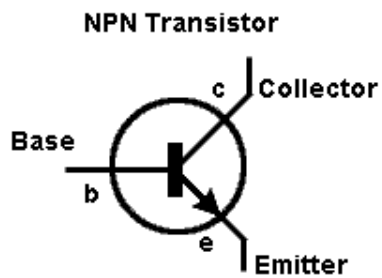
Multiple Choice:

NPN

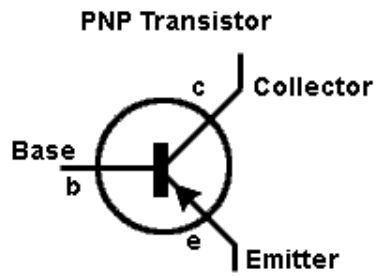
PNP

•

Here's a mnemonic for you:

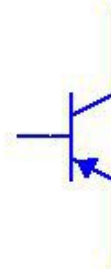


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

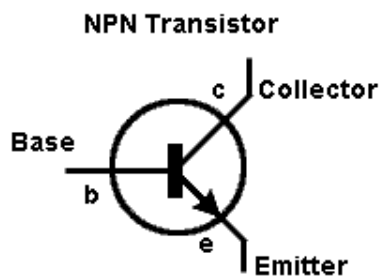
The symbol for pnp transistor is:



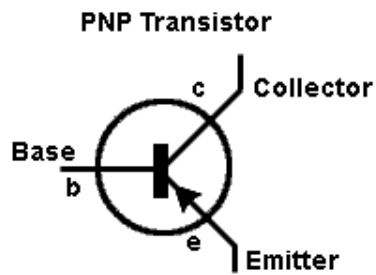
NMOS

•

Here's a mnemonic for you:

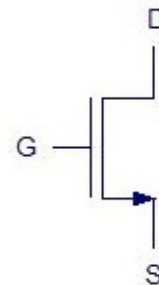


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

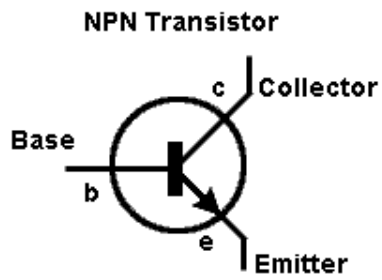
The symbol for NMOS transistor is:



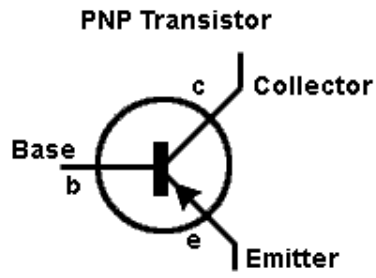
**X** PMOS

- 

Here's a mnemonic for you:

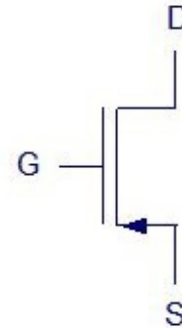


**N** Never  
**P** Points  
**N** i**N**



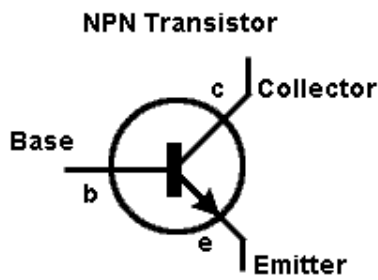
**P** Points  
**N** i**N**  
**P** Permanently

The symbol for PMOS transistor is:

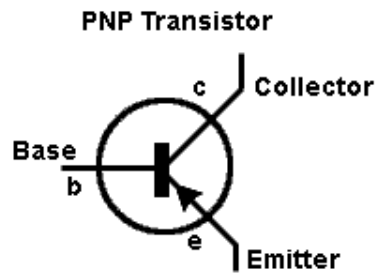


**Hints:**

- For BJT:



**N** Never  
**P** Points  
**N** i**N**



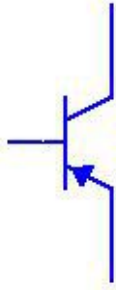
**P** Points  
**N** i**N**  
**P** Permanently

- The answer is NPN.

Select All

Problem #860627 "PRA76UF - PNP 1 Symbol"

Which transistor corresponds to the symbol below?

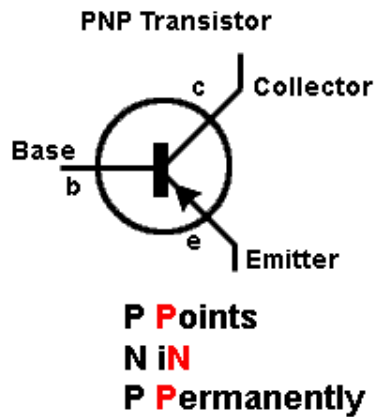
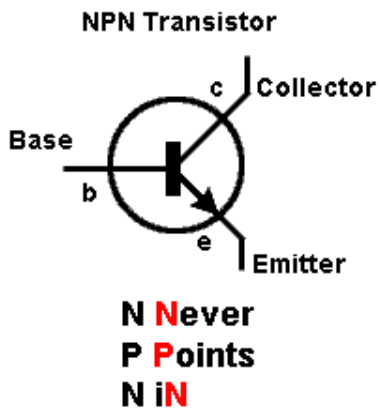


Multiple Choice:

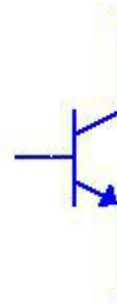
NPN

.

Here's a mnemonic for you:



The symbol for npn transistor is:

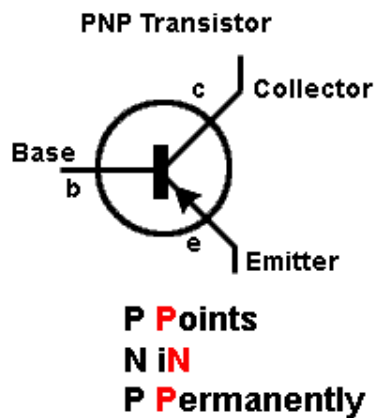
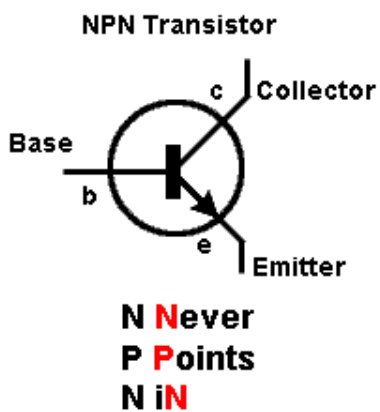


PNP

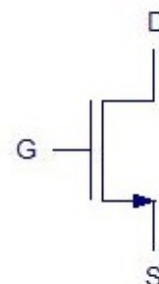
NMOS

.

Here's a mnemonic for you:



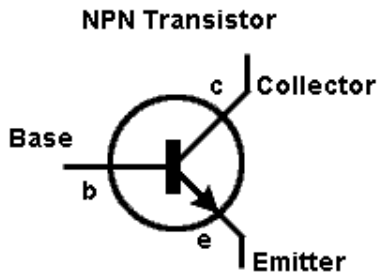
The symbol for NMOS transistor is:



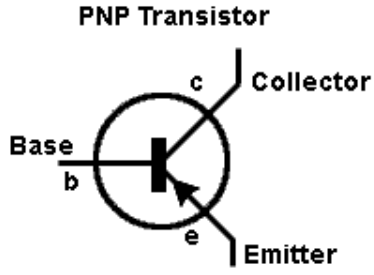
**X** PMOS

•

Here's a mnemonic for you:

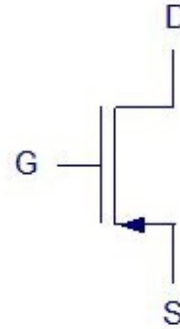


**N** Never  
**P** Points  
**N** iN



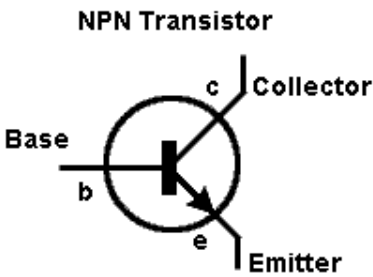
**P** Points  
**N** iN  
**P** Permanently

The symbol for PMOS transistor is:

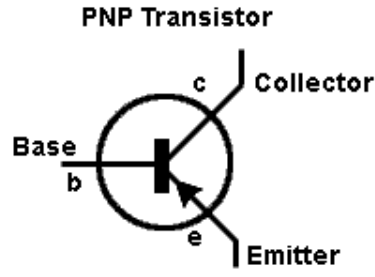


Hints:

• For BJT:



**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

• The answer is NPN.

Select All

Problem #860628 "PRA76UG - PNP 2 Symbol"

Which transistor corresponds to the symbol below?

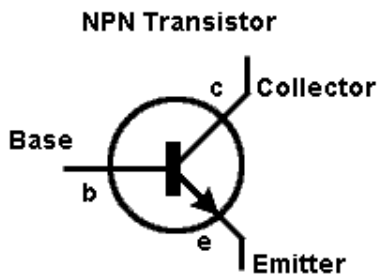


Multiple Choice:

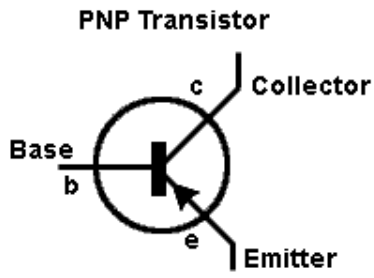
NPN

•

Here's a mnemonic for you:

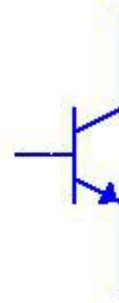


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

The symbol for npn transistor is:

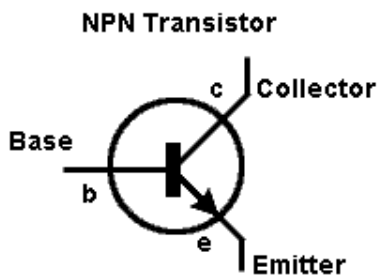


PNP

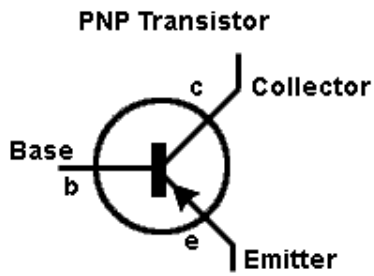
NMOS

•

Here's a mnemonic for you:

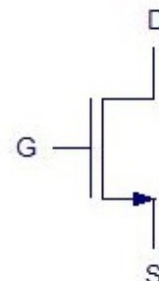


**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

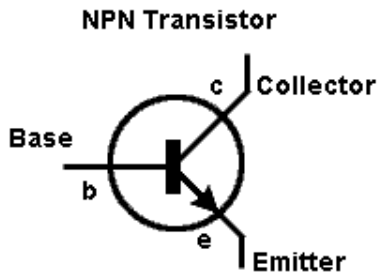
The symbol for NMOS transistor is:



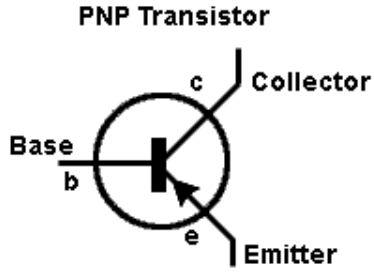
**X** PMOS

•

Here's a mnemonic for you:

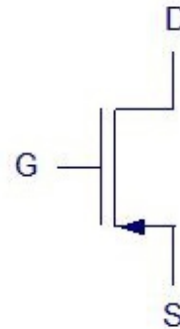


**N** Never  
**P** Points  
**N** iN



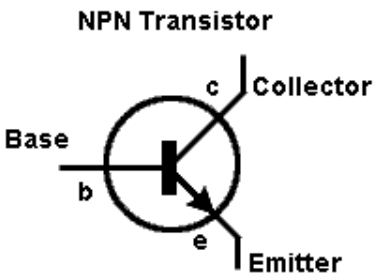
**P** Points  
**N** iN  
**P** Permanently

The symbol for PMOS transistor is:

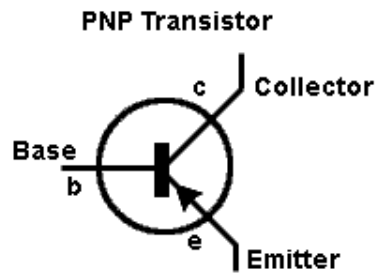


Hints:

• For BJT:



**N** Never  
**P** Points  
**N** iN



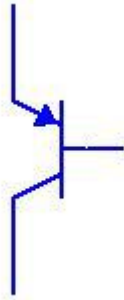
**P** Points  
**N** iN  
**P** Permanently

• The answer is NPN.

Select All

Problem #860629 "PRA76UH - PNP 3 Symbol"

Which transistor corresponds to the symbol below?

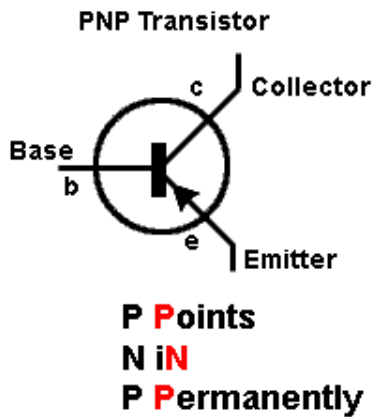
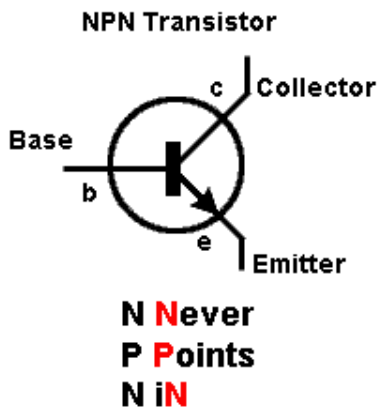


Multiple Choice:

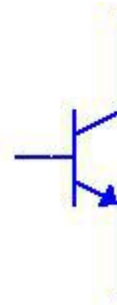
NPN

.

Here's a mnemonic for you:



The symbol for npn transistor is:

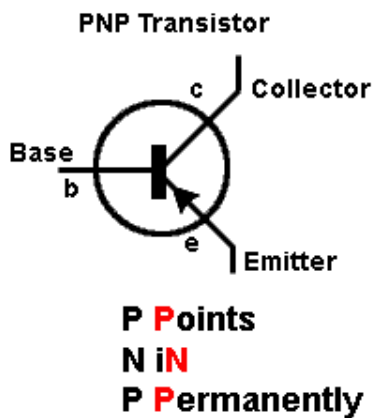
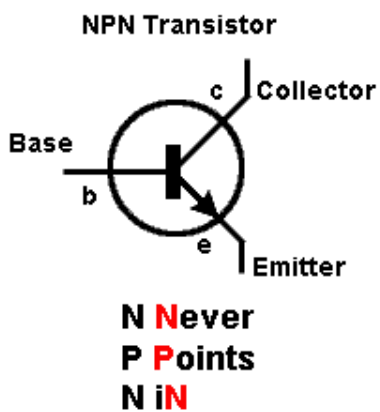


PNP

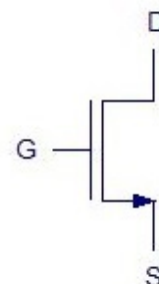
NMOS

.

Here's a mnemonic for you:



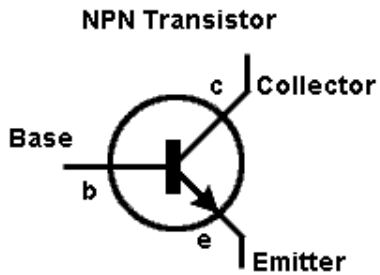
The symbol for NMOS transistor is:



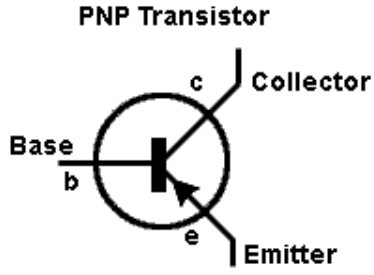
**X** PMOS

•

Here's a mnemonic for you:

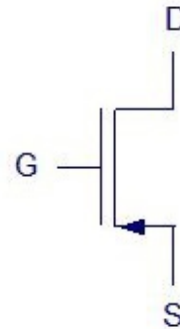


**N** Never  
**P** Points  
**N** iN



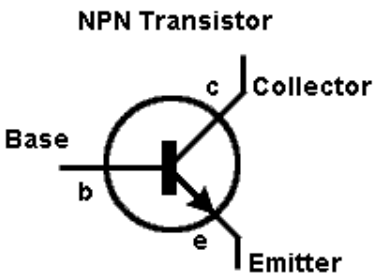
**P** Points  
**N** iN  
**P** Permanently

The symbol for PMOS transistor is:

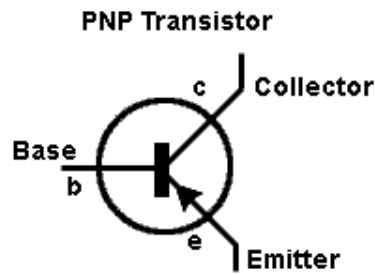


**Hints:**

• For BJT:



**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

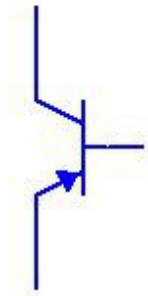
• The answer is NPN.



Select All

Problem #860630 "PRA76UJ - PNP 4 Symbol"

Which transistor corresponds to the symbol below?

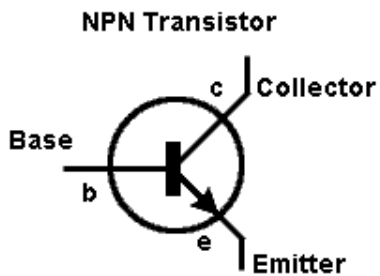


Multiple Choice:

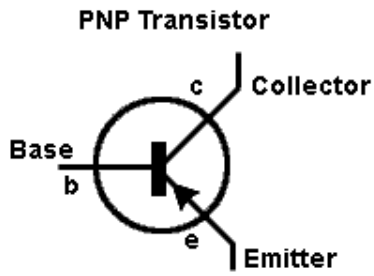
NPN

•

Here's a mnemonic for you:

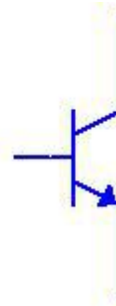


**N** Never  
**P** Points  
**N** in



**P** Points  
**N** in  
**P** Permanently

The symbol for npn transistor is:

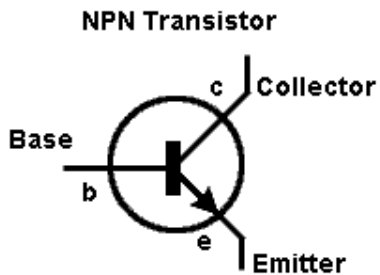


PNP

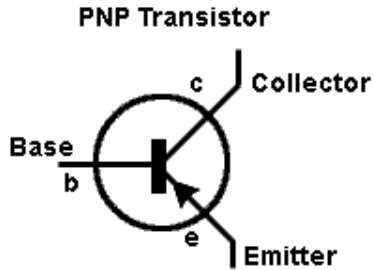
NMOS

•

Here's a mnemonic for you:

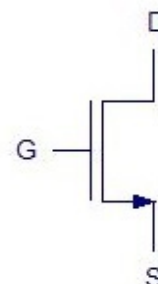


**N** Never  
**P** Points  
**N** in



**P** Points  
**N** in  
**P** Permanently

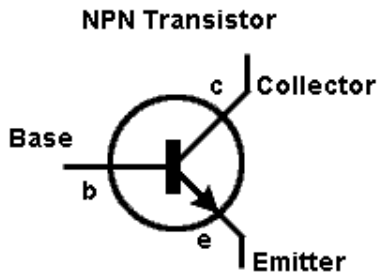
The symbol for NMOS transistor is:



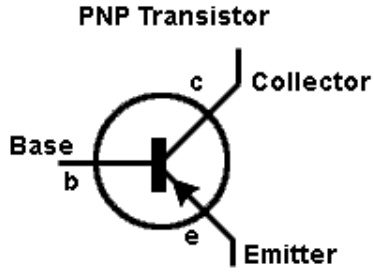
**X** PMOS

•

Here's a mnemonic for you:

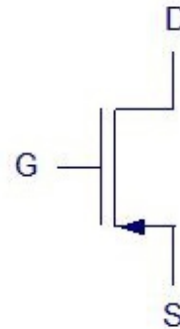


**N** Never  
**P** Points  
**N** iN



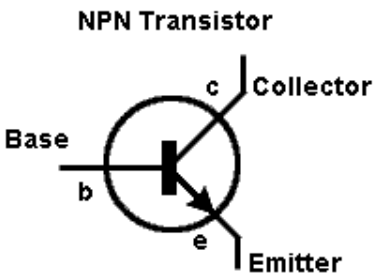
**P** Points  
**N** iN  
**P** Permanently

The symbol for PMOS transistor is:

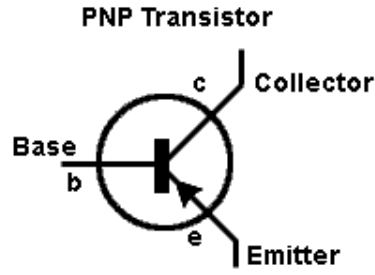


Hints:

• For BJT:



**N** Never  
**P** Points  
**N** iN



**P** Points  
**N** iN  
**P** Permanently

• The answer is NPN.

Select All

Problem #858616 "PRA74RK - NPN Diode Symbol"

Which transistor corresponds to the diode's orientation below?



Multiple Choice:

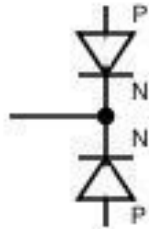
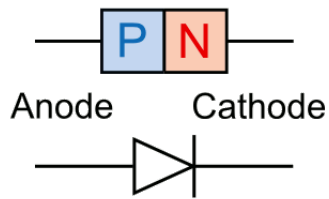
NPN

PNP

•

Generic Diode

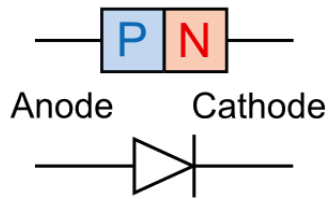
Labelled diagram



NMOS

•

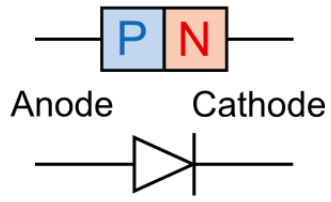
Generic Diode



PMOS

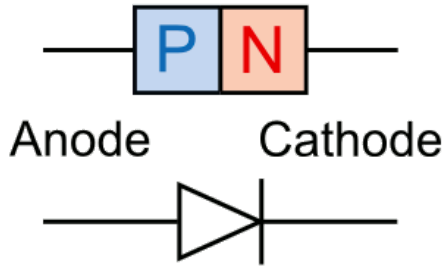
•

Generic Diode

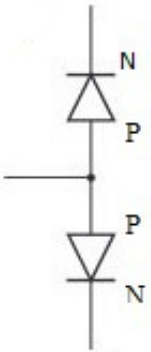


**Hints:**

- A diode is constructed by p-n junction.



- As a result:

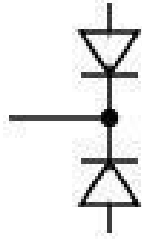


- The answer is:  
NPN

Select All

Problem #865249 "PRA8BNJ - PNP Diode Symbol"

Which transistor corresponds to the diode's orientation below?

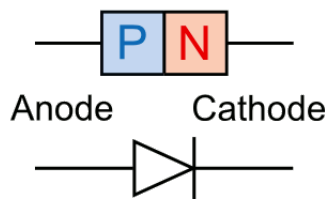


Multiple Choice:

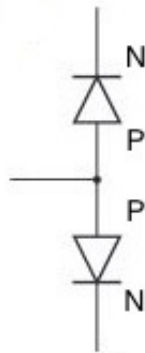
NPN

•

Generic Diode



Labelled diagram

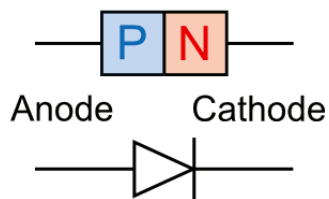


PNP

NMOS

•

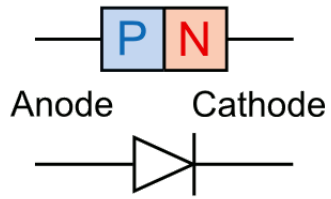
Generic Diode



PMOS

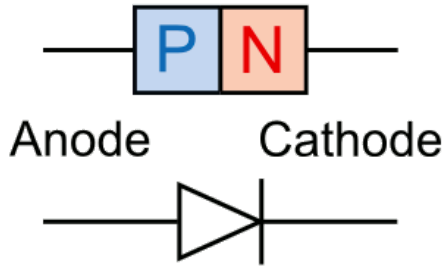
•

Generic Diode

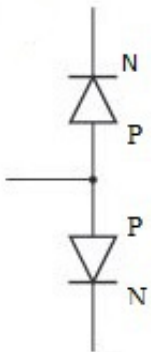


**Hints:**

- A diode is constructed by p-n junction.



- As a result:



- The answer is:  
NPN