ELECTRICAL PRINCIPLES WORKBOOK

Name: Lidia Pascu

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Contents

Electricity

Task 1a:

Define Electricity	Electricity is the flow of electric charge, typically through a conductor such as a wire. It is a form of energy resulting from the movement of electrons, which are negatively charged particles found inside atoms.

Task 1b:

Complete the table below by matching the electrical term with the description, cut and paste the terms into the relevant description box

Electrical Term	Description
Charge	• Made up of protons and electrons
Current	• The rate at which charge is flowing
Voltage	• The force that pushes electric charges through a conductor
Resistance	• Measured in Ohms
Conductance	• Represents how easily electricity flows through a material
Power	• The rate at which energy is transferred by a circuit
Energy	• The capacity to do work

Optional Extension Task:

- Choose two electrical terms and write an example of how they work:

Electrical Term	Example: Voltage Voltage is the common term used to describe the potential difference in electrical systems.
Electrical term	Example: Resistance Resistance is the opposition to the flow of electric current in a material.

AC/DC

Task 2a:

Define AC	AC = Alternating current Definition: AC is a type of current in which the flow of electrons regularly reverses direction. It is the standard form of electricity used in homes, schools and businesses.

Identify & describe TWO characteristics of AC:

Characteristic	Description
Direction Changes	The current alternates direction repeatedly, typically many times per second.
Easily Transformed	AC voltage can be increased or decreased using transformers, making it ideal for long-distance power transmission.

Task 2b:

Define DC	DC = Direct Current Definition: DC is a type of current in which electrons flow in one constant direction. It is commonly used in batteries, solar panels, and electronic devices.

Identify & describe TWO characteristics of DC:

Characteristic	Description
One-way flow	The current flows in a single, constant direction from the positive to the negative terminal.
Stable voltage	DC provides a steady and unchanging voltage, which is ideal for sensitive electronic equipment.

Optional Extension Task:

Identify a smart device that uses AC, DC and both:

AC Smart Device	Device: Smart Washing Machine AC Use: Runs the main motor and heating element directly from AC mains power (standard wall outlet).
DC Smart Device	Device: Smartphone DC Use: Powered by a built-in DC battery. All internal circuits (processor, screen, sensors) run on DC electricity.
Both	Device: Smart TV AC Use: Plugged into the wall and receives AC power from the mains. DC Use: Internally, the AC is converted to DC using a power supply to run internal circuits (display, processor, Wi-Fi module).

Electrical Laws

Task 3a:

In your own words summarise Ohm's law:

Ohm's Law	According to Ohm's Law, the electric current in a circuit increases when the voltage increases and decreases when the resistance increases, provided that the temperature remains the same.

Task 3b:

Using the following Ohm's calculator Ohm's Law Calculator (omnicalculator.com) complete the table below by entering the values of the black text and find the values of the red text (round up or down to the nearest whole number):

Calculation 1	Calculation 2	Calculation 3
Voltage: 240 V	**Voltage: 15 V**	**Voltage: 181.7 V**
Current: 60 A	**Current: 15 A**	**Current: 8.3 A**
Resistance: 4 Ω	**Resistance: 1 Ω**	**Resistance: 22 Ω**
Power: 14400 W	**Power: 225 W**	**Power: 1500 W**

Task 4a:

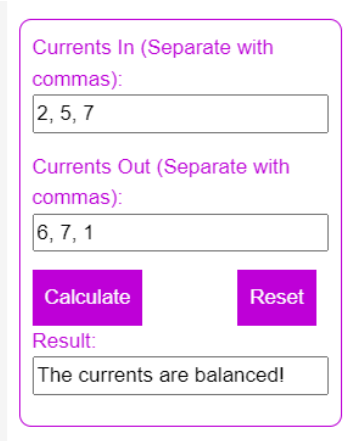
In your own words summarise Kirchhoff's Current Law (KCL):

KCL	Kirchhoff's Current Law says that the total current going into a point (or junction) in a circuit is equal to the total current leaving the junction.

Task 4b:

Using the following KCL calculator Kirchhoff's Current Law Calculator Online (calculatorshub.net) provide screenshots showing balanced currents based on the values you input. All three examples must have a minimum of 3 value entries per currents in and currents out:

Example below shows values equal to 13 with a result stating "The currents are balanced":



Crop and resize your screenprints to fit in the boxes below showing only the calculation:

KCL Calculation 1	KCL Calculation 2	KCL Calculation 3
Currents In (Separate with commas): 6,2.5,1.5 Currents Out (Separate with commas): 4,3,3 Calculate Reset Result: The currents are balan	Currents In (Separate with commas): 5,4,1 Currents Out (Separate with commas): 2,6,2 Calculate Reset Result: The currents are balan	Currents In (Separate with commas): 4,3,2 Currents Out (Separate with commas): 5,1,3 Calculate Reset Result: The currents are balan

Task 5a:

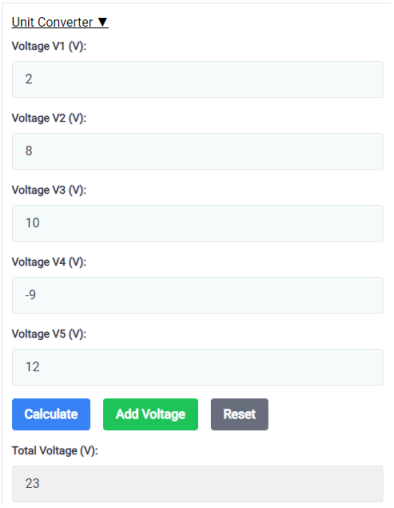
In your own words summarise Kirchhoff's Voltage Law (KCL):

KVL	Kirchhoff's Voltage Law says that the total voltage around any closed loop in a circuit is always equal to zero.

Task 5b:

Using the following KVL calculator Kirchhoff's Voltage Law Calculator & Formula Online Calculator Ultra provide screenshots showing total voltage based on the values you input. One example must include negative value entries (e.g. -3):

Example below shows total voltage result of 23:



Crop and resize your screenprints to fit in the boxes below showing only the calculation:

KVL Calculation 1	KVL Calculation 2	KVL Calculation 3
Voltage V1 (V): 17 Voltage V2 (V): 12 Voltage V3 (V): -5 Voltage V4 (V): 25 Voltage V5 (V): 10 Calculate / Add Voltage / Reset Total Voltage (V): 59	Voltage V1 (V): 27 Voltage V2 (V): 16 Voltage V3 (V): 8 Voltage V4 (V): -20 Voltage V5 (V): 5 Calculate / Add Voltage / Reset Total Voltage (V): 36	Voltage V1 (V): 50 Voltage V2 (V): 21 Voltage V3 (V): 32 Voltage V4 (V): 8 Voltage V5 (V): -26 Calculate / Add Voltage / Reset Total Voltage (V): 85

Optional Extension Task:

From the electrical laws provide a formula for one of your calculated results:

Ohm's Law Formula	Formula: $V = I \times R$; $I = R/V$
KCL Formula	Formula: $\sum I_{in} = \sum I_{out}$
KVL Formula	Formula: $\sum V = 0$

DC Circuits

Task 6a:

From the descriptions in the blue box, name the component they are describing, the choices of components are:

- Resistors
- Capacitors
- Inductors

Components which store electrical energy in an electric field when connected to a voltage source.
Component: Capacitors

Passive components that oppose the flow of electric current, causing a drop in voltage.
Component: Resistors

Components which store energy in a magnetic field when current flows through them.
Component: Inductors

Task 6b:

In your own words write a summary of the DC Circuit types:

Series Circuit	In a series circuit, components are connected one after another in a single path. The same current flows through all of them, and if one part breaks, the whole circuit stops working.
Parallel Circuit	In a parallel circuit, components are connected side by side, so current has multiple paths to flow. Each part gets the full voltage, and if one stops working, the others still work.

Task 6c:

Based on what you know from today's session and from the Smart Technologies session, provide details of the following:

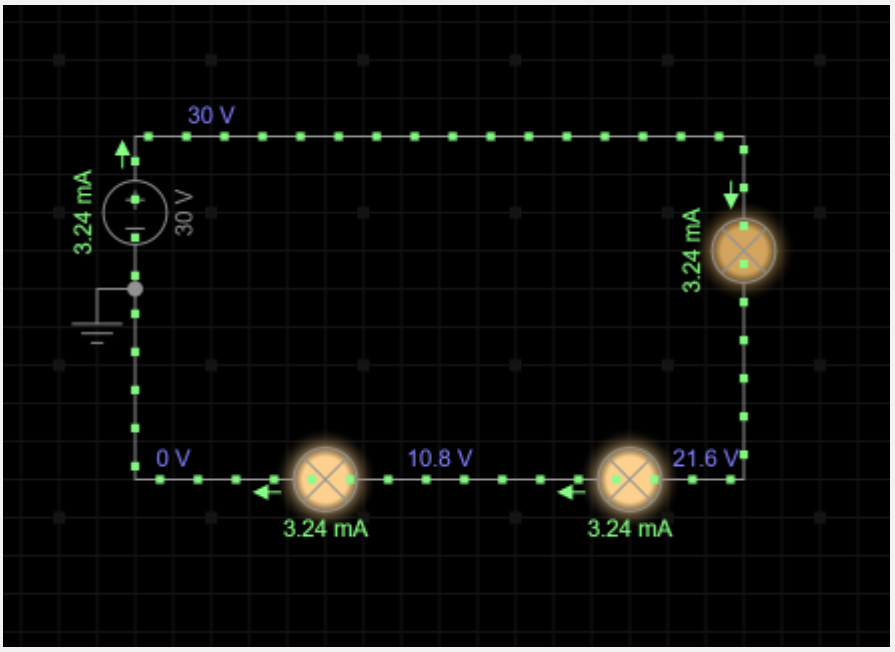
- Smart Device which uses a DC circuit
- Series or Parallel circuit
- Brief description of how the circuit functions in the smart device

Smart Device	Circuit Type	Description

Task 7:

Series Circuit

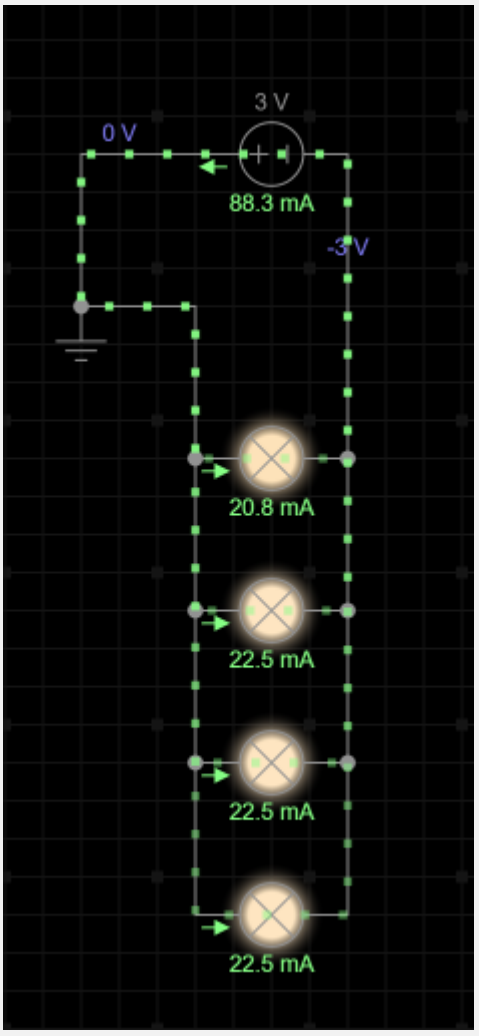
Screenshot of your Series Circuit:



Written explanation of its functionality:
Lights up 3 bulbs (or resistive loads), all connected in series.
Powered by a 30 V voltage source.
The same current (3.24 mA) flows through all the components because it's a series circuit.
Each component drops part of the total voltage:
- First bulb: drops 10.8 V
- Second bulb: drops 21.6 V
- Third bulb: voltage isn't directly labeled but seems to close the loop correctly, showing 0 V at the end.

Parallel Circuit

Screenshot of your Parallel Circuit:



Written explanation of its functionality: A parallel circuit with 4 light bulbs (or similar resistive loads) connected to a 3V power supply.
The voltage across each bulb is the same: 3V, as all are connected directly across the same two nodes of the power supply.
The current divides among the bulbs depending on their resistance:

- **One bulb draws 20.8 mA**
- **Three bulbs each draw 22.5 mA**

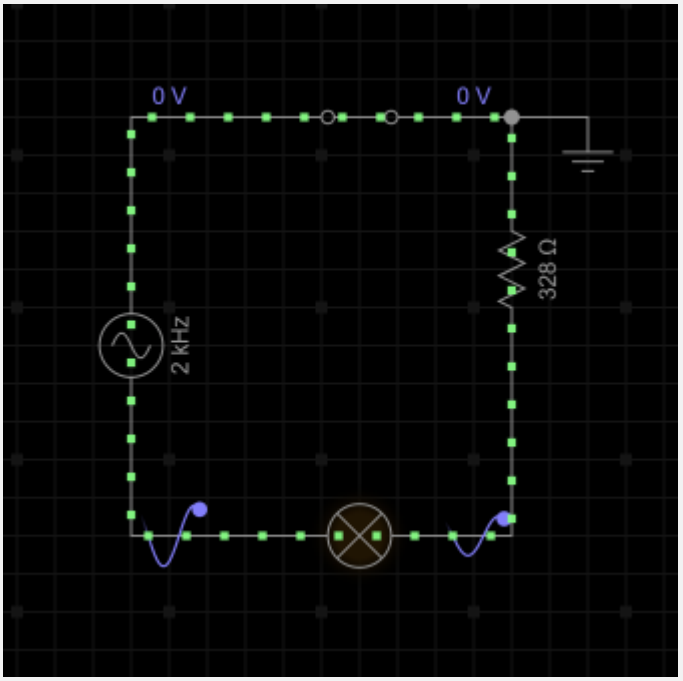
The total current drawn from the battery is the sum of these:
88.3 mA = 20.8 + 22.5 + 22.5 + 22.5
This shows that the battery is supplying enough current to power all bulbs simultaneously.

Optional Extension Task:

Try to create any AC Circuit:

AC Circuit

Screenshot of your AC Circuit:



Written explanation of its functionality:

AC Circuits

Task 8:

Cut and paste the correct diagram and description to complete the table below and match the cut and paste elements to the correct AC characteristic:

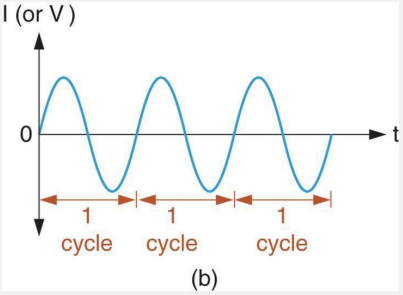
Diagrams – Delete this once cut and paste into table

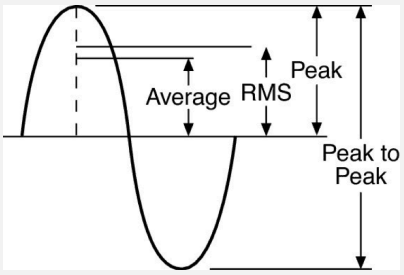
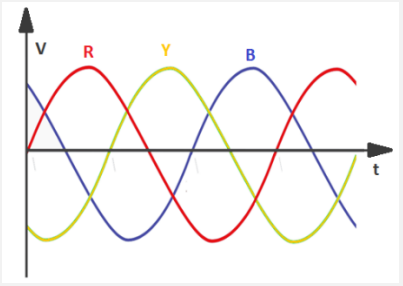
Descriptions – Delete this once cut and paste into table

Relative position of a point in the AC cycle, measured in degrees (°) or radians (rad).

The number of cycles an AC waveform completes in one second, measured in hertz (Hz).

Peak value of the voltage or current in an AC waveform.

Characteristic	Diagram	Description
Frequency		Determines the behaviour of AC circuits and their components such as capacitors and inductors.

Amplitude		Amplitude is the peak value of the voltage or current in an AC waveform.
Phase		Phase refers to the relative position in an AC cycle, measured in degrees or radians.

Task 9a:

Provide a brief description of the following AC circuit components:

Resistors	Description: Resistors are essential components in electronic circuits that control the flow of current and dissipate energy as heat. They play a crucial role in regulating electrical signals and ensuring the proper functioning of electronic devices.
Capacitors	Description: Block DC signals while allowing AC signals to pass through. This property of capacitors is due to their ability to store energy in an electric field and resist slow changes (low frequencies) while allowing fast changes (high frequencies) to pass through easily.
Inductors	Description: Inductors store energy in a magnetic field and oppose changes in current. Inductors resist fast changes in current. The faster you try to change it, the more it resists.

Task 9b:

Match the component with the functionality by using the “Insert” tab and selecting “Shapes” option to add either a plain line or double ended arrow to make a connection between the boxes:

Resistors
Capacitors
Inductors

Optional Extension Task:

For each component write an example of how it is used:

Cause the current to lead the voltage by 90°.	Use:
Cause the current to lag the voltage by 90°.	
Cause a voltage drop proportional to the current.	
Resistors	
Capacitors	Use:
Inductors	Use:

Task 10a:

There are two types of Reactance, name and define them:

Reactance 1:	Name: **Capacitive Reactance** Definition: Is a measure of the opposition that inductors and capacitors present to alternating current (AC). Unlike resistance, which applies to both AC and DC, reactance only affects AC
Reactance 2:	Name: **Inductive reactance** Definition: **Inductive reactance** is the opposition to AC caused by an inductor. It increases with increasing frequency.

Task 10b:

Identify the missing word from the two sentences below:

Unlike resistance, which only applies to direct current (DC) and AC, **reactance_** specifically applies to AC circuits and accounts for the effects of capacitors and inductors.

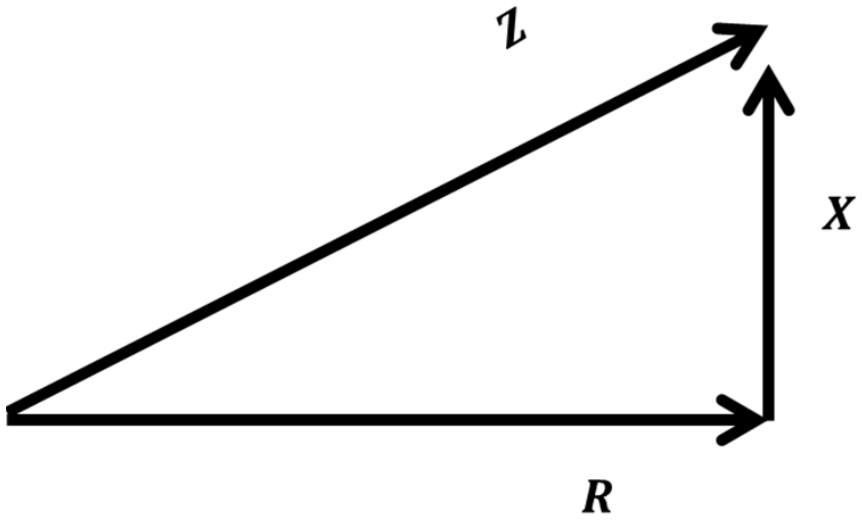
Missing Word =

Impedance (Z) is a complex quantity that combines resistance (R) and reactance (X) to describe the total opposition to AC in a circuit.

Missing Word =

Optional Extension Task:

From the diagram below identify the correct labels for Z, X & R:



Z	Label:
X	Label:
R	Label:

Power Systems

Task 11a:

Provide the required information below in relation to single-phase systems:

Typical Use	1x Advantage	1x Limitation
A single-phase system uses a single alternating current (AC) waveform to supply power. The voltage varies sinusoidally with time.	- Simplicity and ease of installation. - Cost-effective for lower power requirements.	Higher current for the same power output compared to three-phase, leading to greater energy losses.

Optional Extension Task:

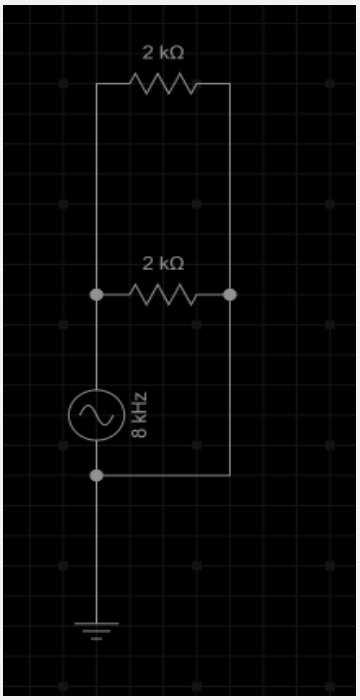
Provide an example of a device/appliance that might use a single-phase system:

Single-phase device/appliance: Lighting, Air-conditioning, TV

Task 11b:

Create a single-phase power system

Single-Phase Power System
Screenshot of your single-phase system:



Written explanation of its functionality:

This is a voltage divider, which splits the input AC voltage between the two resistors.

Since both resistors have the same value (2 kΩ), the voltage is divided equally.

So, the voltage across the second resistor (the one closer to ground) will be half of the input voltage from the source.

Task 12a:

Cut and paste the statements below into the relevant boxes in the table to identify them as relating to either **Star** or **Delta** three-phase system configurations:

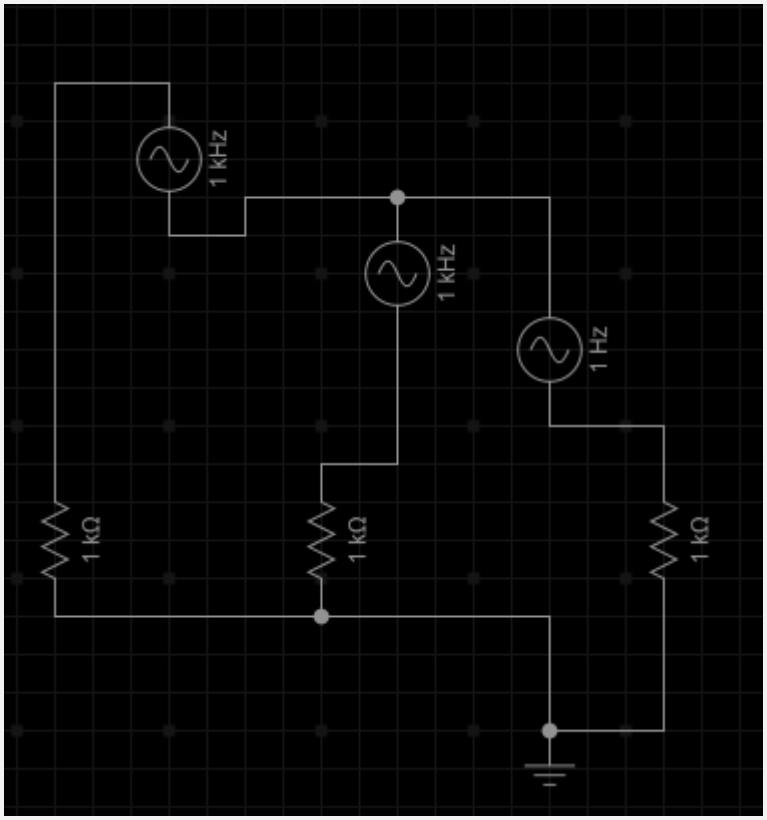
Star Configuration	Delta Configuration
• Each phase is connected to a neutral point	• Also known as Wye configuration
• Commonly used in residential buildings	• Has no neutral point
• Commonly used in transmission systems	• Forms a closed loop

Task 12b:

Create a three-phase power system

Three-Phase Power System

Screenshot of your three-phase system:



Written explanation of its functionality:

A three-phase circuit with 3 resistors and 3 AC sources (balanced):

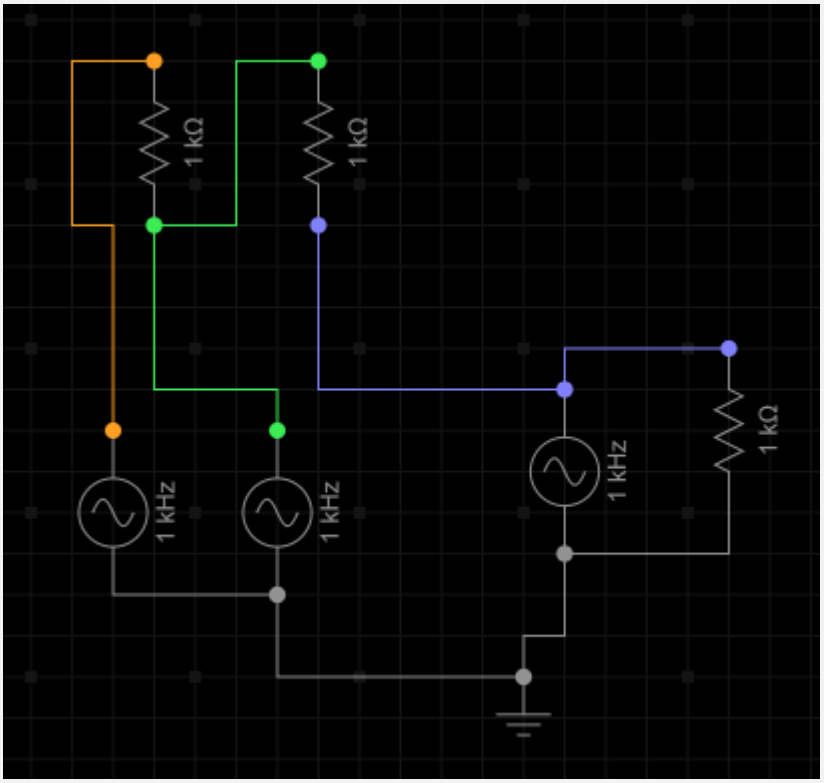
- **Distributes power evenly across the phases.**
- **Provides constant total power.**

Optional Extension Task:

Find your own version of a three-phase diagram and explain what it shows:

Three-Phase diagram

Screenshot of your three-phase diagram:



Written explanation of what it shows:
This circuit is a three-phase resistive load network designed to analyze the voltage and current relationships of a balanced or unbalanced three-phase system.

- Three voltage sources (bottom-left, marked 1 kHz) represent a three-phase AC supply. These are likely 120° out of phase from each other (though not labeled with phases here, this is the standard assumption).

- Each source is connected to a 1 kΩ resistor, forming three identical branches, suggesting a balanced Y (wye) configuration.

- The top junction of each resistor (marked by different colored dots: orange, green, and purple) represents the line-to-neutral voltage points.

- A fourth voltage source on the right (also 1 kHz) connects across a 1 kΩ resistor — this may be simulating a load voltage or an external reference to observe interaction with the three-phase system.

- All returns (gray wires) connect to a common ground (neutral).

Course Notes:

It is recommended to take notes from the course, use the space below to do so:

Additional Information

We have included a range of additional links to further resources and information that you may find useful.

Session Name

- Link
- Link

END OF WORKBOOK

Please check through your work thoroughly before submitting and update the table of contents.