Boğaziçi University

Introductory Phys Labs

AMMETERS & VOLTMETERS

PHYS 201

THEORY AND APPARATUS

AMMETER

An ammeter measures the electric current in a circuit. The name is derived from the Ampere (A), the base unit of electric current in SI.

In general, we do not want to disturb the system when we take measurements. To this end, we connect an ammeter in SERIES. Ideally, an ammeter has ZERO internal resistance, so when connected in series, it will not affect the circuit in any measurable way.

Although the ideal ammeter neither draws power nor reroutes currents, real ammeters necessarily do due to their nonzero internal resistance. Still, typically, the internal resistance is comparatively very low, so we neglect it for all practical purposes.

GALVANOMETER

The galvanometer is a device that detects an electric current. The value it reads is directly proportional to the current it measures.

The galvanometer has following applications:

- It is used for detecting the direction of electric current. It also determines the null (zero) point of the circuit, which is when no current flows.
- It is used for measuring a very small current.
- The voltage between any two points on the circuit may also be determined by a galvanometer.

VOLTMETER

A voltmeter measures electric potential difference between two points in an electric circuit.

The ideal voltmeter has INFINITE internal resistance, and is connected in PARALLEL to the circuit element across which it measures a potential drop. This way, the voltmeter will not alter the original circuit.

An infinite internal resistance is not realizable, though. However, typically, voltmeters have comparatively very high internal resistances, so we treat them as infinite for all practical purposes.

EXPERIMENT

Part 1
Procedure, Data, and Calculations

The following data are for demonstration purposes only.

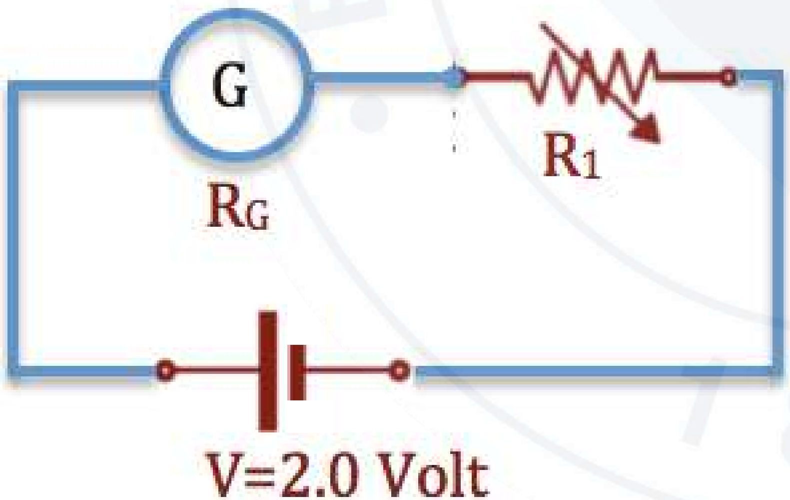
Part 1 will be done by Lab Instructor and the values obtained will be given to you!

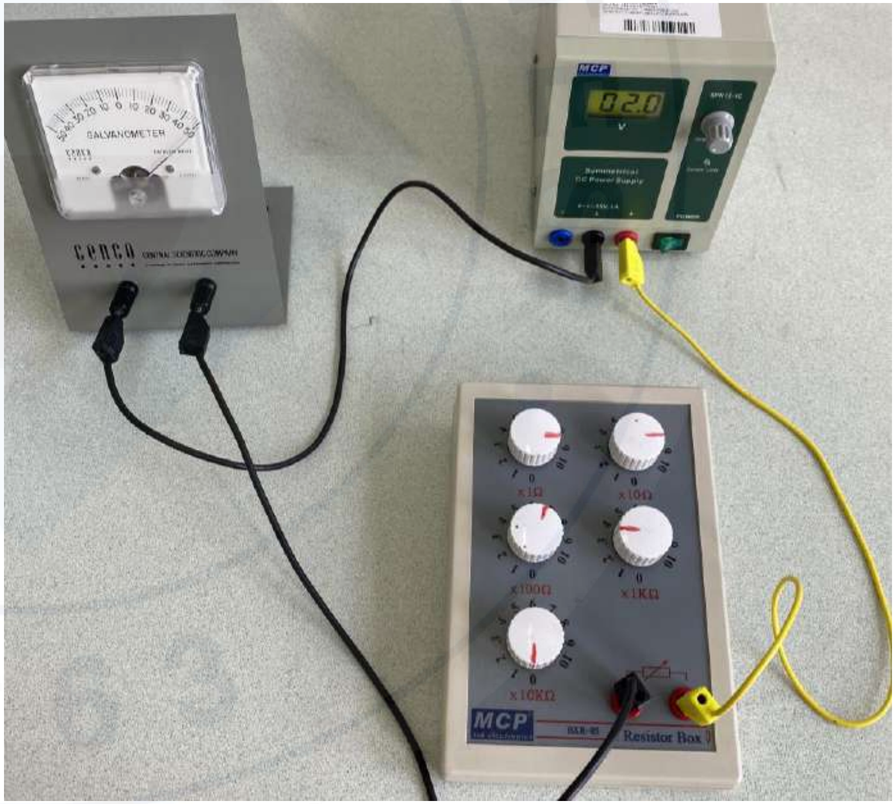
DETERMINATION OF THE CONSTANTS OF A GALVANOMETER

The galvanometer internal resistance R_G, and the galvanometer current I_G are the galvanometer's constants.

Resistance is set to 9999Ω and decreased till you observe FSD on the galvanometer scale. R1 is read from Resistance Box 1.

This part will be done by Lab Instructor and the values obtained will be given to you!





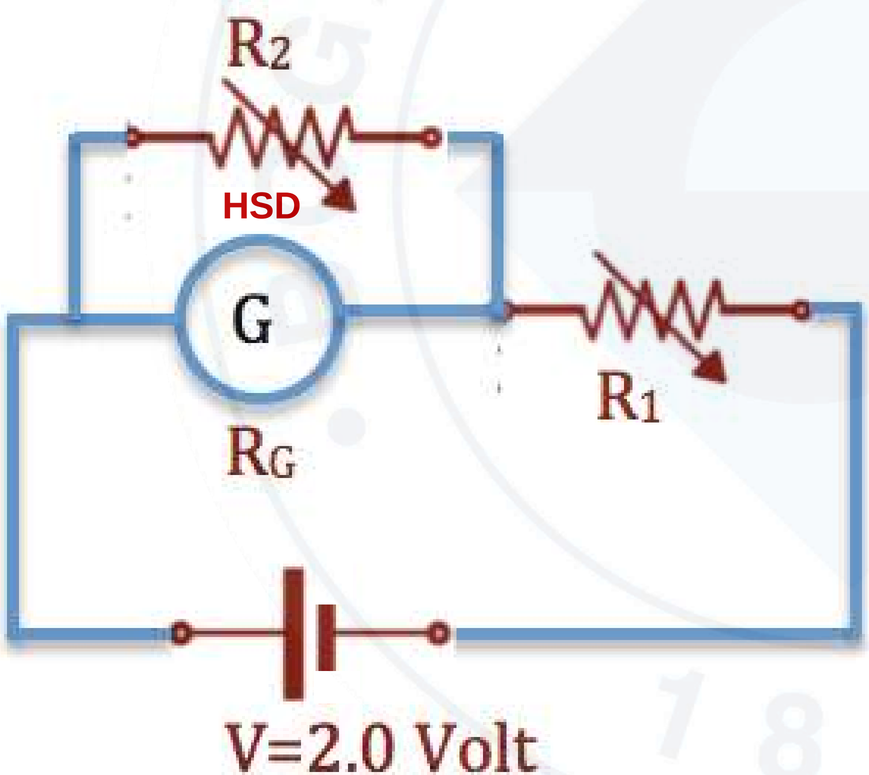
AMMETERS

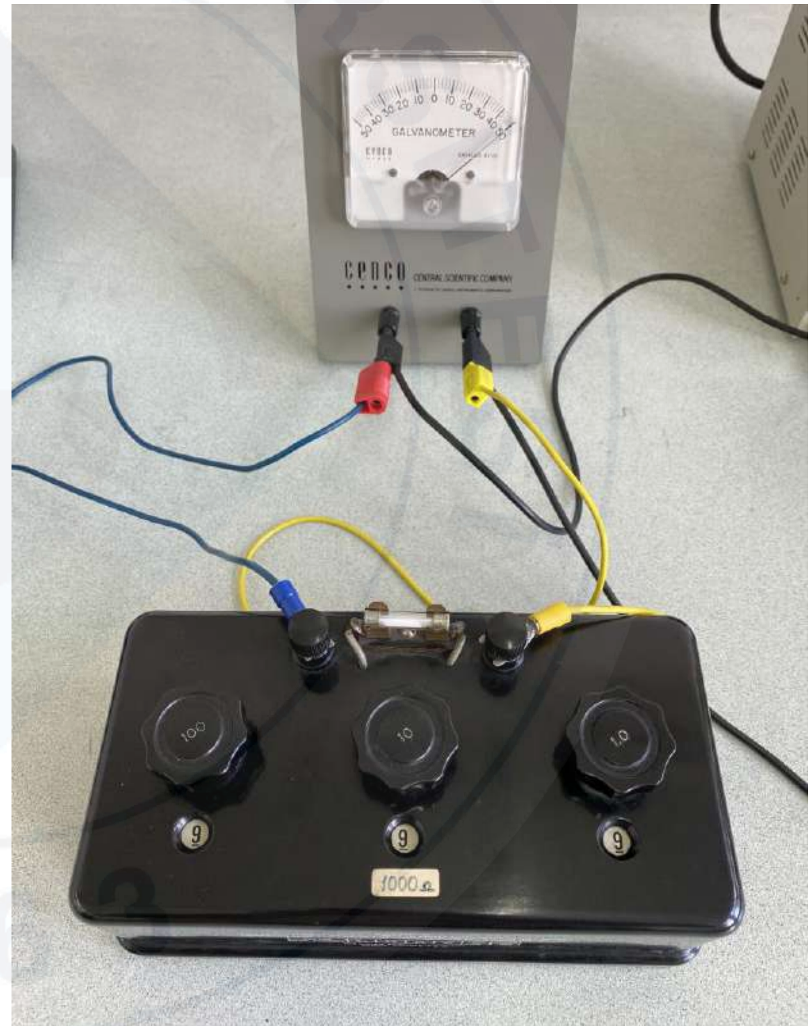
This part will be done by Lab Instructor and the values obtained will be given to you!

Read R_1 from the Resistor Box when FSD is observed.

Set the parallel resistance to 999Ω and decrease it till you observe Half Scale Deflection (HSD) on the galvanometer scale.

This part will be done by Lab Instructor and the values obtained will be given to you!

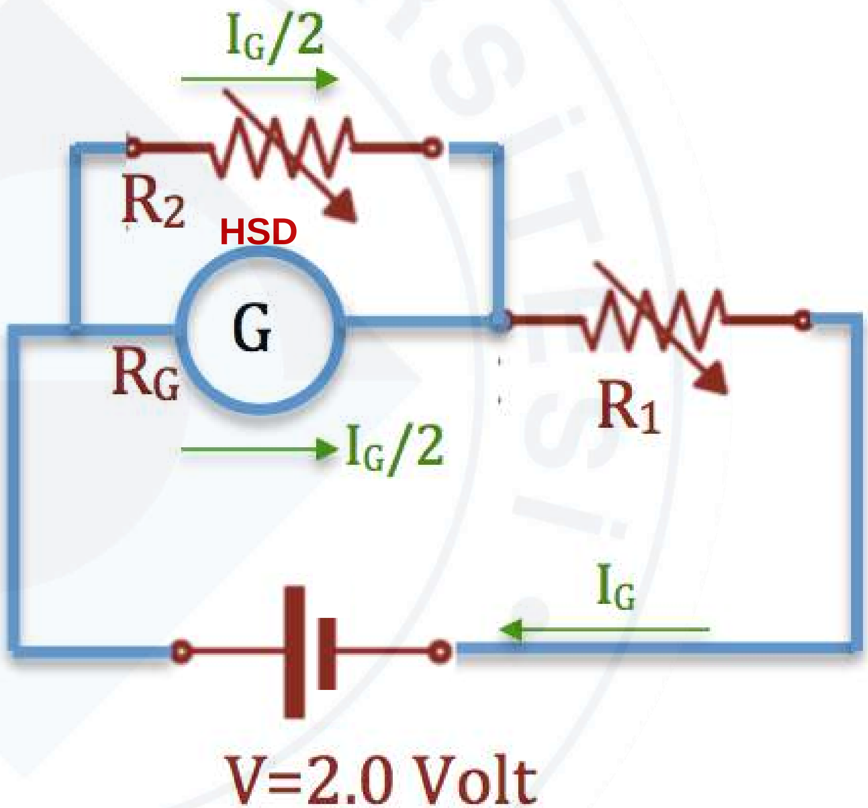




R_1 and R_2 are known

($R_1 >> R_2$).

Using the given circuit, determine R_G.



R_G = ?

This part will be done by Lab Instructor and the values obtained will be given to you!

This part will be done by Lab Instructor and the values obtained will be given to you!

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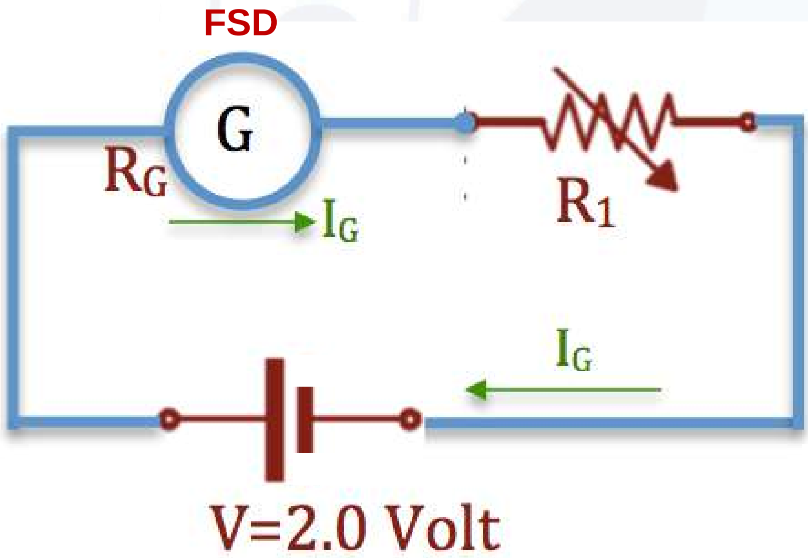
Observe Half Scale Deflection on the galvanometer scale. Read R_2.

R_1 and R_G are known. Using the given circuit determine I_G.

I_G = ?



Description / Symbol		Formula / Value & Unit
Resistance to set for **FSD**	R_1 =	....
Applied Potential	V_{app} =	....
Resistance to set for **HSD**	R_2 =	....
Internal resistance of the Galvanometer	R_G =	....
Max. Galvanometer Current	I_G =	....

You must calculate I_G yourself, it will not be given to you!

The other values will be given by your Instructor!

Part 2
Procedure, Data, and Calculations

The following data are for demonstration purposes only.

In order to build an ammeter, a sensitive galvanometer with an internal resistance of 50-100 Ω is used.

Before we construct our measuring device, we need to know the exact internal resistance of the galvanometer, and what current causes Full Scale Deflection (FSD).

Full Scale Deflection occurs when the pointer shows the maximum value on the scale. Here, the maximum value is 50, and the galvanometer is Full Scale Deflected.

The current causing FSD is called the Galvanometer Current, I_G.

CONSTRUCTION OF AN AMMETER

In Part-1 we determined that the internal resistance of the galvanometer is neither zero nor infinite. So, we cannot use it directly as an ammeter. We must modify the galvanometer to suit our needs.

We will construct an ammeter that measures a maximum of I_R (will be given). That means the galvanometer we use to build an ammeter will Full Scale Deflect when it reads I_R.

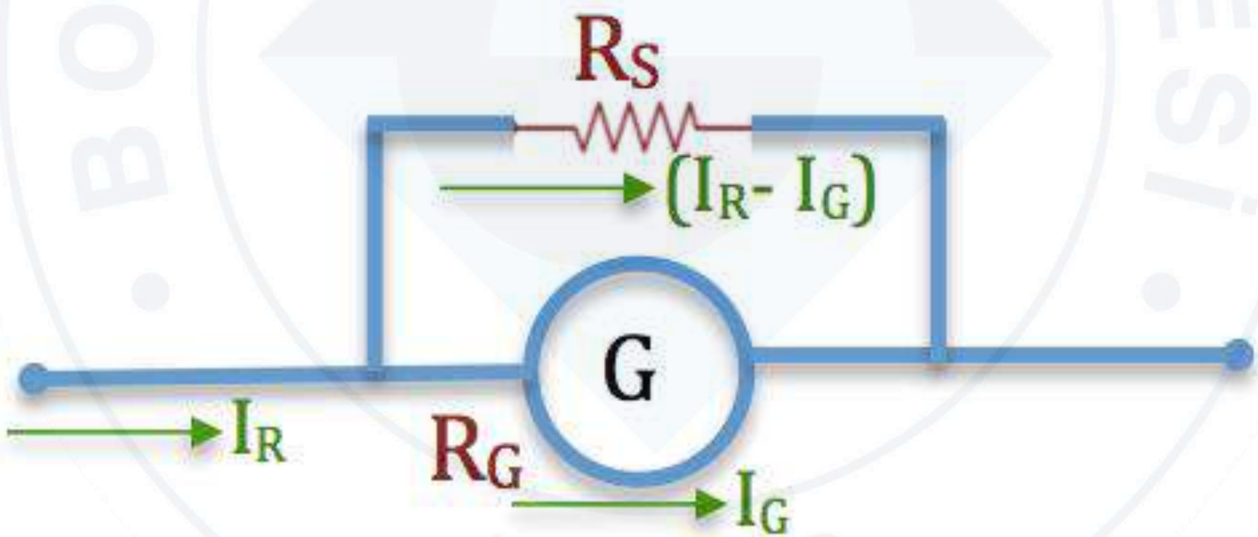
We should remember that the galvanometer current, I_G, causes Full Scale Deflection and is much smaller than the range current, I_R.

CONSTRUCTION OF AN AMMETER

We will construct an ammeter which measures maximum a given I_R.

$$I_R >> I_G$$

Determine the value of R_S, the SHUNT RESISTANCE*, that satisfies this condition.



* Shunt means a component used to divert

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CONSTRUCTION OF AN AMMETER

Since R_S<<1Ω, we will use as R_S a copper wire with resistance per unit length $\rho_{CW} = 1.34 \times 10^{-3}$ Ω/cm. Determine the length of the copper wire, L_{CW} ,which will have a resistance R_S.

L_{CW} = ?

CONSTRUCTION OF AN AMMETER

I_R = 1.0 A.

$\rho_{CW} = 1.34 \times 10^{-3}$ Ω/cm

Please show your calculations in detail.

Description / Symbol	**Value & Unit**
Range for the Constructed Ammeter *(given)* I_R =	....
Resistance per unit length of the Copper Wire ρ_{cw} =	....

Description / Symbol	**Calculation (show each step)**
Shunt Resistance R_S =	....
Length of the Copper Wire L =	....

CONSTRUCTION OF AN AMMETER

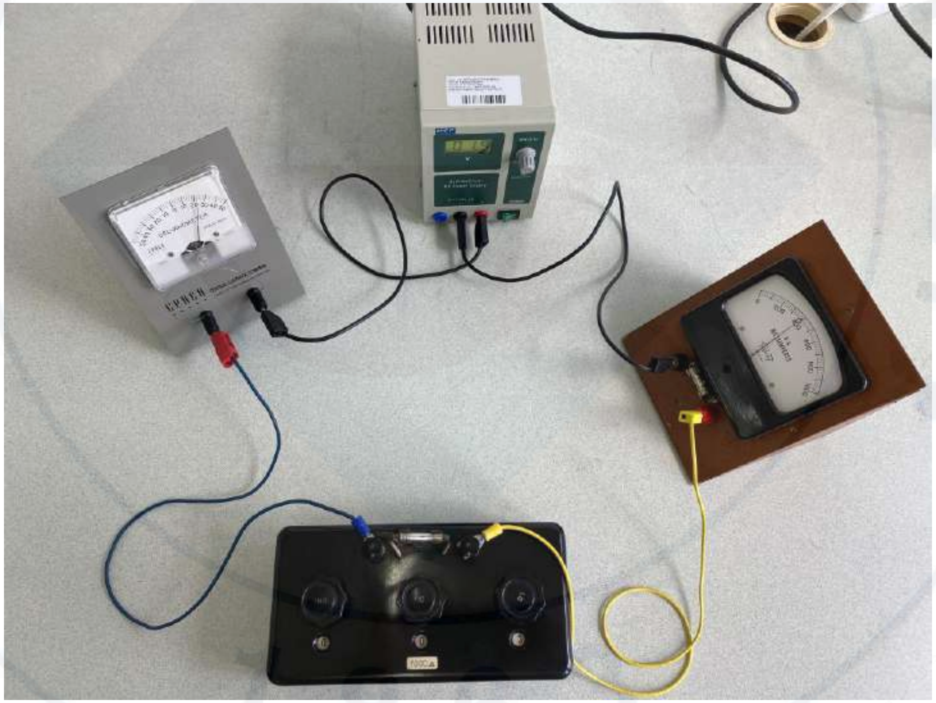
A copper wire with the calculated length is connected in parallel to the galvanometer. This combination is our constructed ammeter, which measures a maximum of I_R.

CONSTRUCTED AMMETER

CONSTRUCTION OF AN AMMETER

Now, we will test our constructed ammeter using a power supply and a 2Ω resistance.

Draw the circuit diagram to test the constructed ammeter in your work book.



TEST CIRCUIT FOR AMMETER

CONSTRUCTION OF AN AMMETER

Use the photo given in the data video to read the current value on the real ammeter and read the scale on the constructed ammeter.

Then determine the ampere value of the constructed ammeter.

CONSTRUCTION OF AN AMMETER

Calculate the ampere value of the constructed ammeter.

Calculate the percentage error.

Answer one of the questions 1 or 2 *–of your choice-* at the end of the experiment.

Description / Symbol	Value / Calculation	Result
Value read from the Galvanometer I_x =	....	....
Value read from the Constructed Ammeter I_{EV} =	....	....
	....	
Value read from a Real Ammeter I_{TV} =	....	....
	....	

% Error for *I*:

Part 3: Construction of a Voltmeter

Procedure, Data, and Calculations

The following data are for demonstration purposes only.

In order to build a voltmeter, a sensitive galvanometer with an internal resistance of 50-100 Ω is used.

Before we construct our measuring device, we need to know the exact internal resistance of the galvanometer, and what current causes <u>F</u>ull <u>S</u>cale <u>D</u>eflection (FSD).

<u>F</u>ull <u>S</u>cale <u>D</u>eflection occurs when the pointer shows the maximum value on the scale. Here, the maximum value is 50, and the galvanometer is Full Scale Deflected.

The current causing FSD is called the Galvanometer Current, I_G.

CONSTRUCTION OF A VOLTMETER

We will construct a voltmeter that will measure a maximum of a given value V_R .

That means the galvanometer we use to build a voltmeter will Full Scale Deflect when we measure V_R volts.

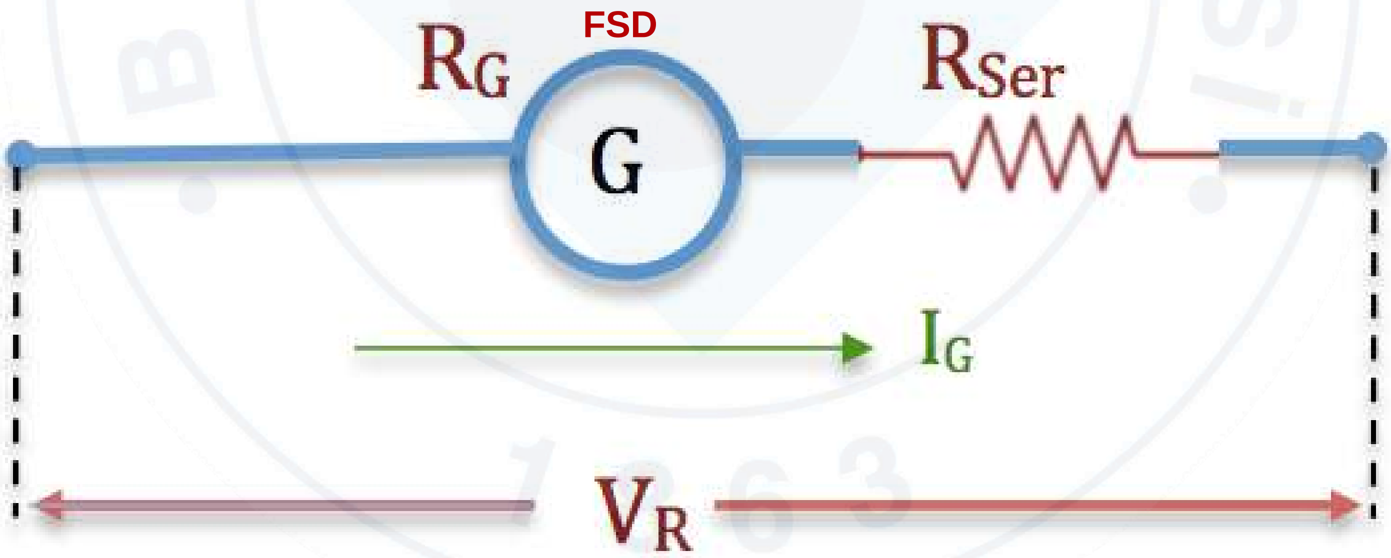
We should remember that galvanometer current, I_G, causes Full Scale Deflection, and the voltmeter has a very high internal resistance.

CONSTRUCTION OF A VOLTMETER

We will construct a voltmeter that will measure a maximum of V_R.

V_R will be given directly; you are not supposed to calculate it as shown in the book.

What R_{Ser} value satisfies this condition? Determine R_{Ser} .



CONSTRUCTION OF A VOLTMETER

We will construct a voltmeter that will measure a maximum of V_R.

What R_{Ser} value satisfies this condition? Determine R_{Ser} .

Description / Symbol		Calculation (show each step)	Result
Range for the Constructed Voltmeter	V_R =	2.3 V + Table# / 10 =	....
Series Resistance	R_{Ser} =	....	....

CONSTRUCTION OF A VOLTMETER

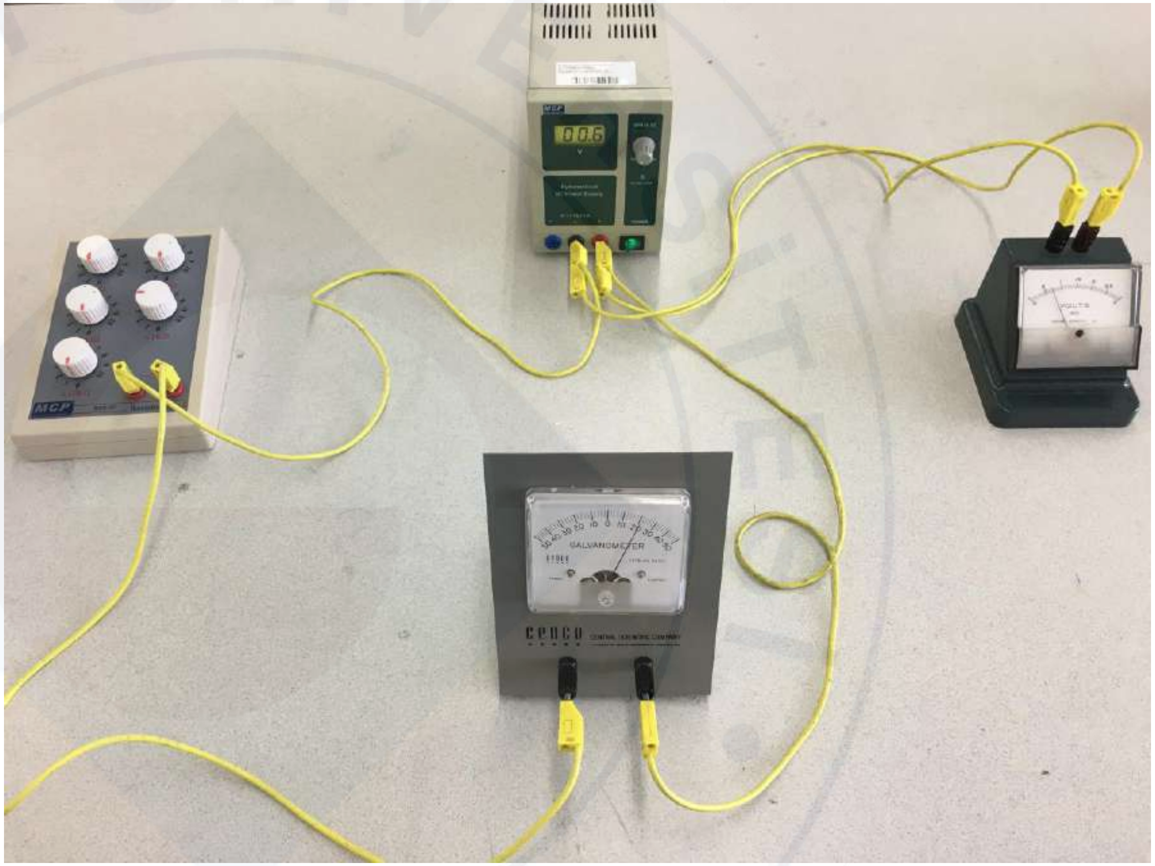
A resistance set to the calculated value R_{Ser} is connected in series to the galvanometer. This combination is our constructed voltmeter, which measures a maximum of V_R volts.

CONSTRUCTED VOLTMETER

CONSTRUCTION OF A VOLTMETER

Now, we will test our constructed voltmeter using a power supply.

Draw the circuit diagram to test the constructed voltmeter in your work book.



TEST CIRCUIT FOR VOLTMETER

CONSTRUCTION OF A VOLTMETER

Use the photo given in the data video to read the voltage value on the real voltmeter and read the scale on the constructed voltmeter.

Then determine the voltage value of the constructed voltmeter.

CONSTRUCTION OF A VOLTMETER

Calculate the voltage value given by the constructed voltmeter.

Calculate the percentage error.

Answer one of the questions 3 or 4 –*of your choice*- at the end of the experiment.

Description	Symbol	Value / Calculation	Result
Value read from the Galvanometer	V_x =	....	....
Value read from the Constructed Voltmeter	V_{EV} =	....	....
Value read from a Real Voltmeter	V_{TV} =	....	....

% Error for V: