Experiment no: 06

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Name of the Experiment: Determination of the ratio of the electromotive forces of two cells by using potentiometre

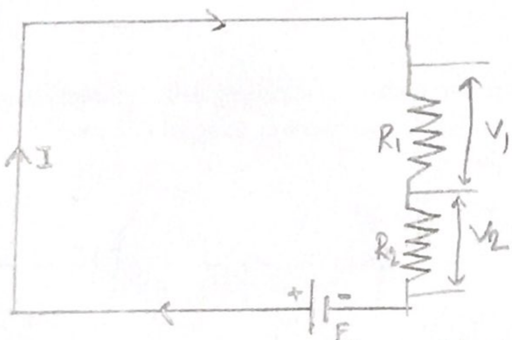
Questions on theory (all diagrams should be drawn by using a pencil and a scale)

*1) What is electromotive force of a cell? [0.25]

Ans: Electromotive force of a cell is the amount of work perform by the cell to move 1 unit of positive charge (1C), starting from a point of a circuit, through the whole circuit, and then bring it back to the starting point.

*2) See Figure 1. Draw it and work out the rule of voltage division for this circuit. [0.25]

Ans:



According to Ohm's law, $V_1 = IR_1$

$V_2 = IR_2$

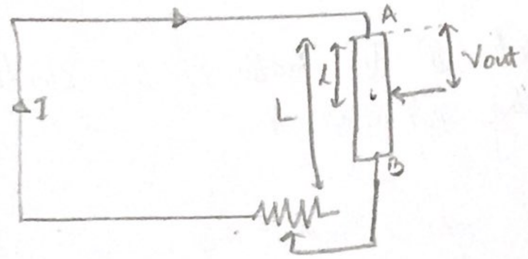
$$\therefore E = V_1 + V_2$$
$$= IR_1 + IR_2$$
$$= I(R_1 + R_2)$$
$$\therefore I = \frac{E}{R_1 + R_2}$$

For, $V_1 = \frac{R_1}{R_1 + R_2}(E)$

$$V_2 = \frac{R_2}{R_1 + R_2}(E)$$

*3) See Figure 2. Draw it and work out an expression of V_{out} in terms of E, l, L, R, R_h and σ. σ is the resistance per unit length of the conductor AB. R is the total resistance of the conductor. [1]

Ans:



Total resistance of the conductor

$$R = R_{AJ} + R_{JB}$$

If σ is the resistance per unit length of the conductor then

$$R_{AJ} = l\sigma \text{ and } R = L\sigma$$

According to potential divider rule:

$$V_{out} = \frac{R_{AJ}}{R_{AJ}(R_{JB}+R_h)}(E)$$

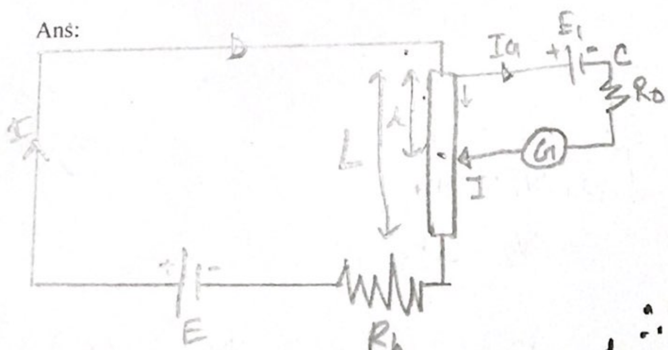
$$= \frac{R_{AJ}}{R+R_h}E$$

$$= \frac{l\sigma}{L\sigma + R_h}E$$

$$\therefore V_{out} = \frac{E}{L + R_h/\sigma}l$$

*4) See Figure 3. Draw it and work out an expression of the current passing through the galvanometer, I_G as shown in equation (6). [2]

Ans:



According to Ohm's laws,

$$V_C - V_J = I_G R_0$$

Voltage difference across E_1,

$$V_A - V_J = E$$

$$\therefore V_A - V_J = E_1 + I_G R_0$$

$$\therefore \frac{El}{L + R_h/\sigma} = E_1 + I_G R_0$$

$$\Rightarrow \frac{El}{L + R_h/\sigma} - E_1 = I_G R_0$$

$$\therefore I_G = \frac{1}{R_0}\left[\frac{El}{L + R_h/\sigma} - E_1\right]$$

*5) When I_G is zero, then s

Ans: I

*5) When I_G is zero, then show that, $E_1 = \frac{E}{L + R_h/\sigma} l$ [0.25]

Ans: $I_G = \frac{1}{R_0}\left[\frac{El}{L+R_h/\sigma} - E_1\right]$

if, $I_G = 0$

$$\frac{1}{R_0}\left[\frac{El}{L+R_h/\sigma} - E_1\right] = 0$$

$$\therefore E_1 = \frac{El}{L+R_h/\sigma}$$

*6) If l_1 and l_2 are the length of the segment of the potentiometer's wire and the null point, correspond to E_1 and E_1, then show that $\frac{E_1}{E_2} = \frac{l_1}{l_2}$ [0.25]

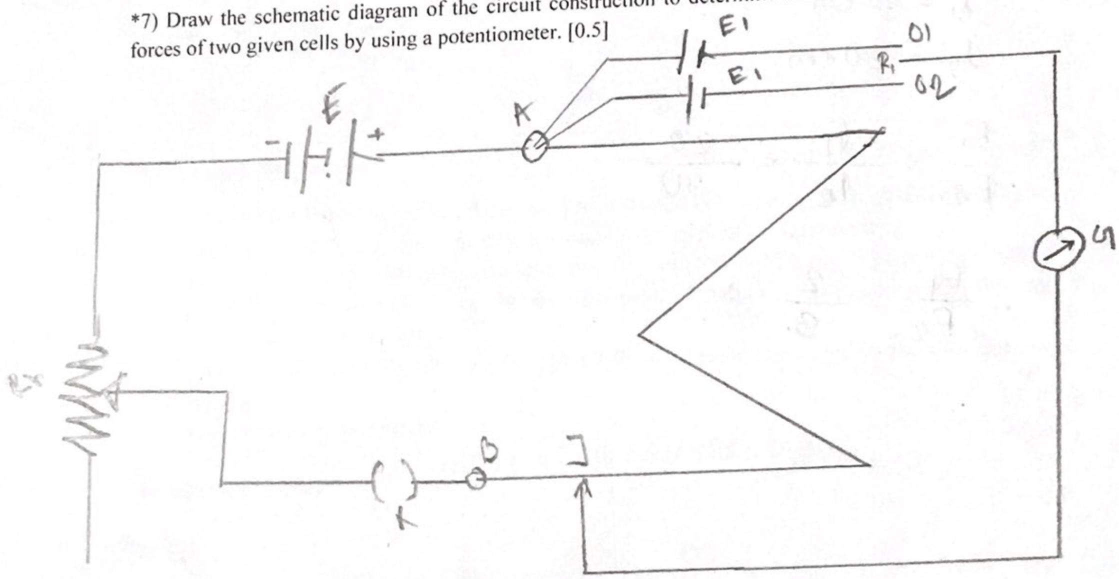
Ans: For, l_1, $E_1 = \frac{El_1}{L+R_h/\sigma}$ — (i)

For l_2, $E_2 = \frac{El_2}{L+\frac{R_h}{\sigma}}$ — (ii)

(i) ÷ (ii)

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

*7) Draw the schematic diagram of the circuit construction to determine the ratio of the electromotive forces of two given cells by using a potentiometer. [0.5]



8) See the Figure 5 which shows the circuit construction to compare the emf of two cells with a potentiometer. When OO_1 is connected then the null point of the galvanometer is found at J_1. When OO_2 is connected then the null point of the galvanometer is found at J_2. What is the approximate value of $\frac{E_1}{E_2}$?

[0.5]

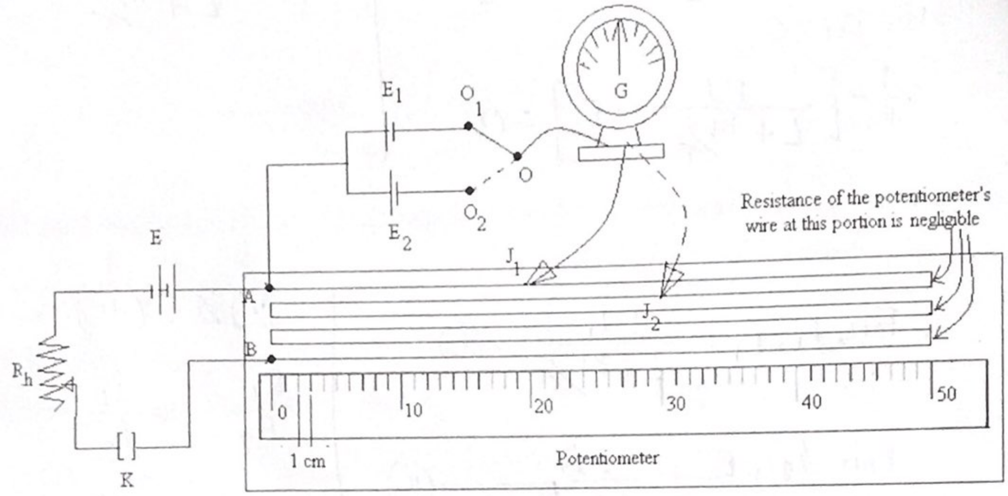


Figure 5: Figure for question 8

Ans:

$l_1 = 20\,cm$

$l_2 = 30\,cm$

$$\frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{20}{30}$$

$$\therefore \frac{E_1}{E_2} = \frac{2}{3}$$

- **Draw the data table(s) and write down the variables to be measured shown below (in the 'Data' section), using pencil and ruler BEFORE you go to the lab class.**
- **Write down your NAME and ID on the top of the page.**
- **This part should be separated from your Answers of "Questions on Theory" part.**
- **Keep it with yourself after coming to the lab.**

Data

Table: Data for calculating the ratio of emf of two cells

No. of obs.	Cell	Null points			Total length (cm)	$E_1/E_2 = l_1/l_2$	Mean E_1/E_2
		Wire - segment number	Scale reading (cm)	Mean scale reading (cm)			
1	First (E_1)	8	79·5	700	779·5	0·996	
	Second (E_2)	8	82	700	782		
2	First (E_1)	9	85	800	885	0·997	
	Second (E_2)	9	87·5	800	887·5		0·996
3	First (E_1)	10	69	900	969	0·996	
	Second (E_2)	10	72	900	972		
4	First (E_1)	6	86	500	586	0·996	
	Second (E_2)	6	88	500	588		
etc.							

- **READ the PROCEDURE carefully and perform the experiment by YOURSELVES. If you need help to understand any specific point draw attention of the instructors.**
- **DO NOT PLAGIARIZE data from other group and/or DO NOT hand in your data to other group. It will bring ZERO mark in this experiment. Repetition of such activities will bring zero mark for the whole lab.**
- **Perform calculations by following the PROCEDURE . Show every step in the Calculations section.**
- **Write down the final result(s)**

Calculations Mean, $\frac{E_1}{E_2} = \frac{0.996 + 0.997 + 0.996 + 0.996}{4} = 0.996$

Results :

The ratio of electromotive force of two cell is 0·996.

Questions for Discussions

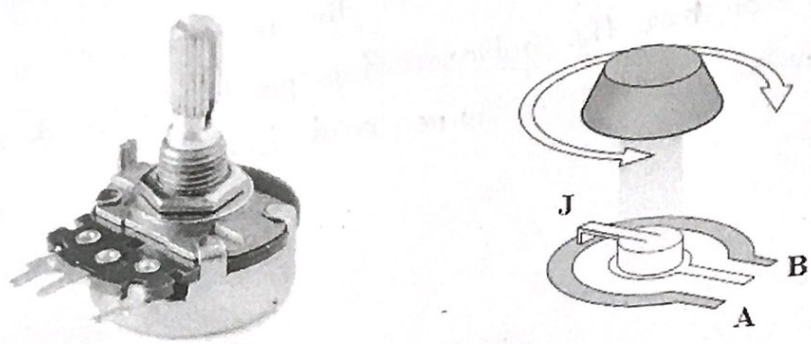
1) If you see the galvanometer's pointer always deflects towards same direction when you make the contact between the jockey and the wire, near end A and end B; what might be the possible reason(s) for this? [0. 5]

Ans: When I ~~w~~ make the contect between the jockey and the wire near ~~ed~~ end A and end B, the possible reason might be high resistance of rehestate if the resistance of rehestate increase a lot then the galvanometer point always defects to the same direction as wire and jockey.

2) We can use a voltmeter or a multi-meter to measure the emf of a cell. What might be a drawback of using a voltmeter or a multi-meter for this purpose? How can a potentiometer be useful to avoid this drawback? [0.5]

Ans: Using a voltometer or multimeter the draw back may be the internal resistance which can give inaqurate measure of emf of a cell. But potentiometer can be usefull to avoid this draw back. Potentiometer has not any internal resistance. That's why we can get accurate measure of emf of a cell.

3) The Figure 6 shows a typical single turn potentiometer, but its structure is quite different from the potentiometer which you have used in the lab. You can see three terminals, and a knob which can be rotated. In the right side, you see its internal structure. The grey colored circular object is a conductor of significant resistance having uniform thickness. Yellow colored object is a good conductor whose resistance can be neglected, an L shaped portion of which touches the circular conductor a point J as shown in the Figure 6. By rotating the knob we can slide this L shaped portion around the circular conductor. Explain how you can use this single turn potentiometer as a potential divider. [1]



(a) External view

(b) Internal structure

Figure 6: Single turn potentiometer (Courtesy: Wikimedia)

Ans: In fig6 (b) we can connect the A and B points like a potentiometer. So, point A is connected to main cell E while point is connected switch k. The knob J is used as a Jockey and rotating it we can get a output voltage difference Vout between point A and J. If the ~~dif~~ distance between A and J increases Vout increases. In this way we can use a single turn potentiometer as a potential divider.