

# INTERNATIONL MATHENATICS AND SCIENCE OLYMPIAD FOR PRIMARY SCHOOLS (IMSO) 2004

## Science Contest in Taiwan

### Experiment III: Black Box Electric Circuit

Name: \_\_\_\_\_ School: \_\_\_\_\_ Grade: \_\_\_\_\_ ID number: \_\_\_\_\_

A black box containing an electric circuit is provided. Inside the box, there is a 2-position switch to select an appropriate circuit. If the switch is in the position S1, the effective circuit is as shown is figure 1. While if it is in the position S2, the circuit will be as shown is figure 2. A voltmeter  $V_m$  is used to measure the voltage difference along the resistor  $R_m$ . The voltage measured are: 0V, 2.5V, 3V, 3.75V, ..., 15V.

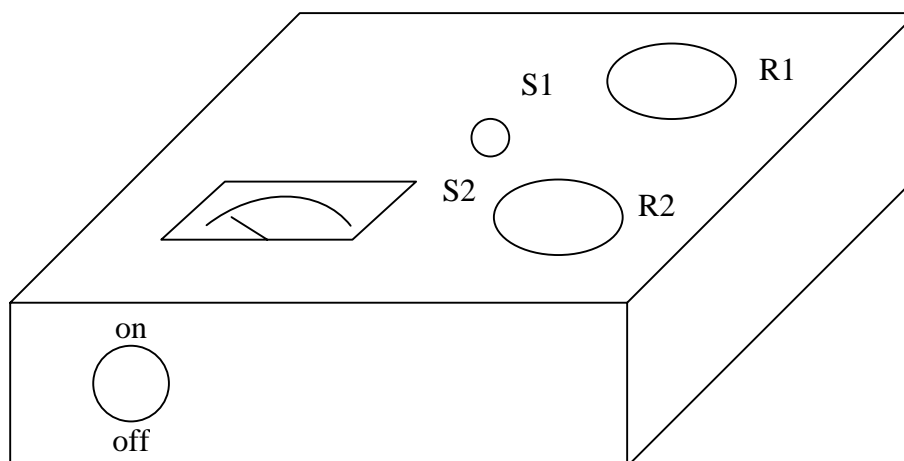


Diagram of the black box

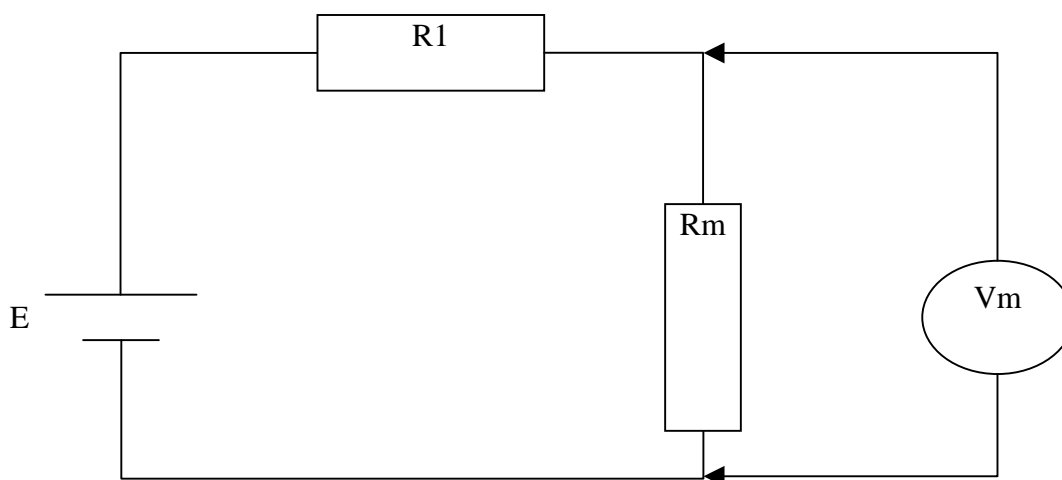
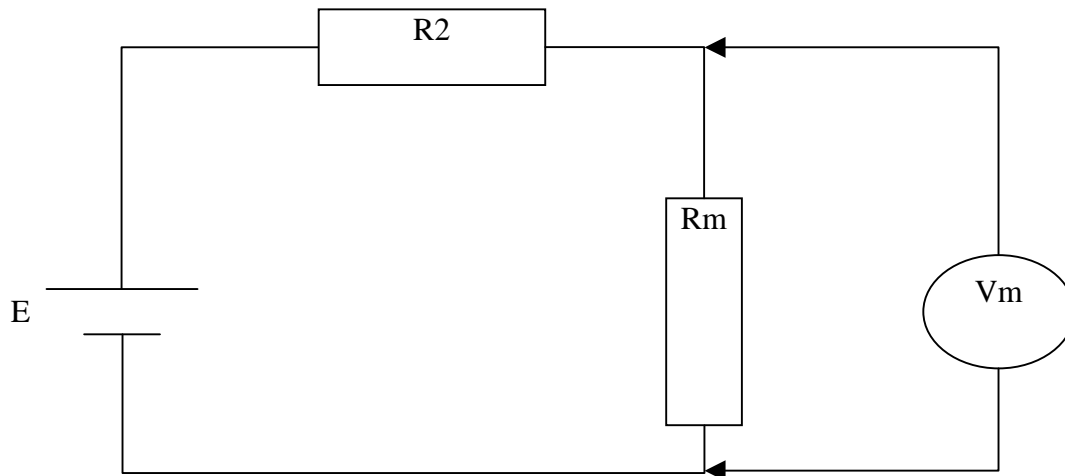


Figure. 1 Electric circuit within the black box with switch at position S1



**Figure. 2 Electric circuit within the black box with switch at position S2**

**A. Set the switch at position S1**

Resistor is varied as shown in.

1. As the changes of  $R_1$ , the readout of  $V_m$  are shown in column 3 from table 1
2. Choose the following right answer. Theoretically, the current across  $R_1$  is
  - a. Less than the current across  $R_m$
  - b. Equal to the current across  $R_m$
  - c. More than the current across  $R_m$
  - d. Less than or equal to the current across  $R_m$ .
  - e. more than or equal to the current across  $R_m$
 (score: 13)
3. Choose the right answer. As the resistance  $R_m$  and the battery voltage are kept constant, when the value of  $R_1$  is increased, then:
  - a. The voltage across  $R_1$  ( $= V_{R1}$ ) will increase.
  - b. The voltage across  $R_1$  ( $= V_{R1}$ ) will decrease
  - c. The voltage across  $R_m$  ( $= V_m$ ) will increase
  - d. The voltage across  $R_m$  ( $= V_m$ ) will decrease
  - e. The voltage across  $R_1$  ( $= V_{R1}$ ) will remain constant.
  - f. The voltage across  $R_m$  ( $= V_{Rm}$ ) will remain constant
 (score: 6)
4. Fill in table 1 by calculating the current flows through resistor  $R_1$ . (score: 3)

**Table 1**

<b>Rotary switch R1</b>	<b>R1 (Ohm)</b>	<b>V<sub>m</sub> (Volt)</b>	<b>V<sub>R1</sub> = E – V<sub>m</sub> (Volt)</b>	<b>I<sub>R1</sub> = V<sub>R1</sub>/ R1 (mA)</b>
1	500	2.50		
2	400	3.00		
3	300	3.75		
4	200	5.00		
5	100	7.50		
6	0	15.00		

5. Draw a graph of the Voltage V<sub>m</sub> versus the current across R1. (score: 6)
6. The curve has a slope (the ratio between voltage difference and its current). The slope is equal to ..... (score: 5)
7. The slope of the curve represents the value of (choose the right answer):
  - a. R1
  - b. R2
  - c. R<sub>m</sub>
  - d. The current across R1
  - e. The current across R2
  - f. The battery voltage E
 (Score: 5)
8. Calculate the current R1 when the resistance R1 equals zero. (score: 6)

**B. Set the switch at position S2**

Resistor R2 (unknown) is varied according to the position of rotary switch R2.

1. As the rotary switch changes of R2, the readout of V<sub>m</sub> are shown in column 2 from table 2
2. Calculate the voltage across R2 and fill in the result into the 3<sup>rd</sup> column of table 2. (score: 6)

### C. Data Analysis

Analyze your data to calculate the estimate value of R2. Write your result into table 2.  
(score: 24)

**Table 2**

<b>Rotary switch R2</b>	<b>V<sub>m</sub> (Volt)</b>	<b>V<sub>R2</sub> = E – V<sub>m</sub> (Volt)</b>	<b>R2 (Ohm)</b>
1	12.50		
2	10.00		
3	7.50		
4	6.00		
5	5.00		
6	3.00		

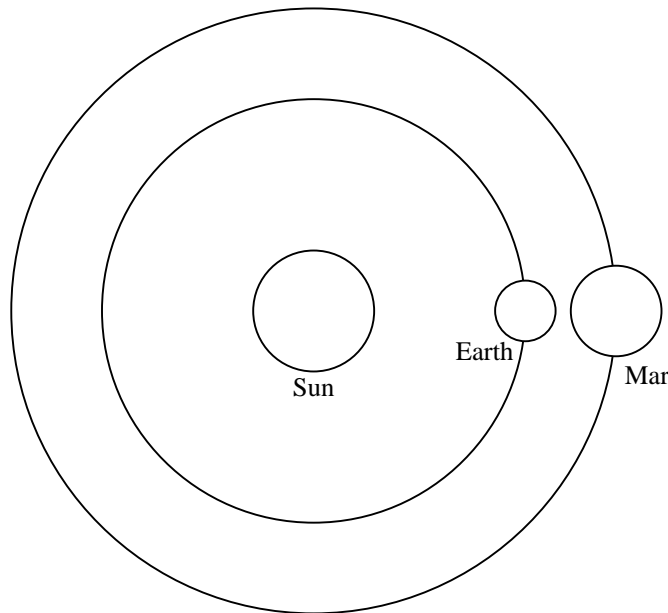
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## Science Contest in Taiwan

### Experiment IV: Our neighbour MARS

Name: \_\_\_\_\_ School: \_\_\_\_\_ Grade: \_\_\_\_\_ ID number: \_\_\_\_\_

On August 27<sup>th</sup>, 2003, Mars was in the opposition (the closest position to the Earth).  
This event is shown at the Following figure:



The next opposition can be estimated using the formula:  $\frac{1}{P_{opp}} = \frac{1}{E} - \frac{1}{M}$

$P_{opp}$  = period of the opposition of Mars

$E$  = period of Earth's revolution = 365 days

$M$  = period of Mars's revolution = 687 days

1. Find the period of the opposition of Mars. (Score: 5)
2.
  - a. How many times should Mars revolve around the Sun to reach the next opposition? (Score: 3)
  - b. How many times should the Earth revolve around the Sun to reach the next opposition with Mars? (Score: 4)
3. Could you predict (approximately), when the next opposition will occur? (date, month, year) (Score: 8)
4. Draw the diagram or figure of the next opposition. (Score: 6)