SOLUTION OF ELECTRICAL QUESTIONS.

By the courtesy of Mr. James Milne, we are enabled to present herewith the solution of the questions submitted for the electricity examination of the Toronto Technical School, at the close of the last session:

1. State clearly Ohm's Law. What is the unit of resistance? the unit of current? and the unit of electro-motive force?

ANSWER. Ohm's Law: The strength of a current varies directly as the E. M. F. and inversely as the R, or the intensity of the current is equal to the E. M. F. divided by the resistance, i.e.,

$$C = \frac{E}{R} \quad R = \frac{E}{C} \quad E = CR.$$

The unit of resistance is called the "Ohm" and is equal to 10^9 C. G. S. units of resistance. It is the resistance of a column of pure mercury 1 square millimeter in section and 106 centimetres long at a temperature of 32° F. The unit of current is called the "Ampere" and is 10^{-1} C. G. S. units. It is that current which will deposit 4.025 grams of silver per hour or decompose .0055944 grams of water per hour. The unit of electro-motive force is called the "Volt" and is equal to 10^8 C. G. S. units, and is also the E. M. F. necessary to send a current of 1 ampere through a resistance of 1 ohm.

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2. A battery of 15 cells, arranged five in series and 3 abreast, produces a current of .5 amperes through an external R of 5 ohms. Find the E M F of each cell if its internal R is 3 ohms.

ANSWER. Let x = Number of cells in series.
y = " " " " in multiple.
E = E M F of each cell.
R = External R.
r = Internal R.

$$C = \frac{E}{R + \frac{x \cdot r}{y}} = \frac{x \cdot E}{x \cdot r + R y}$$

$$C\left(\frac{x \cdot r}{y} + R\right) = x \cdot E$$

and substituting all the data given in the question for the above we get

$$.5\left(\frac{5 \times 3}{3} + 5\right) = 5\ E$$

E = 1 volt.

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3. What is the best way of arranging 28 cells, each having an R of 4 ohms, so as to produce the strongest current in a circuit of 28 ohms.

Ans. In this question the internal R must be = external R,

that is $\frac{x \cdot r}{y} = R$

or $\frac{4\ x}{y} = 28$

$$x = 7\ y$$

but the total number of cells = x, y = 28, and substituting this value of x, viz.: 7 y in the equation, we get

$$7\ y^2 = 28$$

$$y = 2$$

Therefore the number of cells in multiple = 2, and as the total number of cells = 28, ∴ the number in series $\frac{28}{2} = 14$.

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4. Compare the resistances of a wire 30' long, .06" diameter, and that of another wire 15' long and .03" diameter.

ANSWER.

R	Resistance of one wire.	R_1	Resistance of the other.
l	length of " "	l_1	length " " "
d	diameter of " "	d_1	diam. " " "

$$\text{then } \frac{R}{R_1} = \frac{l d^2}{l_1 d_1^2} = \frac{30 \times .03^2}{15 \times .06^2} = \frac{1}{2}$$

$$R : R_1 :: 1 : 2$$

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5. 1,000 feet of copper wire .102" diameter is wound on an armature of a bipolar generator. Find (1) the total resistance of that wire, and (2) the resistance as measured at the brushes of the machine. One mil foot = 10.4 ohms.

Ans. In this question the formula is exactly the same as in the preceeding, that is

$$R = \frac{R\ l\ d^2}{R_1\ l_1\ d_1^2} = \frac{10.4 \times 1000 \times 1}{1 \times 102 \times 102}$$

1 ohm.

1 ohm represents the total resistance in 1000' of copper wire, and in an armature of a bipolar generator there would be two wires of 500' long in parallel, i. e., we have a derived circuit, each of the branches having ½ ohm resistance each, which gives us ¼ ohm as the resistance as measured at the brushes.

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6. Take the above question but substitute iron wire. What is the thickness so that the resistance will be the same in each case? The specific resistance of copper to that of iron is as 1 : 6.

Ans. The cross section will be six times that of the copper,

or the diameter $\sqrt{102^2 \times 6}$
250 mills or .25"

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7. Prove that 746 watts make a horse power. Answer this fully.

Ans.—The unit of power is 10^7 ergs per second = 1 watt.
A horse power = 550 ft. pds. per second.
1 foot = 30.479 centimeters.
1 lb. = 453.6 grams.
∴ 30.379 × 453.6 = 1 ft. pd. = 13825.27 gram. cent.
But a gram = 981 degrees.
∴ 13,825.27 × 981 = 13,562,600 ergs,
generally denoted 1.356 × 10^7 ergs per second,
but a h. p. = 550 ft. pds. per second.
∴ 1.356 × 10^7 × 550 = ergs per second per h. p.
But 10^7 ergs = 1 watt.

$$\therefore \frac{1.356 \times 10^7 \times 550}{10^7} = 746 \text{ watts per h. p.}$$

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8. 1000 feet of wire No. 6 B and S has a resistance of .4 ohms. Find the watts lost in an arc light circuit 5 miles long. Each lamp takes 10 amperes of current.

Ans.— The total R in the circuit =

$$\frac{5 \times 5280 \times .4}{1000} = 10.56 \text{ ohms}$$

$$C^2 R = 10^2 \times 10.56 = 1056 \text{ watts}$$

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9. The E M F of a certain dynamo machine is 100 volts, and the total R of the circuit is 1 ohm. What H. P. would have to be expended in working under these conditions.

Ans.—

$$\text{H. P.} = \frac{C^2 R}{746} = \frac{C E}{746} = \frac{E^2}{746}$$

$$\therefore \frac{100^2}{746 \times 1} = 13.4 \text{ h. p.}$$

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10. Distinguish between work and power. What is the unit of each? What is the British heat unit [772 ft. pounds] equivalent to in electrical units of power?

Ans.—Work is the product of a force and the distance through which it acts. The unit of work is the work done in overcoming unit force through unit distance, i. e., in pushing a body through a distance of 1 centimetre against a force of 1 dyne. It is called the "erg." Since the weight of 1 gram = 981 dynes, the work of raising 1 gram 1 centimetre against gravity would be 981 ergs or 9 ergs. Power is the rate of working, the unit is called the watt = 10^7 ergs per second. If 746 watts = 550 ft. pds., how many watts will 772 ft. pds. be equal to?

550 : 772 : : 746 : 1047 watts, answer.

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11. Describe fully the Edison chemical meter; knowing that 1 ampere passing for 1 hour between zinc plates immersed in a solution of salt of that metal will remove from one plate and deposit 1125 milligrams on the other. What would be the amount of current that would pass in the above meter if the resistance of the German silver shunt was .02 ohms, and the resistance of the other circuit in which the zinc voltameter of 2.5 ohms is inserted in series with another R of 46.46 ohms, if the deposit was 200 milligrams? Make a sketch of the arrangement.

Ans.—The answer to this question is 400 ampere hours. The Edison chemical meter was fully described and illustrated in the paper on "Meters" read before the Canadian Electrical Association by Mr. James Milne, and which appeared in the July issue of the ELECTRICAL NEWS.

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12. Describe the Wheatstone's bridge as fully as you can, and illustrate the application of the instrument by an example.

Ans.—The Wheatstone bridge may be represented by the diagram shown,