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THE MAGNETIC PROPERTIES MEASUREMENT OF COIL FOR GRAVITATIONAL ACCELERATION DETERMINATION

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ABSTRACT

The value of the gravitational acceleration of the Earth above the Earth's surface depends on the position of the latitude and longitude of the Earth's surface, in other words, because the shape of the Earth's surface is not round like a ball. The magnitude of gravity is not the same everywhere on the surface of the Earth. The purpose of this study is to analyze the value of the Earth's gravitational acceleration in a laboratory using a current balance with a graphical method. Fluctuations in the value of the magnetic field strength (B) and the value of the electric current strength (i) on the current balance cause the value of laboratory gravitational acceleration (g_{lab}) to vary in the transfer of electric charge (q) according to coil type. The magnitude of the earth's gravitational acceleration value obtained in a laboratory with a current balance for each type of coil is as follows: SF-37 $g_{lab\text{-}nr}$=9.89 m/s^2, SF-38 $g_{lab\text{-}nr}$=9.90 m/s^2, SF-39 $g_{lab\text{-}nr}$=9.76 m/s^2, SF-40 $g_{lab\text{-}nr}$=9.95 m/s^2, SF-41 $g_{lab\text{-}nr}$=9.75 m/s^2 dan SF-42 $g_{lab\text{-}nr}$=9.93 m/s^2. The results obtained indicate that the value of the Earth's gravitational acceleration in a laboratory close to the literature value is the value of the $g_{lab\text{-}nr}$ in the SF-37 coil type of 9.89 m/s^2.

Keywords: graphic method, gravity acceleration, current balance

INTRODUCTION

The concept of gravity is one of the basic foundations of classical physics. Gravity can explain the phenomenon of weight, the acceleration of objects falling from the orbit of Earth's satellite [1]. One of the basic parameters attached to the Earth is the acceleration due to gravity, which is closely related to everyday life [2]. Acceleration due to the gravity of the Earth is the acceleration of a body caused by the gravitational field acting on the body towards the center of the Earth [3]. Earth's gravitational acceleration is influenced by the position of the height and mass of the object so that the magnitude of the Earth's gravitational acceleration value in each region will be different [4]. The magnitude of the gravitational force is proportional to the mass of the sun and the planet, and inversely proportional to the square of the distance between the two objects. According to Newton, the planets are attracted to the sun by a gravitational force that works based on mass [1,5]. Modified gravity may be thought of as the presence of a force altering the motion of a freely falling particle [6].

The magnetic force produces the gravitational force of an object due to its weight. So the weight of an object is nothing but the force of gravity of the Earth acting on an object. Electromagnetic fields are considered the best of approaches to produce or manipulate gravity values [7]. The relationship of the magnetic force produces the gravitational force of an object because of its weight. So the weight of an object is nothing but the force of gravity of the Earth acting on an object. Mass is a measure of the number of substances contained by an object, where the mass does not depend on the surface of the Earth. So because the gravitational force on an object changes slightly from one place to another, while its mass is constant, the acceleration factor of gravity (g) changes from one place to another on the surface of the Earth.

Gravity affects all living things, from cells to humans; at the same time, all beings on Earth go through periods of waking and sleeping. Sleep can be associated with gravity. According to some research, results show that gravity forces all living things to go to the center of the Earth [8]. In this study, the laboratory will determine the value of gravitational acceleration in the conductor/coil in this case as a conductor of electric charge, which in turn will produce magnetic induction. To investigate the magnitude of the value of gravitational acceleration, the current balance equipment is used. The function of the current balance is to calibrate the value of the change in mass due to the transfer of charge to the coil (conductor). The magnitude of the value of the mass change obtained depends on variations in the value of the electric current strength as well as the value of the magnetic induction produced. Obtaining the value of gravitational acceleration in a laboratory with this current balance using the graphical method. The results of determining the value of the Earth's gravitational acceleration of the five coils/conductors which have the value of Earth's gravitational acceleration in laboratories are close to the value of the Earth's acceleration gravity literature.

MAGNETIC FIELD

The concept of magnetic fields is certainly not new to us. Since we accept the enactment of the law for forces acting on two-point charges and define the intensity of the electric field as the force per unit charge caused by a point charge at another point's charge, charges that are considered as sources cause a force whose magnitude can be measured in other charges, where we can see this second group of charges as detectors to determine the existence of these forces. The fact that we associate this field with a particular charge, and then monitor the effects it has on a group of other charges. The relationship between a constant magnetic field and its source is significantly more complex than the relationship between an electrostatic field and its source [9].

POINT LOAD CHARGES IN A MAGNETIC FIELD

An important characteristic of the magnetic force on charged particles that move through a magnetic field is that the force is always perpendicular to the velocity of the particle. The magnetic force changes the direction of velocity but not the magnitude. Therefore the magnetic force does not act on the particle and does not affect the particle's kinetic energy. In this case, the particle velocity is perpendicular to the uniform magnetic field. If a piece of wire conducts current in a magnetic field, there is a force on the wire that is equal to the sum of the magnetic forces on charged particles whose motion produces current. And if the wire is in a magnetic field $\vec{B}$ then the magnetic force on each charge can be searched using the following EQUATION (1).

$$\overrightarrow{F_B} = q\overrightarrow{v_d} \times \vec{B} \tag{1}$$

with:

$\vec{F}_B = MagneticForce(N)$

$q \ = ElectricalCh\,arg\,e\,(C)$

$\vec{V}_d = Elctronspeed\,(m/s)$

$\vec{B} = MagneticField\,(T)$

$\overrightarrow{v_d}$ is the charge carrier drift speed, q is the number of particles or charge moving in the conductor in the direction of the charged particle vector. The coulomb forces that exist between positive and negative charges are far greater than the force imposed by the magnetic field, so the actual shift experienced by electrons is very small [10].

THE MAGNETIC FORCE ON A CURRENT WIRE

Electric current is a collection of moving charges. Because a magnetic field moves a sideways force on a moving charge, we expect that the magnetic field will also direct a sideways force on a wire that carries a current [11]. If a charged particle moves with a certain speed through a magnetic field, then the particle will experience the magnetic force known through EQUATION (1). With q is the charge of the particle. If the angle between the particle velocity vector and the direction of the magnetic field is then the magnitude of the magnetic force can be rewritten as

$$\vec{F}_B = q\vec{v} \times \vec{B}\sin\vec{\theta} \tag{2}$$

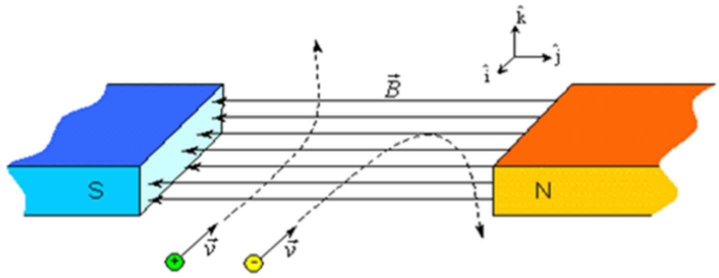

FIGURE 1. Two charged particles move into a magnetic field and experience a magnetic force. The positive charge experiences an upward force, and the negative charge experiences a downward force.

FIGURE 1 shows two charged particles entering a uniform magnetic field. The velocity vector of each particle is given by **v**, showing that the two velocity vectors are perpendicular to the direction of the magnetic field.

THE FORCE ON A MOVING CHARGE

The force acting on a charged particle moving in a constant magnetic field can be written as the differential force on a differential charge element.

$$d\vec{F} = dq\,\vec{v} \times \vec{B} \tag{3}$$

Physically, the differential charge element consists of charged particles that are so small in size and occupy a specific volume in very large numbers. Where even though this volume is also very small, the size is still far greater than the average distance between particles. Therefore, the differential force expressed in EQUATION (3) is the sum of the forces acting on each charged particle. The result of this addition, or the resultant force that arises, is not a force acting on a single object. We will analogize this to the differential gravitational force experienced by a small handful of sand dropped on the ground. The volume of sand in our grasp, although small, contains millions of grains of sand, and the differential force on this volume is the sum of the gravitational forces acting on each grain of sand, taken into account as a whole for that volume. However, if the charged particles we mean are free electrons moving inside the conductor, we will show that this magnetic field force is actually exerted on the conductor object itself and that the very small differential forces in a number very much can have effects that are seen as significant from a practical standpoint. The magnetic force that affects these electrons tends to cause them to shift slightly from their original position, thus causing the movement of centers of gravity or the positions of balance between negative charges and positive charges in the crystal [9].

Negative charges, which move to the right in the wire, are equivalent to positive charges that move to the left, ie, in the direction of the current arrow, as shown in FIGURE 2 below. For such a positive charge the velocity $\vec{v}$ will go left, and the force on the wire, given by EQUATION (1) will go up. This same conclusion is obtained if we review the actual negative charge carriers for $\vec{v}$ the right but q_0 has a negative sign. So by measuring the magnetic force that leads sideways to a wire that carries a current and is placed in a magnetic field, we cannot say whether the current carriers are negative charges moving in a given direction or charges. Positive charge moving in the opposite direction.

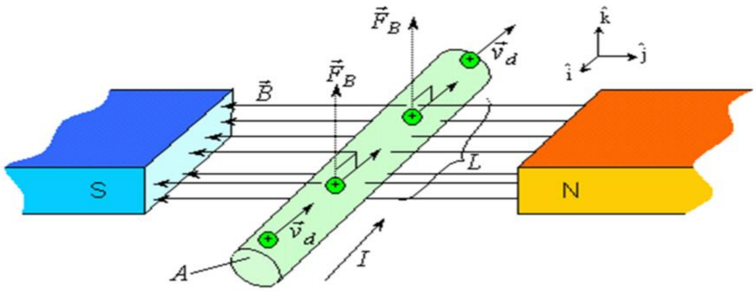

FIGURE 2. The conductor is electrically charged and placed in a magnetic field.

METHOD

There are several experiments that can be used to determine the value of the Earth's gravitational acceleration. Example: Simple Classical pendulum, A rotating water column, and the establishment of the focal length of the resulting inner column water paraboloid, and Atwood's machine [2,3]. However, the current balance is used because this equipment is still relatively new in determining the value of the Earth's gravitational acceleration in the laboratory (g_{Lab}). This research is experimental. From the magnetic field strength and mass shift values that have been obtained, the determination of laboratory gravity acceleration values with current balance equipment can be determined using the following equation:

$$B = \frac{g}{l}\frac{\Delta m}{I} \tag{4}$$

based on graphical linear equations (straight lines): $y = \alpha . x$, where B as the y axis (the dependent variable) and $\frac{\Delta m}{i}$ as the x axis (the independent variable), and $\alpha = \frac{g}{l}$ as the graph gradient (slope).

$$y = B$$

$$\alpha = \frac{g}{l}$$

$$x = \frac{\Delta m}{I}$$

$$g = (slope)\ l$$

Because $m = \alpha$, then the value of laboratory gravitational acceleration (g) in EQUATION (4) can be determined by the graph method using the following equation:

$$g = \alpha . x \ \ ; g = m .\ x \tag{5}$$

In general, current balance equipment can be shown in FIGURE 3. The magnetic force will appear when an electric current passes through the coil board “Current Loop PC Board” this force acts on a permanent magnet and can cause changes in the magnetic weight. This change is directly equivalent to the magnetic force. Three parameters might change in this experiment, namely the magnetic field strength, the length of the wire (may vary due to the change of one coil to another), and the current wave (can vary due to the output of the electric power source that changes or the direction of current flow can also be changed).

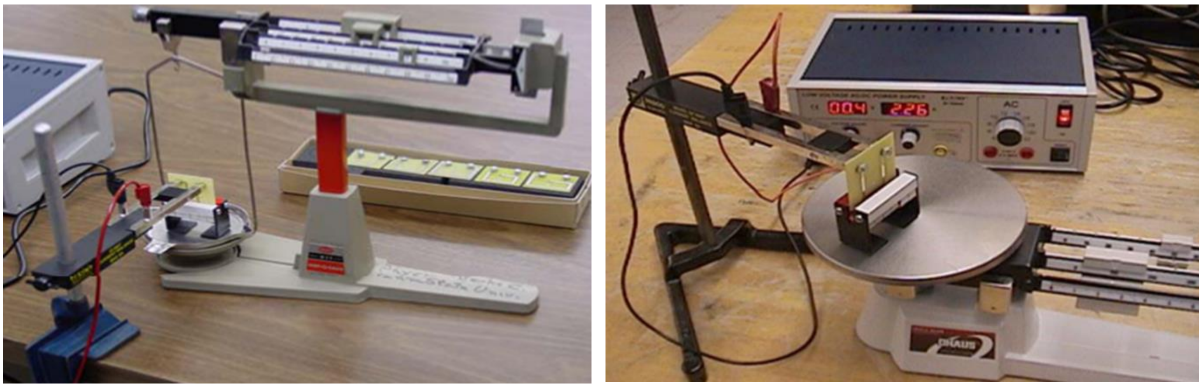

FIGURE 3. Set up current flow equipment.

ERRATA CALCULATION

Based on the laboratory gravity acceleration values obtained using a current balance, the uncertainty of the Δg value can be calculated using the following equation:

$$\Delta g = \sqrt{\left(\frac{\partial g}{\partial m}\Delta m\right)^2 + \left(\frac{\partial g}{\partial l}\Delta l\right)^2} \qquad (6)$$

From EQUATION (7) because, $\frac{\partial g}{\partial m} = l$ and $\frac{\partial g}{\partial l} = m$; then, EQUATION (7) will become:

$$\Delta g = \sqrt{(l\,\Delta m)^2 + (m\,\Delta l)^2} \qquad (7)$$

$$g \pm \Delta g \qquad (8)$$

RESULT AND DISCUSSION

The results of data collection were analyzed graphically to obtain the value of gravitational acceleration (g) in the laboratory for each type of coil. Then a graph of the relationship between the magnetic field strength B (tesla) as ordinate (y) is formed, and the mass ratio is equal to the strong current I (ampere) as abscissa (x) as shown in FIGURE 4 - 9.

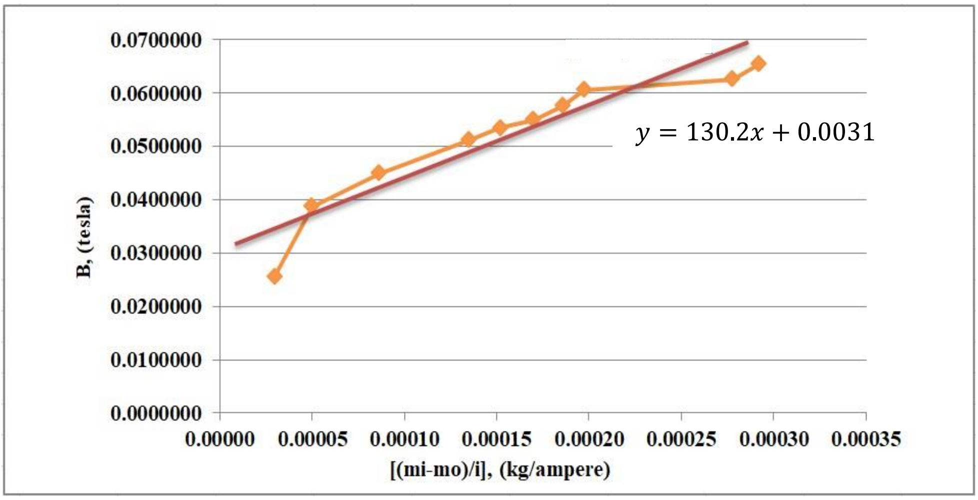

FIGURE 4. Graph B vs $(m_i-m_0)/I$ for the coil type SF-37

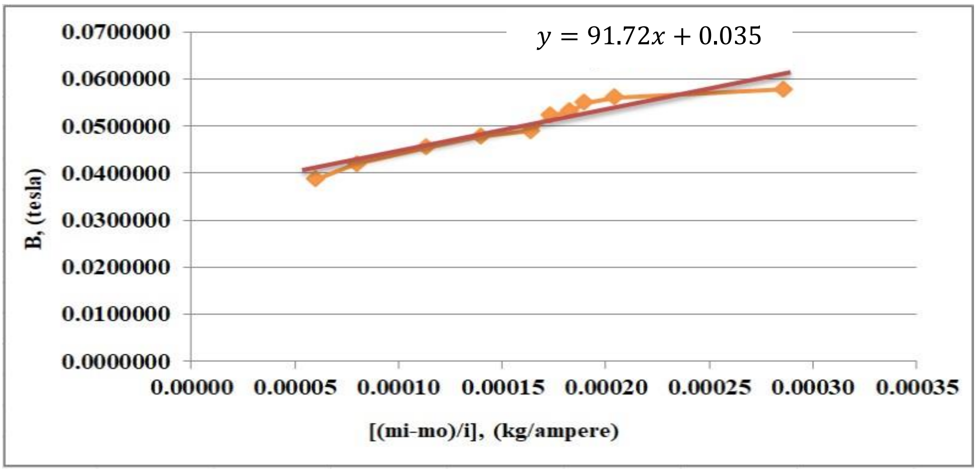

FIGURE 5. Graph B vs $(m_i-m_0)/i$ for the coil type SF-38

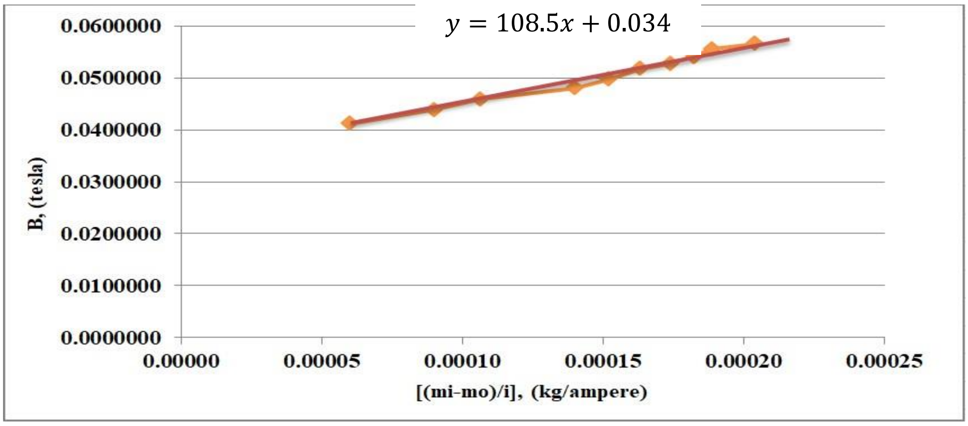

FIGURE 6. Graph B vs $(m_i-m_0)/i$ for the coil type SF-39

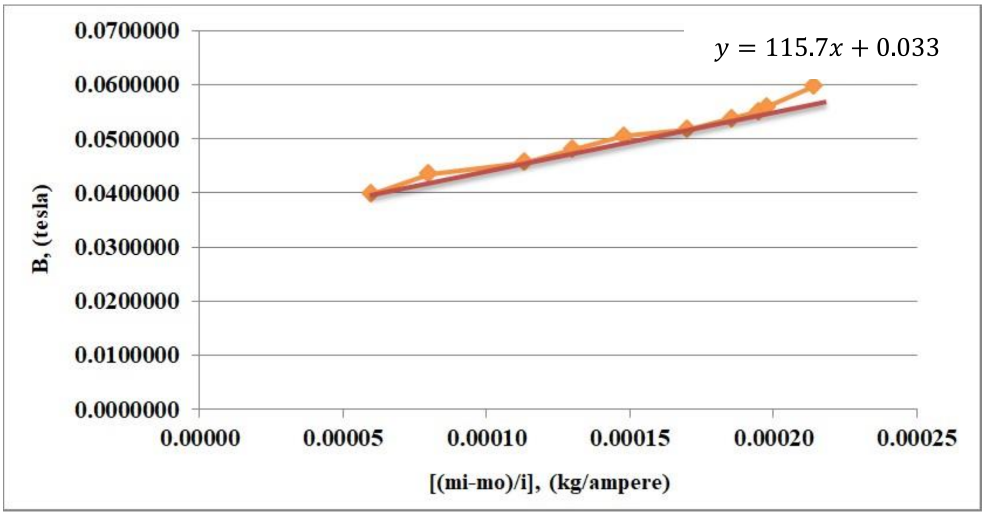

FIGURE 7. Graph B vs $(m_i\text{-}m_0)/i$ for the coil type SF-40

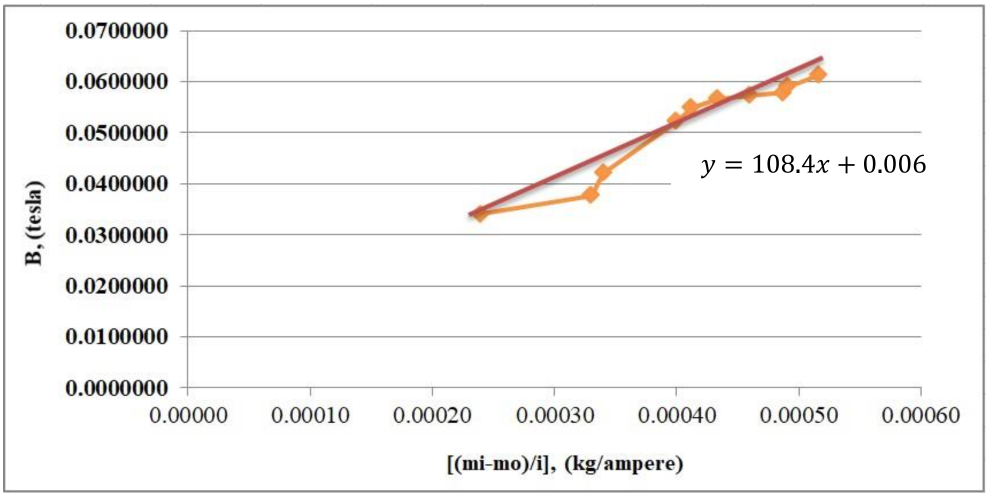

FIGURE 8. Graph B vs $(m_i\text{-}m_0)/i$ for the coil type SF-41

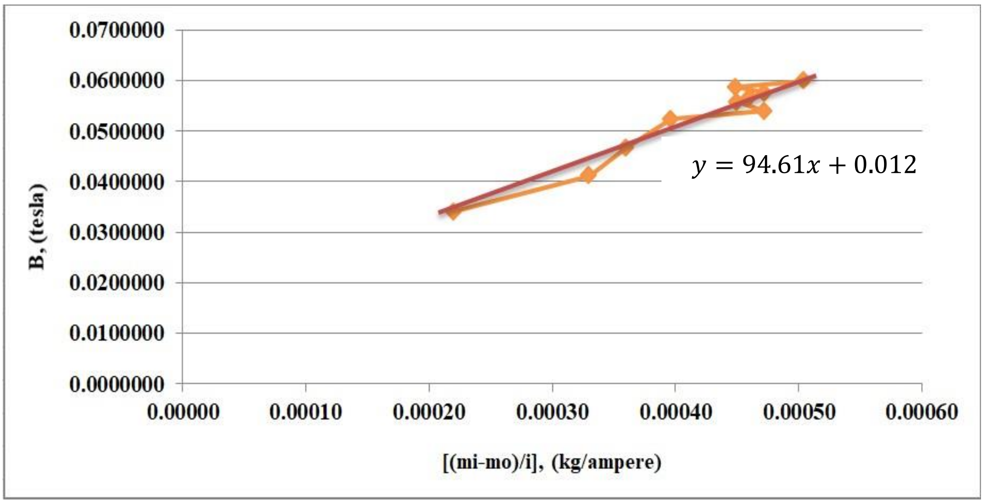

FIGURE 9. Graph B vs $(m_i\text{-}m_0)/i$ for the coil type SF-42

Based on the data in FIGURE 4 - 9, graph gravity acceleration values can be calculated graphically using the current balance equipment, as presented in TABLE 1 below.

TABLE 1. Graphic Calculation of Laboratory Gravity Acceleration

Coil Type	Laboratory gravity acceleration $g(m/s^2)$	
	Slope	Current balance
SF-37	130.200	9.89 ± 0.0651
SF-38	91.720	9.90 ± 0.0458
SF-39	108.500	9.76 ± 0.0542
SF-40	115.700	9.95 ± 0.0578
SF-41	108.400	9.75 ± 0.542
SF-42	94.610	9.93 ± 0.0473

Based on the data in TABLE 1, it can be seen that the results of graphical calculations to obtain the value of the acceleration of the Earth's gravity (g) with the current balance in each type of coil are slightly different. This is influenced by variations in the value of the magnetic field strength and the value of the current strength and shift coil mass so that the laboratory acceleration value obtained also varies. Comparison of the value of the Earth's gravitational acceleration in laboratories using the current balance in each type of coil (SF-37 to SF-42) which approaches the Earth's gravity acceleration literature is the glab-nr value in the coil type SF-37 (g_{lab-nr}=9.89). Obtaining a laboratory gravity acceleration value with the current balance depends on the value of the magnetic field strength, changes in mass, and variations in the value of the electric current strength. If the current strength is increased, the value of the magnetic field strength will increase so that the change in coil mass when flowed by an electric current will increase from the original mass, due to the displacement of moving charges. In other words, the value of laboratory gravitational acceleration with the current balance depends on the value of the magnetic field strength obtained according to variations in the value of the electric current strength. If the value of the detected magnetic field strength is large, the value of laboratory gravitational acceleration with the current balance will be closer to the Earth's gravity acceleration literature(g) is 9.80665 m/s^2.

CONCLUSION

Sourced on the description previously stated, a conclusion can be drawn as follows: The value of laboratory gravitational acceleration with a current balance is $(9.895 \pm 0.0651) m/s^2$with a coil length of 0.076 m in the SF-37 coil type approaching the literature with a percentage below 10%. It should be noted in the use of this current balance equipment, the retrieval of magnetic field strong data by the sensor must be more careful and careful in placing the sensor according to the position or direction of the magnetic field on the used permanent magnet. If this is not the case, then the results of calculating the value of gravitational acceleration in a laboratory with the desired current balance will diverge away from the literature value of Earth's gravitational acceleration.

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