

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
UNIVERSITY SEMESTER I EXAMINATIONS APRIL 2009

Sim 2009

EE 392
ELECTRICAL ENGINEERING PRACTICE

TIME: Three hours.

SECTIONS A AND B-ELECTRICAL ENGINEERING COMPONENTS

SECTION C-MECHANICAL ENGINEERING COMPONENT

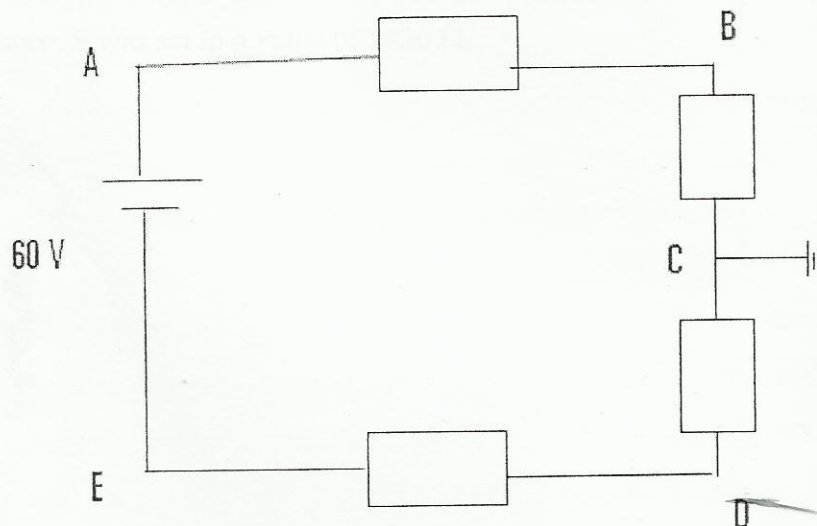
ATTEMPT ANY TWO QUESTIONS FROM EACH SECTION. USE SEPARATE ANSWER BOOKLET FOR SECTION C

ANSWER: SIX questions – All carry equal marks

SECTION A-ELECTRICAL DESIGN, DRAWING AND FAULT FINDING

Question 1.

- Mention the types of graphic symbols used to identify different electrical components.
- Explain the types of maintenance used to safeguard electrical equipment.
- Explain what grounding is and also determine the types of earth rods used in electrical grounding.
- For the diagram given below, determine the voltages at the points A,B,C,D,E, if the drop is 15 V across each resistor.



Question 2

Figure Q5 shows the circuit diagram for a regulated power supply you encountered in the fault-finding experiment.

- a) Show that the output voltage will vary as follows: $V_R \left(\frac{R_8 + P + R_7}{R_7} \right) \geq E_O \geq V_R \frac{R_8 + P + R_7}{R_7 + P}$, where V_R is the voltage at test point 13
- b) If the a.c voltage across test points 1 and 3 is as expected, and the d.c voltage measure across test point 4 and 5 is 90% of the a.c. Voltage across test points 1 and 3, what could be the fault
- c) The thyristor (Thy) requires a gate voltage of 0.6 Vv to turn-on and conduct anode to cathode current. What does turn-on action do to the regulator function?
- d) Calculate the corresponding load current for this condition
- e) Explain the resetting action of switch SW2
- f) If the voltage between test points 11 and 13 is zero, what could be fault?

Question 3

Determine the total uncertainty in the value found for a resistor measured using a bridge circuit for which the balance equation is $X = SP/Q$, given $P = 1000 \Omega \pm 0.05\%$ and $Q = 100 \Omega \pm 0.05\%$ and S is a resistance box having four decades as follows:

Decade 1 of 10 by 1000Ω resistors each $\pm 0.5 \Omega$

Decade 2 of 10 by 100Ω resistors each $\pm 0.1 \Omega$

Decade 3 of 10 by 10Ω resistors each $\pm 0.05 \Omega$

Decade 4 of 10 by 1Ω resistors each $\pm 0.05 \Omega$

At balance, S was set to a value of 5436Ω .

SECTION B-ELECTRICAL MEASUREMENTS

Question 4

- Given the bridge in fig Q6, derive an expression to find the value of R_x and explain what should happen to the galvanometer, G , for Nanyondo to conclude that the bridge has been balanced
- Using Kirchhoff's laws, prove that $(R_1/R_2) = (R_3/R_x)$
- Explain what is meant by 'insertion error'
- Given that $X=A^2 \cdot B$. calculate the total error of the expression if:

$$A = 10 \pm 2\% , B = 20 \pm 3\%$$

Question 5

- Two ohmmeters are connected in series indicate $20 \Omega + 2\%$ and $200 \Omega + 4\%$.
Determine:
 - the maximum value of the current in the circuit
 - the minimum value of the voltage in the 20Ω resistor if the indication of the voltmeter at the source with negligible resistance is $120 V + 5\%$
 - sketch the circuit
- Explain what is meant by preventive maintenance and give four tools that would assist you in maintenance and repair of equipment

Question 6

- Compare analogue methods of measurement to comparison methods. i) Describe the main elements of a moving coil ammeter and their functions. ii) What can be the causes of the malfunctioning of the moving coil?
- A $15 V$ moving-iron voltmeter has a resistance of 500Ω and an inductance of $0.12 H$. assuming that this instrument reads correctly on D.C., what will be its reading on A.C, at the same voltage when the frequency is:
 - $25 Hz$
 - $100 Hz$
- A moving-iron instrument gives a full-scale reading with $100 V$. it has a coil of $10,000$ turns and a resistance of $2,000 \Omega$. If the instrument is to be used as an ammeter to give a full-scale deflection at $20 A$, calculate the necessary number of turns in the coil.

SECTION C: STATICS AND DYNAMICS

- Q7. Attached to a uniformly rotating shaft are four discs A, B, C and D, spaced at equal intervals along the shaft, of mass 7.5 kg, 12.5 kg, 7 kg and 6 kg respectively; the mass centres of the discs are at 4 mm, 3 mm, 5 mm and 8 mm respectively from the axis of rotation. An additional mass M may be attached to D at an effective radius of 60 mm from the axis of rotation. Find the minimum value of the mass of M, and the relative angular positions of the mass centres of all the masses to ensure complete dynamic balance for the rotating shaft.
- Q8. (a) Obtain an expression for the maximum slope and deflection of a cantilever of length l carrying;
- (i) a concentrated load W at its free end,
 - (ii) a uniformly distributed load w along its whole length.
- (b) Determine the diameter of a solid shaft which will transmit 440 H.P. at 300 rpm. The angle of twist must not exceed one degree in 2 metres length nor the maximum shear stress 400 kg/cm^2 . Modulus of rigidity $C = 0.84 \times 10^6 \text{ kg/cm}^2$. $\text{H.P} = 2\pi NT/4500$.
- Q9. A closed-coiled helical spring has to absorb 50 Nm of energy when compressed 5 cm. The coil diameter is eight times the wire diameter. If there are ten coils, estimate the diameters of coil and wire and the maximum shear stress. Modulus of rigidity $G = 85,000 \text{ N/mm}^2$.

END OF SECTION C

END OF EXAMINATION – EE392

CICUIT DIAGRAMS REFERRED TO IN EXAM

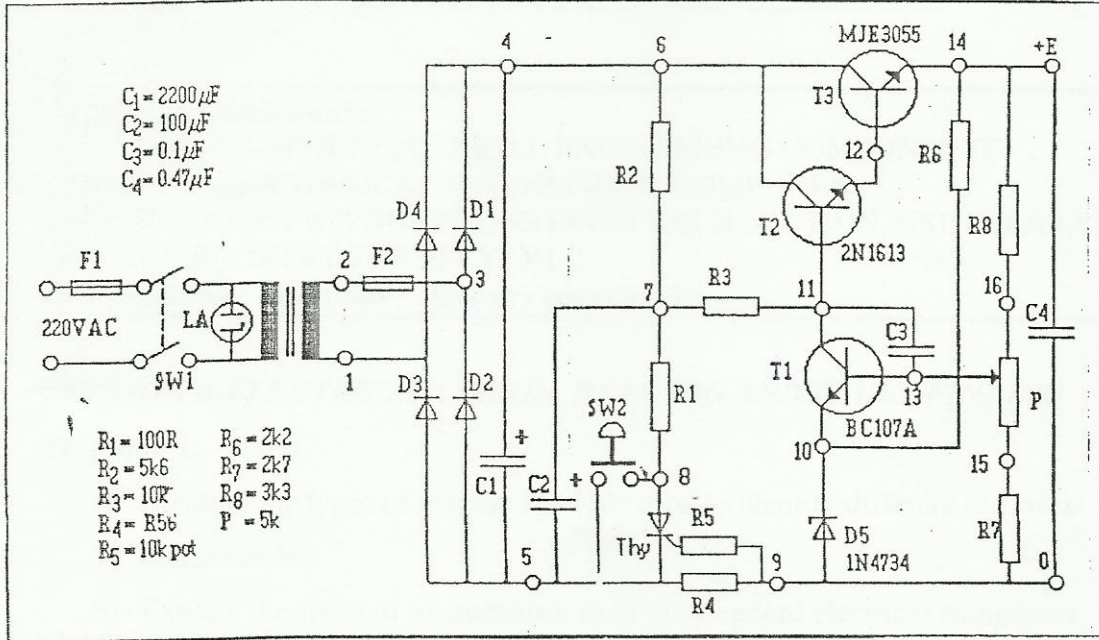


Fig.Q5 Regulated Power Supply

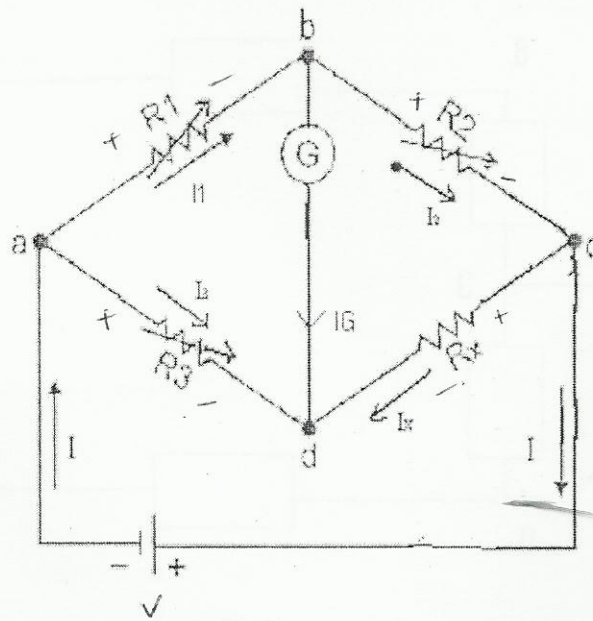


FIG Q6

QUESTION 1

(a) Describe briefly with the aid of a diagram the principle of operation of a permanent magnet moving coil instruments. [5 Marks]

(i) Explain types instrument drifts and show graphically [4 Marks]

(ii) Explain what is meant by instrument and scale range ; [2 Marks]

(b) Explain the troubleshooting process for the following conditions of the motor used in the case study and subsequent repairs ;

(i) The motor takes too long to accelerate [4 Marks]

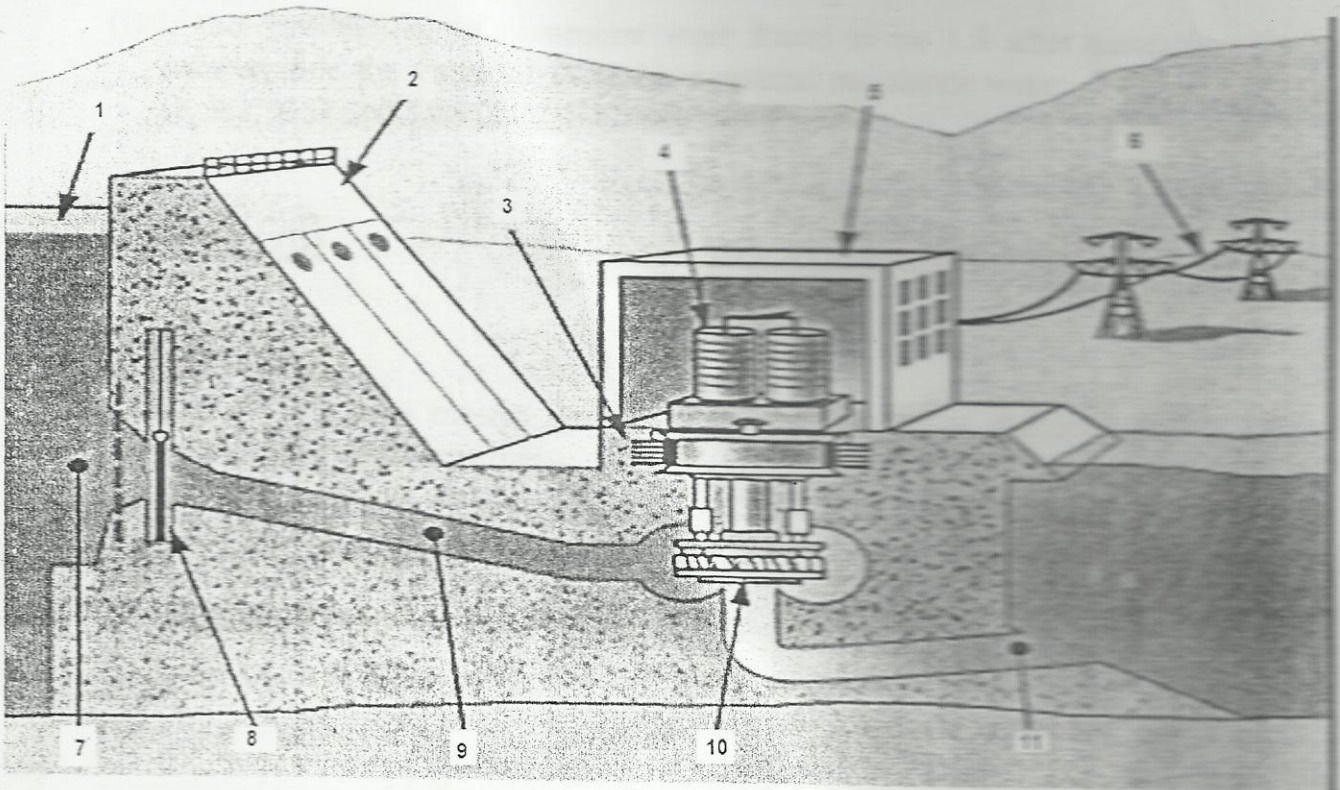
(ii) The motor runs in wrong direction [1 Marks]

(iii) The motor overload protection continuously trips [4 Marks]

Leak drift

QUESTION 2

(a) Name and state the functions of the cross section diagram given below; [11 Marks]



(b) Define and state the difference between instrument accuracy and precision [6 Marks]

(c) Describe what is meant by absolute and secondary instruments [3 Marks]

QUESTION 3

- (a) Draw and explain the diagram of a float water level. [8 Marks]
- (b) Describe with the aid of diagrams types and methods of damping as per case study of the measuring instruments. [8 Marks]
- (i) If the repeatability of ohmmeter were found to be 1.8 after measuring the same resistor, find the value of X if the measured resistance were; 2.3Ω , 2Ω , 2.1Ω , 1.8Ω , 3Ω , $X\Omega$ and 3.88Ω [4 Marks]

SECTION (B)

ANSWER ANY THREE (3) QUESTIONS

QUESTION 4

A beam AB of 4 metres span is simply supported at the ends and is loaded as shown in fig.1. Determine;

- (i) Slope at the end A. [8 Marks]
(ii) Maximum deflection. [12 Marks]

Take $E = 200\text{GN/m}^2$ and $J = 20 \times 10^{-6}\text{m}^4$.

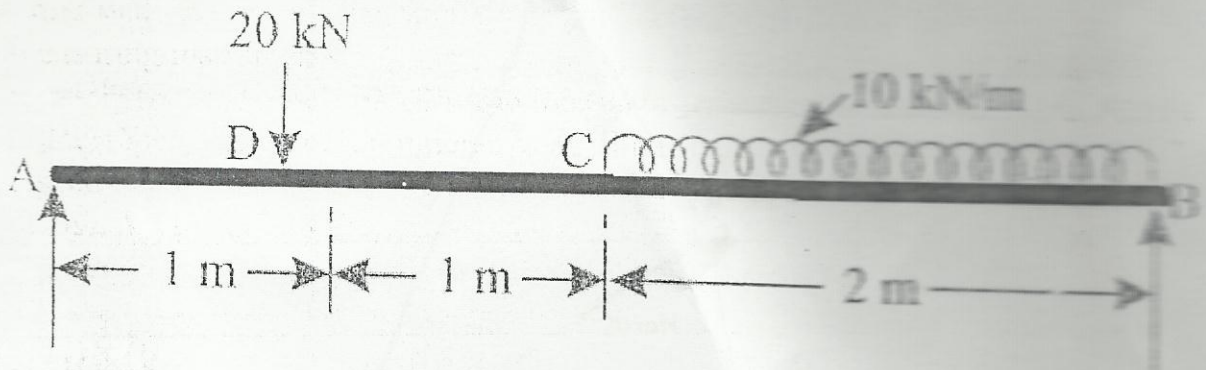


Fig.1

QUESTION 5

A solid steel shaft is subjected to a torque of 45 kNm. If the angle of twist is 0.5° per metre length of the shaft and the shear stress is not to be allowed to exceed 90MN/m^2 , find:

- (i) Suitable diameter for the shaft. [15 Marks]
(ii) Shear stress and angle of twist for the diameter chosen in (i).

Take $G = 80\text{GN/m}^2$ [5 Marks]

QUESTION 6

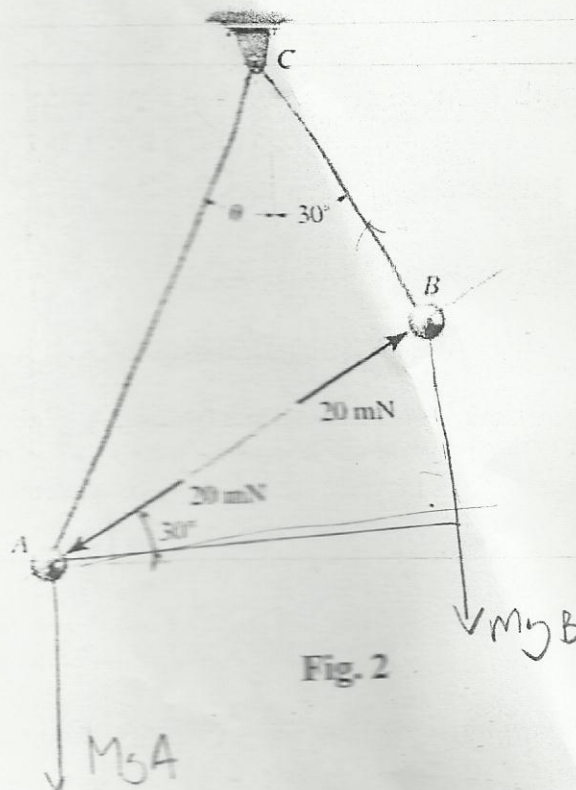
A system comprising of a body of mass 8 kg interconnected to a spring of stiffness $k = 32 \text{ N/m}$ is acted upon by an external force of $3.2\sin(3t) \text{ N}$. Initially it was displaced by 0.2 m to the right of its equilibrium position and released from rest at time $t = 0$. Determine:

- (i) The displacement of the mass after 2 seconds. [15 Marks]
- (ii) What would happen if the external force changes to $1.2\sin(2t) \text{ N}$ justify your answer. [5 Marks]

QUESTION 7

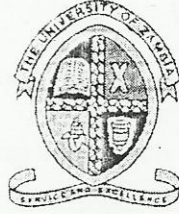
Two spheres A and B have an equal mass and are electro statically charged such that the repulsive force acting between them has a magnitude of 20 mN and is directed along line AB as shown in Fig. 2. Determine:

- (i) The mass m of each sphere. [5 Marks]
- (ii) The tension in cords AC and BC. [10 Marks]
- (iii) The angle θ . [5 Marks]



END

Answers Attached
R.



THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

**DEPARTMENT OF ELECTRICAL AND ELECTRONIC
ENGINEERING**

**2010 ACADEMIC YEAR SECOND SEMESTER
MID-TEST**

EE 392: ELECTRICAL ENGINEERING PRACTICE

TIME: 2 HOURS

INSTRUCTIONS

1. This test contains five questions
 2. ANSWER all the questions and Show all the work leading to the solution
-

Jungirido Boydo
 Friday
 20/08/20

QUESTION 1:

Describe in details with the diagram the principle of operation and damping of dynamometer type of instruments. **[10 Marks]**

i. Define the methods of damping and sketch the graphs **[10 Marks]**

QUESTION 2: $T_d = T_c @ f_{sd}$; $T_d = B \omega L D N$
 $T_d = B I N A$

Calculate the torque produced in a permanent-magnet moving coil voltmeter with a full scale deflection current of 5mA. The coil has 100 turns, effective depth of 3cm and width of 2.5cm. The controlling torque of the spring is 4.9×10^{-5} N-m full scale deflection. **[10 Marks]**

i. Estimate the flux density in the gap. **[5 Marks]**
 ii. Define the range of instruments; **[5 Marks]**

$T_d = T_c$
 Last Range
 Scale Range

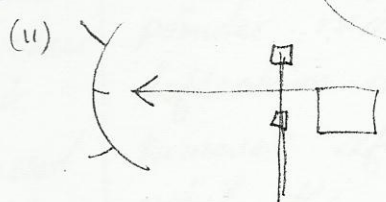
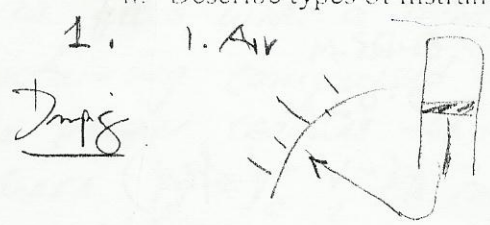
QUESTION 3:

Mr. Jason Phiri was carrying out the transformer silica test to determine the moisture content of the silica, he carried out measurements of the same silica and the following were the weight results he found using the same balance instrument;

2.5kg, 2.03kg, 2.8kg, 2.45kg, 3.0kg and 2.0kg

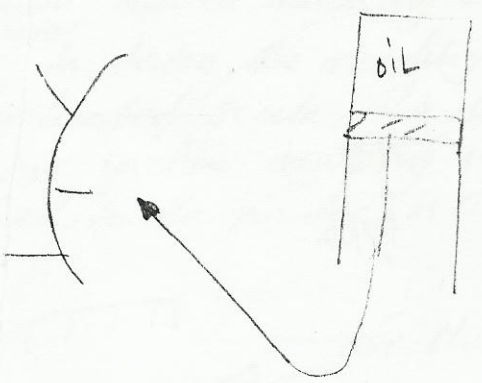
i. Find the repeatability of the balance instrument and the actual silica weight. **[12 Marks]**

ii. Describe types of instrument drifts and show graphically. **[8 Marks]**

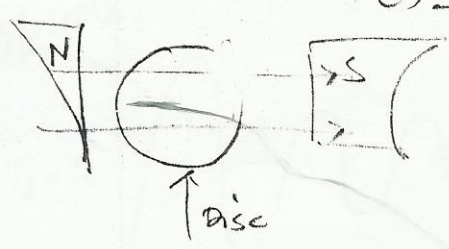


Drift
 (i) Zero drift

2. Oil Friction Dampg



(3) Eddy I



(ii) Sensitivity

QUESTION 4:

Describe in details the principle of operation of both types of Moving Iron Instruments.

- i. Define absolute instruments [10 Marks]
 - ii. Define and state the difference between instrument accuracy and precision [2 Marks]
- [8 Marks]

QUESTION 5:

- (a) A moving-coil instrument has 100 turns of wire with a resistance of 10Ω , an active length in the gap of 3cm and width of 2cm. A p.d of 45mV produces full-scale deflection. The control spring exerts a torque of 490.5×10^5 N-m at full-scale deflection. Calculate the torque and flux density in the gap. [10 Marks]
- (b) A direct current ammeter and leads have total resistance of 1.5Ω . The instrument gives a full-scale deflection for a 50mA. Calculate the resistance of the shunts necessary to give full-scale ranges of 2.5, 5.0 and 25 amperes. [10 Marks]

$$N = 100$$

$$R_m = 10$$

$$L = 0.03 \text{ m}$$

$$D = 0.02 \text{ m}$$

$$V = 45 \text{ mV (f.s.d.)}$$

$$T_c = 490.5 \times 10^5 \text{ @ f.s.d.}$$

Moving Iron type

- ✓ Repulsion type
- ✓ Attraction type

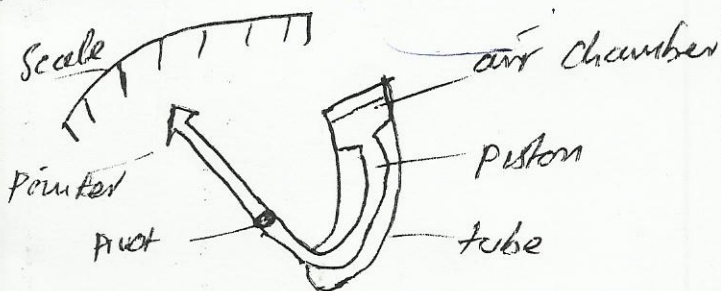
QUESTION 1

Dynamometer damping system:

A dynamometer instrument is a moving coil instrument whose field is produced by a field coil and not a permanent magnet. The damping employed is called air friction damping.

In air friction damping the

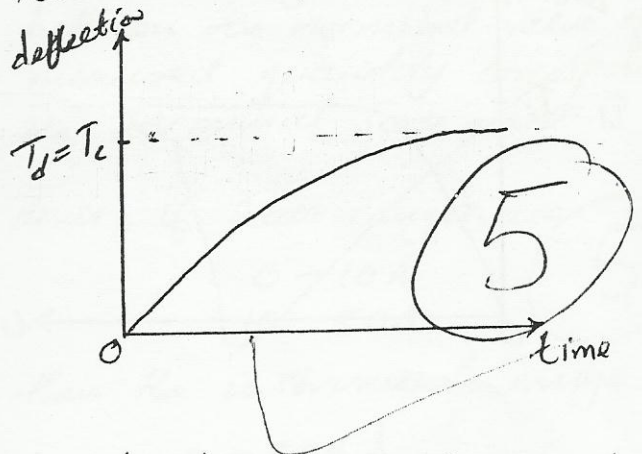
Damping is the prevention of oscillation motion about the measured value ($T_d = T_c$). In air friction damping is achieved by compressed air as a cushion. The tail of the pointer is attached to a semi-cylindrical tube fitted with a light piston containing compressed air. When the pointer reaches the mark where $T_d = T_c$, the compressed air in the tube via the piston stops the pointer from continuous oscillation hence making it easier ^{& faster} to take the reading on the calibrated scale. The diagram of the air friction damping system attached to the pointer is shown below.



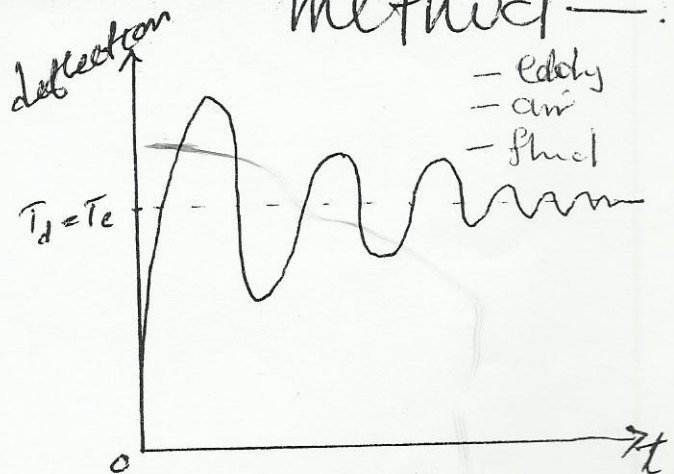
The methods of damping are:

a) ~~air friction~~

a) over damping: This is when the pointer moves slowly till it reaches the deflection where deflection torque is equal to control torque, where it stays without oscillation. This is illustrated below



b) under damping: This is when the pointer moves quickly to the deflection where $T_c = T_d$, but however after reaching this point the pointer continues to oscillate ^{for some time} about the final deflection mark. This is illustrated below

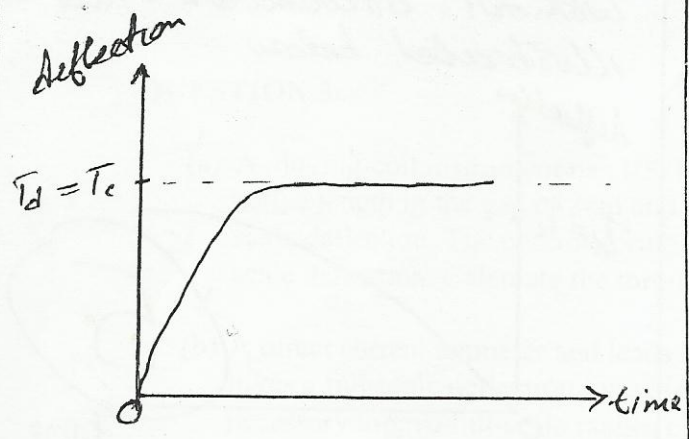


After some time the pointer comes to a dead beat.

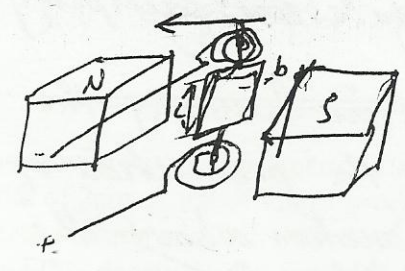
19.06.15

QUESTION 2

c) Critical damping: This is when the pointer moves quickly to the deflection point where $T_d = T_c$, where it comes to a dead beat immediately (doesn't oscillate). This is shown below.



- $I_m = 5 \text{ mA}$ full scale deflection
- $N = 100$ turns
- $l = 3 \text{ cm} = 0.03 \text{ m}$
- $b = 2.5 \text{ cm} = 0.025 \text{ m}$
- $T_c = 4.9 \times 10^{-5} \text{ N}\cdot\text{m}$



Torque = $BILbN = BIAN$

$T_d = T_c$ at full scale deflection

$T_d = 4.9 \times 10^{-5} \text{ N}\cdot\text{m}$ at full scale deflection

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This torque is produced by the quantity to be measured.

QUESTION 2

i) Flux density B :

$$T_d = BILbN = BIAN$$

$$B = \frac{T_d}{IAN}$$

$$I = 5 \times 10^{-3} \text{ A}$$

$$A = 0.03 \text{ m} \times 0.025 \text{ m} = 0.00075 \text{ m}^2$$

$$N = 100$$

$$T = 4.9 \times 10^{-5} \text{ N-m}$$

$$\therefore B = \frac{4.9 \times 10^{-5} \text{ N-m}}{5 \times 10^{-3} \text{ A} \times 0.00075 \text{ m}^2 \times 100}$$

$$B = 0.13066667 \text{ Wb/m}^2$$

$$\therefore \text{Flux density } B \approx 0.131 \text{ T}$$

ii) The range of an instrument is the total scale (range) or the values capable of being measured by the instrument. This range runs from the lowest scale range value to the maximum scale range value.

The scale range itself is the difference between the nominal value of the measured quantity corresponding to the terminal scale marks.

Hence, if scale ranges are

0-10A
10-50A

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then the instrument range is

0-50A
excellent

QUESTION 3

Weights measured are:

2.5 kg, 2.03 kg, 2.8 kg, 2.45 kg,
3.0 kg and 2.0 kg

i) ~~Repeat~~

Repeatability is the ability of an instrument to give identical outputs for on measuring a constant (same) quantity under same conditions. If repeatability is less than 2 then the instrument is good. If it's greater than 2 then recalibration is required.

Repeatability is the ratio of the highest value to the lowest measured value.

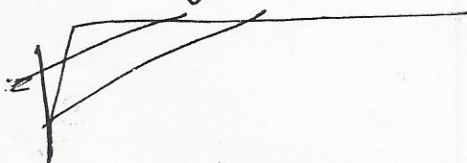
$$R = \frac{\text{Highest}}{\text{Lowest}} = \frac{3.0 \text{ kg}}{2.0 \text{ kg}}$$

$$R = 1.5$$

Hence the instrument is good ($1.5 < 2$).

Actual silica weight W :

$$W_{r.m.s} = \sqrt{\frac{\sum W_i^2}{n}}$$



$$\therefore W_{r.m.s} = \sqrt{\frac{2.5^2 + 2.03^2 + 2.8^2 + 2.45^2 + 3^2 + 2^2}{6}}$$

$$= \sqrt{\frac{37.2134 \text{ kg}^2}{6}}$$

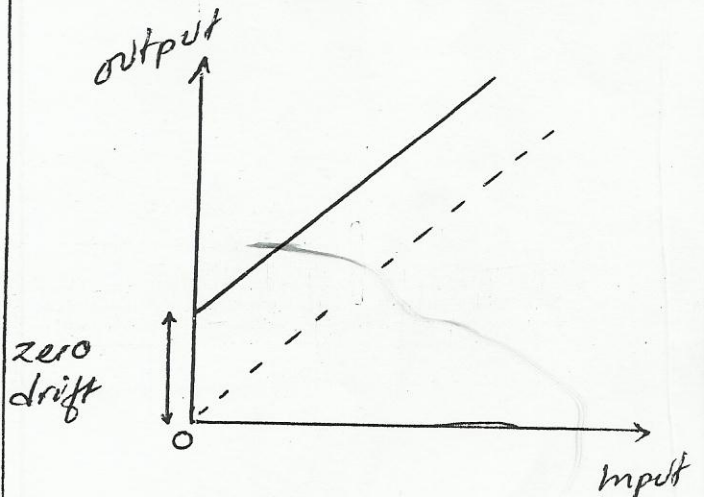
$$\approx 2.490428343 \text{ kg}$$

~~Actual weight $W_{rms} \approx 2.49 \text{ kg}$~~

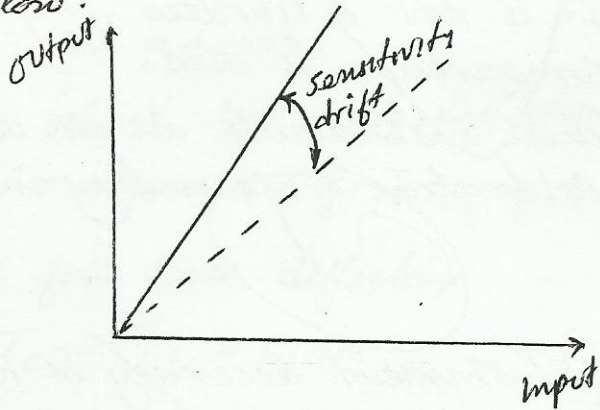
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ii) The following are the types of instrument drifts:

a) Zero drift: This is the variation in the output of an instrument that is not caused by any change in input. This is usually as a result of internal temperature changes or component instability. This is illustrated below:



Sensitivity drift: This is the variation in the sensitivity of an instrument as ambient conditions change. This is illustrated below.



In this case, sensitivity is taken to be linear. However, it can also be non-linear.

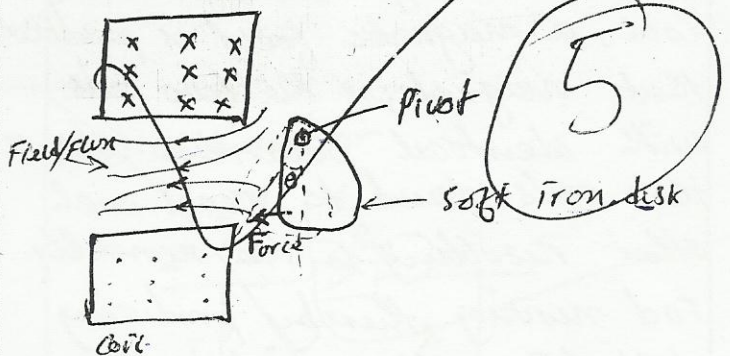
8

QUESTION 1.

There are two types of moving iron instruments. These are;

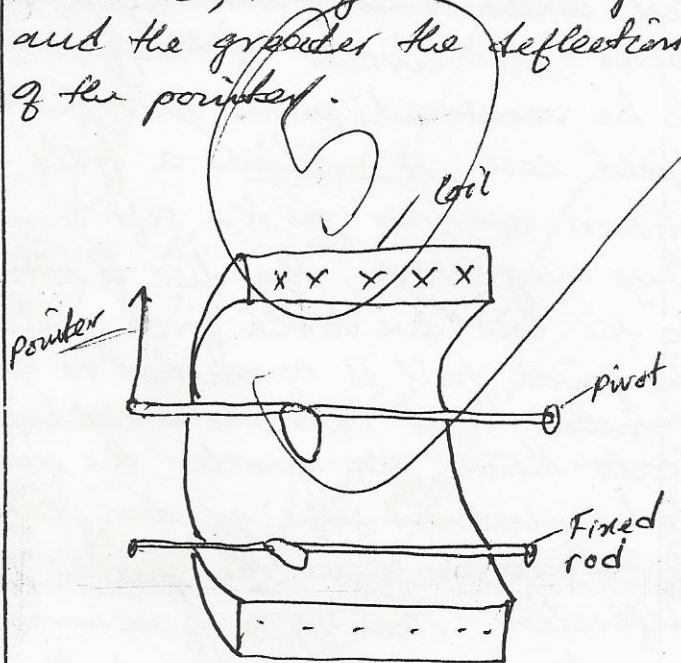
a) Attraction type - This is a moving iron instrument in which the magnetizing field is produced by a coil field coil in which the quantity to be measured passes. Hence the field produced is proportional to the measured quantity.

Cross section of coil



A soft oval iron^{disk} is placed near the coil while it is pivoted about the pivot. As current of the quantity to be measured passes through the field coil, it produces a field that in turn magnetizes the soft iron disc. Once magnetized, the disc is attracted to the coil due to the force produced. The pivot tail is connected to a pointer that runs on a calibrated scale. Hence, the greater the quantity to be measured, the greater the force of attraction and the greater the deflection. This type of instrument can be used to measure both a.c. and d.c. quantities since the iron is attracted either way.

b) Repulsion type: The field is produced by quantity to be measured through the field coil. In the field coil, two parallel soft iron rods are mounted, with one fixed and one movable. The movable one of the movable rods end is attached to a pointer sundry on a calibrated scale. As the quantity to be measured passes current through the field coil, a magnetic field is produced that magnetizes the two rods with identical polarities. Hence the rods tend to repel each other resulting in the movable rod moving, thereby producing deflection of the pointer. Hence the greater the quantity to be measured, the greater the repulsion and the greater the deflection of the pointer.



Damping for both types is achieved by air friction method.

i) An absolute instrument is an instrument that gives the value of the quantity to be measured in terms of instrument constants and by virtue of their deflection. It is not calibrated, only comparison is used.

These instruments are also used in calibration of secondary instruments.

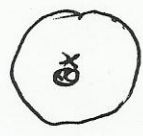
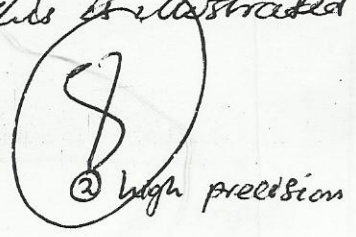
ii) Instrument accuracy is the closeness with which an instrument can measure the true value of a quantity to be measured under stated conditions.

Instrument precision is the measure of degree of random variation of the outputs of a constant measured quantity under stated conditions.

The difference between the two is that in accuracy the output should be close to the true value of the measured quantity where as in precision the outputs can be far from the true value but should be close to each other. This is illustrated below.

o → True value
x → output

① High accuracy



QUESTION 5

$$N = 100$$

$$R_m = 10 \Omega$$

$$l = 3 \text{ cm} = 0.03 \text{ m}$$

$$b = 2 \text{ cm} = 0.02 \text{ m}$$

$$V_m = 45 \text{ mV} \text{ full scale deflection}$$

$$T_c = 490.5 \times 10^{-5} \text{ N}\cdot\text{m} \text{ at f.s.d}$$

at full scale deflection

$$T_c = T_d = BIAN \checkmark$$

Therefore

$$T_d = 490.5 \times 10^{-5} \text{ N}\cdot\text{m}$$

Flux density :

$$T_d = BIAN = BIlbN$$

$$I = \frac{V_m}{R_m} = \frac{45 \times 10^{-3} \text{ V}}{10 \Omega}$$

$$I = 0.0045 \text{ A}$$

$$I = 4.5 \text{ mA}$$

$$A = lb = 0.02 \text{ m} \times 0.03 \text{ m} = 0.0006 \text{ m}^2$$

Since

$$T_d = BIAN$$

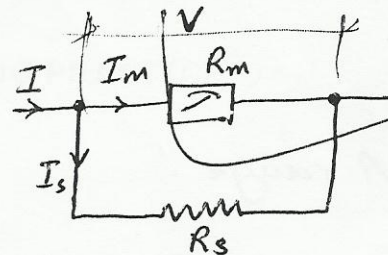
$$\therefore B = \frac{T_d}{IAN}$$

$$= \frac{490.5 \times 10^{-5} \text{ N}\cdot\text{m}}{4.5 \times 10^{-3} \text{ A} \times 0.0006 \text{ m}^2 \times 100}$$

$$B = 1.816667 \times 10^{-11} \text{ Wb/m}^2$$

$$\therefore \text{Flux density } B = 1.82 \times 10^{-11} \text{ T}$$

b) D.C ammeter



$$R_m = 1.5 \Omega$$

$$I_m = 50 \text{ mA}$$

Since potential difference is same

$$\Rightarrow I_m R_m = I_s R_s$$

$$\text{where } I_s = I - I_m$$

$$\Rightarrow I_m R_m = (I - I_m) R_s$$

$$\therefore R_s = \frac{I_m R_m}{I - I_m}$$

For 2.5A range :

$$R_s = \frac{I_m R_m}{I - I_m}, \quad I_m = 50 \times 10^{-3} \text{ A}$$
$$R_m = 1.5 \Omega$$
$$I = 2.5 \text{ A}$$

$$\therefore R_s = \frac{50 \times 10^{-3} \text{ A} \times 1.5 \Omega}{2.5 \text{ A} - (50 \times 10^{-3} \text{ A})}$$
$$= \frac{0.075 \text{ A} \Omega}{2.45 \text{ A}}$$

$$R_s = 0.030612244 \Omega$$

\therefore Shunt resistor, $R_s \approx 0.0306 \Omega$

For 5.0A range :

$$R_s = \frac{I_m R_m}{I - I_m}, \quad I_m = 50 \times 10^{-3} \text{ A}$$
$$R_m = 1.5 \Omega$$
$$I = 5 \text{ A}$$

$$= \frac{50 \times 10^{-3} \text{ A} \times 1.5 \Omega}{5 \text{ A} - (50 \times 10^{-3} \text{ A})}$$
$$= \frac{0.075 \text{ A} \Omega}{4.95 \text{ A}}$$

$$R_s = 0.0151515 \Omega$$

\therefore Shunt resistor $R_s \approx 0.015 \Omega$

For 25A range :

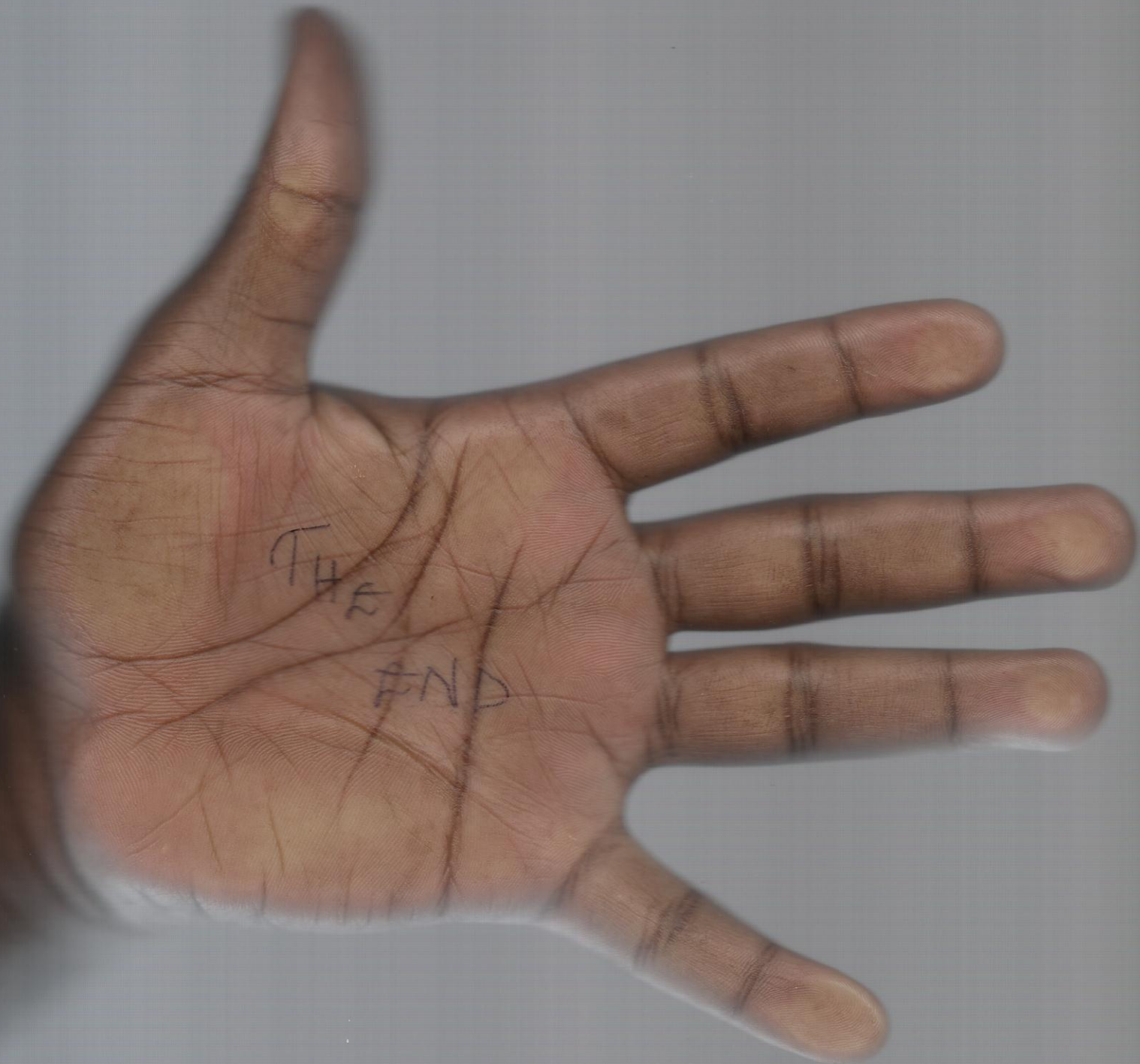
$$R_s = \frac{I_m R_m}{I - I_m}, \quad I_m = 50 \times 10^{-3} \text{ A}$$
$$R_m = 1.5 \Omega$$
$$I = 25 \text{ A}$$

$$= \frac{50 \times 10^{-3} \text{ A} \times 1.5 \Omega}{25 \text{ A} - (50 \times 10^{-3} \text{ A})}$$
$$= \frac{0.075 \text{ A} \Omega}{24.95 \text{ A}}$$

$$R_s = 0.003006012 \Omega$$

\therefore Shunt resistor $R_s \approx 0.003 \Omega$

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THE

END