



## Electrical Engineering and Measurement (EE1101) (Meas. of Resis.)

Presented

by

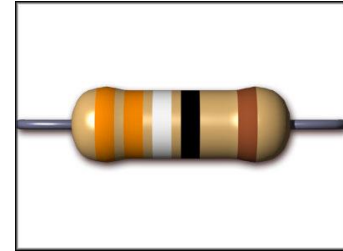
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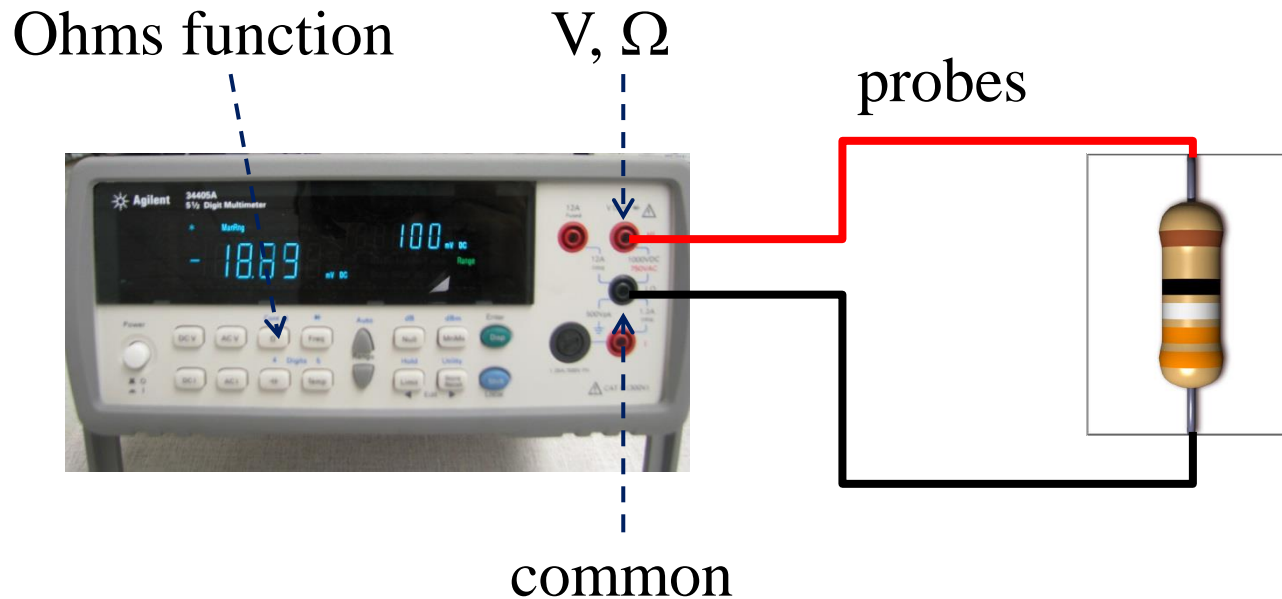
# Resistors



## Properties:

- Value (resistance)
  - Determined by measurement or color code (next slide)
- Power Rating
  - What is the largest power dissipation before damage or danger?
- Tolerance
  - What is the largest likely variation from the stated resistance value?
  - Your lab kit resistors: 5 %

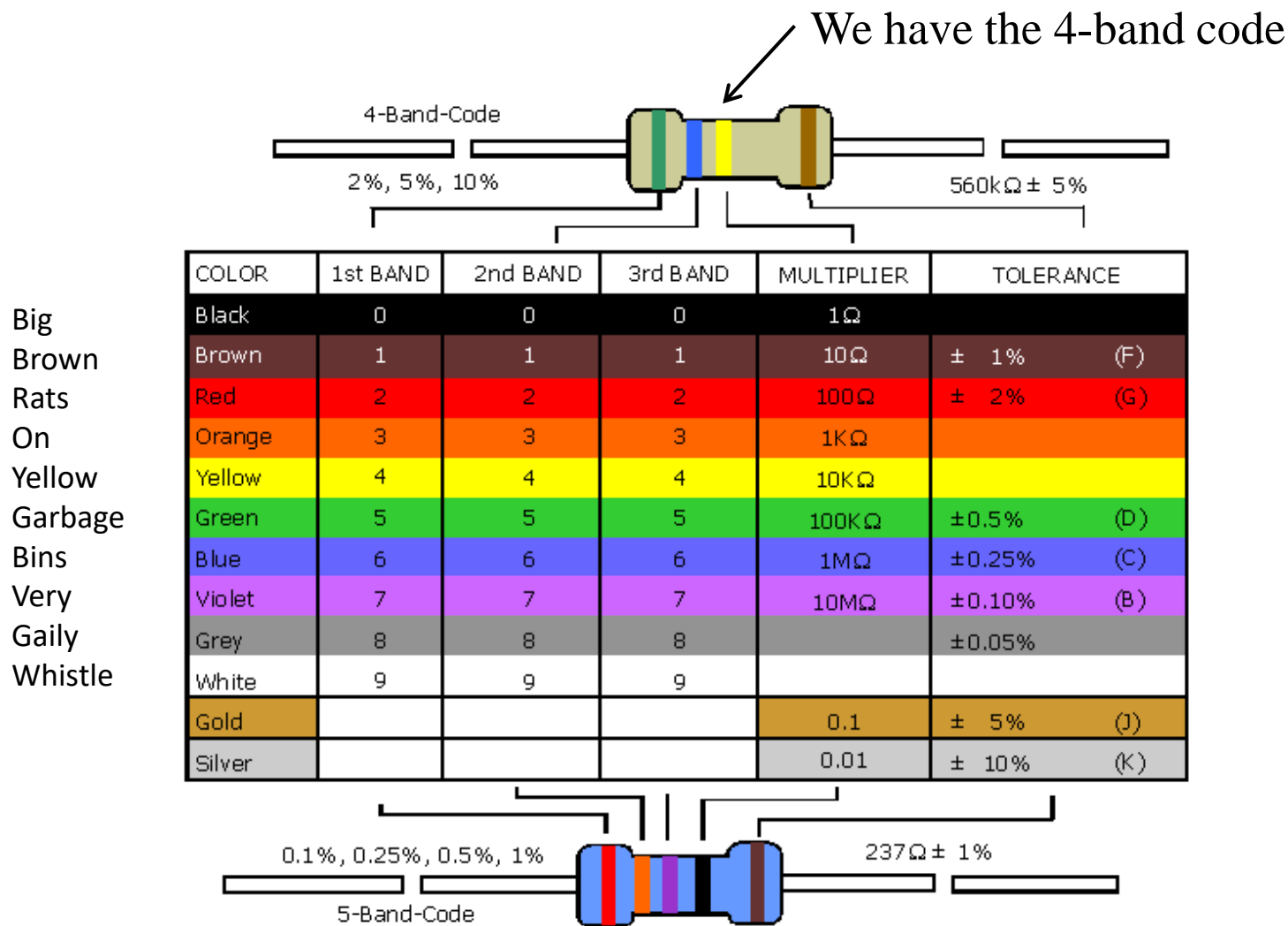
# Resistance Measurement



Does polarity matter? Reverse the leads and see.

Measure at least four of your resistors. What is the error in the resistance for each of these?

# Color Code



Electronix Express / RSR  
<http://www.elexp.com>

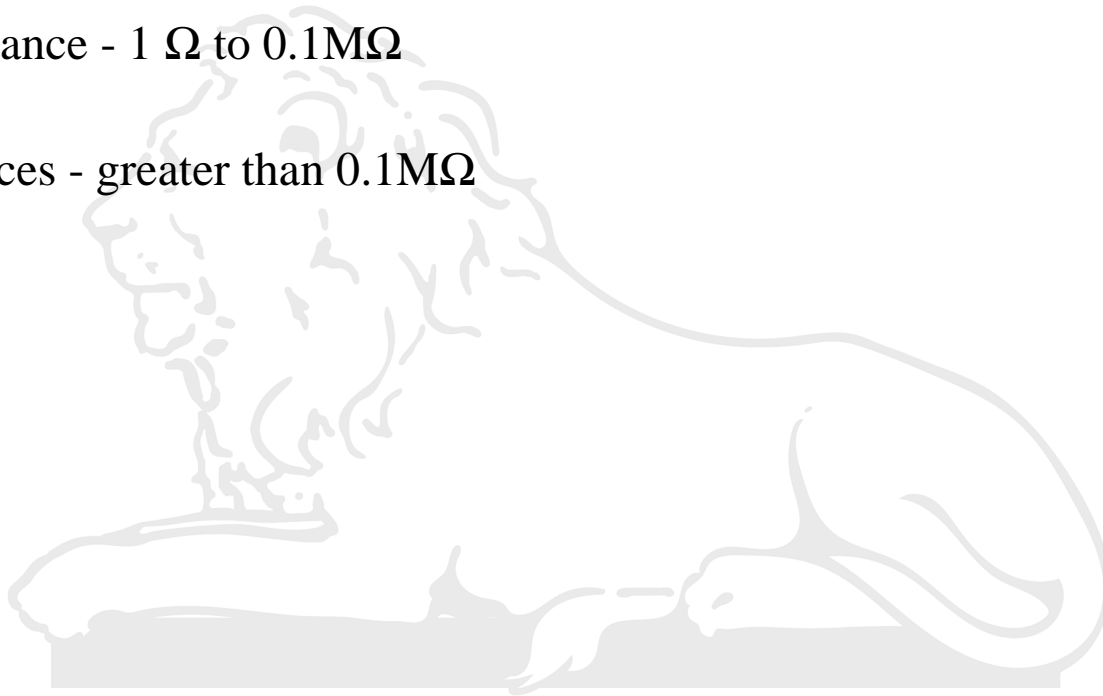
1-800-972-2225  
 In NJ 732-381-8020

# Measurement of Resistance



## Classification of resistances

- (I) Low resistances - Less than  $1\Omega$
- (II) Medium Resistance -  $1\Omega$  to  $0.1M\Omega$
- (III) High Resistances - greater than  $0.1M\Omega$

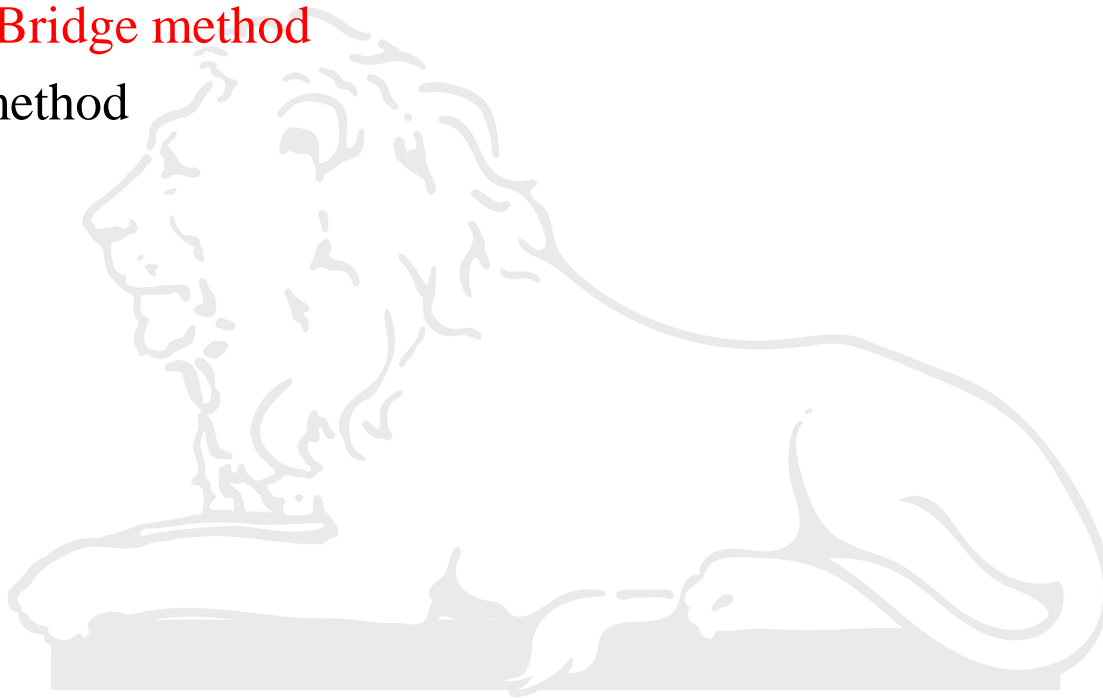


# Measurement of Resistance



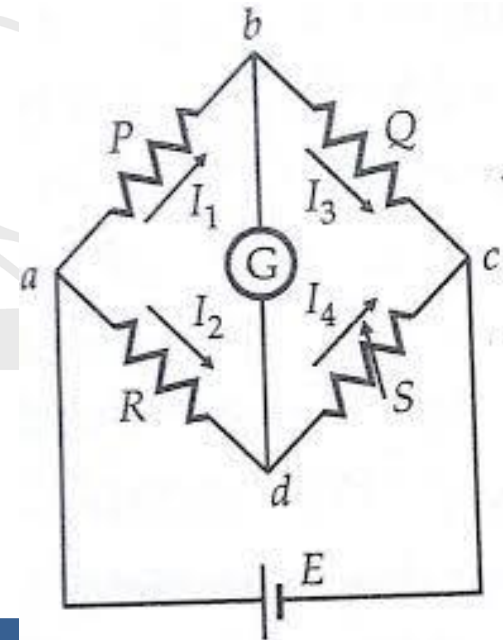
## Measurement of medium resistance

- (a) Ammeter Voltmeter method
- (b) Substitution method
- (c) **Wheatstone Bridge method**
- (d) Ohmmeter method



# Wheatstone bridge method

- ❖ The Wheatstone bridge is an **electrical bridge circuit used to measure resistance**. It consists of a common source of electrical current (such as a battery) and a galvanometer or a multimeter that connects two parallel branches, containing four resistors, three of which are known.
- ❖ A very important device for the measurement of medium resistance.
- ❖ It is used for making comparison measurements and operates upon null indication principle.
- ❖ This makes it a very accurate instrument because the indication is independent of the calibration of the null indicating instrument.



# Wheatstone bridge method

- ❖ It has four resistive arms, consisting of resistances P, Q, R and S with a source of emf and a null detector, usually a galvanometer G
- ❖ The current through the galvanometer depends on the potential difference between points b and d.
- ❖ The bridge is said to be balanced when there is no current through the galvanometer or when the potential difference across the galvanometer is zero.
- ❖ This occurs when the voltage from point 'b' to point 'a' equals voltage from point 'd' to point 'a'.
- ❖ Under balanced condition,

$$I_1 P = I_2 R \quad (1)$$

For galvanometer current to be zero, following conditions also exist

$$I_1 = I_3 = \frac{E}{P+Q} \quad (2)$$

$$I_2 = I_4 = \frac{E}{R+S} \quad (3)$$



# Wheatstone bridge method

❖ Substituting equations (2) and (3) in (1)

$$\frac{P}{P+Q} = \frac{R}{R+S}$$
$$PR + PS = PR + QR$$

$$PS = QR$$

$$\frac{P}{Q} = \frac{R}{S}$$

If three resistances are known then, fourth can be determined by using the equation

$$R = S \frac{P}{Q}$$

where, R = unknown resistance; S= standard arm; P and Q = ratio arms.

# Measurement of Resistance

## Low resistances - Less than $1\Omega$

- 1) AV Method,
- 2) **Kelvin Double Bridge,**
- 3) Potentiometer,
- 4) Ohmmeter

## Measurement of Low resistance

- ❖ Methods used for measurement of medium resistances are unsuitable for measurement of low resistance i.e. resistance  $< 1\Omega$ .
- ❖ The resistance of leads and contacts, though small, are appreciable in comparison to the low resistance to be measured.
- ❖ Hence special type of construction & techniques have to be used to avoid errors due this.

# Measurement of Resistance



## Kelvin Double Bridge

- ❑ The Kelvin double bridge is one of the best devices available for the precise measurement of low resistances.
- ❑ It is the modification of Wheatstone bridge by which the errors due to contact resistance and lead resistances are eliminated.
- ❑ This bridge is named double bridge because it contains a second set of ratio arms.
- ❑ An interesting variation of the Wheatstone bridge is the Kelvin Double bridge, used for measuring very low resistances (typically less than  $1/10$  of an ohm)

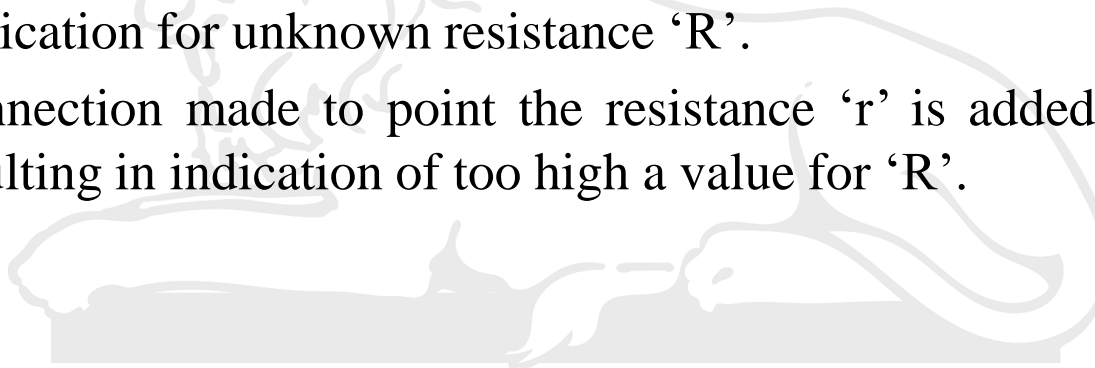


# Measurement of Resistance



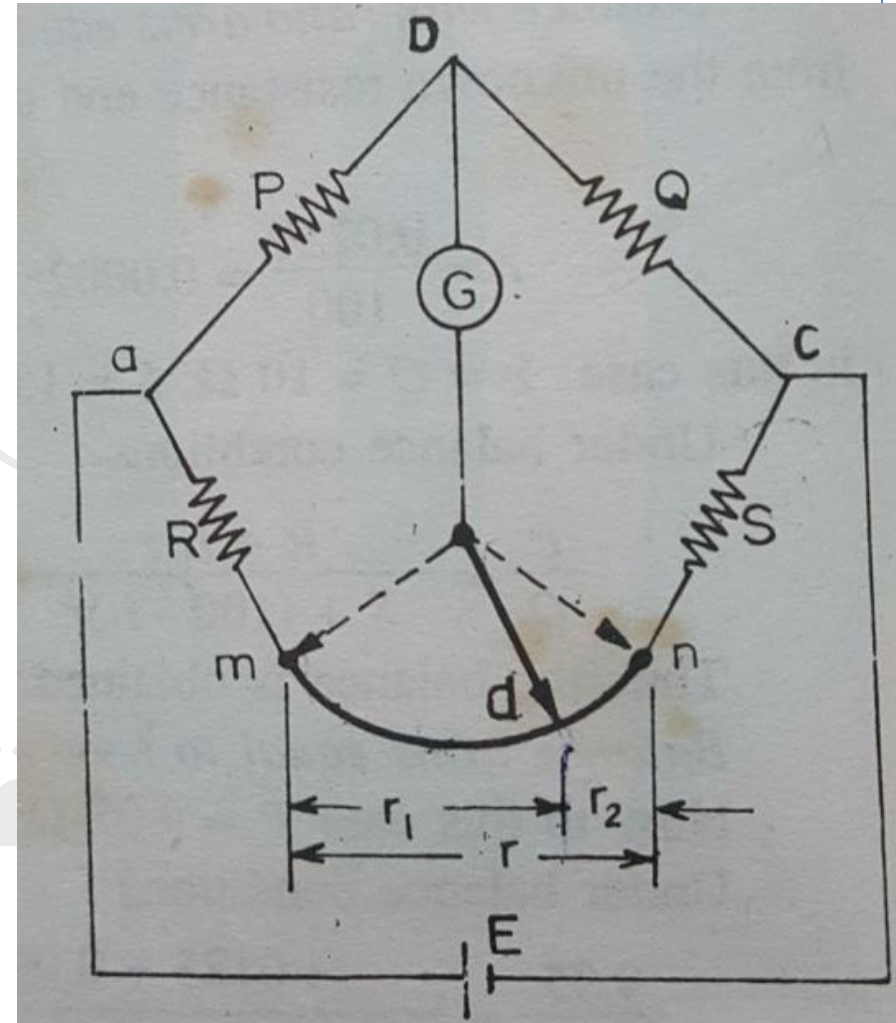
## Theory

- Consider the bridge circuit shown in figure below. Here ' $r$ ' represents the resistance of the lead that connects the unknown resistance ' $R$ ' to standard resistance ' $S$ '.
- Two galvanometer connections indicated by dotted lines are possible. The connection may be either to point 'm' or to point 'n'.
- When the galvanometer is connected to point ' $m$ ' the resistance ' $r$ ' of the connecting leads is added to the standard resistance ' $S$ ' resulting in indication of too low an indication for unknown resistance ' $R$ '.
- When the connection made to point the resistance ' $r$ ' is added to the unknown resistance resulting in indication of too high a value for ' $R$ '.



# Kelvin Double Bridge

- ❖ It is modification of Wheatstone bridge.
- ✓ Consider the bridge circuit where  $r$  represents the lead that connects the unknown resistance  $R$  to standard resistance  $S$ .
- ✓ Two galvanometer connections are possible. The connection may be either to point  $m$  or to point  $n$ .
- ✓ When galvanometer is connected to point  $m$ , the resistance  $r$  is added to standard resistance  $S$ , resulting in the indication of too low an indication for unknown resistance  $R$ .
- ✓ When connection is made to point  $n$ , the resistance  $r$  is added to the unknown resistance resulting in indication of too high a value for  $R$ .



# Kelvin Double Bridge

- ❖ Suppose the connection is made to any intermediate point d. If at point d the resistance is divided into two parts,  $r_1$  and  $r_2$ , such that

$$\frac{P}{Q} = \frac{r_1}{r_2}$$

- ❖ Then the presence of  $r_1$ , the resistance of connecting leads, causes no error in the result.

$$R + r_1 = \frac{P}{Q} (S + r_2) \quad (1)$$

But,

$$\frac{P}{Q} = \frac{r_1}{r_2}$$

Or

$$\frac{P}{P+Q} = \frac{r_1}{r_1+r_2} \quad \text{since } r = r_1 + r_2$$

$$r_1 = \frac{P}{P+Q} r$$

$$r_2 = \frac{Q}{P+Q} r$$

# Kelvin Double Bridge



❖ Substituting  $r_1$  and  $r_2$  in Eq. (1)

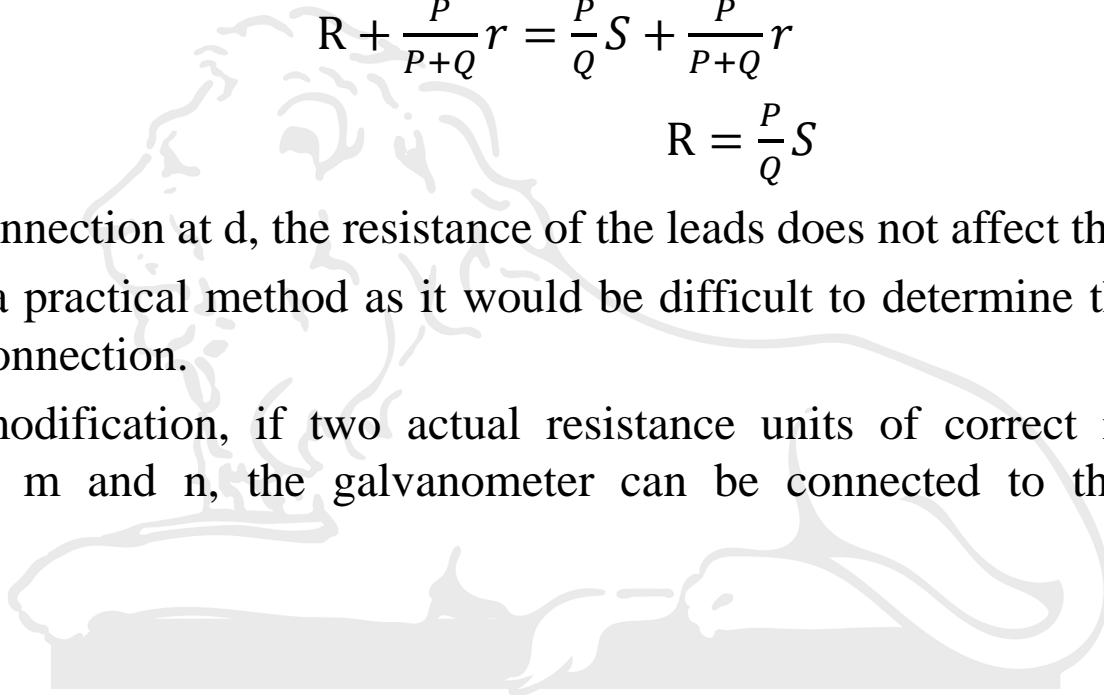
$$(R + \frac{P}{P+Q}r) = \frac{P}{Q}(S + \frac{Q}{P+Q}r)$$

$$R + \frac{P}{P+Q}r = \frac{P}{Q}S + \frac{P}{P+Q}r$$

$$R = \frac{P}{Q}S$$

∴ By making the connection at d, the resistance of the leads does not affect the result.

- ❑ But this is not a practical method as it would be difficult to determine the correct point of galvanometer connection.
- ❑ By a simple modification, if two actual resistance units of correct ratio is connected between points m and n, the galvanometer can be connected to the junction of the resistors.



# Measurement of Resistance

## Measurement of high resistance

There are different methods that can be employed for the measurement of high resistances. Some of the important methods are as follows.

- i) Direct deflection method
- ii) Loss of charge method
- iii) Megohm bridge method
- iv) **Megger method**



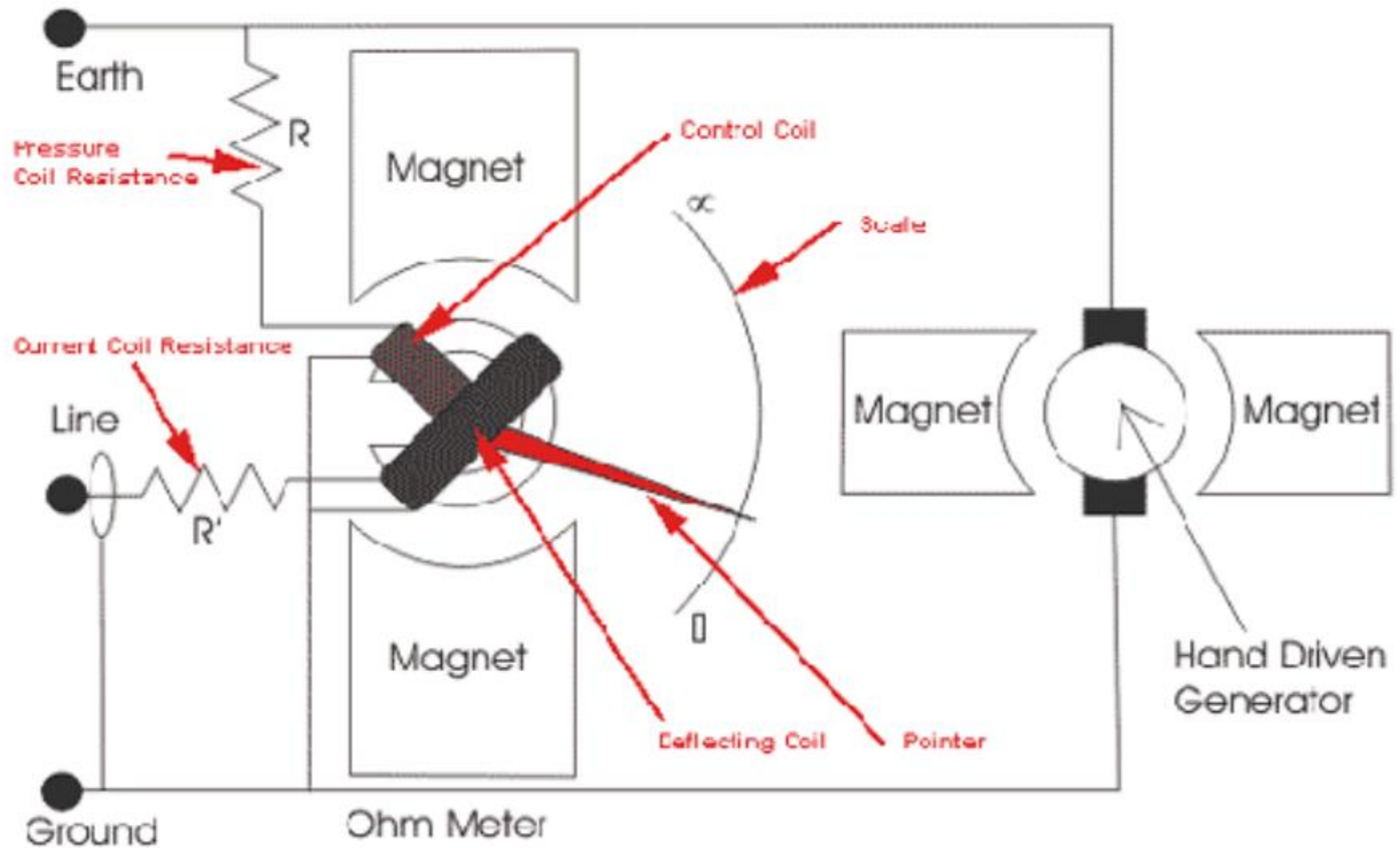


# Megger method

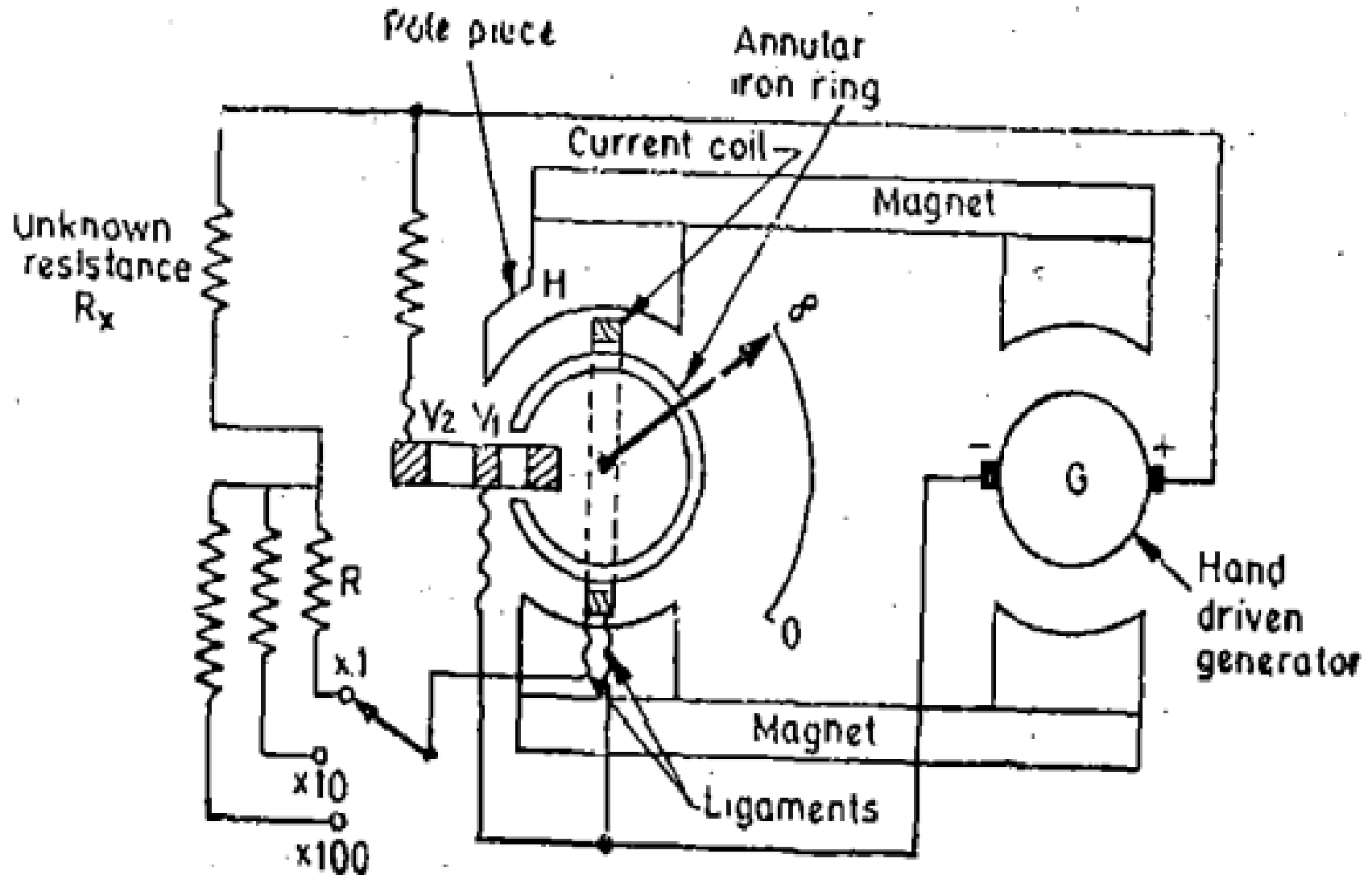


- 1) **Deflecting & Control coil** : Connected parallel to the generator, mounted at right angle to each other and maintain polarities in such a way to produced torque in opposite direction.
- 2) **Permanent Magnets**: Produce magnetic field to deflect pointer with North-South pole magnet.
- 3) **Pointer** : One end of the pointer connected with coil another end deflects on scale from infinity to zero.
- 4) **Scale** : A scale is provided in front-top of the megger from range 'zero' to 'infinity', enable us to read the value.
- 5) **D.C generator or Battery connection** : Testing voltage is produced by hand operated D.C generator for manual operated Megger. Battery / electronic voltage charger is provided for automatic type Megger for same purpose.
- 6) **Pressure coil resistance and Current coil resistance** : Protect instrument from any damage because of low external electrical resistance under test.

# Megger method



# Megger method



# Megger method



## Working Principle of Megger

- ❑ Voltage for testing produced by hand operated Megger by rotation of crank in case of hand operated type, a battery is used for electronic tester.
- ❑ 500 Volt DC is sufficient for performing test on equipment range up to 440 Volts. 1000V to 5000V is used for testing for high voltage electrical systems.
- ❑ Deflecting coil or current coil connected in series and allows flowing the electric current taken by the circuit being tested.
- ❑ The control coil also known as pressure coil is connected across the circuit. Current limiting resistor (CCR & PCR ) connected in series with control and deflecting coil to protect damage in case of very low resistance in external circuit.
- ❑ In hand operated Megger electromagnetic induction effect is used to produce the test voltage i.e. armature arranged to move in permanent magnetic field or vice versa.
- ❑ Where as in electronic type Megger battery are used to produce the testing voltage.
- ❑ As the voltage increases in external circuit the deflection of pointer increases and deflection of pointer decreases with a increases of current.

# Megger method



## Working Principle of Megger

- ❑ Hence, resultant torque is directly proportional to voltage & inversely proportional to current.
- ❑ When electrical circuit being tested is open, torque due to voltage coil will be maximum & pointer shows 'infinity' means no shorting throughout the circuit and has maximum resistance within the circuit under test.
- ❑ If there is short circuit pointer shows 'zero', which means 'NO' resistance within circuit being tested.
- ❑ Work philosophy based on ohm-meter or ratio-meter. The deflection torque is produced with Megger tester due to the magnetic field produced by voltage & current, similarly like 'Ohm's Law' Torque of the Megger varies in ration with  $V/I$ , (Ohm's Law :-  $V=IR$  or  $R=V/I$ ). Electrical resistance to be measured is connected across the generator & in series with deflecting coil. Produced torque shall be in opposite direction if current supplied to the coil.

# Megger method



- ❑ High resistance = No current :- No current shall flow through deflecting coil, if resistance is very high i.e. infinity position of pointer.
- ❑ Small resistance = High current :- If circuit measures small resistance allows a high electric current to pass through deflecting coil, i.e. produced torque make the pointer to set at 'ZERO'.
- ❑ Intermediate resistance = varied current :- If measured resistance is intermediate, produced torque align or set the pointer between the range of 'zero to infinity'.

