# PHYSICS

# BOOKS - NN GHOSH PHYSICS (HINGLISH)

# GALVANOMETERS: AMMETER AND VOLTMETERS

Example

**1.** A current of 10 A produces a deflection of $45^\circ$ in a tangent galvanometer. What is the value of the current which will produce a deflection of $30^\circ$ in the same galvanometer?

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**2.** Show that in a tangent galvanometer the percentage error in the measurment of current is a minimum when the deflection is $45^\circ$.

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**3.** A suspended, vertical, circular coil of 50 turns and area $100cm^2$ carrying a current of 30 mA, is in equilibrium in a uniform magnetic field of intensity 0.4 tesla, when the normal to the plane of the coil makes an angle of $30^\circ$ with the field. Calcualte the torque on the coil due to the current.

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**4.** A weston galvanometer whose resistance is $25\Omega$ shows full-scale deflection for $500\mu A$. Explain how you would convert it into (i) an ammeter reading up to 10 A and (ii) a voltmeter reading up to 10V, What will be the sensitivity of the voltmeter so formed?

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**5.** A cheap voltmeter with resistance $500\Omega$ is used to measure the emf of a cell of internal

resistance $4\Omega$. What is the % error in the reading of the voltmeter?

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**6.** An ammeter of resistance $0.5\Omega$ is connected in the usual way to a circuit which has a cell of emf 1.5 V and an internal resistance $2\Omega$ and a resistor $8\Omega$. What is the percentage error in the reading of the ammeter?

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**7.** A voltmeter of 20 V range and $50000\Omega$ in connected in series with a resistor of $30000\Omega$ by mistake. If the emf of the battery to which they are connected is 6V what will be the reading of the voltmeter?

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**8.** In a suspended type moving coil galvanometer the coil has 60 turns, each of area $2 \times 10^{-4} m^2$ and the strength of the magnetic field is 0.001 T. A current of 20 mA

produced a deflection of 10 cm on a scale at a distance of 1m form the instrument. Calcualte the torque per unit twist.

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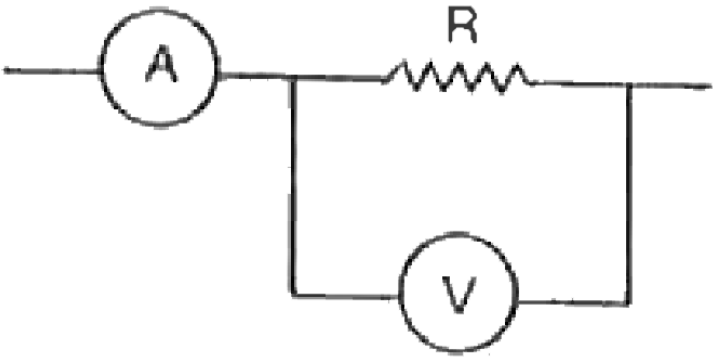
**9.** The circuit shown here is used to measure resitance R. An ammeter shows a current of 2A and a voltmeter of a potential difference of 120 V. what is the resitance R if the internal resistance of the voltmeter is $R_v$ = 3000$\Omega$?

How large will the error in measuring R be, if

the resistance of the voltmeter is assumed to be infinitely large?

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**10.** A milliammeter with a current sensitivity of 1mA per division is utilised as a voltmeter.

Determine the voltage per division of this instrument if its resistance is made $500\Omega$

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## Exercise

**1.** A circular coil of radius $20cm$ and $20$ turns of wire is mounted vertically with its plane in magnetic meridian.A small magnetic needle (free to rotate about vertical axis) is placed at the center of the coil.It is deflected through

$45^\circ$ when a current is passed through the coil and in equilbrium (Horizontal component of earth's field is $0.34 \times 10^{-4} T$).The current in coil is:

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**2.** Calculate the current through a tangent galvanometer whose cells has 50 turns and a mean diameter of 22 cm when the needle is deflected through $30^\circ$ at a place where $H = 30 Am^{-1}$

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**3.** A current is sent through two tangent galvenometers in series. The deflectionis seen to be the same in both the galvanometer. Compare the radii of the coils of the galvanometer, if the number of turns in the coil of the first galvanometer is 110 and in the second 25.

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**4.** Show that a tangent galvanometer is most sensitive when the deflection is near zero.

[hint: Sensitivity = (dtheta)/(dt)]`

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**5.** The total resistance of a simple circuit is $80\Omega$ including the resistance of a tangent galvanometer which is $4\Omega$. The galvanometer shows a deflection of $60^\circ$. It is then shunted with $1\Omega$. What is the new deflection?

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**6.** A tangent galvanometer of resistance $10\Omega$ shows a deflection of $60^\circ$ when inserted in a circuit whose total resistance (including that of the galvanometer) is $100\Omega$. What shunt must be used to reduce the deflection to $30^\circ$?

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**7.** A circular loop of 50 turns and an area of 20 $cm^2$ is placed in a magnetic field of 0.2 T.

Calcualte the torque required to deflect the loop through $90^\circ$ in the magnetic field when a current of 1A is passing through the loop.

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**8.** A galvanometer coil of rectangular shape of length 4 cm and width 2 cm contains 200 turns of insulated copper wire. It is suspected in a magnetic field of 0.005 T and the suspension produces a torque of $10^{-6}$ Nm per

unit twist. What steady current passing through the coil will produce deflection of $5^{\circ}$?

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**9.** A moving coild galvanometer with a lamp-and-scale arrangement has a coil of 50 turns of mean area 1.5 $cm^2$ per turn and the effective strength of the field (radial) is 0.02T. If a current of $10^{-9}$ A produces a deflection of 1 cm on a scale placed at 1 m away, calcualte

the steady torque required to hold the suspension twisted through 1 radian.

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**10.** In a moving coil galvanometer, the magnetic field used is 5T. The coil has 100 turns, each of mean area $10 \times 10^{-4}$ m^(2). If a current of $10^{-7}$ A produces a deflection of 1 mm on a scale 1m away, calcualte the current reduction factor of the galvanometer and the torsional rigidity of the suspension wire.

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**11.** A milliammeter has a resistance of $10\Omega$ and each division of its graduation reads 1mA. How will you convert it into a voltmeter reading 1V per division? What will be the sensitivity of the voltmeter? (There are 10 divisions on the scale).

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**12.** A moving coil galvanometer has a resistance of $200\Omega$ and gives a full-scale deflection with a current of 10mA. Explain how you would convert it into (i) an ammeter reading up to 1A, (ii) voltmeter reading up to 10 V. Also calculate the resistance of an ammeter and voltmeter so formed.

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**13.** A voltmeter with a resistance of $8000\Omega$ is used to measure the emf of a cell of internal resistance $4\Omega$. What is the percentage error in the reading of the voltmeter?

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**14.** A cheap voltmeter with an internal resistance of $30\Omega$ is connected to the terminals of a battery whose internal resistance is $5\Omega$ and true emf 1.5 V. What

would be the terminal voltage as read by the voltmeter?

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**15.** A voltmeter of range of 10 V and resistance $5000\Omega$ is connected in series with a battery and a resistor of $500\Omega$ by mistake. If the voltmeter reading is 8V, what is the emf of the battery? (Neglect internal resistance of battery).

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**16.** There is a milliameter, each division of which reads 1 mA. It has a resistance of $15\Omega$. How would you convert it into a voltmeter, each division of which would read 1V?

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**17.** An ammeter of resistance 0.02 $\Omega$ is connected in the usual may to a circuit in a circuit consisting of a cell of emf 2V and internal resistance $1\Omega$ and a resistor of $9\Omega$.

What is the percentage error in the reading of the ammeter?

[Hint: $I_{real} = \frac{2}{10} = 0.2, I_{apparent} = \frac{2}{10.02}$ )

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**18.** A voltmeter of resistance $3000\Omega$ can read up to 10 V. how would you adjust it to measure voltages up to 220V? How would the sensitivity of voltmeter be affected?

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**19.** A millimmater of resistance $20\Omega$ reads up to 50 mA. Explain how the instrument can be used to read a) currents up to 5A, b) voltages up to 50V.

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**20.** A battery of emf 5V and internal resistance $20\Omega$ is connected to a combination of two resistance $50\Omega$ and $40\Omega$ in series. If the p.d. across the $50\Omega$ resistor is measured by a

voltmeter of resistance $1000\Omega$, what will be the percentage error?

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**21.** A 150 V voltmeter has a resistance of $20{,}000\Omega$ when connected in series with a large resistance R across a 110-volt line the meter reads 5V. Find the resistance R.

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**22.** A moving coild galvanometer of resistance $20\text{Omega}$ gives a full scale deflection when a current of 1mA is passed through it. It is to be converted into an ammeter reading 20A. But the resistance of the only shunt available is $0.005\Omega$. What resistance should be connected in series with the galvanometer coil?

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**23.** Two tangent galvanometer of 50 and 100 tunrs of the same wire and radii 10cm, and 5cm respectively are connected in parallel. Calculate the ratio $\tan(\theta_1 : \tan(\theta_2$ where $\theta_1$ and $\theta(2)$ are the deflections produec in them.

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**24.** A $600\Omega$ resistor and a $400\Omega$ resistor are connected in series across a 90-volt line. A voltmeter acros the $600\Omega$ resistor reads 45V.

What is the value of the voltmeter resistance?

If the same voltmeter is connected across the $400\Omega$ resistor, what will be its reading?

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**25.** Three voltmeters A, B and C have the same range but different resistances $R_A$=1200Ω, $R_B = 1000\Omega$ and R_(C)=800 Omega. A is connected in parallel to C and B is connected in series with the combination of A and C. When the combination of ABC so formed is

connected across a constant potential difference $V_{ab}$□ meter A reads 4.8V and meter B reads 10 volts. What will be the reading of each meter when they are all connected in series across the same potential difference $V_{ab}$ ?

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**26.** A galvanometer with a coil resistance of $100\Omega$ shows a full-scale deflection when a current of 1 mA is passed through it. What is

the value of the resistance which can convert this galvanometer into an ammeter showing a full-scale deflection for a current of 10A?

A resistance of the required value is available but it will get burnt if the energy dissipated in it is greater than 1W. Can it be used for the conversion of the galvanometer described above? [Hint:Power dissipated $=I^2$watt)

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**27.** When the modified galvanometer of exercise 26 is connected across the terminals of a battery, it shows a current of 4A. The current drops to 1A when a resistance of $1.5\Omega$ is connected in series with the modified galvanometer. Find the emf and the internal resistance of the battery.

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**28.** An ammeter and a voltmeter are connected in series to a battery of emf 6V. When a certain resistance is connected in parallel with the voltmeter, the reading of the latter decreases $n = 2$ times, whereas the reading of the ammeter increases the same number of times. What is the ratio of the voltmeter resistance to the ammeter resistance? Find the voltmeter reading after the connection.

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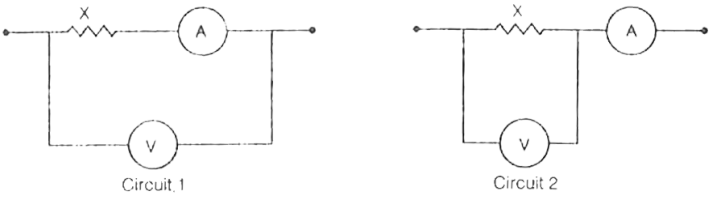
**29.** An ammeter and a voltmeer are connected as in figures in order to




measure an unknown resistance. Justify quantitatively which connection is to be perfected.

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**30.** It is required to measure the resistance ofa circuit operating at 120V. There is only one

galvanometer of current sensitivity $10^{-6}$ A per division. How should the galvanometer be connected in the circuit to operate as an ohmmeter? What minimum resistance can be measured with such a galvanometer if its full scale has 40 division? Construct the entire scale of such an ohmmeter in ohms per 5 division? Neglect galvanometer resistance.

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**31.** A resistance $\Delta R$=1980 $\Omega$ is connected in series with a voltmeter when its scale divisons decreases $\eta$=10%. Calculate the resistance R_(V) of the voltmeter.

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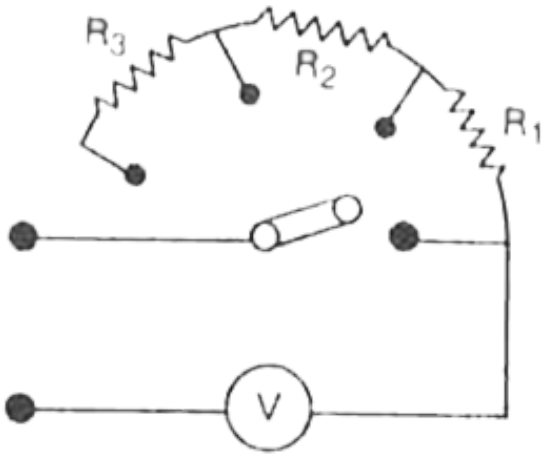
**32.** What should the resistance of the sections of a rheostat $R_1$, $R_2$ and $R_3$ be in order that the voltmeter ($R_V = 3000\Omega$) range may change 10,100 and 1000 times when the

rheostat slide is shifted from one contact to another.

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