Physics · Electric Current and Electromagnetism · Magnetic Effect of Electric Current and Measuring Instruments

Electrical Measuring Instruments

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214	3	98
questions	sets	pages

Contents

Multiple choice questions (134 questions) — Questions · p. 2 — Answers · p. 69

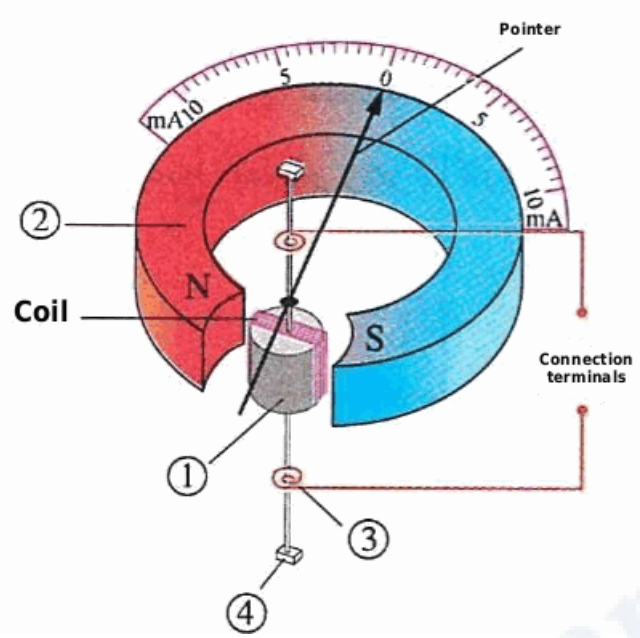
Essay questions (27 questions) — Questions · p. 43 — Answers · p. 87

Past exam questions (53 questions) — Questions · p. 51 — Answers · p. 91

Click a question number to jump to its answer, and an answer number to go back to the question.

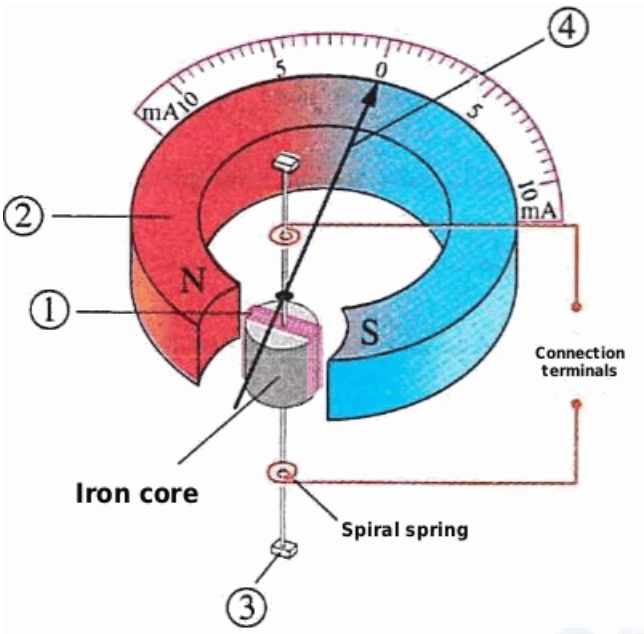
Multiple choice questions — 134 questions

1 The opposite figure shows the internal structure of a moving-coil galvanometer. The component made of agate to reduce friction while the coil moves is .....



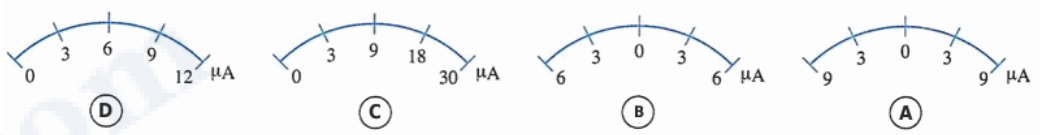
(A) component (1) (B) component (2) (C) component (3) (D) component (4)

2 The opposite figure shows the internal structure of a moving-coil galvanometer. The component made of copper is .....



(A) component (1) (B) component (2) (C) component (3) (D) component (4)

3 Which of the following figures represents the scale of a sensitive galvanometer that can be used to determine the direction of the electric current?



4 The magnetic torque acting on the galvanometer coil due to a current passing through it always equals .....

(A) BIAN sin 0 (B) BIAN sin 45 (C) BIAN sin 90 (D) BIAN sin 30

5 The resultant torque acting on the galvanometer coil when its pointer settles at a certain reading equals .....

(A) BIAN (B) 2 BIAN (C) 2 BIAN sin θ (D) zero

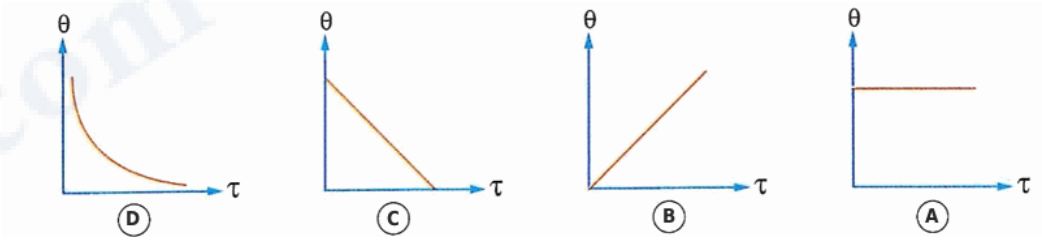
6 When a current is passed through the coil of a sensitive galvanometer, its pointer takes a time t to deflect from zero and settle at a certain reading. What happens during that time to the magnetic torque (τ_1) acting on the coil and the torsion torque (τ_2) of the two spiral springs respectively?

(A) τ_1: increases, τ_2: constant
(B) τ_1: increases, τ_2: increases
(C) τ_1: constant, τ_2: constant
(D) τ_1: constant, τ_2: increases

7 When a direct current (I) is passed through the coil of a galvanometer, the torque acting on the coil does not change while it rotates, because of .....

(A) the spiral springs
(B) the agate bearings
(C) the aluminium pointer
(D) the concave magnet poles together with a soft iron core

8 Which of the following graphs expresses the relation between the angle (θ) through which the galvanometer pointer is deflected from zero and the torque (τ) acting on the galvanometer coil due to a direct current?



9 When a direct current of suitable intensity passes through a moving-coil galvanometer, which quantity changes from the moment the pointer starts moving until it settles at a certain reading?

(A) The magnetic torque acting on the coil

(B) The torque due to the twisting of the two spiral springs

(C) The sensitivity of the galvanometer

(D) The angle between the coil and the direction of the magnetic flux

10 When an alternating current of low frequency (1 Hz) passes through a galvanometer, its pointer .....

(A) does not deflect from the zero of its scale

(B) deflects and settles at a certain value

(C) oscillates about the zero of its scale

(D) deflects to the end of its scale

11 When a high direct current passes through the galvanometer coil .....

(A) the galvanometer pointer is not deflected

(B) no torque acts on the galvanometer coil

(C) a high heat is produced that may damage the coil

(D) the sensitivity of the galvanometer increases

12 If a galvanometer pointer is deflected through 50° when a current of 500 μA passes, the sensitivity of the galvanometer equals ..... deg/μA

(A) 550 (B) 450 (C) 0.1 (D) 10

13 A galvanometer has a sensitivity of 2 deg/μA. If the value of one division is 5 μA and the maximum deflection angle of the pointer from zero is 50°, the number of divisions on the galvanometer scale equals .....

(A) 5 divisions (B) 10 divisions (C) 20 divisions (D) 25 divisions

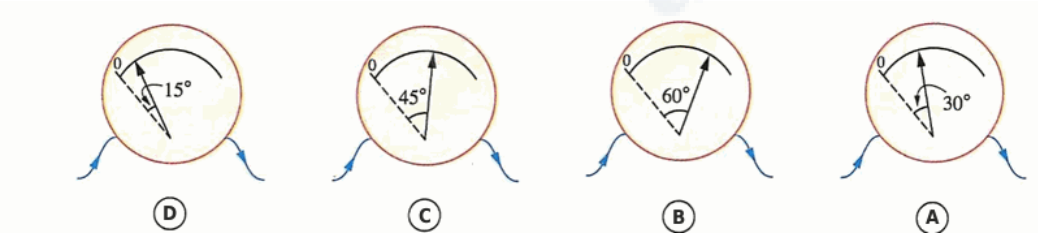
14 The scale of a sensitive galvanometer has twenty divisions, and its pointer deflects to the middle of the scale when a current of 0.1 milliampere passes through its coil. The value of one division on the scale equals .....

(A) 20 microamperes (B) 10 microamperes (C) 5 microamperes (D) 2 microamperes

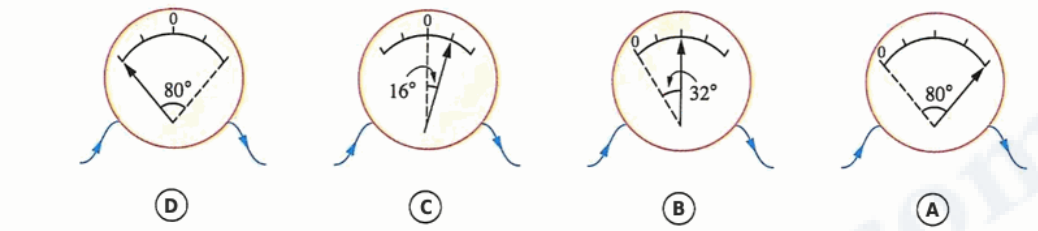
15 The pointer of a moving-coil galvanometer deflects to half the scale when a current of 200 μA passes. If the value of one division is 0.08 mA, the number of divisions on the galvanometer scale equals ..... divisions.

(A) 10 (B) 9 (C) 7 (D) 5

16 The following figures show the deflection of the pointers of four sensitive galvanometers when the same current passes through each. Which of them represents the galvanometer with the greatest sensitivity?



17 The following figures show the deflection of the pointers of four sensitive galvanometers when a current of 250 μA passes through each. Which of these instruments has a sensitivity of 0.16 deg/μA?



18 Two copper wires of the same length are used to make the coils of two galvanometers P and Q. Each wire is wound around a square aluminium frame of side X and 2X respectively. If the two galvanometers are identical in the magnetic flux density acting on the coil and the elasticity constant of the two spiral springs, the ratio of the sensitivity of galvanometer (P) to that of galvanometer (Q) equals .....

(A) *1/2* (B) *1/4* (C) *2/1* (D) *1/1*

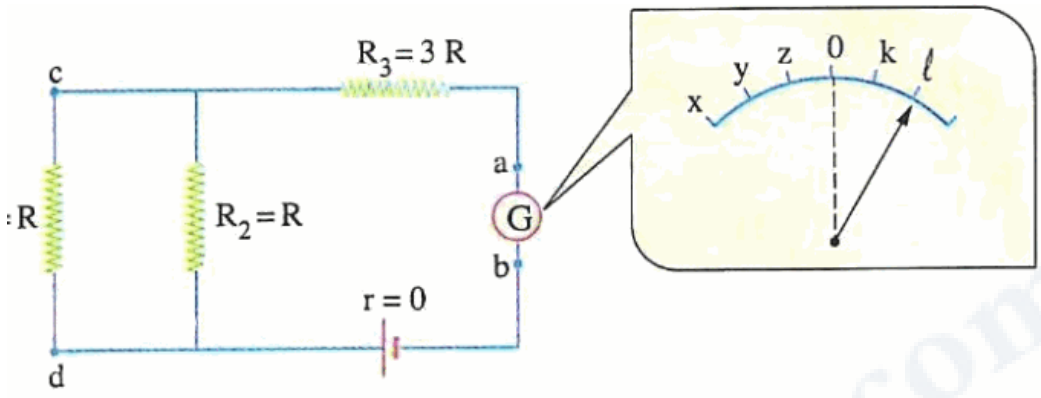
19 A galvanometer coil of cross-sectional area 6 cm^2 and 600 turns is suspended in a magnetic field of flux density 0.1 T. The current needed to produce a torque of 4.32×10^{-3} N.m equals .....

(A) 0.01 A (B) 0.02 A (C) 0.12 A (D) 0.21 A

20 A sensitive galvanometer has a coil of 1200 turns, each of face area 3 cm^2, rotating in a uniform magnetic field of flux density 0.01 T. When a current of 1 mA is passed through the coil, the pointer deflects from zero through 30°. The torsion torque in the two spiral springs when the pointer settles equals .....

(A) 2.55×10^{-6} N.m (B) 3.6×10^{-6} N.m
(C) 4.22×10^{-6} N.m (D) 6.4×10^{-6} N.m

21 A sensitive galvanometer with terminals a and b, resistance R and its zero at the middle of the scale deflects to position ℓ when connected in the circuit shown in the following figure. When the galvanometer swaps places in the circuit with resistance R_1, so that its terminal a is connected to point c and its terminal b to point d, the galvanometer pointer deflects to position .....



(A) x (B) y (C) z (D) k

22 The smaller the shunt connected to the galvanometer, the sensitivity of the ammeter .....

(A) increases
(B) decreases
(C) stays the same
(D) increases then decreases

23 The ratio of the resistance of the shunt to the resistance of the whole ammeter is ..... one.

(A) greater than
(B) equal to
(C) less than
(D) cannot be determined

24 In an ammeter, if the shunt connected to the galvanometer is decreased and the same current is passed through the ammeter, the quantity that increases is .....

(A) the torsion torque acting on the two spiral springs of the galvanometer
(B) the magnetic force acting on the sides of the galvanometer coil
(C) the sensitivity of the ammeter
(D) the accuracy of the ammeter in measuring the current

25 An ammeter connected in a circuit deflects to the end of its scale. What happens to the galvanometer if the resistance of the shunt is increased and the same current passes through the ammeter?

(A) Its pointer deflects in the opposite direction
(B) Its sensitivity decreases greatly
(C) A current less than its full-scale reading passes through its coil
(D) A current greater than its full-scale reading passes through its coil

26 In an ammeter, the range for measuring current is greatest when the galvanometer is connected to a shunt whose resistance is .....

(A) one third of the galvanometer resistance
(B) twice the galvanometer resistance
(C) half the galvanometer resistance
(D) one fifth of the galvanometer resistance

27 The pointer of a moving-coil galvanometer deflects to the end of its scale when a current (I) passes through it. A 12 Ω resistance was connected in parallel with its coil, and its pointer deflected to one fifth of the scale when the same current (I) was passed. The resistance of the galvanometer coil (R_g) is .....

(A) 24 Ω (B) 36 Ω (C) 48 Ω (D) 60 Ω

28 If the ratio of the resistance of an ammeter to the resistance of the galvanometer inside it is *1/10*, the ratio of the shunt resistance to the galvanometer resistance is .....

(A) *1/10* (B) *10/1* (C) *1/99* (D) *1/9*

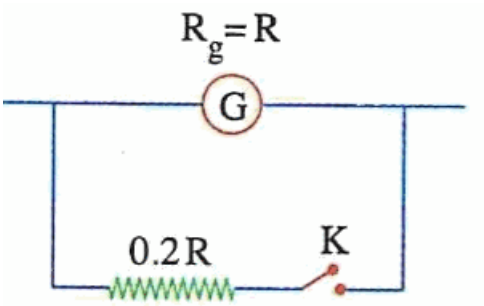
29 For a galvanometer of coil resistance R, the shunt resistance that reduces the sensitivity of the galvanometer to one quarter is .....

(A) R (B) *R/2* (C) *R/3* (D) *R/4*

30 A shunt of resistance 0.1 Ω reduces the sensitivity of an ammeter to one tenth. The resistance of the shunt that reduces the sensitivity of this ammeter to one quarter equals .....

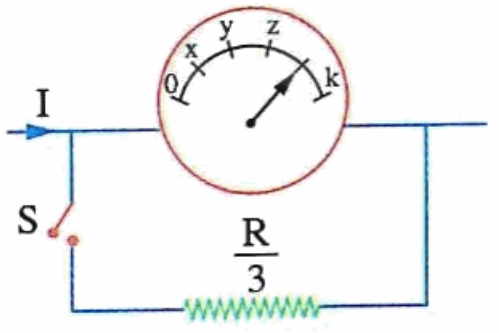
(A) 0.2 Ω (B) 0.3 Ω (C) 0.6 Ω (D) 0.9 Ω

31 In the opposite figure, a shunt is connected to a galvanometer through a switch K. When the switch is closed, the sensitivity of the instrument decreases to .....



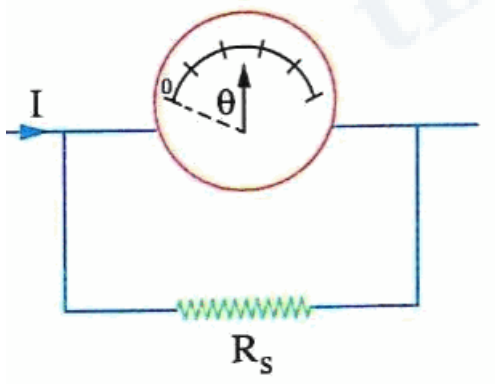
(A) one half (B) one fifth (C) one sixth (D) one quarter

32 A galvanometer of resistance (R) is connected to a shunt of $(R/3)$ through a switch (S) to form an ammeter. When a current (I) passes through the galvanometer, its pointer deflects as in the opposite figure. If switch (S) is closed and the same current passes through the ammeter, the galvanometer pointer deflects to position .....



(A) x (B) y (C) z (D) k

33 An ammeter consists of a galvanometer and a shunt whose resistance equals that of the galvanometer. When a current I passes through the ammeter, the galvanometer pointer deflects through an angle θ as in the opposite figure. If the shunt resistance is decreased to one third of the galvanometer resistance with the same current (I) in the ammeter, the deflection angle of the pointer from zero becomes .....



(A) θ (B) $(\theta)/2$ (C) $(\theta)/3$ (D) $(\theta)/4$

34 An ammeter has a galvanometer of resistance R_g. When it is connected in a closed circuit, 2% of the circuit current passes through the galvanometer. The resistance of the shunt equals .....

(A) $R_g/50$ (B) $R_g/49$ (C) $49\ R_g$ (D) $50\ R_g$

35 A galvanometer of resistance 54 Ω is connected to a shunt R_s so that 0.1 of the total current passes through the galvanometer. The resistance R_s equals .....

(A) 4.5 Ω (B) 6 Ω (C) 8.25 Ω (D) 10 Ω

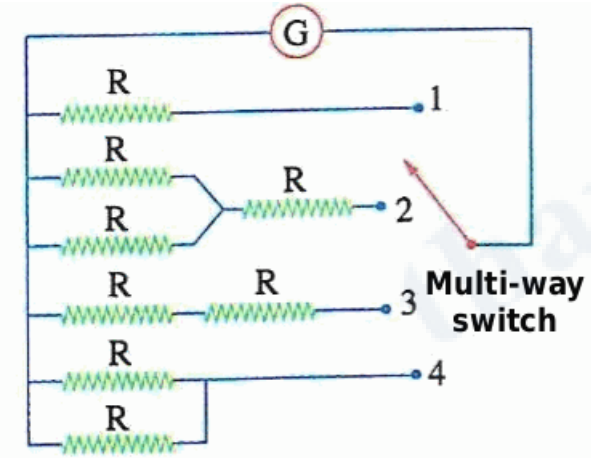
36 A galvanometer of resistance 36 Ω has a 4 Ω shunt connected to its coil, and the resulting instrument is connected in a closed circuit. The percentage of the current passing through the galvanometer to the total current equals .....

(A) 8 % (B) 9 % (C) 10 % (D) 91 %

37 A galvanometer with a coil resistance of 0.1 Ω reads a current I_g at the end of its scale. The shunt resistance needed to increase its range to 10 times equals .....

(A) 0.03 Ω (B) 0.02 Ω (C) 0.01 Ω (D) 0.003 Ω

38 A sensitive galvanometer is connected to a multi-way switch that can connect it to one of the numbered positions $(1, 2, 3, 4)$ to convert it into an ammeter. The ammeter has the greatest range when the switch is at position .....



(A) 1 (B) 2 (C) 3 (D) 4

39 A galvanometer of resistance 54 Ω deflects to the end of its scale when a current of 0.01 A passes through it. It is to be modified to measure a current of 0.1 A, so .....

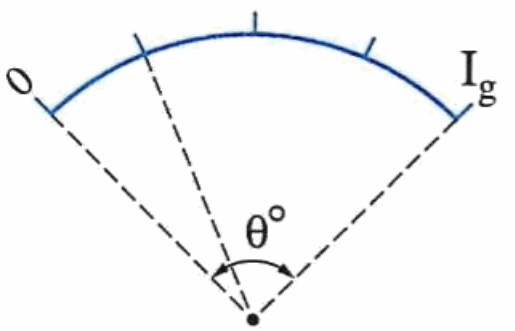
(A) the shunt is 6 Ω, connected in series with the galvanometer

(B) the shunt is 3 Ω, connected in series with the galvanometer

(C) the shunt is 6 Ω, connected in parallel with the galvanometer

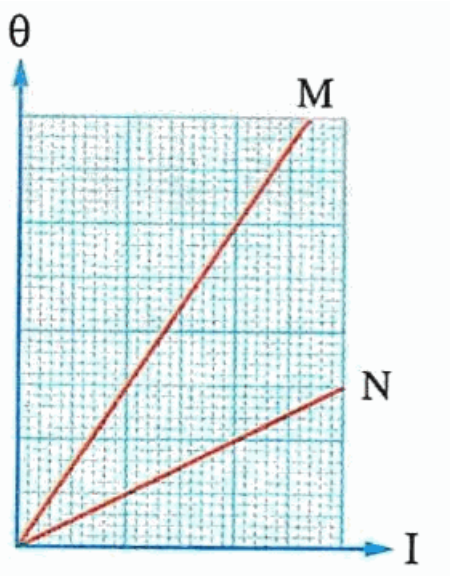
(D) the shunt is 3 Ω, connected in parallel with the galvanometer

40 In the opposite figure, a moving-coil galvanometer deflects through an angle θ to the end of its scale when a current (I_g) passes through its coil. When a shunt is connected to the galvanometer to convert it into an ammeter and the same current (I_g) is passed through the ammeter, the deflection angle of the pointer decreases by 75%. The sensitivity of the instrument .....



(A) increased by 75 %
(B) decreased by 75 %
(C) increased by 25 %
(D) decreased by 25 %

41 A galvanometer is connected in a circuit whose components are connected in series. The two graph lines M and N in the opposite figure represent the relation between the deflection angle of the galvanometer pointer (θ) and the current (I) in the circuit before and after converting it into an ammeter. The sensitivity of the ammeter equals .....



(A) half the sensitivity of the galvanometer
(B) one third of the sensitivity of the galvanometer
(C) one quarter of the sensitivity of the galvanometer
(D) the sensitivity of the galvanometer

42 A galvanometer was connected to a shunt R_1, and the maximum current the instrument could measure was (I), as in figure (1). When the same galvanometer was connected to a shunt R_2, the maximum current the instrument could measure was $(2\ \mathrm{I})$, as in figure (2). In which figure is the potential difference across the instrument greater?

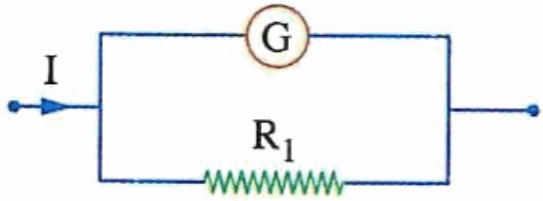


Figure (1)

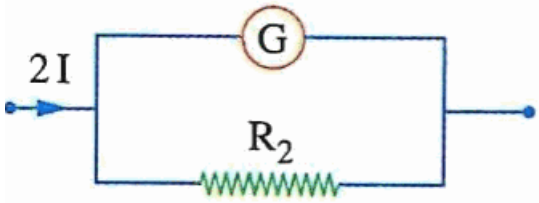
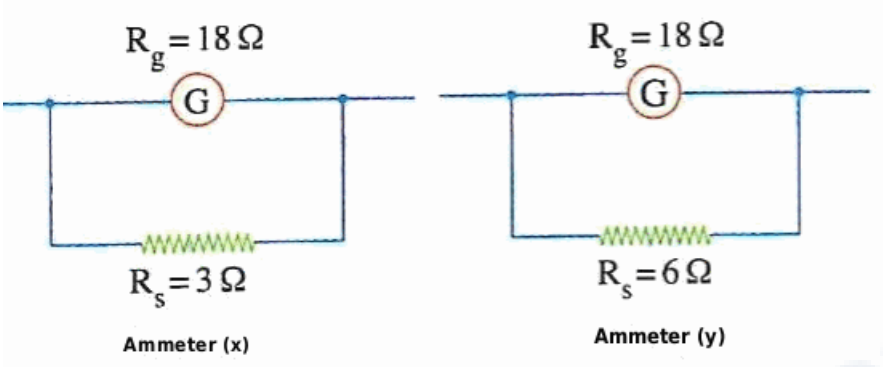


Figure (2)

(A) In figure (1)
(B) In figure (2)
(C) Equal in both figures
(D) Cannot be determined

43 The opposite figure shows two identical galvanometers, each connected to a shunt to convert it into an ammeter. The ratio of the maximum currents the two ammeters measure (I_x/I_y) is .....



(A) *4/7*
(B) *2/1*
(C) *3/1*
(D) *7/4*

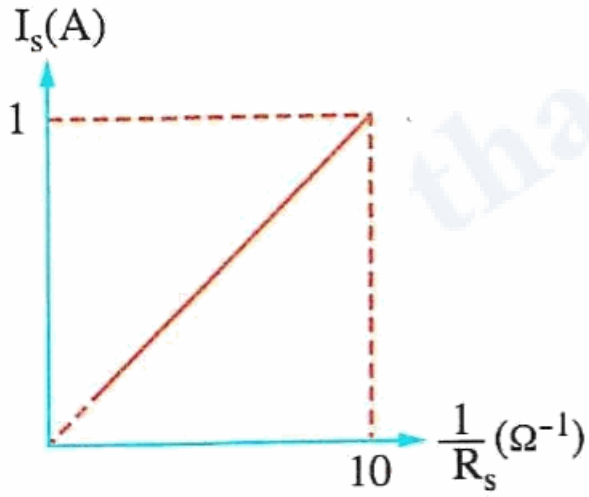
44 A moving-coil galvanometer has a full-scale reading of 500 μA, and its pointer deflects to it when the potential difference across it is 0.04 V. The resistance of the shunt that converts it into an ammeter measuring currents up to 500 mA equals .....

(A) 0.07 Ω (B) 0.035 Ω (C) 0.4 Ω (D) 0.08 Ω

45 An ammeter deflects to the end of its scale when a current of 200 mA passes through it, and when the ammeter reads 50 mA the potential difference across it is 0.04 V. The shunt that makes it suitable for measuring currents up to 2 A equals .....

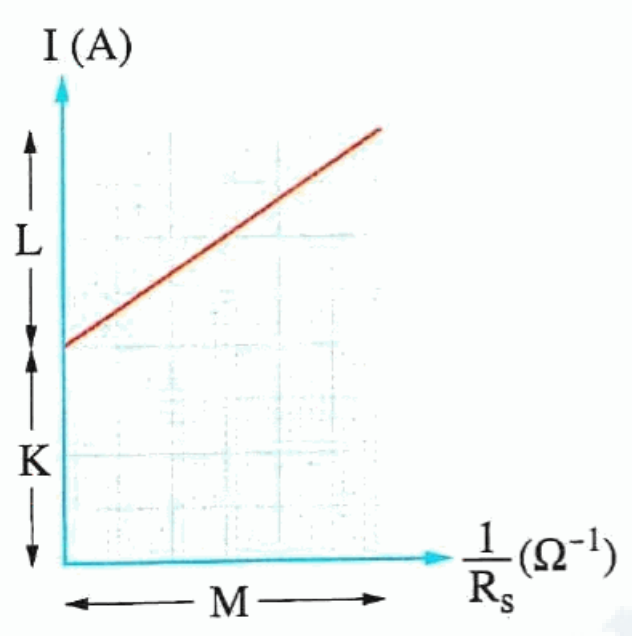
(A) 0.089 Ω (B) 0.037 Ω (C) 0.52 Ω (D) 0.41 Ω

46 A sensitive galvanometer with a coil resistance of 50 Ω is converted into an ammeter. The opposite graph represents the relation between the current through the shunt (I_s) when the galvanometer pointer deflects to the end of its scale and the reciprocal of the shunt resistance $(1/R_s)$. The full-scale reading of the galvanometer (I_g) is .....



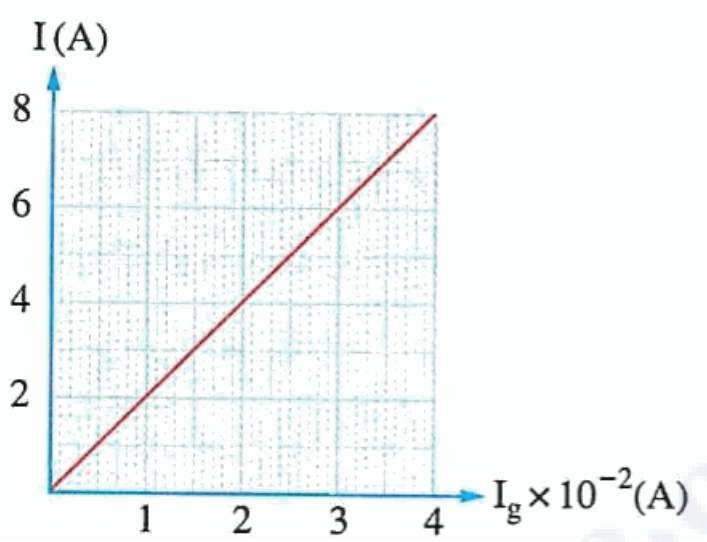
(A) 2×10^{-3} A (B) 3×10^{-2} A (C) 6×10^{-3} A (D) 9×10^{-2} A

47 An ammeter consists of a galvanometer of resistance R_g and a variable resistance (R_s) acting as a shunt. The opposite graph represents the relation between the current (I) measured by the ammeter and the reciprocal of the shunt resistance $(1/R_s)$. The resistance of the galvanometer is calculated from the relation .....



(A) $R_g = L/M$ (B) $R_g = L/KM$ (C) $R_g = M/L$ (D) $R_g = (L + K)/M$

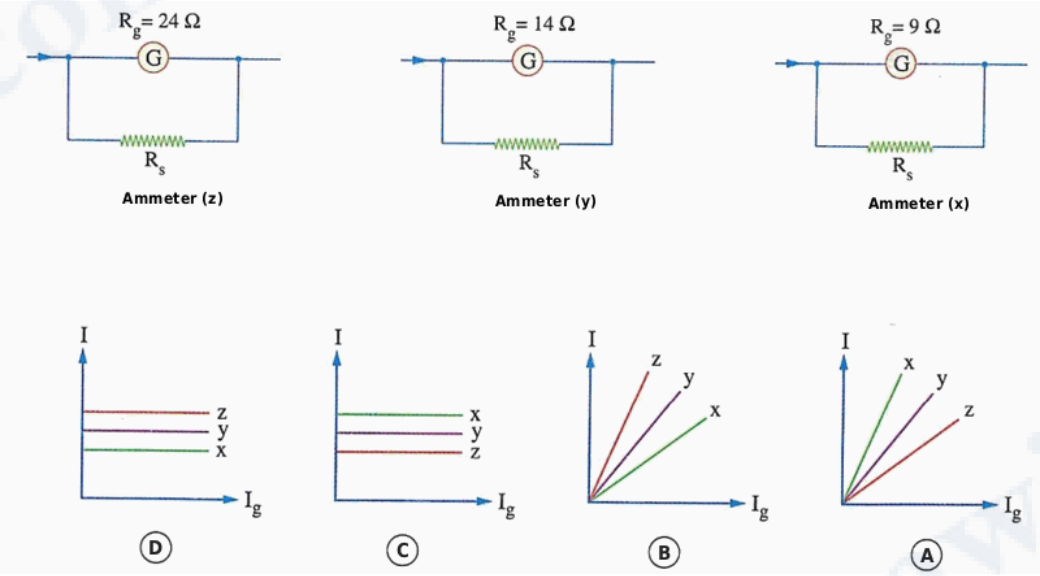
48 A sensitive galvanometer with a coil resistance of 6 Ω is connected to a shunt R_s to convert it into an ammeter, and the ammeter is connected in a circuit. The opposite graph represents the relation between the ammeter reading (I) and the current (I_g) through the galvanometer coil. The shunt R_s equals .....



(A) 0.1 Ω (B) 0.03 Ω (C) 0.5 Ω (D) 0.8 Ω

49 A shunt of resistance R_s is connected to each of three galvanometers of different resistances, separately, to form three ammeters x, y and z, as in the following figures.

Which of the following graphs represents the relation between the current measured by the ammeter (I) and the current through the galvanometer (I_g)?



50 A moving-coil galvanometer with a coil resistance of 100 Ω has each division of its scale indicating a current of 25 mA. If its coil is connected to a shunt of resistance 0.05 Ω, the current indicated by one division becomes .....

(A) 30.06 A (B) 40.01 A (C) 25.02 A (D) 50.025 A

51 A moving-coil galvanometer has a maximum deflection angle from zero of 80°. If a current of 30 mA passes through it, its deflection angle from zero is 60°. Then:

the sensitivity of the galvanometer equals .....

(A) 5 deg/mA (B) 3 deg/mA (C) 2 deg/mA (D) 1 deg/mA

52 A moving-coil galvanometer has a maximum deflection angle from zero of 80°. If a current of 30 mA passes through it, its deflection angle from zero is 60°. Then:

the maximum current the galvanometer coil can carry equals .....

(A) 0.02 A (B) 0.04 A (C) 0.06 A (D) 0.08 A

53 A moving-coil galvanometer has a maximum deflection angle from zero of 80°. If a current of 30 mA passes through it, its deflection angle from zero is 60°. Then:
the maximum current the instrument can measure if its coil is connected to a shunt of 0.01 of its coil resistance equals .....

(A) 1.51 A (B) 2.12 A (C) 3.75 A (D) 4.04 A

54 A galvanometer with a coil resistance of 20 Ω has a shunt connected in parallel with it, consisting of a wire 20 cm long with a resistance of 5 Ω, and the maximum current the instrument measures is 1 A. If another wire of the same material and the same cross-sectional area but half the length of the first wire is used as a shunt with the same galvanometer, the maximum current the instrument measures becomes .....

(A) 1.2 A (B) 1.4 A (C) 1.6 A (D) 1.8 A

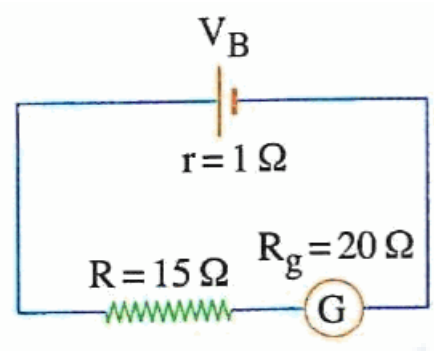
55 A sensitive galvanometer measures a maximum current of 8×10^{-3} A when connected to a 1 Ω shunt, and a maximum current of 71×10^{-3} A when connected to a 0.1 Ω shunt. Then:
(1) the resistance of the galvanometer coil equals .....

(A) 7 Ω (B) 9 Ω (C) 11 Ω (D) 15 Ω

56 A sensitive galvanometer measures a maximum current of 8×10^{-3} A when connected to a 1 Ω shunt, and a maximum current of 71×10^{-3} A when connected to a 0.1 Ω shunt. Then:
(2) the maximum current the galvanometer coil can carry equals .....

(A) 1×10^{-3} A (B) 2×10^{-3} A (C) 3×10^{-3} A (D) 4×10^{-3} A

57 The opposite circuit consists of a battery V_B of internal resistance 1 Ω connected to a fixed resistance of 15 Ω and a galvanometer of coil resistance 20 Ω. The ratio between the currents in the circuit before and after connecting the galvanometer coil to a 5 Ω shunt equals .....



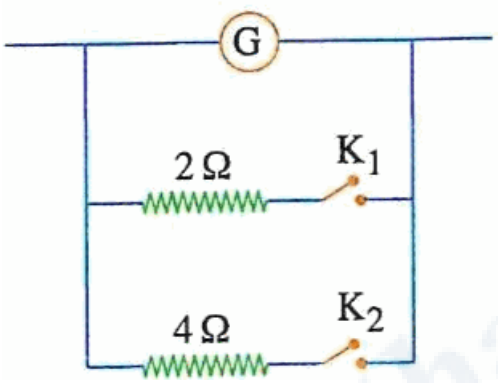
(A) 5/9 (B) 9/5 (C) 4/3 (D) 3/4

58 A galvanometer with a coil resistance of 10 Ω and a maximum measurable current of 40 mA is connected to a shunt (R_s), then connected in a circuit containing an 8 Ω resistance and a cell of emf 1.5 V with negligible internal resistance. When the circuit is closed, the galvanometer pointer deflects to $3/4$ of its scale. The shunt equals .....

(A) 7.6 Ω (B) 5 Ω (C) 2.5 Ω (D) 0.3 Ω

59 In the opposite figure, a galvanometer can be connected to one of two shunts or to both. When only switch K_1 is closed, the sensitivity of the instrument drops to one quarter and it becomes suitable for measuring a current of 0.5 A. Then:

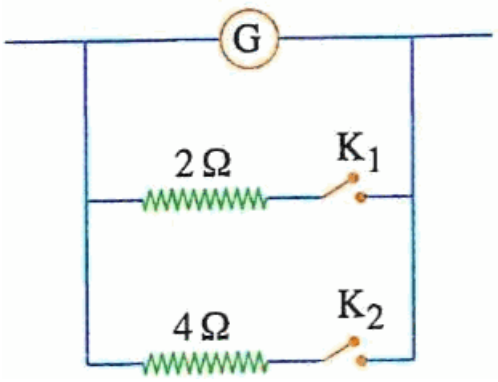
(1) the maximum current that can be measured when only switch K_2 is closed equals .....



(A) 0.45 A (B) 0.31 A (C) 0.25 A (D) 0.17 A

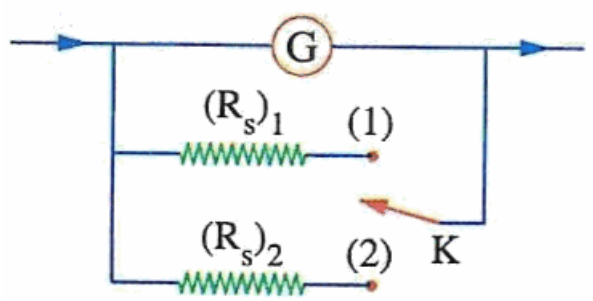
60 In the opposite figure, a galvanometer can be connected to one of two shunts or to both. When only switch K_1 is closed, the sensitivity of the instrument drops to one quarter and it becomes suitable for measuring a current of 0.5 A. Then:

(2) the maximum current that can be measured when both switches K_1 and K_2 are closed equals .....



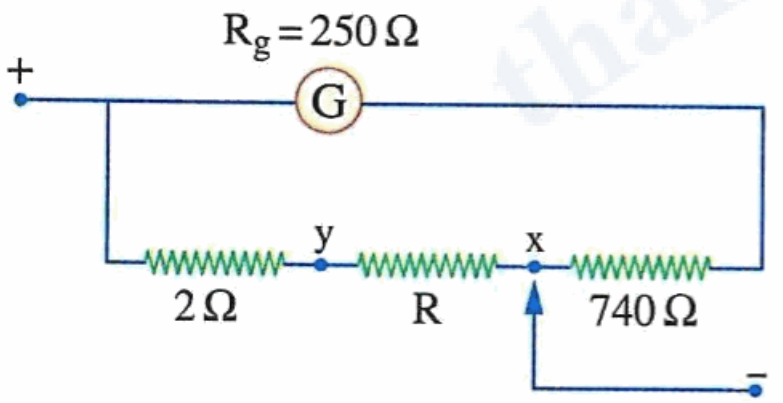
(A) 0.38 A (B) 0.43 A (C) 0.52 A (D) 0.69 A

61 A galvanometer is connected to a two-way switch (K) as in the opposite figure. When the switch is at position (1), 90% of the total current passes through the shunt $(R_s)_1$, and when the switch is at position (2), 99% of the total current passes through the shunt $(R_s)_2$. The ratio between the resistances of the two shunts $((R_s)_1)/((R_s)_2)$ equals .....



(A) 10 (B) 11 (C) 9 (D) 99

62 A galvanometer with a coil resistance of 250 Ω and a maximum measurable current of 0.1 A has several resistances connected to it to form an ammeter, as in the opposite figure. When the slider is at position (x), the maximum reading of the instrument is 10 A. The maximum reading of the instrument after moving the slider to position (y) is .....



(A) 20 A (B) 30 A (C) 40 A (D) 50 A

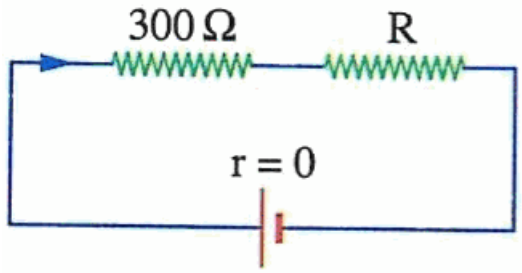
63 A circuit consists of a battery of negligible internal resistance, a fixed resistance of 350 Ω and a galvanometer connected in parallel with a 20 Ω shunt. If the shunt is replaced by another of 30 Ω, the fixed resistance must be changed to 450 Ω so that the deflection of the galvanometer pointer stays the same. The resistance of the galvanometer equals .....

(A) 20 Ω (B) 40 Ω (C) 60 Ω (D) 80 Ω

64 Three voltmeters (A, B, C) have the same range and resistances of 1000 Ω, 4000 Ω and 8000 Ω respectively. The most accurate voltmeter when used to measure the potential difference between the same two points in a circuit is .....

(A) voltmeter A
(B) voltmeter B
(C) voltmeter C
(D) they all have the same accuracy

65 In the opposite circuit, the potential difference across the 300 Ω resistance is (V_1). When a voltmeter of resistance 3000 Ω is connected across the 300 Ω resistance, its reading is (V_2), and when a voltmeter of resistance 6000 Ω is connected across the 300 Ω resistance, its reading is (V_3). Which of the following relations is correct for (V_1), (V_2) and (V_3)?



(A) $V_1 = V_2 = V_3$ (B) $V_1 > V_2 > V_3$ (C) $V_1 > V_3 > V_2$ (D) $V_1 < V_2 < V_3$

66 A galvanometer deflects to the end of its scale when a current of 50 μA passes through it. It is converted into a voltmeter with a full-scale reading of 10 V. Then:

(1) the total resistance of the voltmeter equals .....

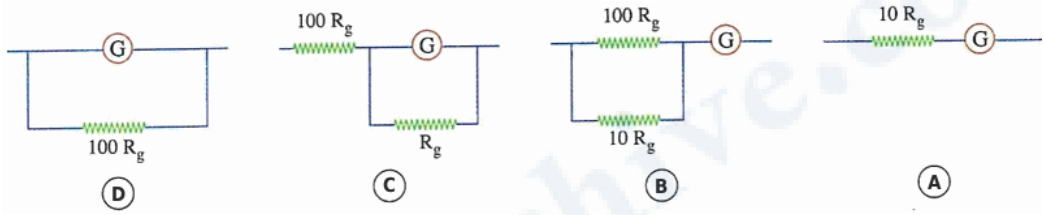
(A) $100 \times 10^3\ \Omega$ (B) $200 \times 10^3\ \Omega$ (C) $300 \times 10^3\ \Omega$ (D) $400 \times 10^3\ \Omega$

67 A galvanometer deflects to the end of its scale when a current of 50 μA passes through it. It is converted into a voltmeter with a full-scale reading of 10 V. Then:

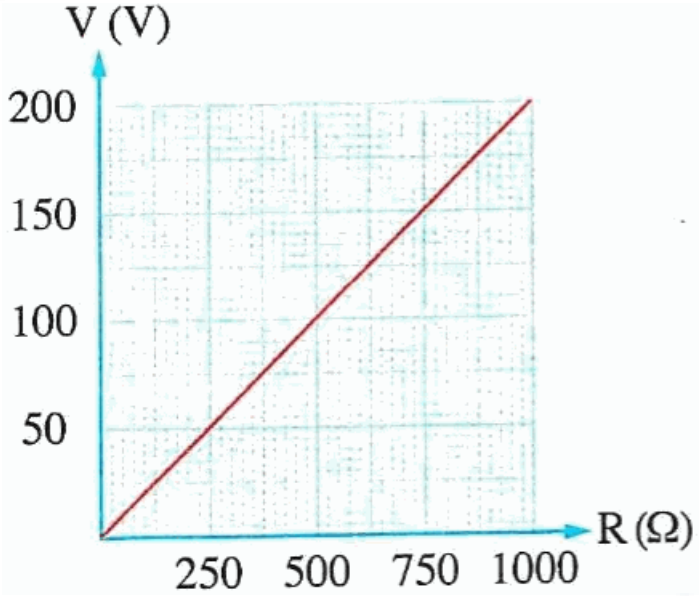
(2) the multiplier, if the resistance of the galvanometer coil is 1 kΩ, equals .....

(A) $111 \times 10^3\ \Omega$ (B) $150 \times 10^3\ \Omega$ (C) $199 \times 10^3\ \Omega$ (D) $245 \times 10^3\ \Omega$

68 Four identical galvanometers, each of resistance R_g, are each connected to one or more resistances as in the following figures. Which of the following voltmeters can withstand the greatest potential difference?

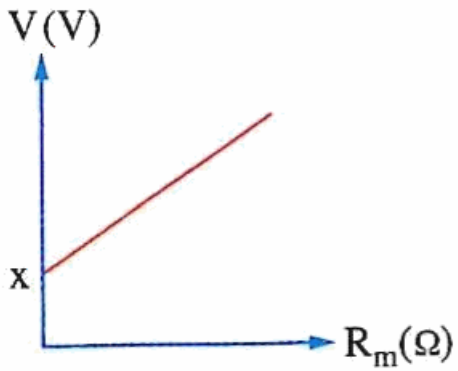


69 A sensitive galvanometer can measure a maximum current I_g. Several multipliers are connected to the galvanometer, each separately, to convert it into a voltmeter. The opposite graph represents the relation between the maximum potential difference measured by the voltmeter (V) and the total resistance of the voltmeter (R). The value of I_g is .....



(A) 0.1 A (B) 0.2 A (C) 0.25 A (D) 0.5 A

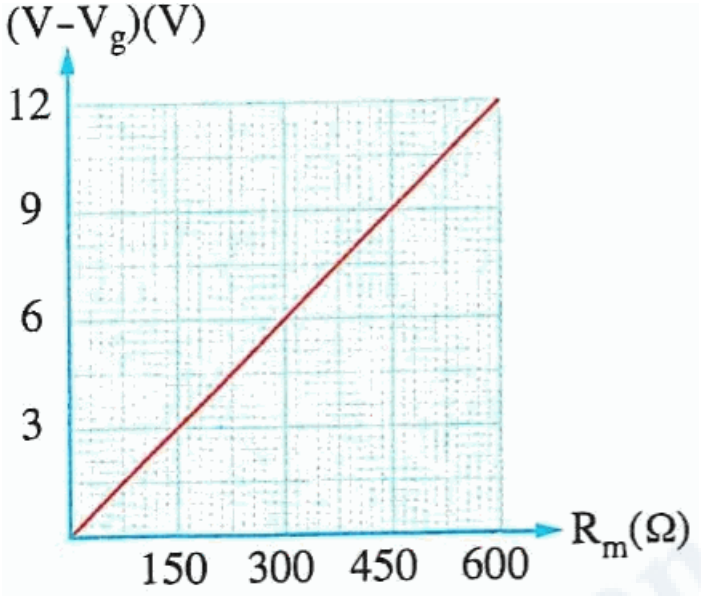
70 The opposite graph represents the relation between the total potential difference (V) across a voltmeter and the multiplier (R_m) of the voltmeter. The value (x) divided by the slope of the line represents .....



(A) R_g (B) V_m (C) $1/I_m$ (D) V_g

71 The opposite graph represents the change of the difference between the maximum potential difference measured by the galvanometer after and before connecting a multiplier $(V - V_g)$ with the multiplier (R_m):

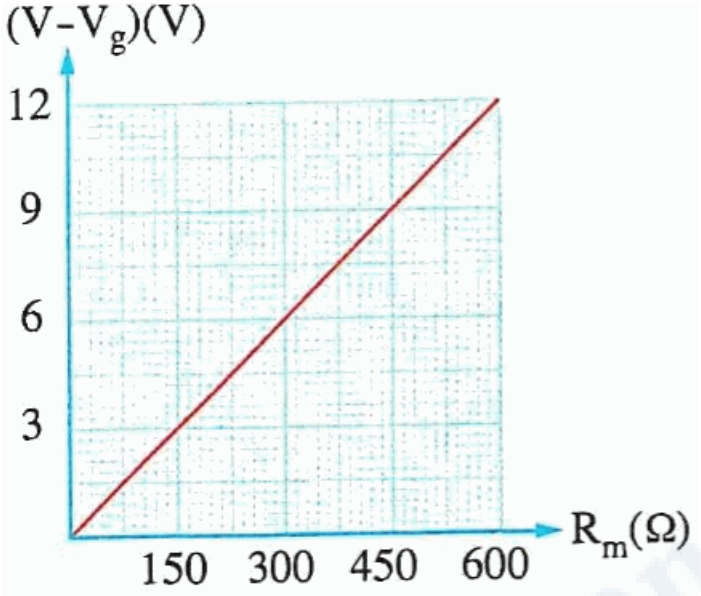
(1) the maximum current the galvanometer can carry before connecting the multiplier equals .....



(A) 0.01 A (B) 0.02 A (C) 0.03 A (D) 0.04 A

72 The opposite graph represents the change of the difference between the maximum potential difference measured by the galvanometer after and before connecting a multiplier $(V - V_g)$ with the multiplier (R_m):

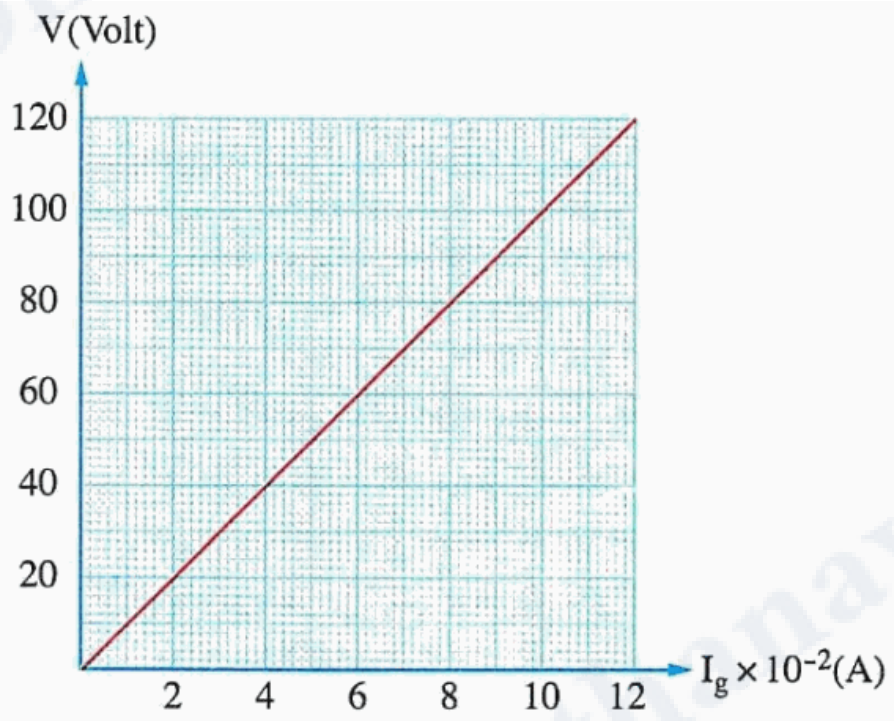
(2) if the maximum potential difference the galvanometer coil can withstand before connecting the multiplier is 1 V, the resistance of the galvanometer coil equals .....



(A) 30 Ω (B) 50 Ω (C) 80 Ω (D) 100 Ω

73 A sensitive galvanometer with a coil resistance of 50 Ω and a maximum coil current of 0.12 A is connected to a multiplier (R_m) to convert it into a voltmeter. The opposite graph represents the relation between the voltmeter reading (V) and the current through its coil (I_g). Then:

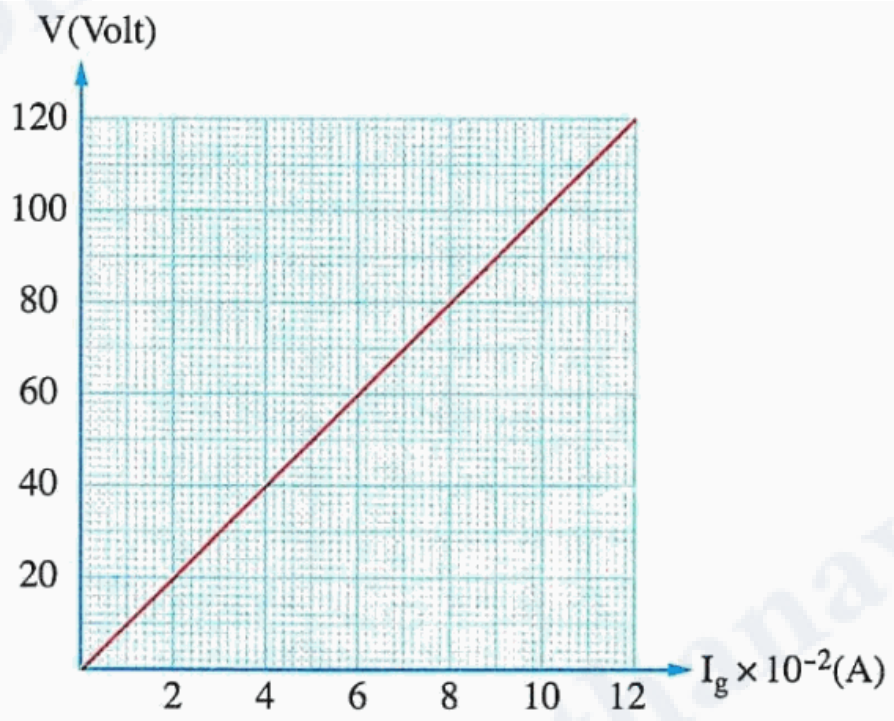
(1) the multiplier (R_m) equals .....



(A) 125 Ω (B) 240 Ω (C) 460 Ω (D) 950 Ω

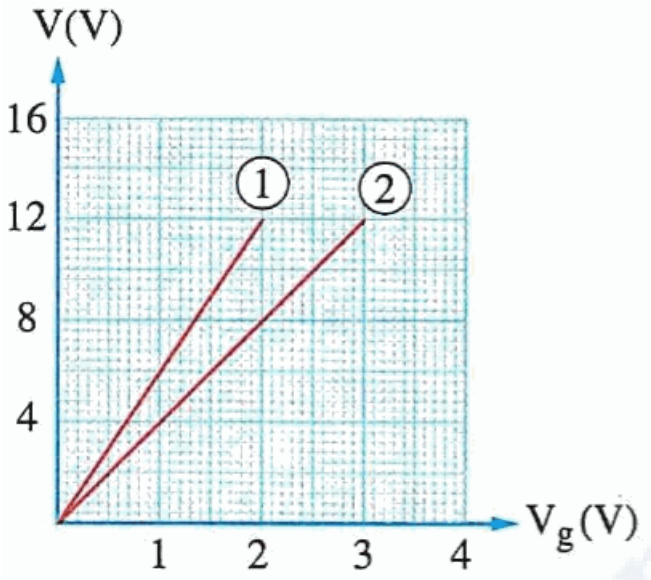
74 A sensitive galvanometer with a coil resistance of 50 Ω and a maximum coil current of 0.12 A is connected to a multiplier (R_m) to convert it into a voltmeter. The opposite graph represents the relation between the voltmeter reading (V) and the current through its coil (I_g). Then:

(2) the maximum potential difference that can be measured by the voltmeter equals .....



(A) 90 V (B) 120 V (C) 210 V (D) 180 V

75 A sensitive galvanometer can measure a maximum potential difference (V_g). It is connected to two multipliers, 1 kΩ and R, each separately, to convert it into two voltmeters (1) and (2) respectively. The opposite graph represents the relation between the potential difference across each voltmeter (V) and the potential difference across the galvanometer (V_g). The multiplier R equals .....



(A) 200 Ω (B) 400 Ω (C) 600 Ω (D) 800 Ω

76 If the multiplier resistance in a voltmeter is ten times the galvanometer resistance, the maximum potential difference measured by the voltmeter equals ..... (where (V_g) is the maximum potential difference the galvanometer can withstand)

(A) $10\ V_g$ (B) $9\ V_g$ (C) $0.1\ V_g$ (D) $11\ V_g$

77 A voltmeter consists of a galvanometer of resistance R and a multiplier of resistance 50 R. Which of the following ratios has a value of 0.02?

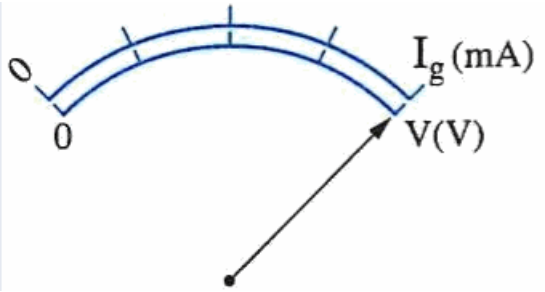
(A) The ratio of the current in the galvanometer to the current in the voltmeter

(B) The ratio of the current in the galvanometer to the current in the multiplier

(C) The ratio of the potential difference across the multiplier to the potential difference across the voltmeter

(D) The ratio of the potential difference across the galvanometer to the potential difference across the multiplier

78 The opposite figure shows the scale of a galvanometer after calibrating it into a voltmeter scale. What does the ratio of the voltmeter scale reading to the galvanometer scale reading (V/I_g) represent?



(A) $R_m + R_g$ (B) $R_m - R_g$ (C) $R_m R_g$ (D) R_m/R_g

79 A galvanometer of resistance 100 Ω and maximum current 0.01 A is to be converted into a voltmeter. Then:

(1) the multiplier that makes it measure potential differences up to 5 V is .....

(A) 5 Ω (B) 100 Ω (C) 400 Ω (D) 500 Ω

80 A galvanometer of resistance 100 Ω and maximum current 0.01 A is to be converted into a voltmeter. Then:

(2) the maximum potential difference it measures when connected to a 900 Ω multiplier is .....

(A) 0.9 V (B) 9 V (C) 10 V (D) 90 V

81 A galvanometer deflects to the end of its scale when a current of 0.02 A passes through it, and the potential difference across it is then 5 V. Then:

(1) the multiplier that makes it suitable for measuring a potential difference of 150 V equals .....

(A) 2916 Ω (B) 4374 Ω (C) 5841 Ω (D) 7250 Ω

82 A galvanometer deflects to the end of its scale when a current of 0.02 A passes through it, and the potential difference across it is then 5 V. Then:

(2) the resistance of the galvanometer coil equals .....

(A) 110 Ω (B) 250 Ω (C) 315 Ω (D) 520 Ω

83 In a voltmeter, the ratio of the current in the galvanometer coil to the current in the multiplier connected to it is always .....

(A) greater than one
(B) equal to one
(C) less than one
(D) cannot be determined

84 The greater the multiplier resistance in a voltmeter, the .....

(A) smaller the total resistance of the instrument
(B) greater the sensitivity of the instrument
(C) smaller the range of the instrument for measuring potential difference
(D) greater the accuracy of the instrument in measuring potential difference

85 A voltmeter of resistance 2000 Ω can measure a maximum potential difference of 2 V. When a multiplier R_m is connected to it, its range increases by 8 V. The value of R_m is .....

(A) 2000 Ω (B) 4000 Ω (C) 6000 Ω (D) 8000 Ω

86 A voltmeter of resistance 500 Ω has each of its divisions indicating 0.1 V. The multiplier that must be connected to the voltmeter to make each division indicate 1 V is .....

(A) 5000 Ω (B) 2400 Ω (C) 4500 Ω (D) 2700 Ω

87 A galvanometer with a coil resistance of 5 Ω measures a maximum current of 20 mA. Then:
(1) the maximum current the galvanometer can measure if connected to a shunt of 0.1 Ω equals .....

(A) 0.96 A (B) 1.02 A (C) 3.16 A (D) 4.05 A

88 A galvanometer with a coil resistance of 5 Ω measures a maximum current of 20 mA. Then:
(2) the multiplier connected to the galvanometer to make it work as a voltmeter measuring a maximum potential difference of 5 V equals .....

(A) 100 Ω (B) 175 Ω (C) 245 Ω (D) 332 Ω

89 A moving-coil galvanometer has a coil resistance of 18 Ω. Then:
(1) the shunt resistance that allows *1/3* of the total current to pass through the galvanometer coil equals .....

(A) 3 Ω (B) 6 Ω (C) 9 Ω (D) 12 Ω

90 A moving-coil galvanometer has a coil resistance of 18 Ω. Then:

(2) the multiplier resistance that makes the galvanometer suitable for measuring a potential difference ten times the potential difference across its coil equals .....

(A) 162 Ω (B) 81 Ω (C) 324 Ω (D) 202.5 Ω

91 A moving-coil galvanometer becomes suitable for measuring a maximum current of 0.11 A when connected to a 0.5 Ω shunt, and for measuring a maximum potential difference of 2.5 V when connected to a 245 Ω multiplier. Then:

(1) the maximum current the galvanometer coil can carry (I_g) equals .....

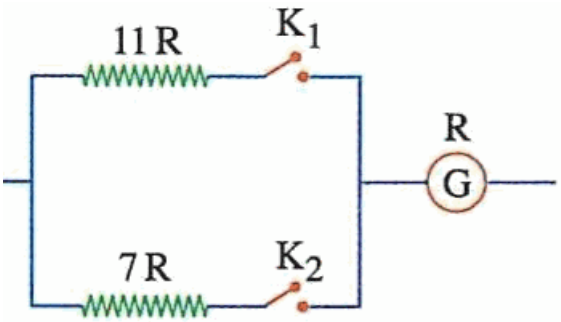
(A) 0.5 A (B) 0.25 A (C) 0.01 A (D) 0.005 A

92 A moving-coil galvanometer becomes suitable for measuring a maximum current of 0.11 A when connected to a 0.5 Ω shunt, and for measuring a maximum potential difference of 2.5 V when connected to a 245 Ω multiplier. Then:

(2) the resistance of the galvanometer equals .....

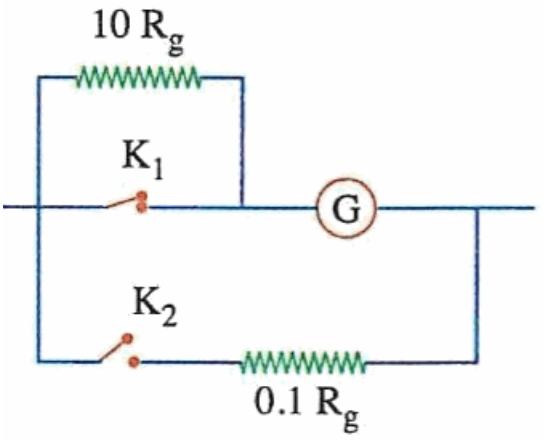
(A) 5 Ω (B) 3 Ω (C) 2.5 Ω (D) 1.5 Ω

93 In the opposite figure, a galvanometer of resistance (R) is connected to two multipliers, 7 R and 11 R. When only switch (K_1) is closed, the maximum reading of the instrument is 24 V. The maximum reading of the instrument when only switch (K_2) is closed decreases by .....



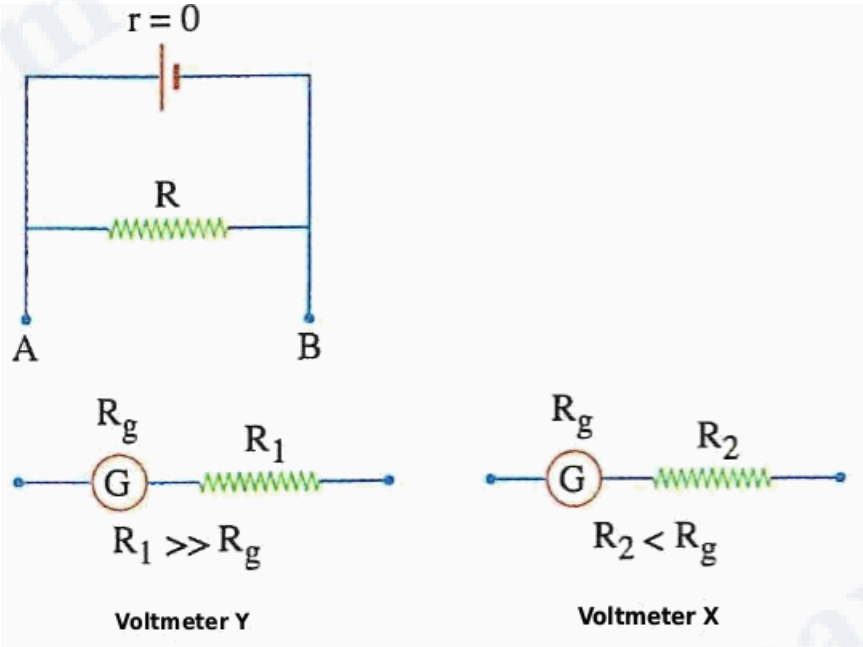
(A) 6 V (B) 8 V (C) 12 V (D) 16 V

94 In the opposite figure, part of a circuit contains a galvanometer of resistance R_g and maximum current I_g. When switch K_1 is open, it becomes a voltmeter measuring a maximum potential difference of 11 V, and when both switches K_1 and K_2 are closed, the galvanometer becomes an ammeter measuring a maximum current of 0.11 A. The values of I_g and R_g are .....



(A) I_g: 0.1 A, R_g: 10 Ω
(B) I_g: 0.1 A, R_g: 100 Ω
(C) I_g: 0.01 A, R_g: 10 Ω
(D) I_g: 0.01 A, R_g: 100 Ω

95 Two voltmeters X and Y each contain the same galvanometer and a different multiplier. Which statement correctly describes the movement of the pointer of each voltmeter when each is connected separately between points A and B in the circuit shown in the figure?



(A) The pointer of instrument X deflects through a greater angle

(B) The pointer of instrument Y deflects through a greater angle

(C) The pointers of both instruments deflect through the same angle

(D) The pointers of the two voltmeters do not deflect

---

96 A circuit contains a 10 Ω resistance connected in parallel with a voltmeter of resistance 50 Ω. When a total current of 0.6 A passes in the circuit, the voltmeter pointer deflects to the end of its scale. Then:

(1) the voltmeter reading then equals .....

(A) 2 V (B) 3 V (C) 5 V (D) 9 V

---

97 A circuit contains a 10 Ω resistance connected in parallel with a voltmeter of resistance 50 Ω. When a total current of 0.6 A passes in the circuit, the voltmeter pointer deflects to the end of its scale. Then:

(2) the maximum potential difference the voltmeter can measure if its coil is connected in series with a 4950 Ω resistance equals .....

(A) 100 V (B) 250 V (C) 370 V (D) 500 V

---

98 A circuit has a fixed resistance of 6 Ω with a voltmeter of resistance 30 Ω connected in parallel with it. When a current of 0.2 A passes in the circuit, the voltmeter pointer deflects to the end of the scale. If a resistance (multiplier) of 144 Ω is connected in series with the voltmeter and the same current passes in the circuit, then:

(1) the voltmeter reading in this case equals .....

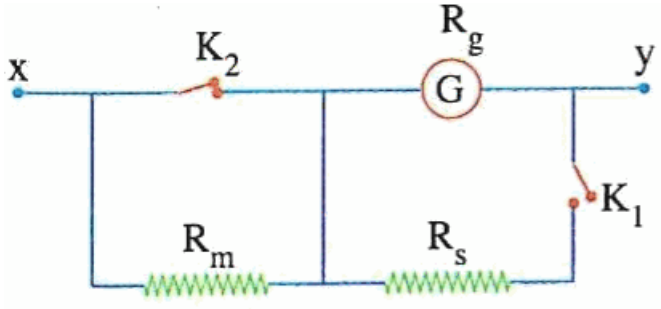
(A) 3.48 V (B) 2.34 V (C) 1.16 V (D) 0.98 V

99 A circuit has a fixed resistance of 6 Ω with a voltmeter of resistance 30 Ω connected in parallel with it. When a current of 0.2 A passes in the circuit, the voltmeter pointer deflects to the end of the scale. If a resistance (multiplier) of 144 Ω is connected in series with the voltmeter and the same current passes in the circuit, then:

(2) the maximum potential difference the instrument can measure after connecting the multiplier equals .....

(A) 7.2 V (B) 9.6 V (C) 11.2 V (D) 5.8 V

100 An electric measuring instrument xy consists of a galvanometer, a multiplier (R_m), a shunt (R_s) and two switches K_1 and K_2, as in the opposite figure. When both switches are open, the sensitivity of the instrument for measuring potential difference decreases to one quarter, and when both switches are closed, the sensitivity of the instrument for measuring current decreases to one quarter. The ratio (R_m/R_s) equals .....



(A) 3 (B) 4 (C) 9 (D) 16

101 A sensitive galvanometer with a coil resistance of 4 Ω and a maximum current of 1 mA has its coil connected in parallel with a 1 Ω resistance to form one instrument. This instrument is then connected in series with a 999.2 Ω resistance to form a voltmeter. The maximum potential difference this voltmeter can measure equals .....

(A) 2 V (B) 5 V (C) 7 V (D) 9 V

102 A milliammeter deflects to the end of its scale when a current of 10 mA passes through it. If the instrument contains a 0.2 Ω resistance connected in parallel with a galvanometer of resistance 33 Ω, the resistance that must be connected in series to convert the milliammeter into a voltmeter measuring potential differences up to 10 V equals .....

(A) 880.2 Ω (B) 950.3 Ω (C) 999.8 Ω (D) 1250.4 Ω

---

103 A circuit contains a cell of emf 10 V and negligible internal resistance, connected to two resistances of 16 Ω and 40 Ω in series. When a voltmeter is connected in parallel with the 40 Ω resistance, it reads 6 V:

(1) the resistance of the voltmeter equals .....

(A) 25 Ω (B) 53 Ω (C) 60 Ω (D) 67 Ω

---

104 A circuit contains a cell of emf 10 V and negligible internal resistance, connected to two resistances of 16 Ω and 40 Ω in series. When a voltmeter is connected in parallel with the 40 Ω resistance, it reads 6 V:

(2) if the maximum reading of the voltmeter is 7.5 V, the shunt resistance that converts it into an ammeter measuring a maximum current of 5 A equals .....

(A) 0.6 Ω (B) 1.54 Ω (C) 2.17 Ω (D) 3.72 Ω

---

105 A galvanometer of resistance R_g is connected to two multipliers, 950 Ω and 3950 Ω, each separately, to convert it into two voltmeters (1) and (2). If the ratio between the maximum potential differences the two voltmeters can measure (V_1/V_2) equals $1/4$, the resistance of the galvanometer (R_g) equals .....

(A) 20 Ω (B) 36 Ω (C) 50 Ω (D) 100 Ω

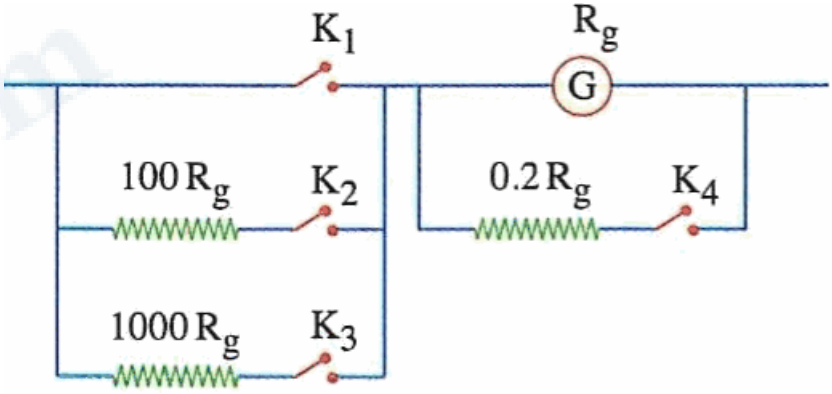
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106 A galvanometer can measure a maximum potential difference (V_g). When connected to two multipliers R_1 and R_2, each separately, the maximum potential difference each instrument can measure is nV_g and mV_g respectively. The ratio (R_1/R_2) equals .....

(A) $(n-1)/(m-1)$ (B) $(n+1)/(m+1)$ (C) $(m-1)/(n-1)$ (D) $(m+1)/(n+1)$

---

107 In the opposite figure, to convert the galvanometer into a voltmeter measuring the greatest possible potential difference, the switches that must be closed are .....



(A) K_1, K_4 (B) K_1, K_3 (C) K_3, K_4 (D) K_2, K_4

108 When the ohmmeter circuit is closed and its pointer reaches the end of the current scale, the measured resistance is .....

(A) large (B) small (C) zero (D) infinite

109 The terminals of an ohmmeter are connected to the ends of a resistance R, and its pointer deflects to the middle of the current scale. The resistance R .....

(A) is infinite

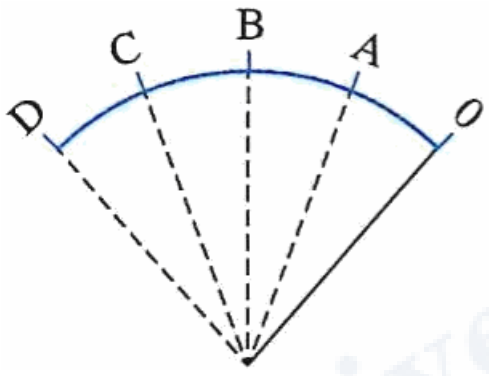
(B) equals the resistance of the ohmmeter

(C) equals zero

(D) is greater than the resistance of the ohmmeter

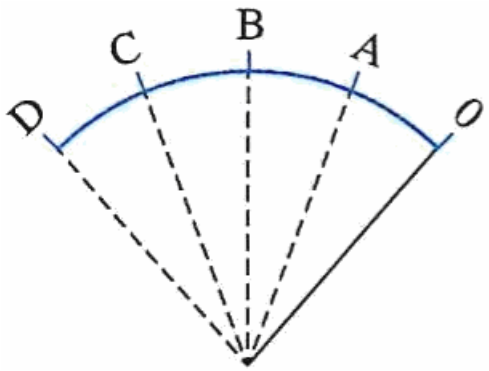
110 The opposite figure represents equal divisions on the resistance scale of an ohmmeter whose pointer was adjusted to the zero of the scale:

(1) which of the marks shown on the scale indicates the value of the ohmmeter's resistance?



111 The opposite figure represents equal divisions on the resistance scale of an ohmmeter whose pointer was adjusted to the zero of the scale:

(2) when the pointer settles at mark C, this means that the value C .....



(A) is less than the resistance of the ohmmeter

(B) equals the sum of the ohmmeter resistance and the resistance connected to its terminals

(C) is twice the resistance of the ohmmeter

(D) equals the resistance connected between the terminals of the ohmmeter

---

112 A milliammeter with a coil resistance of 4 Ω and a maximum coil current of 16 mA is to be converted into an ohmmeter using a dry cell of emf 1.5 V and internal resistance 1.75 Ω. Then:

(1) the standard resistance needed equals .....

(A) 25 Ω (B) 43 Ω (C) 88 Ω (D) 95 Ω

---

113 A milliammeter with a coil resistance of 4 Ω and a maximum coil current of 16 mA is to be converted into an ohmmeter using a dry cell of emf 1.5 V and internal resistance 1.75 Ω. Then:

(2) the external resistance that makes its pointer deflect to 10 mA equals .....

(A) 311.75 Ω (B) 150.9 Ω (C) 112.5 Ω (D) 56.25 Ω

---

114 A milliammeter with a coil resistance of 4 Ω and a maximum coil current of 16 mA is to be converted into an ohmmeter using a dry cell of emf 1.5 V and internal resistance 1.75 Ω. Then:

(3) the current through it if it is connected to an external resistance of 300 Ω equals .....

(A) 2×10^{-3} A (B) 3.8×10^{-3} A (C) 5×10^{-3} A (D) 6.4×10^{-3} A

---

115 A galvanometer with a coil resistance of 250 Ω deflects to the end of the scale when a current of 400 μA passes through it. It is connected to a cell of emf 1.5 V with negligible internal resistance, a fixed resistance of 3000 Ω and a variable resistance R_v. Then:

(1) the resistance taken from the variable resistance to convert the galvanometer into an ohmmeter equals .....

(A) 2000 Ω (B) 1500 Ω (C) 1000 Ω (D) 500 Ω

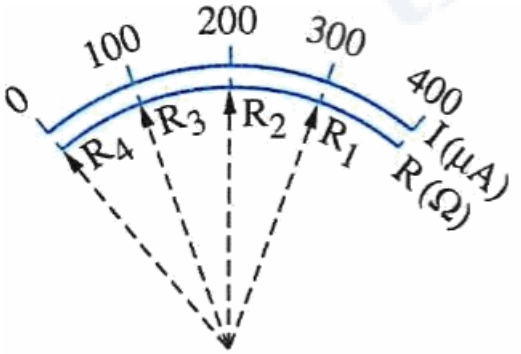
116 A galvanometer with a coil resistance of 250 Ω deflects to the end of the scale when a current of 400 μA passes through it. It is connected to a cell of emf 1.5 V with negligible internal resistance, a fixed resistance of 3000 Ω and a variable resistance R_v. Then:

(2) the resistance which, when connected to the terminals of the ohmmeter, makes the pointer deflect to one quarter of the current scale equals .....

(A) 3750 Ω (B) 7500 Ω (C) 15315 Ω (D) 11250 Ω

117 In the opposite figure, a resistance scale has been added to the current scale. If the total internal resistance of the ohmmeter is 3750 Ω and the maximum current on its scale is 400 μA, then:

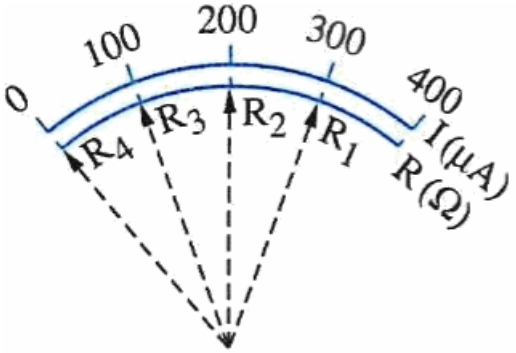
(1) the resistance R_1 equals .....



(A) 5317 Ω (B) 3750 Ω (C) 1250 Ω (D) 999 Ω

118 In the opposite figure, a resistance scale has been added to the current scale. If the total internal resistance of the ohmmeter is 3750 Ω and the maximum current on its scale is 400 μA, then:

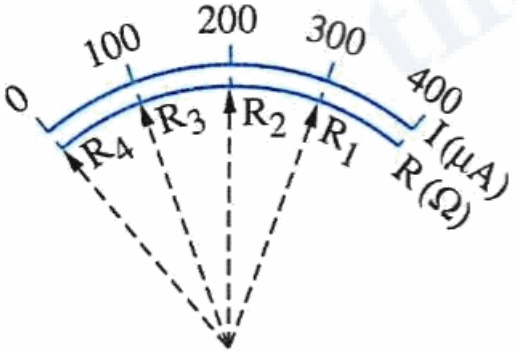
(2) the resistance R_2 equals .....



(A) 1250 Ω (B) 2500 Ω (C) 3750 Ω (D) 5412 Ω

119 In the opposite figure, a resistance scale has been added to the current scale. If the total internal resistance of the ohmmeter is 3750 Ω and the maximum current on its scale is 400 μA, then:

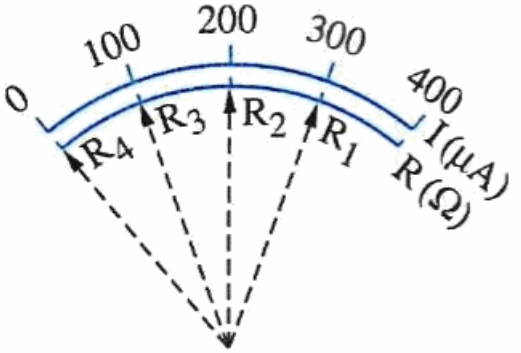
(3) the resistance R_3 equals .....



(A) 3750 Ω (B) 7500 Ω (C) 9713 Ω (D) 11250 Ω

120 In the opposite figure, a resistance scale has been added to the current scale. If the total internal resistance of the ohmmeter is 3750 Ω and the maximum current on its scale is 400 μA, then:

(4) the expected value of the resistance R_4 and the reason for it are .....



(A) value: ∞, reason: because the current there is zero

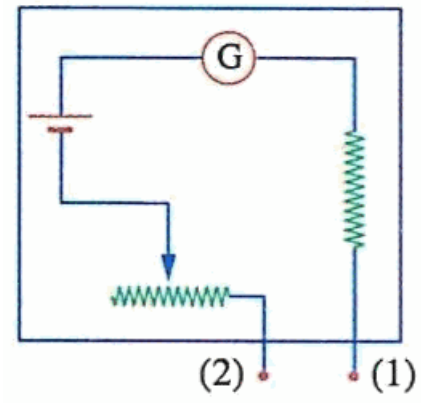
(B) value: ∞, reason: because the current there is maximum

(C) value: 0, reason: because the current there is zero

(D) value: 0, reason: because the current there is maximum

---

121 The opposite figure shows the components of an ohmmeter. The maximum deflection of the galvanometer pointer was 600 μA when terminals (1) and (2) of the ohmmeter touched each other. If a resistance R_x equal to twice the total resistance of the ohmmeter between its terminals is connected, the reading of the galvanometer pointer equals .....



(A) 200 μA (B) 300 μA (C) 600 μA (D) 1200 μA

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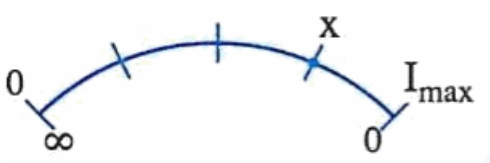
122 An ohmmeter of total resistance R_0 contains a battery of emf V_B with negligible internal resistance. When an unknown resistance R is connected to the terminals of the ohmmeter, its pointer deflects to *1/5* of the current scale. The resistance of the ohmmeter *(R_0)* equals .....

(A) 5 R (B) *R/5* (C) 4 R (D) *R/4*

123 If a resistance of 200 Ω makes the ohmmeter pointer deflect to *1/2* of the current scale, the resistance that makes it deflect to *1/3* of the current scale is .....

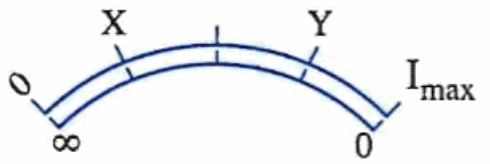
(A) 300 Ω (B) 400 Ω (C) 600 Ω (D) 1200 Ω

124 The opposite figure shows equal divisions on the scale of an ohmmeter. If an external resistance is connected between the terminals of the instrument, its pointer deflects to position x on the current scale. This resistance equals ..... the resistance of the ohmmeter.



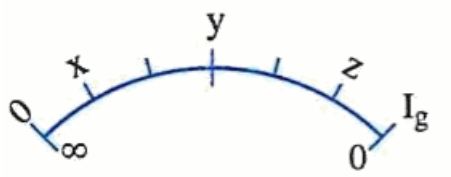
(A) one third of (B) half (C) twice (D) three times

125 The opposite figure shows equal divisions on the scale of an ohmmeter. When the instrument is used to measure an unknown resistance R, its pointer deflects to position X on the scale. The external resistance that makes the pointer deflect to position Y on the scale equals .....



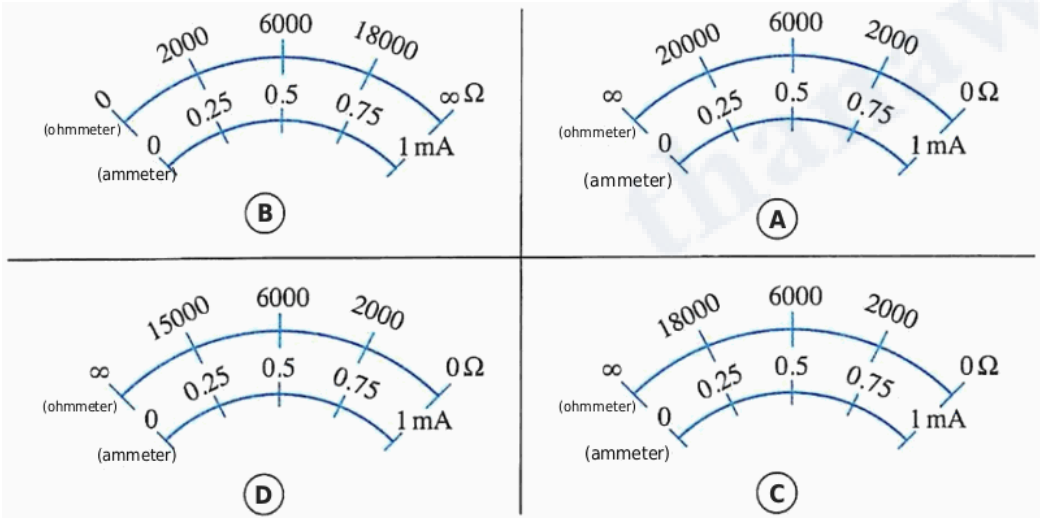
(A) *R/3* (B) 3 R (C) *R/9* (D) *3R/4*

126 The opposite figure represents equal divisions on the scale of a calibrated ohmmeter, where position y is exactly the middle of the scale. The ratio between the resistances connected between the terminals of the ohmmeter when the pointer settles at positions x and z (R_x/R_z) is .....

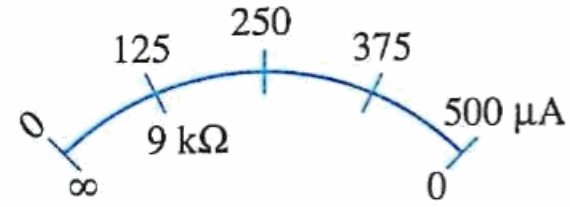


(A) 4 (B) 9 (C) 16 (D) 25

127 An ohmmeter consists of an ammeter, a standard resistance and a 6 V battery, and its pointer deflects to the end of the scale when a current of 1 mA passes through it. If an ohm scale is added to the ammeter scale, the correct figure representing the ammeter and ohmmeter scales is .....

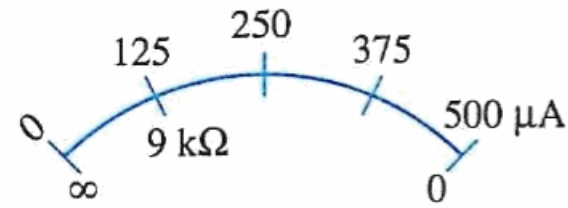


128 The opposite figure shows equal divisions on the scale of an ohmmeter. Using the given data: (1) the resistance of the ohmmeter is .....



(A) 9000 Ω (B) 6000 Ω (C) 3000 Ω (D) 1000 Ω

129 The opposite figure shows equal divisions on the scale of an ohmmeter. Using the given data:
(2) the emf of the cell in the ohmmeter is .....

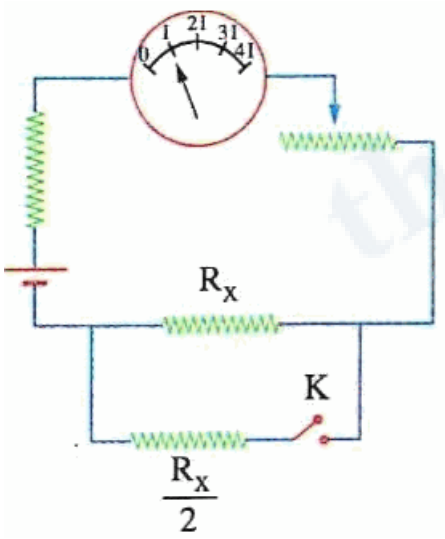


(A) 1.5 V (B) 2 V (C) 2.5 V (D) 3 V

130 An ohmmeter deflects to *1/4* of the current scale when a 300 Ω resistance is connected to it. The resistance that makes its pointer deflect to *1/6* of the current scale equals .....

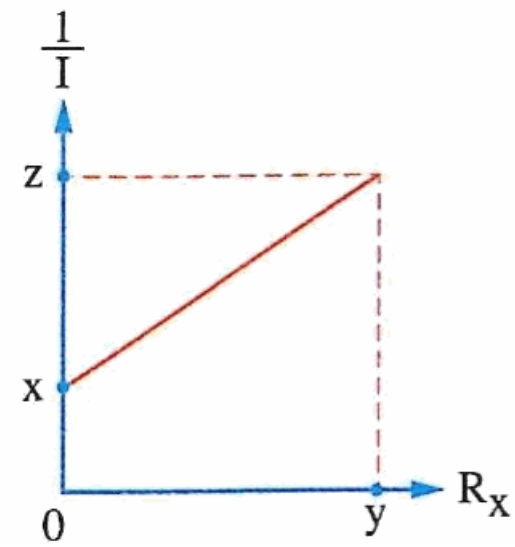
(A) 1500 Ω (B) 1000 Ω (C) 500 Ω (D) 250 Ω

131 In the ohmmeter circuit shown, when switch K is closed the pointer becomes .....



(A) at 2 I (B) between I and 2 I
(C) at 3 I (D) between 2 I and 3 I

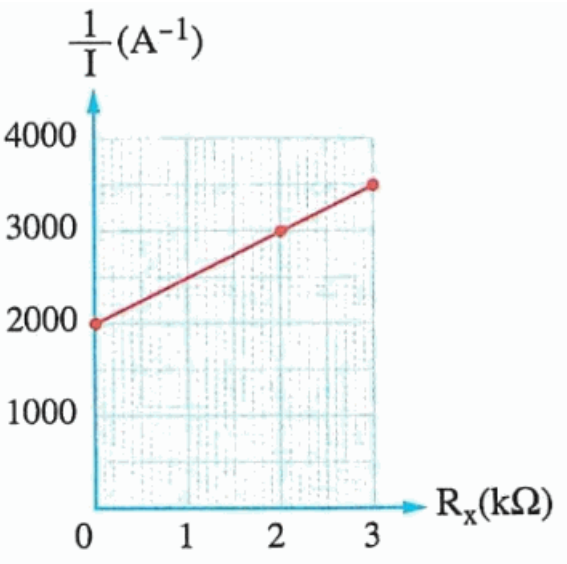
132 An ohmmeter was calibrated and its total resistance is (R_0). The opposite graph represents the relation between the reciprocal of the current $(1/I)$ in the ohmmeter circuit and the external resistance (R_x) connected between the terminals of the ohmmeter. The resistance of the ohmmeter (R_0) equals .....



(A) $zy/(z-x)$ (B) $xy/(z-x)$ (C) $(z-x)/zy$ (D) $(z-x)/xy$

133 An ohmmeter was calibrated and its total resistance is (R_0). The opposite graph represents the relation between the reciprocal of the current $(1/I)$ in the ohmmeter circuit and the external resistance (R_x) connected between the terminals of the ohmmeter. Then:

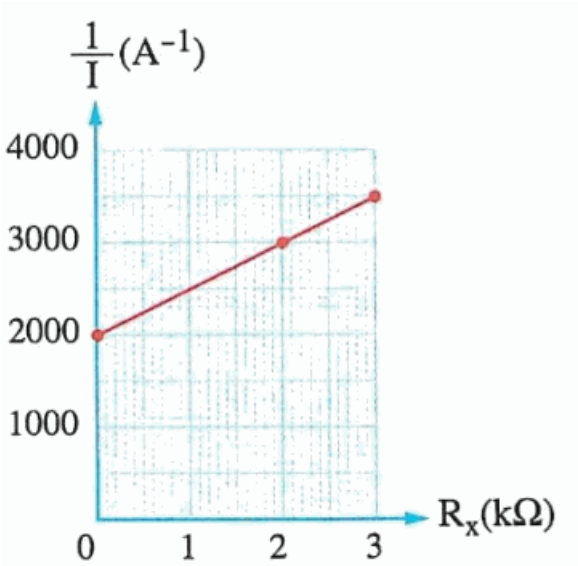
(1) the emf of the battery used in the ohmmeter equals .....



(A) 0.5 V (B) 1 V (C) 1.5 V (D) 2 V

134 An ohmmeter was calibrated and its total resistance is (R_0). The opposite graph represents the relation between the reciprocal of the current $(1/I)$ in the ohmmeter circuit and the external resistance (R_x) connected between the terminals of the ohmmeter. Then:

(2) the resistance of the ohmmeter (R_0) equals .....



(A) 2 kΩ (B) 4 kΩ (C) 6 kΩ (D) 8 kΩ

Essay questions — 27 questions

1 In a moving-coil galvanometer, explain:

(1) When a current passes, the galvanometer pointer is deflected and then settles at a certain reading.

(2) When the current is cut off, the galvanometer pointer returns to zero.

2 State two features considered when making a moving-coil galvanometer to make its scale uniform.

3 Give a reason: the magnetic torque acting on a galvanometer coil carrying a current I does not change while the coil rotates.

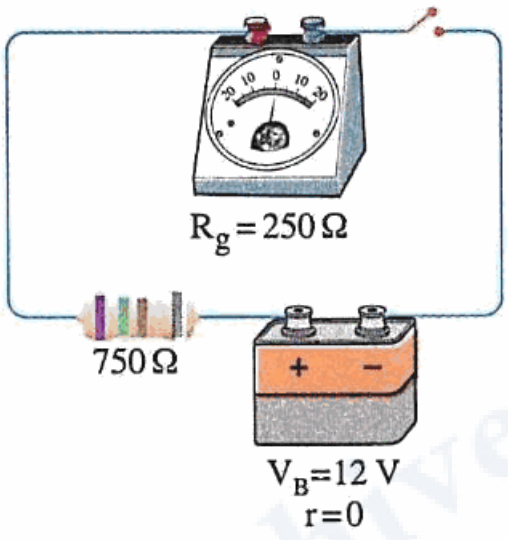
4 A moving-coil galvanometer has a scale divided into 20 divisions, each division indicating 200 microamperes. Calculate the current needed to make the galvanometer pointer deflect to one quarter of its scale.

5 Why is the galvanometer reading of the current in a circuit always less than the current when the galvanometer is not part of the circuit?

6 A galvanometer with a maximum scale reading of $20\ \mu A$ is connected in a circuit as in the figure:

(1) Explain why the galvanometer is not suitable for measuring the current in this circuit when the switch is closed.

(2) Suggest a way to make the galvanometer suitable for measuring the current in this circuit.



7 A galvanometer with a coil resistance of $30\ \Omega$ and a maximum measurable current of 0.01 A is to be converted into an ammeter. Calculate the shunt resistance needed so that the ammeter measures a maximum current of 1 A, and the total resistance of the ammeter in this case.

8 A galvanometer of resistance R_g and maximum scale reading I_g is connected to a shunt R_s, so the total resistance of the instrument becomes $R_g/4$ and the maximum current it measures becomes I. Find the ratio between:

(1) the two resistances (R_s/R_g).

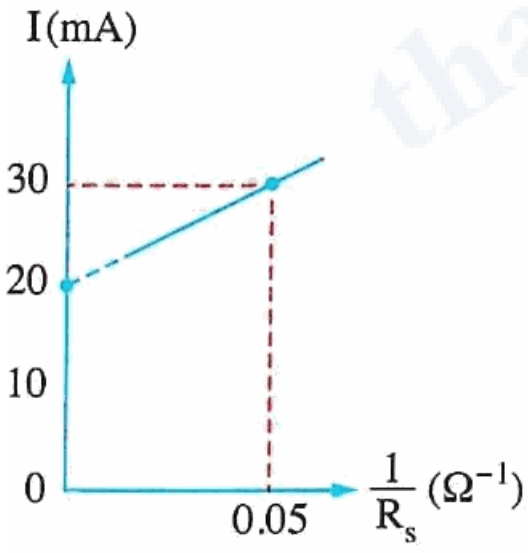
(2) the two currents (I/I_g).

9 A sensitive galvanometer can have its coil connected to several shunt resistances, each separately. The opposite graph represents the relation between the maximum current the ammeter can measure (I) and the reciprocal of the shunt resistance $(1/R_s)$. Calculate:

(1) the maximum current the galvanometer can measure (I_g).

(2) the resistance of the galvanometer (R_g).

(3) the shunt resistance needed to make the ammeter measure a maximum current of 0.3 A

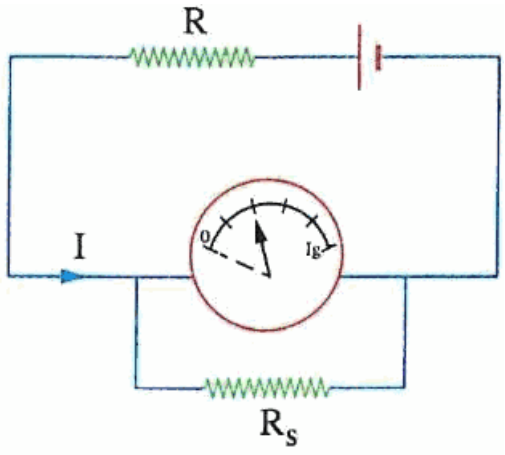


10 A galvanometer is converted into an ammeter whose range reaches 0.06 A when connected to a shunt of resistance R_s, and 0.03 A when connected to a shunt of resistance $4\ R_s$. What is the greatest current the galvanometer can measure without a shunt?

11 A moving-coil galvanometer of resistance R_g has a scale divided into five divisions, each indicating 0.01 A. It is connected to a shunt of resistance $0.2\ R_g$ and included in a circuit, and its pointer deflects as in the opposite figure. Calculate:

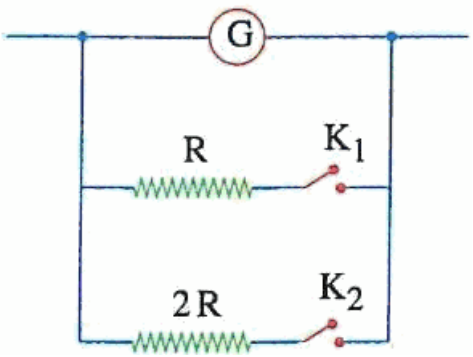
(1) the current I in the circuit.

(2) the maximum current the ammeter can measure.



12 An ammeter has a resistance of $24\ \Omega$. Calculate the shunt needed to reduce the sensitivity of the ammeter to $1/9$ of its value.

13 In the opposite figure, when switch K_1 is closed, the sensitivity of the instrument becomes half the sensitivity of the galvanometer. Calculate the ratio of the sensitivity of the instrument to that of the galvanometer when only switch K_2 is closed.



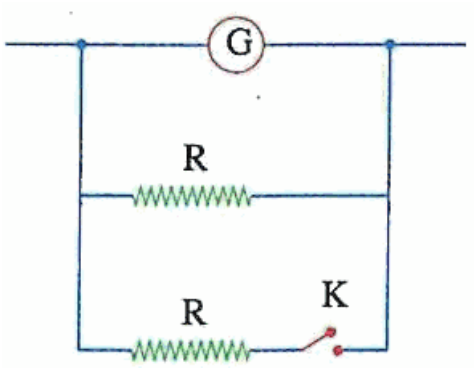
14 The opposite figure shows the structure of an ammeter. What happens when switch K is closed to:

(1) the resistance of the ammeter?

(2) the maximum current the ammeter can measure?

(3) the accuracy of the ammeter?

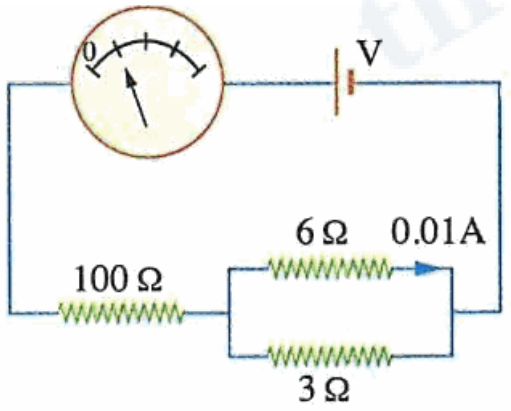
(4) the sensitivity of the ammeter?



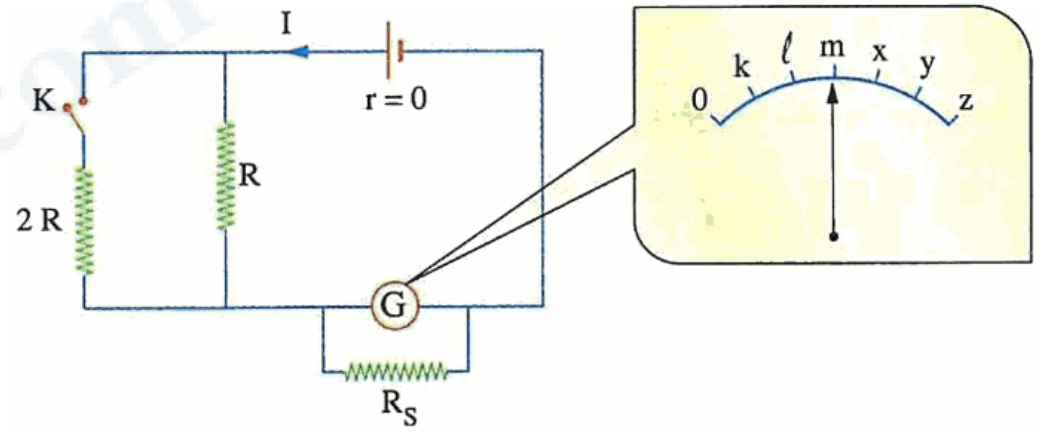
15 In the opposite figure, a galvanometer of resistance $50\ \Omega$ is connected in a circuit:

(1) What is the maximum reading of the galvanometer?

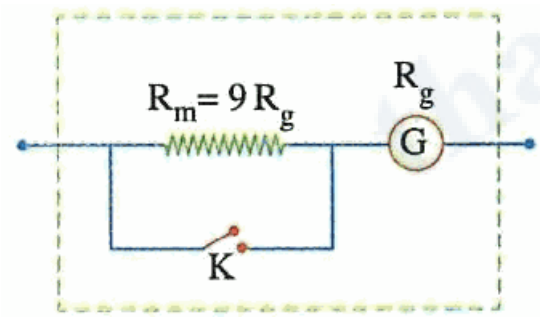
(2) How is it converted into an ammeter measuring a maximum current of 0.6 A?



16 The following figure shows the position of the pointer of a galvanometer of resistance R connected to a shunt of resistance 0.5 R and included in a circuit. Deduce the position of the pointer when switch K is closed.



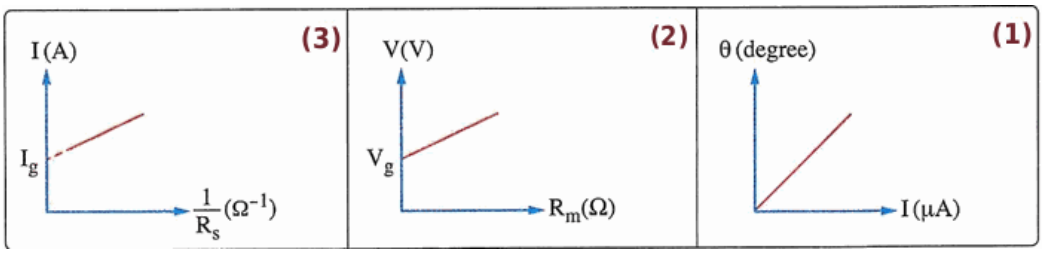
17 The opposite figure represents an instrument that measures a maximum potential difference of 1 V with switch (K) open. What is the maximum potential difference the instrument measures when switch K is closed?



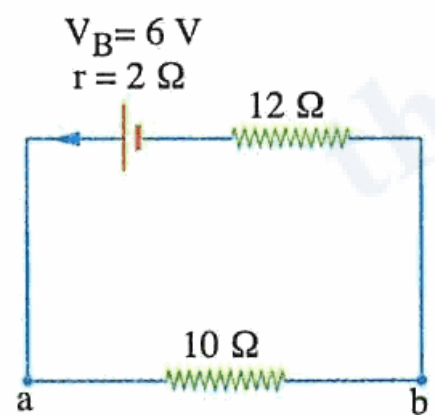
18 Explain: a voltmeter is connected in parallel across the conductor whose potential difference is to be measured.

19 Write the mathematical relation represented by the graph and what the slope of the straight line equals for each of the following:

where: (θ) is the deflection angle of the galvanometer pointer, (I) the current, (V) the potential difference, (V_g) the maximum potential difference across the galvanometer, (R_m) the multiplier resistance, (R_s) the shunt resistance, (I_g) the maximum current the galvanometer coil can carry.



20 In the opposite circuit, compare the total current and the potential difference across the *10* Ω resistance before and after connecting a voltmeter of resistance *190* Ω across points a and b, explaining your answer.

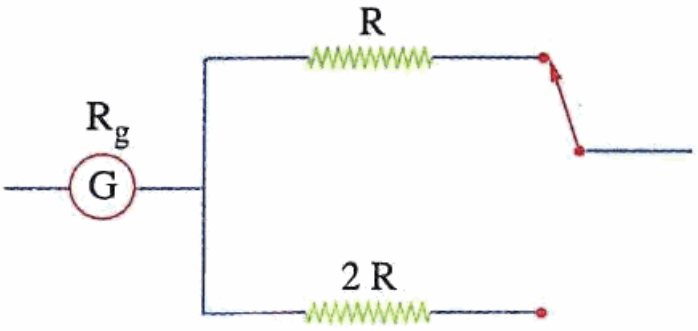


21 The opposite figure shows a voltmeter consisting of a galvanometer of resistance R_g, two multiplier resistances R and 2 R, and a two-way switch that can connect either of them to the galvanometer. State which of the two multipliers gives the voltmeter:

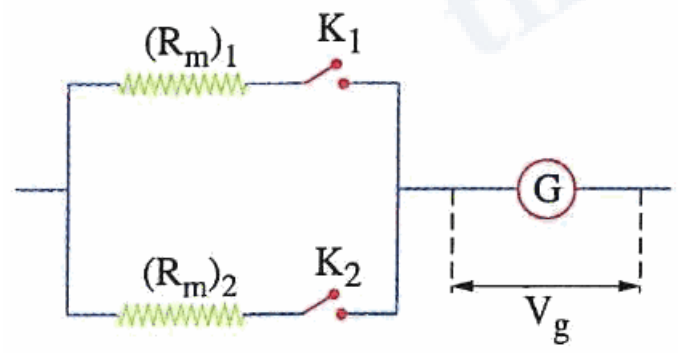
(1) a greater range.

(2) a greater accuracy in measuring potential difference.

(3) a greater sensitivity.



22 In the opposite figure, a galvanometer measures a maximum potential difference V_g. When only switch K_1 is closed, the instrument can measure a maximum potential difference of $7\ V_g$, and when both switches K_1 and K_2 are closed, it can measure a maximum potential difference of $3\ V_g$. Find the ratio of the two resistances $(((R_m)_1)/((R_m)_2))$.



23 In an ohmmeter:

(1) Why must the emf of the cell be constant?

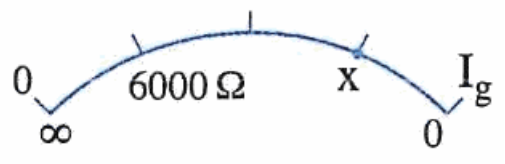
(2) Suppose the emf of the cell has decreased below its standard value. State, with explanation, what you notice when the two terminals of the ohmmeter are connected together.

24 Compare, with explanation, between the scales of a microammeter and an ohmmeter (in terms of: uniformity of the scale).

25 The opposite figure represents equal divisions on the scale of an ohmmeter consisting of a galvanometer, a standard resistance and a cell of emf 2 V with negligible internal resistance. Calculate:

(1) the maximum reading on the galvanometer scale (I_g).

(2) the external resistance which, connected to the terminals of the ohmmeter, makes its pointer deflect to mark (x) on its scale.



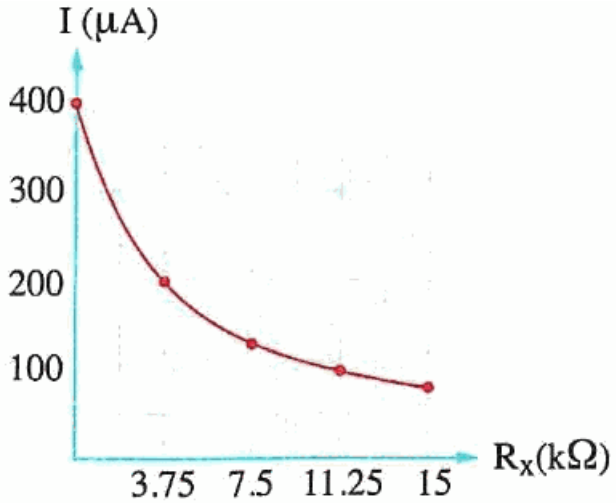
26 An ohmmeter of resistance R_0 contains a cell of emf V_B. If its terminals are connected to a resistance R_x, a current I passes in its circuit. Prove that: $R_x = V_B/I - R_0$

27 The opposite graph represents the relation between the current (I) in an ohmmeter and the external resistance (R_x) connected to its terminals. Find:

(1) the maximum current that can pass through the ohmmeter.

(2) the resistance of the ohmmeter.

(3) the resistance R_x which, when connected to the terminals of the ohmmeter, makes the current through it $50\ \mu A$



Past exam questions — 53 questions

1 You have two galvanometers (1) and (2). A current (I) passes through each of them; the pointer of galvanometer (1) deflects from zero through 30°, and the pointer of galvanometer (2) deflects from zero through an angle ten degrees greater than that of galvanometer (1). Which of the following statements is correct after the current is increased to 2 I in each of them? (1st session 2024)

(A) The deflection angle of the pointer of galvanometer (1) from zero equals 20°

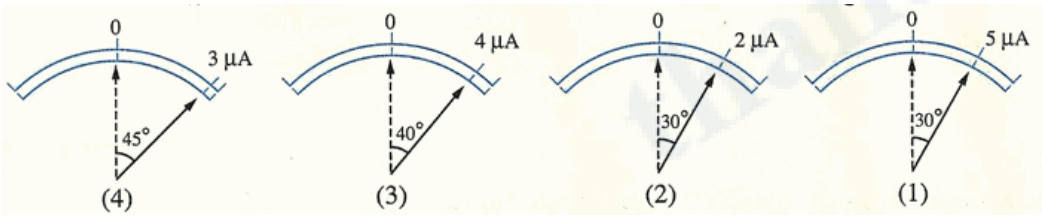
(B) The sensitivity of galvanometer (1) is $60/I$

(C) The sensitivity of galvanometer (2) is $40/I$

(D) The deflection angle of the pointer of galvanometer (2) from zero equals 40°

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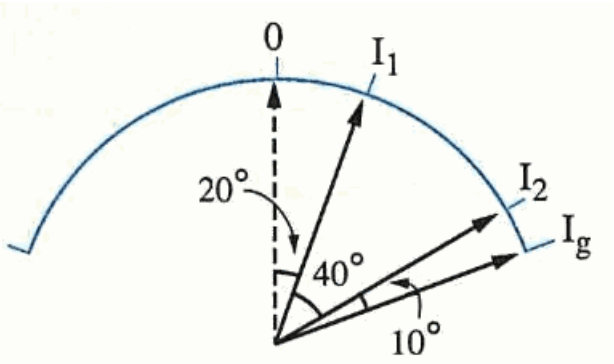
2 The following figures show the deflection angles of the pointers of four galvanometers when different currents pass through them. Which two galvanometers have the same sensitivity? (2nd session 2024)



(A) (1), (3) (B) (1), (4) (C) (2), (4) (D) (3), (4)

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3 The opposite figure shows a diagram of two deflection angles of the pointer of a moving-coil galvanometer in two DC circuits carrying currents I_1 and I_2. The ratio (I_1/I_2) equals ..... (Sample exam 2025)



(A) *1/2* (B) *1/3* (C) *2/1* (D) *3/1*

---

4 You have an old sensitive galvanometer in the lab with a full-scale reading of $200\ \mu A$. When a current of $50\ \mu A$ is passed through its coil, its pointer points to $60\ \mu A$. Which of the following has probably happened to the galvanometer due to frequent use? (Sample exam 2025)

(A) The permeability of the iron cylinder decreased

(B) The spiral springs were damaged

(C) The friction with the agate bearing increased

(D) The magnetic field of the magnet became weaker

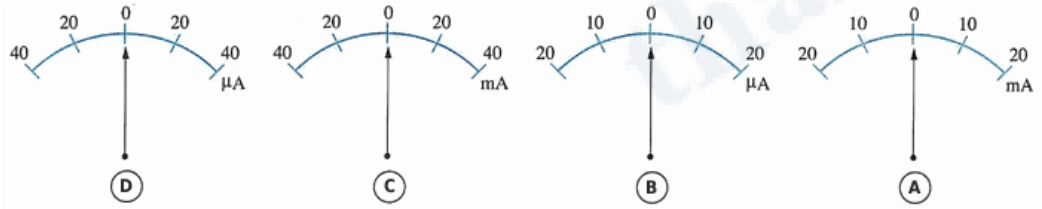
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5 In a moving-coil galvanometer, every 5 divisions indicate a current of 1 mA and every 20 divisions indicate a potential difference of 1 V. The resistance of the galvanometer equals ..... (Sample exam 2025)

(A) $250\ \Omega$ (B) $500\ \Omega$ (C) $40\ \Omega$ (D) $25\ \Omega$

---

6 Which of the following figures shows the scale of the galvanometer with the highest sensitivity, given that the angle between the two ends of each scale is the same? (1st session 2025)



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7 Two galvanometers X and Y are connected in series in a circuit. When a current passes in the circuit, the deflection of the pointer of galvanometer (X) is observed to be greater than that of galvanometer (Y). If the coils of the two instruments are identical, which of the following statements explains this observation? (2nd session 2025)

(A) The magnetic dipole moment of the coil of galvanometer (X) is greater

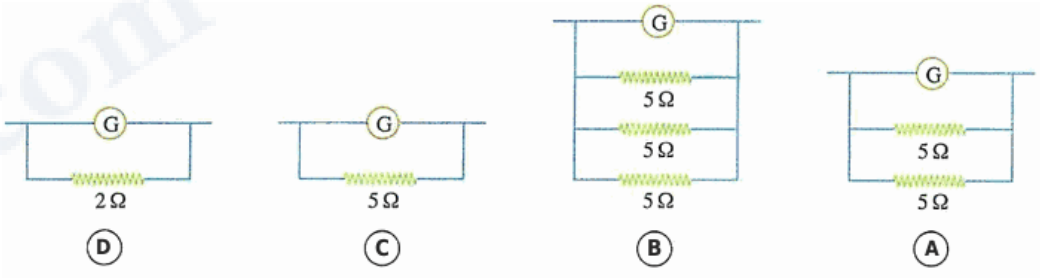
(B) The friction of the pivot of the coil of galvanometer (X) with the base is greater

(C) The current through the coil of galvanometer (X) is greater

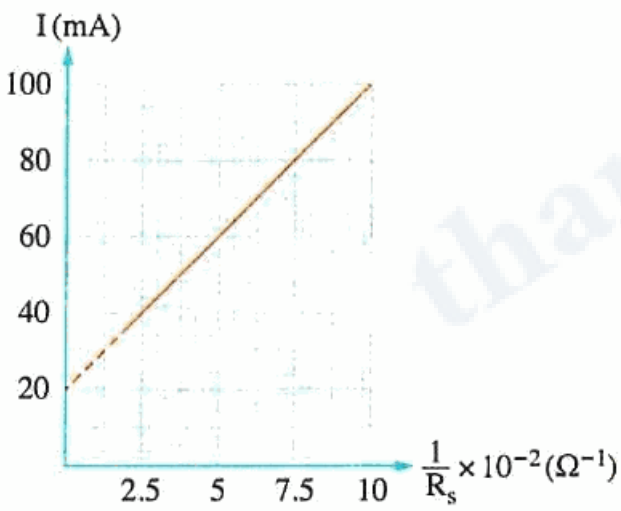
(D) The magnet used in galvanometer (X) is stronger

---

8 A sensitive galvanometer with a coil resistance of $15\ \Omega$ is connected to different shunts to convert it into an ammeter with a different range each time. Which of the following figures represents the ammeter with the greatest range? (Trial exam / May 2021)

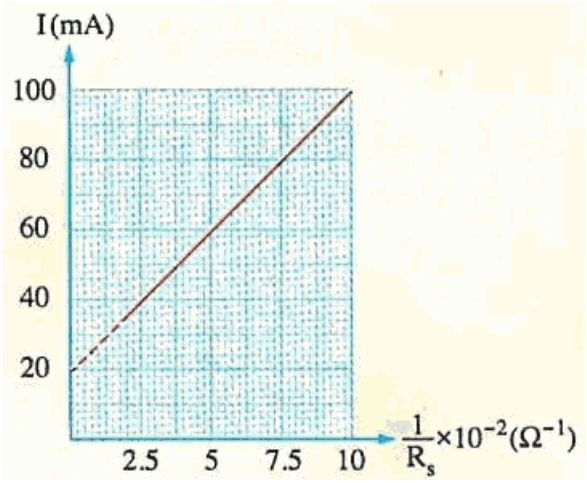


9 The opposite graph represents the relation between the maximum current measured by the ammeter and the reciprocal of the shunt resistance. The maximum potential difference across the shunt equals ..... (Trial exam / June 2021)



(A) 0.1 V (B) 0.8 V (C) 1.2 V (D) 1 V

10 The opposite graph represents the relation between the maximum current measured by an ammeter and the reciprocal of the shunt resistance. The resistance of the galvanometer (R_g) equals ..... (1st session 2021)



(A) $20\ \Omega$ (B) $40\ \Omega$ (C) $80\ \Omega$ (D) $100\ \Omega$

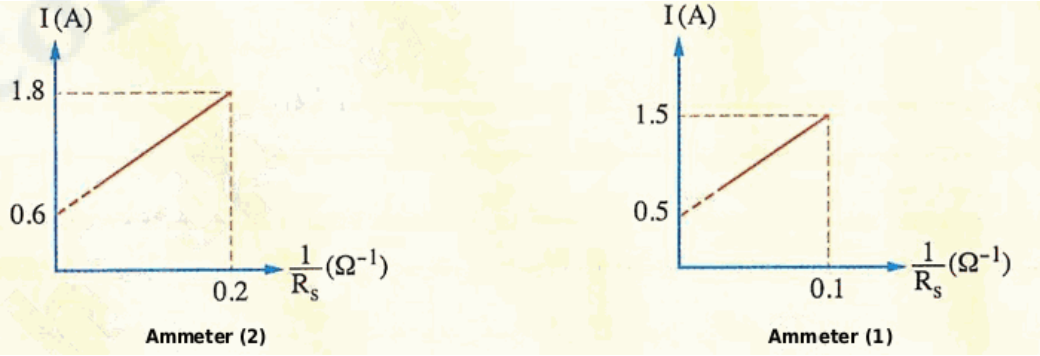
11 A galvanometer with a coil resistance R_g measures a maximum current I_g. When its coil is connected to a shunt of resistance R_1, the sensitivity of the instrument decreases to $3/4$ of its original value, and when R_1 is replaced by another shunt of resistance R_2, the sensitivity decreases to $3/8$ of its original value. The ratio of the shunt resistance R_1 to the shunt resistance R_2 equals ..... (2nd session 2021)

(A) 2 (B) 3 (C) 4 (D) 5

12 A galvanometer with a coil resistance R_g measures a maximum current I_g. When a shunt R is used, the greatest measurable current becomes $4\ I_g$. When the shunt is replaced by another of 3 R, the greatest measurable current becomes ..... (1st session 2022)

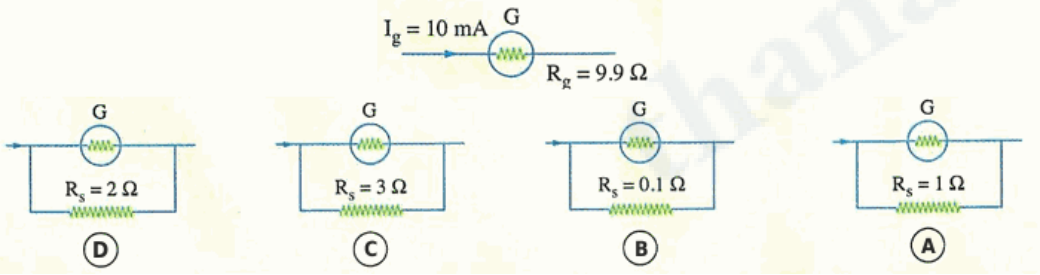
(A) $1.5\ I_g$ (B) $3\ I_g$ (C) $2.5\ I_g$ (D) $2\ I_g$

13 The two graphs express the relation between the maximum measurable current in two different ammeters and the reciprocal of a variable resistance $(1/R_s)$ acting as the shunt in each. The ratio of the galvanometer resistance in the first ammeter to that in the second ammeter $(((R_g)_1)/((R_g)_2))$ equals ..... (2nd session 2022)

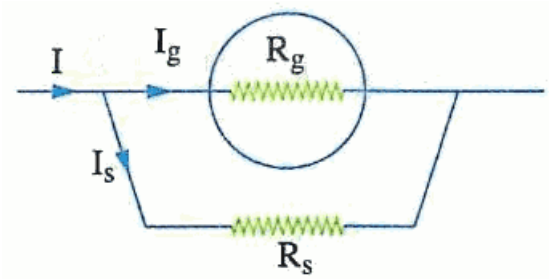


(A) $1/3$ (B) $2/1$ (C) $3/1$ (D) $1/2$

14 The figure represents a sensitive galvanometer. Which of the figures represents converting the galvanometer into an ammeter with a maximum current of 1 A? (Trial exam 2023)



15 In the opposite figure, if the shunt is changed so that the sensitivity of the instrument increases with the same current (I) passing, which of the following ratios increases? (1st session 2023)



(A) I_g/I_s (B) V_g/V_s (C) R_g/R_t (D) R_g/R_s

16 The opposite table records different values of shunt resistance R_s, each connected separately to the same galvanometer to obtain a DC ammeter in each of the cases Z, Y, X and W. What is the correct order of these cases according to the sensitivity of the instrument? (2nd session 2023)

R_s	Case
20 Ω	W
5 Ω	X
40 Ω	Y
10 Ω	Z

(A) $Y > W > X > Z$ (B) $X > Z > W > Y$ (C) $Y > W > Z > X$ (D) $W > Y > Z > X$

---

17 A galvanometer of resistance (R_g) was connected to a shunt of $(1/2\ R_g)$, then the galvanometer was connected again to a shunt of $(1/4\ R_g)$. The ratio of the sensitivity of the ammeter in the first case to that in the second case equals ..... (1st session 2024)

(A) 1/5 (B) 3/5 (C) 1/3 (D) 5/3

---

18 A galvanometer has a resistance of 60 Ω. The shunt that reduces the sensitivity of the instrument to one sixth equals ..... (2nd session 2024)

(A) 24 Ω (B) 6 Ω (C) 3 Ω (D) 12 Ω

---

19 A microammeter has a coil resistance of 100 Ω and a maximum coil current of 100 μ A. Its range can be increased to 0.1 A by connecting it to a shunt of ..... (Sample exam 2025)

(A) 0.5 Ω (B) 0.1 Ω (C) 0.05 Ω (D) 0.01 Ω

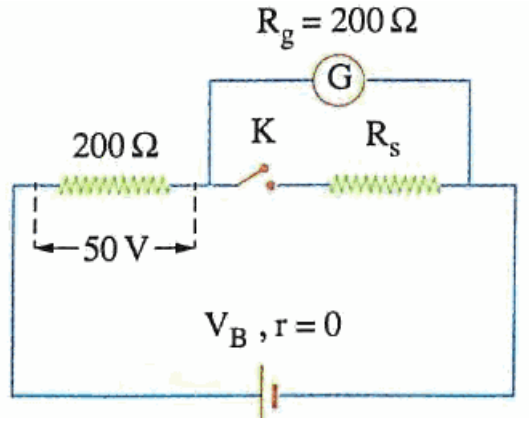
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20 A galvanometer with a coil resistance of 100 Ω has a scale divided into N divisions. If a current I passes through it, its pointer deflects to the end of its scale. When a resistance of 20 Ω is connected in parallel with the galvanometer coil to convert it into an ammeter and the same current I passes through the ammeter, its pointer deflects to only two divisions. The number of divisions on the galvanometer scale (N) equals ..... (Sample exam 2025)

(A) 2 (B) 6 (C) 12 (D) 24

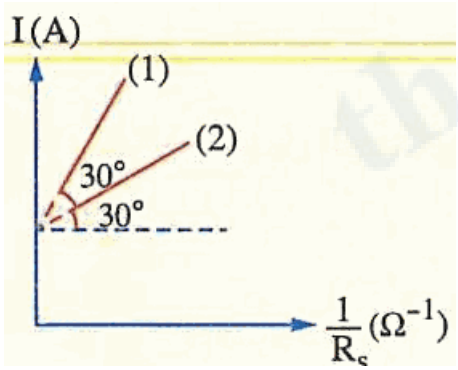
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21 In the figure, if switch K is closed, the sensitivity of the galvanometer decreases to one fifth. The values of R_s and V_B respectively are ..... (Sample exam 2025)



(A) *40* Ω , 100 V (B) *100* Ω , 60 V (C) *50* Ω , 100 V (D) *40* Ω , 60 V

22 The graph represents the relation between the maximum range of two ammeters (I) and the reciprocal of the shunt $(1/R_s)$ connected to the galvanometer coil in each. The ratio between the resistances of the two galvanometers $((R_g)_1)/((R_g)_2)$ equals ..... (Sample exam 2025)

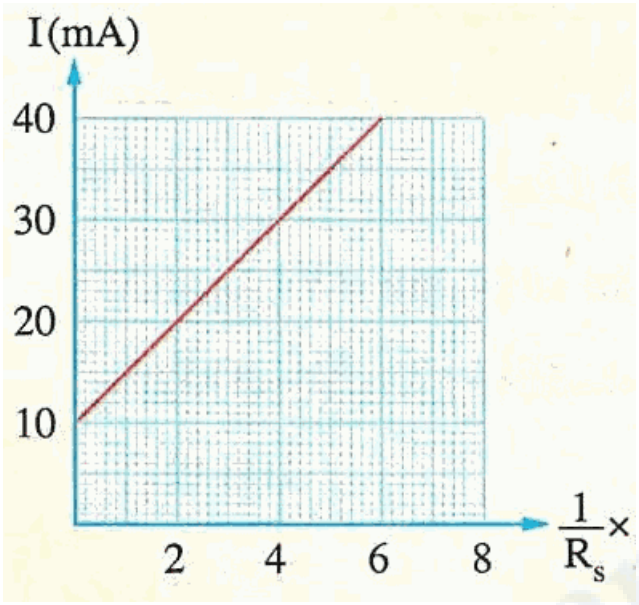


(A) *1/2* (B) *2/1* (C) *1/3* (D) *3/1*

23 An ammeter of resistance (R) consists of a galvanometer of resistance *45* Ω and a shunt (R_s). If the current in the galvanometer is *1/5* of the current in the shunt, what is the resistance of the ammeter (R)? (1st session 2025)

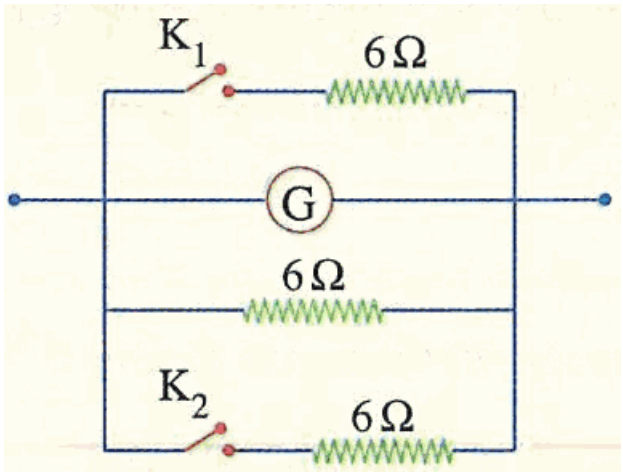
(A) *9* Ω (B) *7.5* Ω (C) *10* Ω (D) *15* Ω

24 An ammeter consists of a galvanometer of resistance (R_g) and full-scale reading (I_g), and a variable resistance (R_s) acting as a shunt. The opposite graph represents the relation between the maximum current (I) the ammeter measures and the reciprocal of the shunt resistance $(1/R_s)$. What is the potential difference across the galvanometer when its pointer deflects to the end of the scale? (2nd session 2025)



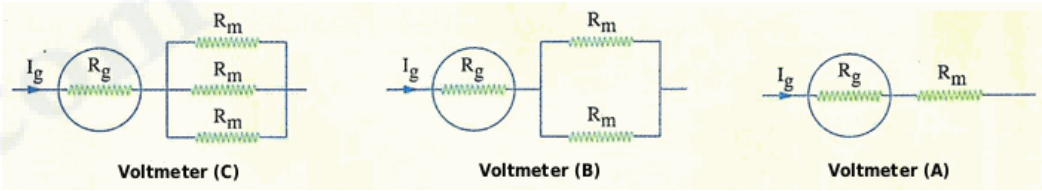
(A) 0.5 V (B) 5000 V (C) 5 V (D) 5×10^{-3} V

25 The opposite figure represents a galvanometer (G) converted into an ammeter. If the resistance of the galvanometer is $(R_g = 18\ \Omega)$, the ratio between the sensitivity of the instrument before and after closing switches K_1 and K_2 equals ..... (Sample exam 2026)



(A) 2/5 (B) 5/2 (C) 7/4 (D) 4/7

26 Three galvanometers, each with a coil resistance R_g, are connected to three multipliers to convert them into three voltmeters A, B and C as in the following figures. The order of the maximum reading of each instrument is ..... (Trial exam / June 2021)



(A) $V_B > V_A > V_C$ (B) $V_A < V_C < V_B$ (C) $V_C > V_B > V_A$ (D) $V_C < V_B < V_A$

---

27 A galvanometer with a coil resistance of *50* Ω is connected to a multiplier of *450* Ω, and its maximum reading is 1 V. When the galvanometer is connected to a multiplier $(R_m)_2$, the maximum voltmeter reading is 18 V. The value of $(R_m)_2$ is ..... (1st session 2021)

(A) *9000* Ω (B) *8950* Ω (C) *9050* Ω (D) *9500* Ω

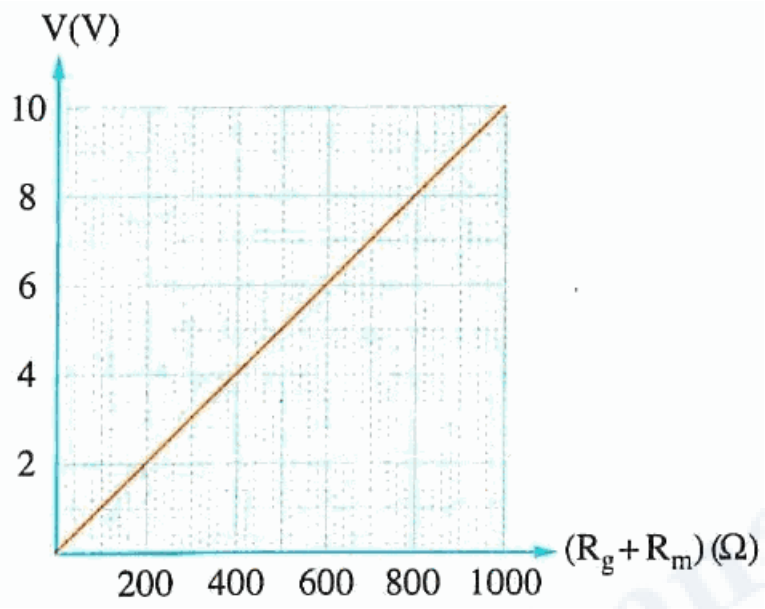
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28 A galvanometer measures a maximum potential difference of 0.1 V when a maximum current of 2 mA passes, and each division indicates 0.01 V. When it is connected to a multiplier of *450* Ω, each division indicates ..... (2nd session 2021)

(A) 0.01 V (B) 1 V (C) 0.1 V (D) 0.001 V

---

29 A galvanometer with a maximum potential difference of 1 V across its coil is connected to a multiplier to convert it into a voltmeter several different times. The graph in front of you represents the relation between the maximum potential difference measured by the voltmeter (V) and the total resistance of the voltmeter $(R_g + R_m)$. The resistance of the galvanometer (R_g) equals ..... (1st session 2022)



(A) *100 Ω* (B) *1000 Ω* (C) *500 Ω* (D) *50 Ω*

---

30 A voltmeter has a resistance of *100* Ω and can measure a maximum potential difference of 1 V. The multiplier that must be connected to increase the measured potential difference by 10 times equals ..... (2nd session 2022)

(A) *0.9 kΩ* (B) *10 kΩ* (C) *1.1 kΩ* (D) *1 kΩ*

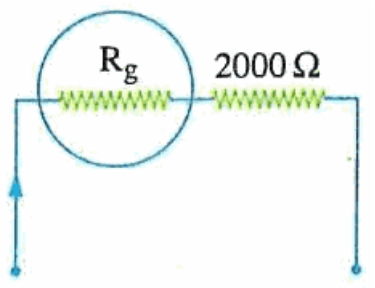
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31 A voltmeter has a resistance of *40* Ω. When a current of 0.1 A passes through it, its pointer reaches the end of its scale. The multiplier that makes the maximum potential difference it measures 100 V is ..... (Trial exam 2023)

(A) *25 Ω* (B) *2.5 Ω* (C) *960 Ω* (D) *1040 Ω*

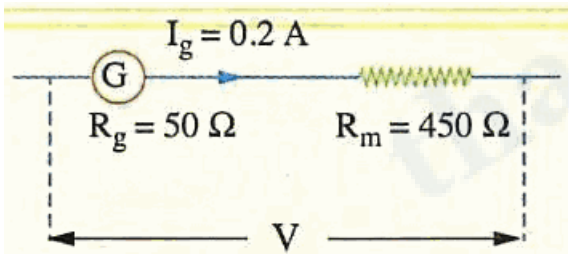
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32 A galvanometer with a full-scale reading of 0.01 A is connected in series with a *2000* Ω resistance to convert it into a voltmeter, as in the figure, and the maximum potential difference measured by the voltmeter is 20.5 V. For the maximum potential difference measured by the instrument to become 10.25 V, the *2000* Ω resistance must be replaced by a resistance of ..... (1st session 2023)



(A) *1025* Ω (B) *1000* Ω (C) *975* Ω (D) *4000* Ω

33 According to the data shown in the figure, the potential difference measured by the voltmeter is ..... (2nd session 2023)



(A) 50 V (B) 100 V (C) 20 V (D) 10 V

34 A voltmeter has a total resistance of *1200* Ω and can withstand a maximum potential difference of 3 V. If it is connected to a multiplier *(R_m)*, the maximum potential difference it can withstand becomes 10 V. The value of the multiplier *(R_m)* equals ..... (Sample exam 2025)

(A) *1800* Ω (B) *2400* Ω (C) *2800* Ω (D) *4000* Ω

35 A moving-coil galvanometer with a coil resistance R_g can withstand a maximum potential difference V_g. When the galvanometer is connected to a resistance R in series with its coil, it becomes a voltmeter of range V_1, and when the same galvanometer is connected to a resistance 2 R in series with its coil, it becomes a voltmeter of range V_2. Then ..... (Sample exam 2025)

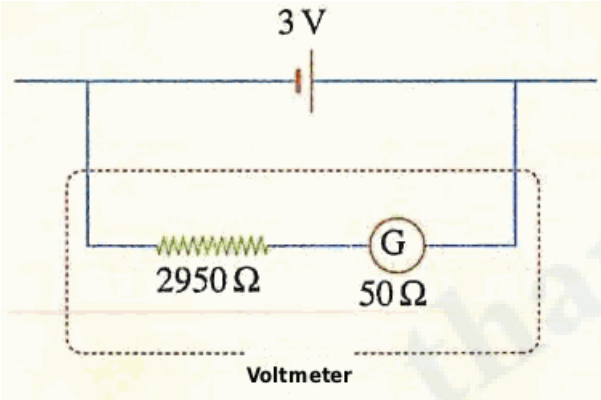
(A) $V_2 = V_1 - 2\,V_g$ (B) $V_2 = 2\,V_1 - V_g$ (C) $V_2 = 2\,V_1 + V_g$ (D) $V_2 = 2\,V_1$

36 A moving-coil galvanometer has 15 divisions. If every 5 divisions indicate 5 mA and every two divisions indicate 10 mV, the resistance that must be connected in series with the galvanometer coil so that each division indicates 1 V is ..... (Sample exam 2025)

(A) *995* Ω (B) *99.5* Ω (C) *9.95* Ω (D) *9950* Ω

---

37 A voltmeter consists of a galvanometer of resistance *50* Ω and a multiplier of resistance *2950* Ω. When the voltmeter is connected across a battery of emf 3 V with negligible internal resistance, as shown in the figure, its pointer deflects to the end of its scale. When a resistance (R) is connected with the multiplier inside the voltmeter while it is connected to the battery terminals, its pointer deflects to the middle of its scale. What is the resistance (R) and how is it connected? (1st session 2025)



(A) *1500* Ω, in series (B) *3000* Ω, in parallel
(C) *1500* Ω, in parallel (D) *3000* Ω, in series

---

38 An ohmmeter is connected to an external resistance (x) of *400* Ω and the pointer deflects to *3/4* of the galvanometer scale. When resistance (x) is replaced by another (y) of *6000* Ω, the pointer deflects to ..... of the galvanometer scale. (Trial exam / May 2021)

(A) *1/6* (B) *3/5* (C) *1/5* (D) *5/6*

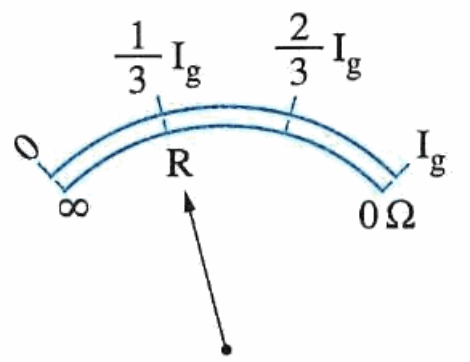
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39 An ohmmeter contains a galvanometer with a full-scale reading I_g. When an external resistance of *12 k*Ω is connected between the terminals of the ohmmeter, the current becomes *1/5* I_g. When the ohmmeter is connected to an external resistance of *1.5 k*Ω, the current becomes ..... (Trial exam / June 2021)

(A) *2/3* I_g (B) *1/8* I_g (C) *1/5* I_g (D) *3/4* I_g

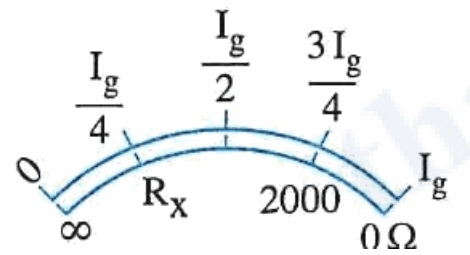
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40 The opposite figure represents the reading of the galvanometer inside an ohmmeter. When a resistance R is connected between the terminals of the ohmmeter, the pointer deflects to *1/3* I_g. The resistance of the ohmmeter equals ..... (1st session 2021)



(A) 0.5 R (B) R (C) 2 R (D) 3 R

41 The opposite figure shows equal divisions on the galvanometer scale in an ohmmeter circuit. The value of R_x shown in the figure equals ..... (2nd session 2021)



(A) *6000 Ω* (B) *18000 Ω* (C) *12000 Ω* (D) *10000 Ω*

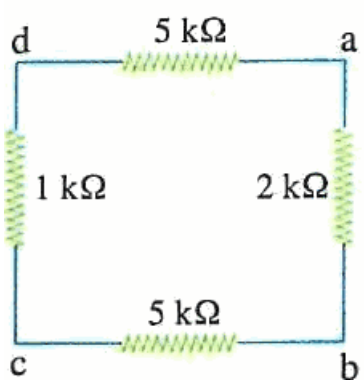
42 An ohmmeter contains a galvanometer with a full-scale reading I_g. When an external resistance of *50 kΩ* is connected between the terminals of the ohmmeter, the current through it becomes *1/3* I_g. The external resistance that makes the current in the ohmmeter *3/4* I_g equals ..... (1st session 2022)

(A) *25/3 kΩ* (B) *225/2 kΩ* (C) *50/3 kΩ* (D) *50/4 kΩ*

43 An ohmmeter contains a galvanometer with a full-scale reading I_g. When an external resistance (R) is connected between the terminals of the ohmmeter, the current through it becomes *3/4* I_g, and when resistance (R) is replaced by another of (3 R), the current becomes ..... (2nd session 2022)

(A) *1/4* I_g (B) *1/3* I_g (C) *4/9* I_g (D) *1/2* I_g

44 Four resistances are connected together as in the figure. The ohmmeter pointer shows the same reading when its terminals are connected to ..... (Trial exam 2023)



(A) points (c), (b) or points (b), (d)
(B) points (a), (c) or points (a), (d)
(C) points (a), (c) or points (b), (d)
(D) points (a), (d) or points (c), (d)

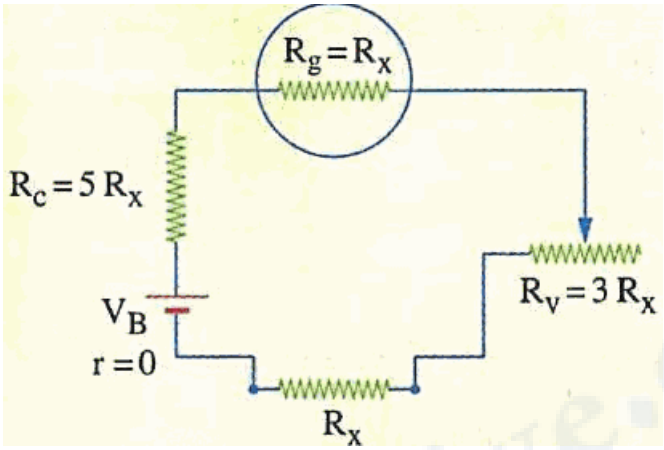
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45 An ohmmeter of total resistance *3000* Ω has its pointer deflect through an angle θ to reach the end of the current scale when its terminals touch each other. When its terminals are connected to a resistance R_1, the pointer deflects through *(θ)/3* from the zero of the current scale, and when R_1 is replaced by another resistance R_2, the pointer deflects through *(θ)/4* from the zero of the current scale. The values of R_1 and R_2 respectively are ..... (Trial exam 2023)

(A) *3000* Ω , *9000* Ω
(B) *6000* Ω , *12000* Ω
(C) *3000* Ω , *12000* Ω
(D) *6000* Ω , *9000* Ω

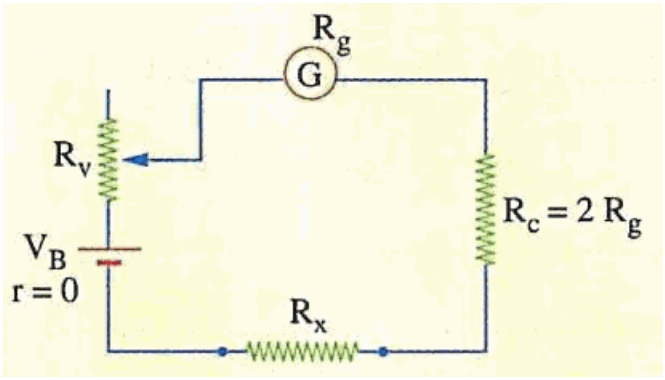
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46 In the ohmmeter circuit shown, when another resistance is connected in series with the unknown resistance *(R_x)*, the pointer deflects to *3/5* of the galvanometer scale. The other resistance connected equals ..... (1st session 2023)



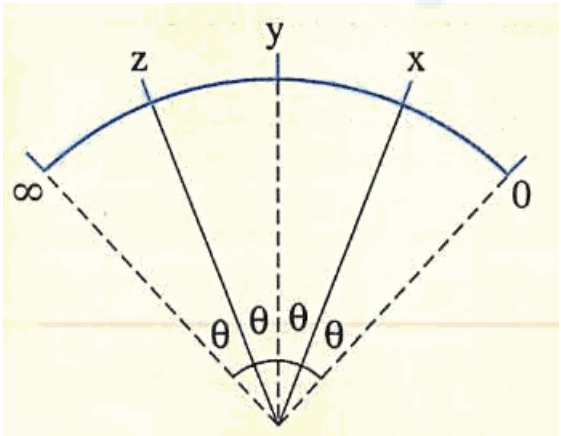
(A) *6 R_x*
(B) *5 R_x*
(C) *2/3 R_x*
(D) *3 R_x*

47 The opposite figure shows an ohmmeter circuit containing a galvanometer of coil resistance (R_g). When an external resistance (R_x) equal to $15\ R_g$ is connected to the terminals of the ohmmeter, the galvanometer pointer deflects to $1/5$ of the current scale. The resistance taken from the rheostat (R_v) equals ..... (2nd session 2023)



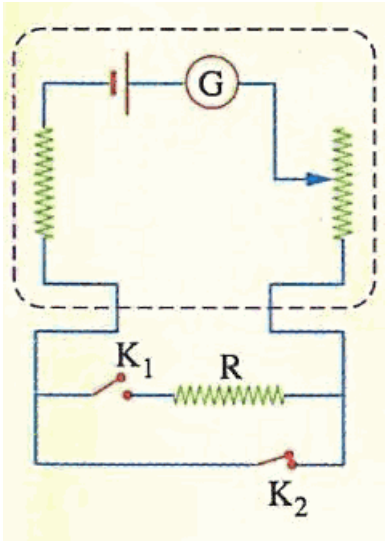
(A) $3.75\ R_g$ (B) $0.75\ R_g$ (C) $0.25\ R_g$ (D) $3.25\ R_g$

48 The figure shows equal spaces on the scale of an ohmmeter. When a resistance (R) is connected between the terminals of the ohmmeter, its pointer deflects to position (x). When another resistance is connected to resistance (R) between the terminals of the ohmmeter, its pointer deflects to position (z). The resistance connected to resistance (R) equals ..... (1st session 2025)



(A) 9 R (B) 2 R (C) 8 R (D) 3 R

49 An ohmmeter of resistance R has its terminals connected to an external resistance R and two switches K_1 and K_2 as shown in the figure. The ohmmeter pointer settles at the mark (∞) on the resistance scale when ..... (2nd session 2025)



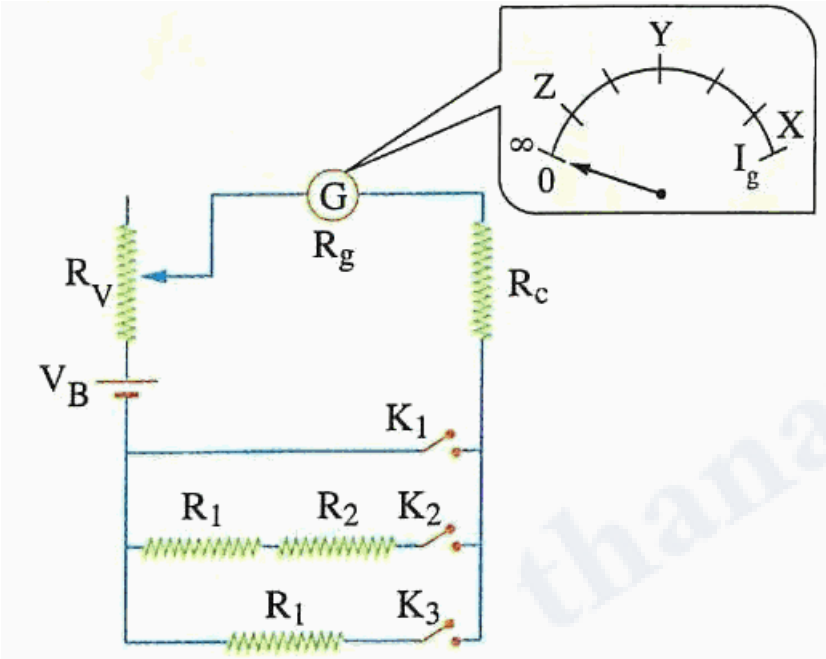
(A) both switches are closed

(B) both switches are open

(C) switch K_1 is open and switch K_2 is closed

(D) switch K_1 is closed and switch K_2 is open

50 The figure represents several switches and several unknown resistances connected to an ohmmeter consisting of a galvanometer of resistance (R_g), a fixed resistance (R_c), a variable resistance (R_v) and a battery of emf (V_B) with negligible internal resistance, and the scale of the instrument is divided into equal divisions. When only switch (K_1) is closed, the pointer deflects to position X; when only switch K_2 is closed, the pointer deflects to position Z; and when switches K_3 and K_2 are both closed, the pointer deflects to position Y. The ratio (R_1/R_2) equals ..... (Sample exam 2026)

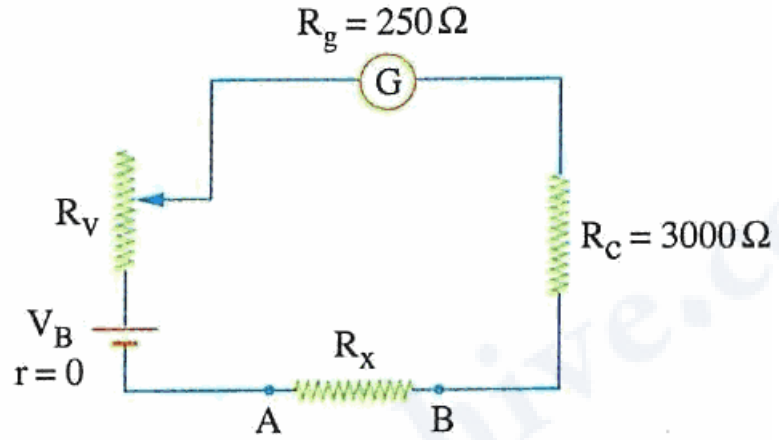


(A) 1/3 (B) 2/3 (C) 3/1 (D) 3/2

51 The figure shows the structure of an ohmmeter whose galvanometer has a maximum scale reading of $900\ \mu A$. If an external resistance (R_x) of $10\ k\Omega$ causes a current of $300\ \mu A$ to pass through the instrument, calculate: (1st session 2024)

(1) the resistance taken from the rheostat (R_v).

(2) the emf of the cell (V_B).



52 An ohmmeter has a total resistance of $(3750\ \Omega)$. Calculate: (2nd session 2024)

(1) the external resistance (R_x) that makes the pointer deflect to $I_g/3$

(2) the resistance (R) connected in parallel with the resistance (R_x) to make the pointer deflect to $(3\ I_g)/4$

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53 An ohmmeter of resistance $1500\ \Omega$ has a galvanometer whose pointer deflects to the end of its scale when a current of 200 mA passes, and the deflection angle of the pointer from zero is then 80°. Calculate: (Sample exam 2025)

(1) the deflection angle of the galvanometer pointer when an external resistance of $4500\ \Omega$ is connected between the terminals of the ohmmeter.

(2) the current in the galvanometer that causes the pointer to deflect through an angle of 60°

Answer key and solutions

Multiple choice questions

1 D	2 A	3 B	4 C	5 D	6 D	7 D	8 B	9 B	10 C
11 C	12 C	13 A	14 B	15 D	16 B	17 D	18 A	19 C	20 B
21 C	22 B	23 A	24 D	25 D	26 D	27 C	28 D	29 C	30 B
31 C	32 A	33 B	34 B	35 B	36 C	37 C	38 D	39 C	40 B
41 B	42 C	43 D	44 D	45 A	46 A	47 B	48 B	49 B	50 D
51 C	52 B	53 D	54 D	55 A	56 A	57 A	58 C	59 B	60 D
61 B	62 D	63 B	64 C	65 C	66 B	67 C	68 C	69 B	70 A
71 B	72 B	73 D	74 B	75 C	76 D	77 D	78 A	79 C	80 C
81 D	82 B	83 B	84 D	85 D	86 C	87 B	88 C	89 C	90 A
91 C	92 A	93 B	94 D	95 A	96 C	97 D	98 C	99 D	100 C
101 B	102 C	103 C	104 B	105 C	106 A	107 C	108 C	109 B	110 B
111 D	112 C	113 D	114 B	115 D	116 D	117 C	118 C	119 D	120 A
121 A	122 D	123 B	124 A	125 C	126 D	127 C	128 C	129 A	130 C
131 A	132 B	133 D	134 B						

1 **Answer (D)**

The agate component is placed at both ends of the coil's axis (a bearing) to reduce friction during rotation.

It is part number ④

2 **Answer (A)**

The moving coil is made of copper (a good, light conductor); it is part number ①

3 **Answer (B)**

To determine the direction of the current, the scale must have its zero in the middle so the pointer can deflect right or left.

(B) has its zero in the middle and a uniform scale $(6\ ,\ 3\ ,\ 0\ ,\ 3\ ,\ 6)$, while (A) has a non-uniform scale.

4 **Answer (C)**

The field in a moving-coil galvanometer is radial, so the coil always makes an angle of 90° with its lines.

$\tau = BIAN\sin 90^\circ$

5 **Answer (D)**

When the pointer settles, the magnetic torque is balanced by the torsion torque of the spiral springs.

So the resultant equals zero.

6 **Answer (D)**

The magnetic torque $\tau_1 = BIAN$ is constant during the motion because the field is radial.

The torsion torque τ_2 increases as the deflection angle increases until it equals it.

7 **Answer (D)**

The two concave poles and the soft iron core make the field radial.

So the field always makes an angle of 90° with the plane of the coil, i.e. 0° with the normal, and $\tau = BIAN$ stays constant.

8 **Answer (B)**

$\tau = kappa\theta$, where $kappa$ is the torsion constant of the spring.

So the angle is directly proportional to the torque: a straight line through the origin.

9 **Answer (B)**

The magnetic torque is constant $(BIAN)$ because the current is constant and the field is radial.

The torsion torque of the spring increases with the deflection angle until it equals it when the pointer settles.

The quantity that changes is the torsion torque.

10 **Answer (C)**

At a low frequency $(1\ Hz)$ the direction of the current changes slowly, so the pointer moves right and left.

So it oscillates about the zero of the scale.

11 **Answer (C)**

A high current produces heat $H = I^2Rt$ that may damage the coil.

12 **Answer (C)**

Sensitivity $= (\theta)/I = 50/500 = 0.1\ deg/\mu\ A$

13 **Answer (A)**

Maximum current $= 50/2 = 25\ \mu\ A$

Number of divisions $= 25/5 = 5$ divisions

14 **Answer (B)**

The current at half the scale is $0.1\ mA$, so the maximum current is $0.2\ mA = 200\ \mu\ A$

Value of one division $= 200/20 = 10\ \mu\ A$

15 **Answer (D)**

Half the scale is at $200\ \mu\ A$, so the maximum current is $400\ \mu\ A$

Number of divisions $= 400/80 = 5$ divisions

16 **Answer (B)**

Sensitivity $= (\theta)/I$; for the same current, the sensitivity is greatest at the greatest deflection angle.

The greatest angle is in (B), which is 60°

17 **Answer (D)**

The required angle is $\theta = S\ I = 0.16 \times 250 = 40^\circ$ from zero.

In (D) the zero of the scale is in the middle and the pointer is at the end of the scale; 80° is the total angle between the two ends, so it is 40° from zero.

While in (A) the zero is at the end, (B) is 32° and (C) 16°

18 **Answer (A)**

Sensitivity $proptoNBA/(kappa)$, where $kappa$ is the elasticity constant of the spring; it does not depend on the material of the coil itself.

The two galvanometers are identical in B and $kappa$, so the sensitivity is proportional to NA

The wire length is the same: $N = L/4x$ for the first and $L/8x$ for the second, and the area is x^2 for the first and $4x^2$ for the second.

$S_P/S_Q = (L/4x \times x^2)/(L/8x \times 4x^2) = 1/2$

19 **Answer (C)**

$\tau = NBIA \Rightarrow I = (\tau)/NBA = (4.32 \times 10^{-3})/(600 \times 0.1 \times 6 \times 10^{-4}) = 0.12\ A$

20 **Answer (B)**

When the pointer settles, the torsion torque balances the magnetic torque: $\tau = NBIAcos\varphi$, where φ is the angle between the plane and the field.

The field is radial, so $\tau = NBIA = 1200 \times 0.01 \times 10^{-3} \times 3 \times 10^{-4} = 3.6 \times 10^{-6}\ N.m$

21 **Answer (C)**

Before the swap: the galvanometer (R) is in series with R_3 and with the group $R/2$: $R_t = R + 3R + R/2 = 4.5R$, and the total current $I = V/4.5R$ passes through it, so it deflects to l

After the swap the galvanometer is in parallel with R_2 and connected the other way round, and R_1 is in series with R_3: the total resistance is $3R + R + R/2 = 4.5R$ as well.

The total current is the same, but it divides in half between the galvanometer and R_2, which are equal, so half the previous current passes through the galvanometer, in the opposite direction.

So the pointer deflects half the deflection l, on the other side of zero, i.e. to z.

22 **Answer (B)**

Decreasing the shunt passes a larger current through it, and the galvanometer current decreases.

So a larger total current is needed for the same deflection, i.e. the sensitivity of the ammeter decreases.

23 **Answer (A)**

The resistance of the ammeter $R_A = (R_G R_s)/(R_G + R_s) < R_s$ because they are in parallel.

So the ratio of the shunt resistance to the ammeter resistance is greater than one.

24 **Answer (D)**

Decreasing the shunt decreases the resistance of the ammeter R_A, so it affects the circuit less when connected.

So its accuracy in measuring the current increases, while its sensitivity decreases and the current in the galvanometer, the torsion torque and the force on the coil decrease.

25 **Answer (D)**

Increasing the shunt resistance makes a larger part of the current pass through the galvanometer and a smaller part through the shunt.

So a current greater than the full-scale reading passes through the coil.

26 **Answer (D)**

The range of the ammeter $I = I_g(1 + R_g/R_s)$ increases as the shunt resistance R_s decreases.

The smallest resistance is one fifth of the galvanometer resistance, so the range is the greatest.

27 **Answer (C)**

The coil current is $I_g = I/5$, so the shunt current is $4I/5$

$I_g R_g = I_s R_s \Rightarrow R_g times I/5 = 12 \times 4I/5$

$R_g = 48\ \Omega$

28 **Answer (D)**

$R_A/R_g = R_s/(R_g + R_s) = 1/10 \Rightarrow 10R_s = R_g + R_s$

$9R_s = R_g \Rightarrow R_s/R_g = 1/9$

29 **Answer (C)**

The sensitivity drops to one quarter: $I_g = I/4$ and $I_s = 3I/4$

$R_g I_g = R_s I_s \Rightarrow R times I/4 = R_s \times 3I/4 \Rightarrow R_s = R/3$

30 **Answer (B)**

The $0.1\ \Omega$ shunt makes $I_g = I/10$ and $I_s = 9I/10$: $R_g = (0.1 \times 9)/1 = 0.9\ \Omega$

For one quarter: $I_g = I/4$ and $I_s = 3I/4$, so $R_s = R_g/3 = 0.9/3 = 0.3\ \Omega$

31 **Answer (C)**

$I_g/I = R_s/(R_g + R_s) = 0.2R/(R + 0.2R) = 1/6$

So the sensitivity decreases to one sixth.

32 **Answer (A)**

When the switch is closed, $R_s/(R_g + R_s) = (R/3)/(R + R/3) = 1/4$ of the current passes through the galvanometer.

So the pointer deflects one quarter of the previous deflection: from k to x

33 **Answer (B)**

At first $R_s = R_g$, so $I/2$ passes through the galvanometer and it deflects θ

After decreasing it to $R_s = R_g/3$: $I_g = R_s/(R_g + R_s)\ I = (1/3)/(4/3)\ I = I/4$

The galvanometer current is now half its first value $(I/4$ instead of $I/2)$, and the deflection is proportional to I_g, so the deflection becomes $(\theta)/2$

34 **Answer (B)**

$I_g = 0.02\ I$ and $I_s = 0.98\ I$

$R_s = R_g\ I_g/I_s = R_g\ 0.02/0.98 = R_g/49$

35 **Answer (B)**

$I_g = 0.1\ I$ and $I_s = 0.9\ I$

$R_s = R_g\ I_g/I_s = 54 \times 0.1/0.9 = 6\ \Omega$

36 **Answer (C)**

$I_g/I = R_s/(R_g + R_s) = 4/(36 + 4) = 0.1 = 10\%$

37 **Answer (C)**

10 times the range: $I = 10\ I_g \Rightarrow I_s = 9\ I_g$

$R_s = R_g/9 = 0.1/9 = 0.0111 \approx 0.01\ \Omega$

38 **Answer (D)**

The range of the ammeter increases as the shunt resistance decreases.

At position (4) two resistances R are connected in parallel, so the shunt resistance is $R/2$, the smallest value.

$(1)\ R$, $(2)\ 1.5R$, $(3)\ 2R$, $(4)\ 0.5R$

39 **Answer (C)**

The maximum coil current is $0.01\ A$ and the required measurement is $0.1\ A$, so $0.09\ A$ passes through the shunt.

$R_s = (54 \times 0.01)/0.09 = 6\ \Omega$, in parallel with the galvanometer.

40 **Answer (B)**

When a shunt is connected, the current through the galvanometer decreases for the same total current, so the deflection angle decreases for the same current.

Sensitivity $= (\theta)/I$, so it decreases by 75%

41 **Answer (B)**

Sensitivity $= (\theta)/I$, i.e. the slope of the line.

Line M is for the galvanometer before conversion and line N for the ammeter; the slope of N is about one third of the slope of M

So the sensitivity of the ammeter is one third of the sensitivity of the galvanometer.

42 **Answer (C)**

The maximum current the instrument measures means the galvanometer is at the end of its scale in both cases, so the same current I_g passes through it.

The potential difference across the instrument $V = I_g R_g$ is constant in both figures, so it is equal.

43 **Answer (D)**

$I = I_g(1 + R_g/R_s)$

$I_x = I_g(1 + 18/3) = 7I_g$ and $I_y = I_g(1 + 18/6) = 4I_g$

$I_x/I_y = 7/4$

44 **Answer (D)**

$R_g = V/I_g = 0.04/(500 \times 10^{-6}) = 80\ \Omega$

$I_s = 500 - 0.5 = 499.5\ mA$ and $R_s = V/I_s = 0.04/0.4995 = 0.08\ \Omega$

45 **Answer (A)**

The resistance of the ammeter is $R_A = V/I = 0.04/0.05 = 0.8\ \Omega$ (constant)

The new range $2\ A$ needs a total resistance of $(V_{max})/2$, where $V_{max} = 0.2 \times 0.8 = 0.16\ V$, so $R_A' = 0.08\ \Omega$

A new shunt in parallel: $1/0.08 = 1/0.8 + 1/R_s \Rightarrow R_s = 0.089\ \Omega$

46 **Answer (A)**

$I_s = I_g R_g \times 1/R_s$, so the slope of the line $= I_g R_g = 1/10 = 0.1\ V$

$I_g = 0.1/R_g = 0.1/50 = 2 \times 10^{-3}\ A$

47 **Answer (B)**

$I = I_g + I_s = I_g + I_g R_g \times 1/R_s$

The intercept on the I axis is $I_g = K$ and the slope $= I_g R_g = L/M$

$R_g = L/(M I_g) = L/KM$

48 **Answer (B)**

$I = I_g(1 + R_g/R_s)$, so the slope of the line is $I/I_g = 1 + R_g/R_s$

From the graph, the slope $= 8/(4 \times 10^{-2}) = 200$

$6/R_s = 199 \Rightarrow R_s = 0.03\ \Omega$

49 **Answer (B)**

$I = I_g(1 + R_g/R_s)$ is a linear relation between I and I_g with slope $1 + R_g/R_s$

The shunt is the same, so the slope is greater for the greater R_g: $z\ (24) > y\ (14) > x\ (9)$

50 **Answer (D)**

$I = I_g(1 + R_g/R_s) = 0.025(1 + 100/0.05) = 0.025 \times 2001 = 50.025\ A$

51 **Answer (C)**

Sensitivity $= (\theta)/I = 60/30 = 2\ deg/mA$

52 **Answer (B)**

Maximum current $= 80/2 = 40\ mA = 0.04\ A$

53 **Answer (D)**

The maximum coil current is $I_g = 0.04\ A$ and $R_s = 0.01R_g$

$I = I_g(1 + R_g/R_s) = 0.04 \times (1 + 100) = 4.04\ A$

54 **Answer (D)**

In the first case: $I = I_g(1 + 20/5) = 1 \Rightarrow I_g = 0.2\ A$

The new wire has the same cross-section and half the length, so its resistance is $5/2 = 2.5\ \Omega$

$I = 0.2(1 + 20/2.5) = 0.2 \times 9 = 1.8\ A$

55 **Answer (A)**

$I_1 = I_g(1 + R_g/1)$ and $I_2 = I_g(1 + R_g/0.1)$

$71/8 = (1 + 10R_g)/(1 + R_g) \Rightarrow 71 + 71R_g = 8 + 80R_g$

$R_g = 7\ \Omega$

56 **Answer (A)**

$I_g = I_1/(1 + R_g) = (8\times10^{-3})/(1 + 7) = 10^{-3}\ A$

57 **Answer (A)**

Before connecting: $R_t = 1 + 15 + 20 = 36\ \Omega$

After connecting: $R_{par} = (20\times 5)/25 = 4\ \Omega$, so $R_t = 1 + 15 + 4 = 20\ \Omega$

The ratio between the currents is the inverse of the ratio between the resistances: $I_1/I_2 = (R_{t2})/(R_{t1}) = 20/36 = 5/9$

58 **Answer (C)**

$I_g = 3/4\times 40 = 30\ mA$

$R_A = 10R_s/(10 + R_s)$ and $I = 1.5/(8 + R_A)$ and $I_g = I\,R_s/(10 + R_s)$

Substituting $R_s = 2.5\ \Omega$: $R_A = 2$, $I = 0.15\ A$ and $I_g = 0.15\times2.5/12.5 = 30\ mA$ ✓

59 **Answer (B)**

When K_1 is closed: $I_g = I/4 \Rightarrow 2/(R_g + 2) = 1/4 \Rightarrow R_g = 6\ \Omega$

The maximum coil current is $I_g = 0.5/4 = 0.125\ A$

With K_2: $I_g/I = 4/(6 + 4) = 0.4 \Rightarrow I = 0.125/0.4 = 0.31\ A$

60 **Answer (D)**

When both switches are closed, the two shunts are in parallel: $R_s = (2\times 4)/6 = 4/3\ \Omega$

$I_g/I = (4/3)/(6 + 4/3) = 4/22$

$I = 0.125\times22/4 = 0.69\ A$

61 **Answer (B)**

At position (1): $I_g = 0.1I$ and $I_s = 0.9I$, so $(R_s)_1 = R_g\ 0.1/0.9 = R_g/9$

At position (2): $(R_s)_2 = R_g\ 0.01/0.99 = R_g/99$

$((R_s)_1)/((R_s)_2) = 99/9 = 11$

62 **Answer (D)**

At position x the shunt is $2 + R$ and the galvanometer is in series with $740\ \Omega$: $(250 + 740)\times 0.1 = (2 + R)\times 9.9 \Rightarrow R = 8\ \Omega$

At position y the shunt becomes $2\ \Omega$ and the other branch $250 + 740 + 8 = 998\ \Omega$

$I_s = (998\times 0.1)/2 = 49.9\ A$ and $I = 49.9 + 0.1 = 50\ A$

63 **Answer (B)**

The deflection of the pointer stays the same, i.e. I_g stays the same in both cases.

$I_g = V/(350 + 20R_g/(R_g + 20)) \times 20/(R_g + 20) = V/(450 + 30R_g/(R_g + 30)) \times 30/(R_g + 30)$

By trial, $R_g = 40\ \Omega$ satisfies the equation: both are $V/1090$

64 **Answer (C)**

The most accurate voltmeter is the one that affects the circuit least, i.e. draws the least current.

So its resistance must be as large as possible: $C\ (8000\ \Omega)$

65 **Answer (C)**

Connecting the voltmeter in parallel with $300\ \Omega$ decreases the equivalent resistance, so the potential difference across it decreases.

The smaller the voltmeter resistance, the greater its effect: V_1 (no voltmeter) $> V_3\ (6000\ \Omega) > V_2\ (3000\ \Omega)$

66 **Answer (B)**

$R_t = V/I_g = 10/(50 \times 10^{-6}) = 200 \times 10^3\ \Omega$

67 **Answer (C)**

$R_m = R_t - R_g = 200 \times 10^3 - 1 \times 10^3 = 199 \times 10^3\ \Omega$

68 **Answer (C)**

The maximum voltage across the voltmeter is $V = I_g R_{eq}$, where I_g is the maximum coil current.

(A) $11R_g$, (B) $111R_g$, (D) $102R_g$

(C) the shunt R_g in parallel with the coil carries the same current as the coil, so $2I_g$ passes through the $100R_g$ resistance: $V = 200I_gR_g + I_gR_g = 201I_gR_g$ (the greatest)

69 **Answer (B)**

$V = I_g\ (R_g + R_m) = I_g\ R$, so the slope of the line is I_g

$I_g = 200/1000 = 0.2\ A$

70 **Answer (A)**

$V = I_g\ R_g + I_g\ R_m$, so the intercept is $x = I_g\ R_g$ and the slope is I_g

Intercept ÷ slope: $(I_g\ R_g)/I_g = R_g$

71 **Answer (B)**

$V - V_g = I_g R_m$, so the slope of the line $= I_g$

$I_g = 12/600 = 0.02\ A$

72 **Answer (B)**

$V_g = I_g R_g \Rightarrow R_g = 1/0.02 = 50\ \Omega$

73 **Answer (D)**

$V = I_g (R_g + R_m)$, so the slope of the line $= R_g + R_m = 120/(12 \times 10^{-2}) = 1000\ \Omega$

$R_m = 1000 - 50 = 950\ \Omega$

74 **Answer (B)**

$V_{max} = I_{g,max} \times R_{total} = 0.12 \times 1000 = 120\ V$

75 **Answer (C)**

$V = V_g(1 + R_m/R_g)$, so the slope of the line $= 1 + R_m/R_g$

Line ① has slope $12/2 = 6$ and line ② has slope $12/3 = 4$; the steeper one has the larger multiplier $(1\ k\Omega)$

$1 + 1000/R_g = 6 \Rightarrow R_g = 200\ \Omega$

$1 + R/200 = 4 \Rightarrow R = 600\ \Omega$

76 **Answer (D)**

$R_m = 10R_g$, so $R_t = R_g + R_m = 11R_g$

$V = I_g R_t = 11\ I_g R_g = 11\ V_g$

77 **Answer (D)**

The coil and the multiplier are in series, so the current is the same in both, and the potential difference is proportional to the resistance.

$V_g/V_m = R/50R = 0.02$

The two current ratios equal 1, and the ratio of the multiplier voltage to the voltmeter voltage is $50/51 = 0.98$

78 **Answer (A)**

The upper scale is for V and the lower one for I_g, for the same pointer position.

$V/I_g = R_g + R_m$

79 **Answer (C)**

$R_t = V/I_g = 5/0.01 = 500\ \Omega$

$R_m = 500 - 100 = 400\ \Omega$

80 **Answer (C)**

$V_{max} = I_g\,(R_g + R_m) = 0.01 \times (100 + 900) = 10\ V$

81 **Answer (D)**

$R_g = V_g/I_g = 5/0.02 = 250\ \Omega$

For the range $150\ V$: $R_t = 150/0.02 = 7500\ \Omega$, so $R_m = 7500 - 250 = 7250\ \Omega$

82 **Answer (B)**

$R_g = V_g/I_g = 5/0.02 = 250\ \Omega$

83 **Answer (B)**

The coil and the multiplier are in series, so the same current passes through them.

So the ratio equals one.

84 **Answer (D)**

Increasing the multiplier increases the total resistance, so the voltmeter draws less current from the circuit.

So its effect on the circuit decreases and its measuring accuracy increases (the range increases and the sensitivity decreases).

85 **Answer (D)**

The original range is $2\ V$ and it becomes $2 + 8 = 10\ V$, i.e. 5 times.

$R_t = 5 \times 2000 = 10000\ \Omega$, so $R_m = 10000 - 2000 = 8000\ \Omega$

86 **Answer (C)**

A division indicates $0.1\ V$ and should indicate $1\ V$, i.e. the range increases 10 times.

$R_t = 10R_g = 5000\ \Omega$, so $R_m = 5000 - 500 = 4500\ \Omega$

87 **Answer (B)**

$I = I_g(1 + R_g/R_s) = 0.02(1 + 5/0.1) = 0.02 \times 51 = 1.02\ A$

88 **Answer (C)**

$R_t = V/I_g = 5/0.02 = 250\ \Omega$

$R_m = 250 - 5 = 245\ \Omega$

89 **Answer (C)**

With a total current I, $I/3$ passes through the coil and $2I/3$ through the shunt.

$R_s = R_g I_g/I_s = 18 \times (1/3)/(2/3) = 9\ \Omega$

90 **Answer (A)**

The voltmeter voltage is $V = 10\ V_g$, i.e. $R_t = 10R_g$

$R_m = 9R_g = 9 \times 18 = 162\ \Omega$

91 **Answer (C)**

As a galvanometer with a shunt: $0.11 = I_g(1 + R_g/0.5)$, and as a voltmeter: $2.5 = I_g\ (R_g + 245)$

Dividing: $(1 + 2R_g)/(R_g + 245) = 0.044 \Rightarrow R_g = 5\ \Omega$

$I_g = 2.5/(5 + 245) = 0.01\ A$

92 **Answer (A)**

From solving the two previous equations, $R_g = 5\ \Omega$

Check: $0.01 \times (1 + 5/0.5) = 0.11\ A$ and $0.01 \times 250 = 2.5\ V$

93 **Answer (B)**

When only K_1 is closed: $R_t = R + 11R = 12R$ and the maximum reading is $24\ V$, i.e. $I_g\ R = 2\ V$

When only K_2 is closed: $R_t = 8R$, so the maximum reading is $8 \times 2 = 16\ V$

So it decreases by $24 - 16 = 8\ V$

94 **Answer (D)**

Voltmeter: $11 = I_g\ (R_g + 10R_g) = 11\ I_gR_g \Rightarrow I_gR_g = 1\ V$

Ammeter: $0.11 = I_g(1 + R_g/0.1R_g) = 11\ I_g \Rightarrow I_g = 0.01\ A$

$R_g = 1/0.01 = 100\ \Omega$

95 **Answer (A)**

The battery has zero resistance, so the voltage AB is constant, and the current in each voltmeter is $I = V/(R_g + R_m)$

The multiplier in X is smaller $(R_2 < R_g)$, so its total resistance is less and a greater current passes through it.

So the pointer of X deflects through a greater angle.

96 **Answer (C)**

The equivalent resistance of the resistance and the voltmeter in parallel: $R_p = (10 \times 50)/60 = 8.33\ \Omega$

$V = I R_p = 0.6 \times 8.33 = 5\ V$

97 **Answer (D)**

The full-scale potential difference: $R_p = (10 \times 50)/60 = 8.33\ \Omega$, so $V_g = 0.6 \times 8.33 = 5\ V$

$I_g = 5/50 = 0.1\ A$

After connecting the multiplier $R_t = 50 + 4950 = 5000\ \Omega$, so the maximum voltage is $V = 0.1 \times 5000 = 500\ V$

98 **Answer (C)**

With the multiplier: $R_p = (6 \times (30 + 144))/(6 + 174) = 5.8\ \Omega$

The reading of the new instrument (the potential difference across it) is $V = 0.2 \times 5.8 = 1.16\ V$

99 **Answer (D)**

At full scale without the multiplier: $R_p = (6 \times 30)/36 = 5\ \Omega$, $V_g = 0.2 \times 5 = 1\ V$ and $I_g = 1/30\ A$

The maximum voltage with the multiplier: $V = I_g\ (30 + 144) = 174/30 = 5.8\ V$

100 **Answer (C)**

The voltage sensitivity decreases to one quarter: $R_g + R_m = 4R_g \Rightarrow R_m = 3R_g$

The current sensitivity decreases to one quarter: $R_s/(R_g + R_s) = 1/4 \Rightarrow R_s = R_g/3$

$R_m/R_s = 3R_g/(R_g/3) = 9$

101 **Answer (B)**

The resistance of the resulting ammeter is $R_A = (4 \times 1)/5 = 0.8\ \Omega$ and its maximum current is $1 \times 5/1 = 5\ mA$

Adding $999.2\ \Omega$ makes the total resistance $1000\ \Omega$

$V = I R = 5 \times 10^{-3} \times 1000 = 5\ V$

102 **Answer (C)**

The resistance of the milliammeter is $R_A = (0.2 \times 33)/33.2 = 0.1988\ \Omega$ and its maximum current is $10\ mA$

To measure $10\ V$ we need $R_t = 10/0.01 = 1000\ \Omega$

$R_m = 1000 - 0.1988 = 999.8\ \Omega$

103 **Answer (C)**

The circuit resistance consists of $16\ \Omega$ in series with the group ($40\ \Omega$ and the voltmeter) in parallel.

The voltage of the group is $6\ V$, so the voltage of $16\ \Omega$ is $4\ V$ and the total current is $4/16 = 0.25\ A$

The current in $40\ \Omega$ is $6/40 = 0.15\ A$, so the voltmeter current is $0.1\ A$ and its resistance $R_v = 6/0.1 = 60\ \Omega$

104 **Answer (B)**

The maximum voltmeter reading is $7.5\ V$, so the maximum current of its coil is $I_g = 7.5/60 = 0.125\ A$

To convert it into an ammeter measuring $5\ A$: $I_s = 5 - 0.125 = 4.875\ A$

$R_s = (I_g R_g)/I_s = (0.125 \times 60)/4.875 = 1.54\ \Omega$

105 **Answer (C)**

The maximum potential difference is proportional to the total resistance: $V_1/V_2 = (R_g + 950)/(R_g + 3950) = 1/4$

$4R_g + 3800 = R_g + 3950 \Rightarrow 3R_g = 150$

$R_g = 50\ \Omega$

106 **Answer (A)**

$V = I_g (R_g + R_m)$, so if $V = nV_g$ then $R_m = (n - 1)R_g$

Multiplier R_1 gives nV_g, so $R_1 = (n-1)R_g$, and multiplier R_2 gives mV_g, so $R_2 = (m-1)R_g$

$R_1/R_2 = (n-1)/(m-1)$

107 **Answer (C)**

Switch K_1 short-circuits the multipliers if closed, so it must stay open; closing K_2 and K_3 together puts the two multipliers in parallel, so their resistance decreases.

The largest multiplier is $1000R_g$, by closing K_3 alone.

Closing K_4 adds a shunt $0.2R_g$ in parallel with the coil, which passes a greater current and increases the maximum measurable voltage (about six times).

So the switches closed are K_4 and K_3

108 **Answer (C)**

In the ohmmeter circuit, when the circuit is closed and the pointer deflects to the end of the scale, the greatest current passes.

So the measured resistance is zero.

109 **Answer (B)**

At the middle of the scale $I = I_g/2$, i.e. the total resistance doubled.

$R = R_i$, where R_i is the resistance of the ohmmeter.

110 **Answer (B)**

The scale is uniform: 0 at the maximum current and D at zero current, so the middle B is at $I_g/2$

At the middle $R = R_i$, so mark B indicates the resistance of the ohmmeter.

111 **Answer (D)**

Mark C is at $I = I_g/4$, and it does not mean twice the ohmmeter resistance (it is $3R_i$).

The ohmmeter reading at any mark equals the resistance connected between its terminals.

112 **Answer (C)**

$R_t = E/I_g = 1.5/0.016 = 93.75\ \Omega$

$R_v = 93.75 - 4 - 1.75 = 88\ \Omega$

113 **Answer (D)**

$R_t = 1.5/0.016 = 93.75\ \Omega$

At $10\ mA$: $R_t + R = 1.5/0.01 = 150\ \Omega$

$R = 150 - 93.75 = 56.25\ \Omega$

114 **Answer (B)**

$R_t = 1.5/0.016 = 93.75\ \Omega$

$I = E/(R_t + R) = 1.5/(93.75 + 300) \approx 3.8 \times 10^{-3}\ A$

115 **Answer (D)**

$R_t = E/I_g = 1.5/(400 \times 10^{-6}) = 3750\ \Omega$

$R_v = 3750 - 250 - 3000 = 500\ \Omega$

116 **Answer (D)**

$I = I_g/4$ means a total resistance four times greater: $4 \times 3750 = 15000\ \Omega$

$R = 15000 - 3750 = 11250\ \Omega$

117 **Answer (C)**

$E = I_g R_t = 400 \times 10^{-6} \times 3750 = 1.5\ V$

Mark R_1 is at $300\ \mu A$: $R_1 = 1.5/(300 \times 10^{-6}) - 3750 = 5000 - 3750 = 1250\ \Omega$

118 **Answer (C)**

$E = I_g R_t = 400 \times 10^{-6} \times 3750 = 1.5\ V$

Mark R_2 is at $200\ \mu A$: $R_2 = 1.5/(200 \times 10^{-6}) - 3750 = 7500 - 3750 = 3750\ \Omega$

119 **Answer (D)**

$E = I_g R_t = 400 \times 10^{-6} \times 3750 = 1.5\ V$

Mark R_3 is at $100\ \mu A$: $R_3 = 1.5/(100 \times 10^{-6}) - 3750 = 15000 - 3750 = 11250\ \Omega$

120 **Answer (A)**

Mark R_4 is at $I = 0$, i.e. the circuit is open.

So the measured resistance is ∞ (where the current is zero).

121 **Answer (A)**

$R_x = 2R_t$, so the total resistance becomes three times.

$I = E/(R_t + 2R_t) = 600/3 = 200\ \mu A$

122 **Answer (D)**

$I = I_g/5$ means the total circuit resistance is $R_0 + R = 5R_0$

$R = 4R_0 \Rightarrow R_0 = R/4$

123 **Answer (B)**

At half the current, the external resistance equals the resistance of the ohmmeter: $R_t = 200\ \Omega$

At $1/3$ of the current: $R_t + R = 3R_t$

$R = 2R_t = 400\ \Omega$

124 **Answer (A)**

Mark x is at $3/4 I_{max}$

$R/R_t = (I_{max})/I - 1 = 4/3 - 1 = 1/3$

That is, the resistance is one third of the resistance of the ohmmeter.

125 **Answer (C)**

Mark X is at $1/4 I_{max}$ and mark Y at $3/4 I_{max}$

At X: $R = R_t(4 - 1) = 3R_t \Rightarrow R_t = R/3$

At Y: $R_Y = R_t(4/3 - 1) = R_t/3 = R/9$

126 **Answer (D)**

Six equal divisions: x is at $I_g/6$ and z at $5I_g/6$

$R_x = R_t(6 - 1) = 5R_t$ and $R_z = R_t(6/5 - 1) = R_t/5$

$R_x/R_z = 25$

127 **Answer (C)**

$R_t = 6/0.001 = 6000\ \Omega$ and $R = E/I - R_t$

$0.25\ mA$: $24000 - 6000 = 18000\ \Omega$, $0.5\ mA$: $12000 - 6000 = 6000\ \Omega$, $0.75\ mA$: $8000 - 6000 = 2000\ \Omega$

Zero is at the maximum current and ∞ at zero current.

128 **Answer (C)**

$125\ \mu A = (I_{max})/4$, so $R = 3R_t$

$9\ k\Omega = 3R_t \Rightarrow R_t = 3000\ \Omega$

129 **Answer (A)**

$9\ k\Omega = (500/125 - 1)R_t \Rightarrow R_t = 3000\ \Omega$

$E = I_{max}R_t = 500 \times 10^{-6} \times 3000 = 1.5\ V$

130 **Answer (C)**

At $I_g/4$: $R_t + 300 = 4R_t \Rightarrow R_t = 100\ \Omega$

At $I_g/6$: $R_t + R = 6R_t \Rightarrow R = 5R_t = 500\ \Omega$

131 **Answer (A)**

132 **Answer (B)**

$1/I = (R_x + R_0)/E = 1/ER_x + R_0/E$

The intercept $x = R_0/E$ and the slope $(z - x)/y = 1/E$

$E = y/(z - x) \Rightarrow R_0 = xE = xy/(z - x)$

133 **Answer (D)**

$1/I = 1/ER_x + R_0/E$, so the slope $= 1/E$

Slope $= (3000 - 2000)/2000 = 0.5\ A^{-1}/\Omega$

$E = 2\ V$

134 **Answer (B)**

The intercept $R_0/E = 2000\ A^{-1}$ and the slope $1/E = 0.5\ A^{-1}/\Omega$, so $E = 2\ V$

$R_0 = 2000 \times 2 = 4000\ \Omega = 4\ k\Omega$

Essay questions

1 **Model answer**

(1) When a current passes through the galvanometer coil, a magnetic torque is produced that rotates the coil, so a torsion torque is produced in the two spiral springs opposing the torque acting on the coil. Its value increases gradually as the deflection angle increases until the torsion torque balances the magnetic torque, so the pointer settles at a certain reading that indicates the current.

(2) Because of the torsion torque in the two spiral springs, which returns the coil to its original position when the current is cut off.

2 **Model answer**

(1) The two magnetic poles are concave.

(2) There is a soft iron cylinder inside the coil.

3 **Model answer**

Because the poles of the magnet used in the galvanometer are concave and there is a soft iron core inside the coil, so the magnetic flux lines between the poles are radial. So the flux lines are parallel to the plane of the coil in any position of the coil, and the magnetic torque acting on the coil is always maximum and constant.

4 **Model answer**

Current = value of one division × number of divisions

$I = 200 \times 10^{-6} \times 20/4 = 0.001\ A$

5 **Model answer**

Because the galvanometer has a resistance, so when it is connected in series in the circuit, the total resistance of the circuit increases and the current decreases according to the relation $(I = V_B/R)$.

6 **Model answer**

(1) When the switch is closed, the current in the circuit is:

$I = V_B/R = 12/(750 + 250) = 0.012\ A = 12 \times 10^3\ \mu A$

The current in the circuit is greater than the maximum reading on the galvanometer scale, so this galvanometer is not suitable for measuring the current in this circuit.

(2) By connecting a resistance (R_s) in parallel with the galvanometer coil:

$R_s = (I_g R_g)/(I - I_g) = (20 \times 10^{-6} \times 250)/(0.012 - (20 \times 10^{-6})) = 0.4\ \Omega$

This is the largest resistance that can be connected in parallel with the galvanometer coil to make it suitable for measuring the current of this circuit.

7 **Model answer**

$R_s = (I_g R_g)/(I - I_g) = (0.01 \times 30)/(1 - 0.01) = 0.303\ \Omega$

$R' = (R_g R_s)/(R_g + R_s) = (30 \times 0.303)/(30 + 0.303) = 0.3\ \Omega$

8 **Model answer**

(1) $R_{(ammeter)} = (R_g R_s)/(R_g + R_s) = R_g/4$, so $R_s = R_g/3$, $R_s/R_g = 1/3$

(2) $I R_{(ammeter)} = I_g R_g$, so $I \times R_g/4 = I_g R_g$, $I/I_g = 4/1$

9 **Model answer**

(1) From the figure, the point where the line meets the vertical axis represents I_g : $I_g = 20\ mA$

(2) $slope = (\Delta I)/(\Delta(1/R_s)) = I_g R_g = ((30 - 20) \times 10^{-3})/(0.05 - 0) = 0.2\ V$

$R_g = slope/I_g = 0.2/(20 \times 10^{-3}) = 10\ \Omega$

(3) $R_s = (I_g R_g)/(I - I_g) = (20 \times 10^{-3} \times 10)/(0.3 - (20 \times 10^{-3})) = 5/7\ \Omega = 0.71\ \Omega$

10 **Model answer**

$R_s = (I_g R_g)/(0.06 - I_g)$ ... (1)

$4 R_s = (I_g R_g)/(0.03 - I_g)$ ... (2)

Dividing (1) by (2): $1/4 = (0.03 - I_g)/(0.06 - I_g)$, so $I_g = 0.02\ A$

11 **Model answer**

(1) $I_g R_g = I_s R_s$: $0.01 \times 2 R_g = I_s \times 0.2 R_g$, so $I_s = 0.1\ A$

$I = I_s + I_g = 0.1 + 0.02 = 0.12\ A$

(2) $0.01 \times 5 R_g = I_s \times 0.2 R_g$, so $I_s = 0.25\ A$

$I = I_s + I_g = 0.25 + 0.05 = 0.3\ A$

12 **Model answer**

When the sensitivity decreases to $1/9$ of its value, $I = 9 I_g$

$R_s = (I_g R_g)/(I - I_g) = (I_g \times 24)/(9 I_g - I_g) = 3\ \Omega$

13 **Model answer**

When only switch K_1 is closed: $(R_s)_1 = R$, $I_1 = 2 I_g$

$R = (I_g R_g)/(2 I_g - I_g) = R_g$

When only switch K_2 is closed: $2R = (I_g R)/(I_2 - I_g)$, so $I_2 - I_g = I_g/2$

$I_2 = 3/2\ I_g$, $I_g/I_2 = 2/3$

The ratio of the sensitivity of the instrument to that of the galvanometer $= 2/3$

14 **Model answer**

(1) It decreases.

(2) It increases.

(3) It increases.

(4) It decreases.

15 **Model answer**

(1) The two resistances $6\ \Omega$ and $3\ \Omega$ are connected in parallel:

$I_{(3)} \times 3 = I_{(6)} \times 6 = 0.01 \times 6$, so $I_{(3)} = 0.02\ A$

Maximum reading of the galvanometer: $I_g = 4(0.02 + 0.01) = 0.12\ A$

(2) By connecting the galvanometer in parallel with a shunt R_s:

$R_s = (I_g R_g)/(I - I_g) = (0.12 \times 50)/(0.6 - 0.12) = 12.5\ \Omega$

16 **Model answer**

When switch K is open: $R'_1 = R + (0.5\ R \times R)/(0.5\ R + R) = 4/3\ R$, $I_1 = (3\ V_B)/4R$

After closing switch K: $R'_2 = (2R \times R)/(2R + R) + (0.5\ R \times R)/(0.5\ R + R) = R$, $I_2 = V_B/R$

$I_1/I_2 = 3/4$, so $I_2 = 4/3\ I_1$

So the pointer deflects to position x

17 **Model answer**

When switch K is closed, no current passes through the multiplier R_m, so the maximum potential difference the instrument can withstand in this case is V_g

When switch K is open: $V = I_g\ (R_g + R_m) = I_g\ (R_g + 9\ R_g) = 10\ V_g = 1$

$V_g = 0.1\ V$

18 **Model answer**

So that the potential difference across the voltmeter equals the potential difference to be measured.

19 **Model answer**

(1) Mathematical relation: galvanometer sensitivity $= (\theta)/I$, slope $= (\Delta\theta)/(\Delta\ I)$ = the sensitivity of the galvanometer.

(2) Mathematical relation: $V = I_g\ R_g + I_g\ R_m$, slope: $slope = (\Delta\ V)/(\Delta\ R_m) = I_g$

(3) Mathematical relation: $I = I_g + V_g/R_s$, slope: $slope = (\Delta\ I)/(\Delta(1/R_s)) = V_g = I_g\ R_g$

20 **Model answer**

Before connecting the voltmeter: $I_1 = 6/(12 + 10 + 2) = 0.25\ A$, $(V_{ab})_1 = 0.25 \times 10 = 2.5\ V$

After connecting the voltmeter: $R_{ab} = (10 \times 190)/(10 + 190) = 9.5\ \Omega$

$I_2 = 6/(12 + 9.5 + 2) = 0.255\ A$, $(V_{ab})_2 = 0.255 \times 9.5 = 2.42\ V$

When the voltmeter is connected between two points, the resistance of that part of the circuit decreases, so the total resistance of the circuit decreases, the total current increases, and the potential difference between the two points the voltmeter is connected to decreases.

21 **Model answer**

(1) The greater range is when the multiplier with the greater resistance is used, i.e. the resistance 2R

(2) The more accurate instrument has a greater total resistance, which happens when the galvanometer is connected to the multiplier with the greater resistance, i.e. the resistance 2R

(3) The more sensitive instrument has a smaller range, which happens when the galvanometer is connected to the multiplier with the smaller resistance, i.e. the resistance R

22 **Model answer**

When only switch K_1 is closed: $(R_m)_1 = (7\ V_g - V_g)/I_g = 6\ R_g$

When both switches are closed: $R'_m = (3\ V_g - V_g)/I_g = 2\ R_g$

$R'_m = ((R_m)_1\ (R_m)_2)/((R_m)_1 + (R_m)_2) : 2\ R_g = (6\ R_g\ (R_m)_2)/(6\ R_g + (R_m)_2)$

$(R_m)_2 = 3\ R_g$, $((R_m)_1)/((R_m)_2) = (6\ R_g)/(3\ R_g) = 2/1$

23 **Model answer**

(1) So that the current in the galvanometer is inversely proportional to the total resistance inside and outside the ohmmeter, according to Ohm's law for a closed circuit.

(2) The ohmmeter pointer does not reach the zero of the resistance scale, because the current in the ohmmeter is given by the relation $(I_g = V_B/(R'))$, and since V_B has decreased, the pointer does not reach the full-scale reading (I_g).

24 **Model answer**

Microammeter scale: uniform, because the deflection angle is directly proportional to the current.

Ohmmeter scale: non-uniform, because the current is inversely proportional to the total resistance of the circuit, not to the unknown resistance alone.

25 **Model answer**

(1) $I_g = V_B/(R_{(ohmmeter)})$ ... (1)

$I_g/4 = V_B/(R_{(ohmmeter)} + 6000)$ ... (2)

Dividing (1) by (2): $4 = (R_{(ohmmeter)} + 6000)/(R_{(ohmmeter)})$, so $R_{(ohmmeter)} = 2000\ \Omega$

$I_g = 2/2000 = 10^{-3}\ A = 1\ mA$

(2) Mark x is at $3/4\ I_g$: $I_g/I_x = 4/3 = (2000 + R_x)/2000$

$R_x = 666.67\ \Omega$

26 **Model answer**

$I = V_B/R_t = V_B/(R_0 + R_x)$

$R_0 + R_x = V_B/I$

$R_x = V_B/I - R_0$

27 **Model answer**

(1) The maximum current (I_g) passes through the ohmmeter when the external resistance (R_x) is zero; from the figure, the point where the line meets the vertical axis represents I_g : $I_g = 400\ \mu A$

(2) At $R_x = 3.75\ k\Omega$: $I_g/I = (R' + R_x)/(R')$: $(400 \times 10^{-6})/(200 \times 10^{-6}) = (R' + 3.75)/(R')$

$R' = 3.75\ k\Omega$

(3) $(400 \times 10^{-6})/(50 \times 10^{-6}) = (3.75 + R_x)/3.75$, so $R_x = 26.25\ k\Omega$

Past exam questions

1	2	3	4	5	6	7	8	9	10
C	C	B	B	A	B	D	B	B	B
11	12	13	14	15	16	17	18	19	20
D	D	B	B	A	C	D	D	B	C
21	22	23	24	25	26	27	28	29	30
C	D	B	C	B	D	B	C	A	D
31	32	33	34	35	36	37	38	39	40
C	C	B	C	B	A	D	A	A	A
41	42	43	44	45	46	47	48	49	50
B	A	D	C	D	B	B	C	B	A
51	52	53							
—	—	—							

1 **Answer (C)**

Sensitivity $= (\theta)/I$ does not change when the current changes.

Sensitivity of $(1) = 30/I$ and sensitivity of $(2) = 40/I$

2 **Answer (C)**

Sensitivity $= (\theta)/I$: $(1)\ 30/5 = 6$, $(2)\ 30/2 = 15$, $(3)\ 40/4 = 10$, $(4)\ 45/3 = 15$

So galvanometers (2) and (4).

3 **Answer (B)**

The scale is uniform: $\theta \propto I$

$I_1/I_2 = 20/(20 + 40) = 1/3$

4 **Answer (B)**

The pointer showed a reading greater than the real current, i.e. the torsion torque became weaker because the spiral springs were damaged.

5 **Answer (A)**

One division: $I = 1/5 = 0.2\ mA$, $V = 1/20 = 0.05\ V$

$R_g = V/I = 0.05/(0.2 \times 10^{-3}) = 250\ \Omega$

6 **Answer (B)**

The angle between the two ends of the scale is constant, so the most sensitive one reaches the end of its scale with the smallest current: $20\ \mu A$

7 **Answer (D)**

The two galvanometers are in series, so the same current passes through them, and their coils are identical.

So the greater deflection is due to a stronger magnetic field in (X).

8 **Answer (B)**

The greatest range is at the smallest shunt resistance.

(B) three $5\ \Omega$ resistances in parallel: $5/3\ \Omega$, the smallest.

9 **Answer (B)**

$I = I_g + (I_g R_g)/R_s$, so the slope $= I_g R_g = V_g$ (the potential difference across the shunt).

$slope = ((100 - 20) \times 10^{-3})/(10 \times 10^{-2}) = 0.8\ V$

10 **Answer (B)**

The intercept: $I_g = 20\ mA$, the slope $= I_g R_g = 0.8\ V$

$R_g = 0.8/(20 \times 10^{-3}) = 40\ \Omega$

11 **Answer (D)**

The sensitivity decreases by the ratio I_g/I

$3/4 : I = 4/3\ I_g$, $I_s = 1/3\ I_g$, $R_1 = (I_g R_g)/I_s = 3\ R_g$

$3/8 : I = 8/3\ I_g$, $I_s = 5/3\ I_g$, $R_2 = 3/5\ R_g$

$R_1/R_2 = 5$

12 **Answer (D)**

With R: $I_s = 3\ I_g$, so $R = R_g/3$

With 3R $= R_g : I_s = I_g$, $I = 2\ I_g$

13 **Answer (B)**

$I = I_g + I_g R_g\ 1/R_s$: the intercept is I_g and the slope is $I_g R_g$

$(1) : I_g = 0.5$, slope $= (1.5 - 0.5)/0.1 = 10$, $(R_g)_1 = 20\ \Omega$

$(2) : I_g = 0.6$, slope $= (1.8 - 0.6)/0.2 = 6$, $(R_g)_2 = 10\ \Omega$

$((R_g)_1)/((R_g)_2) = 2/1$

14 **Answer (B)**

$R_s = (I_g R_g)/(I - I_g) = (0.01 \times 9.9)/(1 - 0.01) = 0.1\ \Omega$

15 **Answer (A)**

The sensitivity increases by increasing R_s, so the current in the shunt decreases and the current in the galvanometer increases.

So the ratio I_g/I_s increases.

16 **Answer (C)**

The greater the shunt resistance, the greater the sensitivity of the ammeter.

$Y\ (40) > W\ (20) > Z\ (10) > X\ (5)$

17 **Answer (D)**

The sensitivity is proportional to $I_g/I = R_s/(R_s + R_g)$

First: $0.5/1.5 = 1/3$, second: $0.25/1.25 = 1/5$

The ratio $= 1/3 \div 1/5 = 5/3$

18 **Answer (D)**

$I = 6\, I_g$

$R_s = (I_g\, R_g)/(I - I_g) = 60/5 = 12\ \Omega$

19 **Answer (B)**

$R_s = (I_g\, R_g)/(I - I_g) = (10^{-4} \times 100)/(0.1 - 10^{-4}) \approx 0.1\ \Omega$

20 **Answer (C)**

$I/I_g = (R_g + R_s)/R_s = (100 + 20)/20 = 6$

Only $1/6$ of the current I, which used to move the pointer to the end of the scale, passes through the galvanometer, so two divisions $= N/6$

$N = 12$

21 **Answer (C)**

With switch K open: $I = 50/200 = 0.25\ A$, which is the galvanometer current.

$V_B = 0.25\ (200 + 200) = 100\ V$

The sensitivity decreases to one fifth: $I = 5\, I_g$, $I_s = 4\, I_g$, so $R_s = R_g/4 = 50\ \Omega$

22 **Answer (D)**

$I = I_g + V_g\ 1/R_s$: the intercept I_g is the same for both instruments, and the slope $= I_g\, R_g$

$((R_g)_1)/((R_g)_2) = (\tan 60)/(\tan 30) = 3/1$

23 **Answer (B)**

$I_g = 1/5\ I_s$, so $R_s = (I_g\, R_g)/I_s = 45/5 = 9\ \Omega$

$R = (45 \times 9)/(45 + 9) = 7.5\ \Omega$

24 **Answer (C)**

The potential difference across the galvanometer $= I_g\, R_g$ = the slope of the line.

$slope = ((40 - 10) \times 10^{-3})/(6 \times 10^{-3}) = 5\ V$

25 **Answer (B)**

Before closing: $R_s = 6\ \Omega$, $I_g/I = 6/(6 + 18) = 1/4$

After closing: $R_s = 2\ \Omega$, $I_g/I = 2/(2 + 18) = 1/10$

The ratio $= 1/4 \div 1/10 = 5/2$

26 **Answer (D)**

$V = I_g\ (R_g + R_m)$: the multiplier in A equals R_m, in B $R_m/2$ and in C $R_m/3$

$V_C < V_B < V_A$

27 **Answer (B)**

$I_g = 1/(50 + 450) = 2 \times 10^{-3}$ A

$(R_m)_2 = 18/(2 \times 10^{-3}) - 50 = 8950\ \Omega$

28 **Answer (C)**

$R_g = 0.1/(2 \times 10^{-3}) = 50\ \Omega$, number of divisions $= 0.1/0.01 = 10$

With the multiplier: $V = 2 \times 10^{-3}\ (50 + 450) = 1$ V

Value of one division $= 1/10 = 0.1$ V

29 **Answer (A)**

$V = I_g\ (R_g + R_m)$, so the slope $= I_g = 10/1000 = 0.01$ A

$R_g = V_g/I_g = 1/0.01 = 100\ \Omega$

30 **Answer (D)**

$I_g = 1/100 = 0.01$ A, and the increase by 10 times means a maximum potential difference of $1 + 10 = 11$ V

$R_m = 11/0.01 - 100 = 1000\ \Omega = 1$ kΩ

31 **Answer (C)**

$R_m = V/I_g - R_g = 100/0.1 - 40 = 960\ \Omega$

32 **Answer (C)**

$20.5 = 0.01\ (R_g + 2000)$, so $R_g = 50\ \Omega$

$10.25 = 0.01\ (50 + R)$, so $R = 975\ \Omega$

33 **Answer (B)**

$V = I_g\ (R_g + R_m) = 0.2\ (50 + 450) = 100$ V

34 **Answer (C)**

$I_g = 3/1200 = 2.5 \times 10^{-3}$ A

$R_m = 10/(2.5 \times 10^{-3}) - 1200 = 2800\ \Omega$

35 **Answer (B)**

$V_1 = V_g + I_g R$, $V_2 = V_g + 2 I_g R$

$I_g R = V_1 - V_g$, so $V_2 = V_g + 2(V_1 - V_g) = 2 V_1 - V_g$

36 **Answer (A)**

One division: $I = 1\ mA$, $V = 5\ mV$, so $R_g = 5\ \Omega$

With the resistance: $1 = 10^{-3}\ (5 + R)$, so $R = 995\ \Omega$

37 **Answer (D)**

End of the scale: $I_g = 3/3000 = 10^{-3}\ A$

Middle of the scale: the total resistance doubles $= 6000\ \Omega$

So a $3000\ \Omega$ resistance is connected in series.

38 **Answer (A)**

$I_g/I = (R_0 + R_x)/R_0 : 4/3 = (R_0 + 400)/R_0$, so $R_0 = 1200\ \Omega$

$I/I_g = 1200/(1200 + 6000) = 1/6$

39 **Answer (A)**

$5 = (R_0 + 12)/R_0$, so $R_0 = 3\ k\Omega$

$I/I_g = 3/(3 + 1.5) = 2/3$

40 **Answer (A)**

$I_g/I = (R_0 + R)/R_0 = 3$, so $R_0 = 0.5\ R$

41 **Answer (B)**

$2000\ \Omega$ at $3/4\ I_g : 4/3 = (R_0 + 2000)/R_0$, so $R_0 = 6000\ \Omega$

R_x at $1/4\ I_g : 4 = (6000 + R_x)/6000$, so $R_x = 18000\ \Omega$

42 **Answer (A)**

$3 = (R_0 + 50)/R_0$, so $R_0 = 25\ k\Omega$

$4/3 = (25 + R)/25$, so $R = 25/3\ k\Omega$

43 **Answer (D)**

$4/3 = (R_0 + R)/R_0$, so $R_0 = 3R$

$I/I_g = 3R/(3R + 3R) = 1/2$

44 **Answer (C)**

Between a and c: two paths $2 + 5 = 7\ k\Omega$ and $5 + 1 = 6\ k\Omega$ in parallel.

Between b and d: two paths $5 + 1 = 6\ k\Omega$ and $2 + 5 = 7\ k\Omega$ in parallel.

The two resistances are equal, so the reading is the same.

45 **Answer (D)**

$(\theta)/3 : R_0 + R_1 = 3\,R_0$, so $R_1 = 6000\ \Omega$

$(\theta)/4 : R_0 + R_2 = 4\,R_0$, so $R_2 = 9000\ \Omega$

46 **Answer (B)**

The resistance of the ohmmeter $R_0 = R_x + 5\,R_x + 3\,R_x = 9\,R_x$

With R_x and the other resistance r: $I/I_g = (9\,R_x)/(9\,R_x + R_x + r) = 3/5$

$10\,R_x + r = 15\,R_x$, so $r = 5\,R_x$

47 **Answer (B)**

$1/5 : R_0 + 15\,R_g = 5\,R_0$, so $R_0 = 3.75\,R_g$

$R_v = 3.75\,R_g - R_g - 2\,R_g = 0.75\,R_g$

48 **Answer (C)**

The scale has 4 equal divisions from ∞: z is at $1/4\ I_g$ and x at $3/4\ I_g$

x : $4/3 = (R_0 + R)/R_0$, so $R_0 = 3R$

z : the external resistance $= 3\,R_0 = 9R$, so the added one $= 9R - R = 8R$

49 **Answer (B)**

The pointer settles at ∞ when no current passes, i.e. the circuit between the terminals is open.

This happens when both switches are open.

50 **Answer (A)**

The scale has 6 equal divisions: Z is at $1/6\ I_g$ and Y at $1/2\ I_g$

$K_2 : R_1 + R_2 = 5\,R_0$

K_2 and $K_3 : (R_1\,(R_1 + R_2))/(2R_1 + R_2) = R_0$, so $R_1 = 1.25\,R_0$, $R_2 = 3.75\,R_0$

$R_1/R_2 = 1/3$

51 **Model answer**

$I_g/I = (R_c + R_g + R_v + R_x)/(R_c + R_g + R_v)$

(1) $900/300 = (3000 + 250 + R_v + (10 \times 10^3))/(3000 + 250 + R_v)$

$R_v = 1750\ \Omega$

(2) $I_g = V_B/(R_g + R_c + R_v) : 900 \times 10^{-6} = V_B/(250 + 3000 + 1750)$

$V_B = 4.5\ V$

52 **Model answer**

(1) $I_g/I_1 = (R' + (R_x)_1)/(R') : 3 = (3750 + R_x)/3750$, so $R_x = 7500\ \Omega$

(2) $I_g/(3/4\ I_g) = (3750 + (R_x)_2)/3750$, so $(R_x)_2 = 1250\ \Omega$

$(R_x)_2 = (R\ R_x)/(R + R_x) : 1250 = (7500\ R)/(R + 7500)$

$R = 1500\ \Omega$

53 **Model answer**

(1) The galvanometer scale is uniform, so the deflection angle is directly proportional to the current in the galvanometer.

$(\theta_g)/(\theta) = I_g/I = (R_{(ohmmeter)} + R_x)/(R_{(ohmmeter)})$

$80/(\theta) = (1500 + 4500)/1500 = 4$, so $\theta = 20^\circ$

(2) $(\theta_g)/(\theta) = I_g/I : 80/60 = 200/I$, so $I = 150\ mA$