Code: Phy/ EM-2/CE/001

Electromagnetism: Current Electricity – Typical Questions (Set 1)

No of Questions: 95 **Time Allotted: 9-1/2 Hours (in 3 parts)**

All questions are compulsory

[Note: a. Figures are conceptual only and not to the scale**]**

[b. Solutions may be taken up in Three parts as, Part I: 1 to 30 of Three Hours;**]**

[Part II: 31 to 60 of Three Hours; and Part III: 61 to 95] of Three and Half Hours**]**

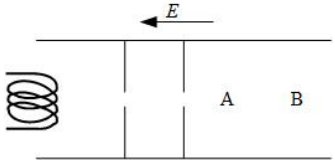
[c. It is advised to attempt question under examination conditions**]**

Important Note: 1. Capacitors are implementation aspect of concepts of electrostatics. The capacitors are integral part of any electrical system or circuit and any kind of application of electricity.

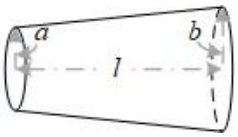
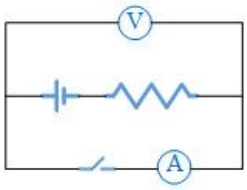
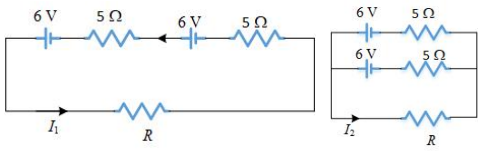
2. A student at a stage to refer to these questions and illustrations is expected to have attained a reasonable understanding of concepts and visualization. Moreover, forward journey involves integration of concepts on a wider canvas. Therefore, illustrations have been made a bit crisp. This would help students to harness their understanding at a faster rate.

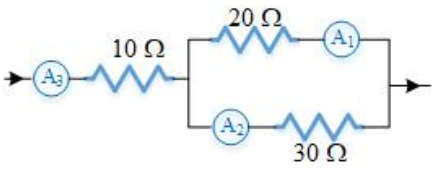
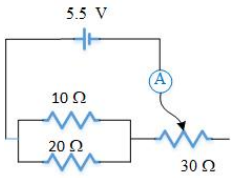
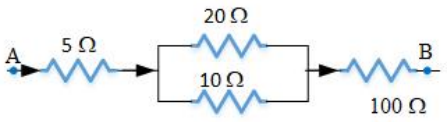
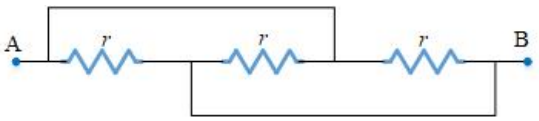
Q-1	Suppose you have three resistors each of value 30Ω. List all the three resistances you can obtain using them.
Q-2	A proton beam is going from east to west. Is there an electric current? If yes, in what direction?
Q-3	In an electrolyte, the positive ions move from left to right and negative ions from right to left. Is there a net current? If yes in which direction?
Q-4	In a TV tube, the electrons are accelerated from rear to the front. What is the direction of current?
Q-5	The drift speed is defined as $v_d = \frac{\Delta l}{\Delta t}$ where Δl is the distance drifted in a time Δt. Why don't we define the drift speed as the limit of $\frac{\Delta l}{\Delta t}$ as $\Delta t \to 0$?
Q-6	One of your friend argues that he has read in previous chapters that there can be no electric field inside a conductor. And hence there can be no current through it. What is the fallacy in the argument?
Q-7	When a current is established in a wire, the free electrons drift in the direction opposite to the current. Does the number of free electrons continuously decrease?
Q-8	A fan with copper winding in its motor consumes less power as compared to an otherwise similar fan having aluminum winding. Explain
Q-9	The thermal energy developed in a current-carrying resistor is given $U = i^2Rt$ and also by $U = iVt$. Should you say that U is proportional to i^2 or to i.
Q-10	Consider a circuit containing an ideal battery connected to a resistor. Do "work done by battery" and the "thermal energy developed" represent two names of the same physical quantity?
Q-11	Is work done by a battery is always equal to thermal energy developed in electrical circuit? What happen if a capacitor is connected in the circuit?
Q-12	A non-ideal battery is connected to a resistor. Is work done by the battery equal to the thermal energy developed in the resistor? Does your answer change if battery is ideal?

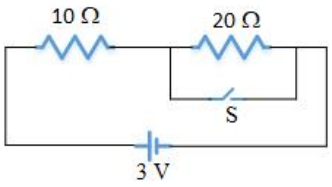
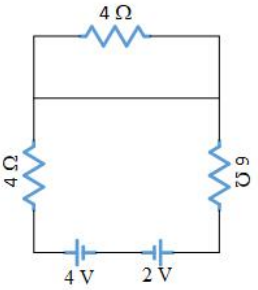
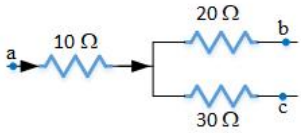
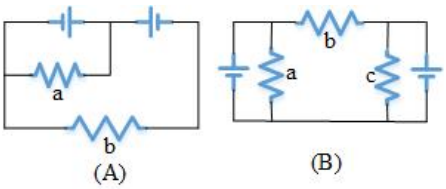
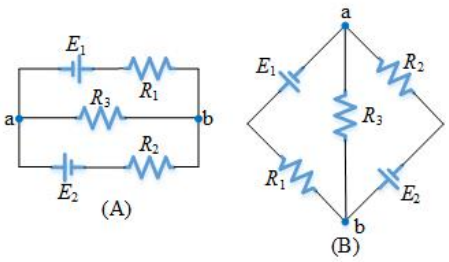
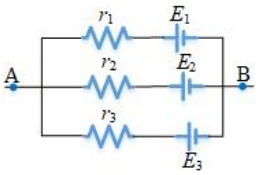
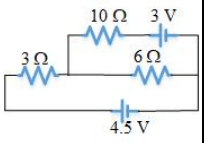
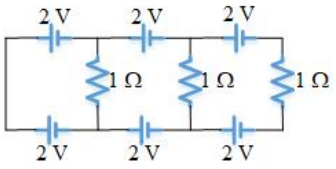
Q-13	Sometime it is said that "heat is developed" in a resistance when there is an electric current in it. Recall heat is defined as the energy being transformed due to temperature difference. Is the statement under quotes technically correct?
Q-14	Why often say "a current is going through the wire". What goes the wire , the charge or the current?
Q-15	Would you prefer a voltmeter or a potentiometer to measure the emf of a battery?
Q-16	Does a conductor become charged when a current is passed through it?
Q-17	Can potential difference across a battery be greater than its emf?
Q-18	A metallic resistor is connected across a battery. If the number of collisions of the free electrons with the lattice is somehow decreased in the resistor (for example by cooling it), the current will (a) Increase (b) Decrease (c) Remain Constant (d) Becomes Zero
Q-19	Two resistors A and B have resistances R_A and R_B respectively with $R_A > R_B$. Resistivities of their material are σ_A and σ_B. (a) $\sigma_A > \sigma_B$ (b) $\sigma_A = \sigma_B$ (c) $\sigma_A < \sigma_B$ (d) The information is not sufficient to find relation between σ_A and σ_B
Q-20	The product of resistivity and conductivity of a cylindrical conductor depends on – (a) Temperature (b) Material (c) Area of cross-section (d) None of these
Q-21	As the temperature of a metallic resistor is increased, the product of its resistivity and conductivity (a) Increases (b) Decreases (c) Remains constant (d) May increase or decrease
Q-22	In an electric circuit containing a battery, the charge (assumed positive) inside the battery – (a) Always goes from the positive terminal to the negative terminal, (b) May go from the positive terminal to the negative terminal (c) Always goes from the negative terminal to the positive terminal (d) Does not move
Q-23	A resistor of resistance *R* is connected to an ideal battery. If the value of *R* is decreased, the power dissipated in the resistor will – (a) Increase (b) Decrease (c) Remain unchanged
Q-24	A current passes through a resistor. Let K_1 and K_2 represent the average kinetic energy of the conduction electrons and the metal ions respectively. (a) $K_1 < K_2$ (b) $K_1 = K_2$ (c) $K_1 > K_2$ (d) Any of these three may occur
Q-25	Two resistors R and $2R$ are connected in series in an electric circuit. The thermal energy developed in R and $2R$ are in ratio –. (a) 1:2 (b) 2:1 (c) 1:4 (d) 4:1
Q-26	Two resistors R and $2R$ are connected in parallel in an electric circuit. The thermal energy developed in R and $2R$ are in ratio – (a) 1:2 (b) 2:1 (c) 1:4 (d) 4:1
Q-27	A uniform wire of resistance $50\ \Omega$ is cut into 5 equal parts. These parts are now connected in parallel. The equivalent resistance of the combination is – (a) $2\ \Omega$ (b) $10\ \Omega$ (c) $250\ \Omega$ (d) $6250\ \Omega$
Q-28	Consider the following two statements – (A) Kirchhoff's junction law follows from conservative nature of charge. (B) Kirchhoff's loop law follows from conservative nature of electric field.

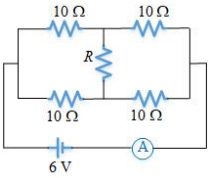
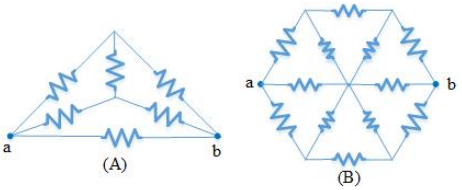
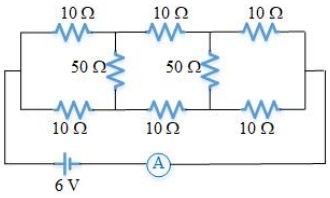
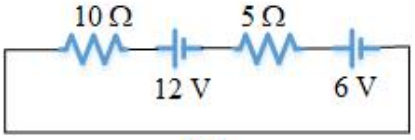
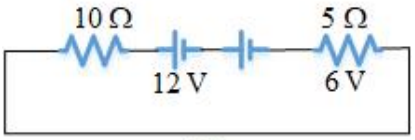
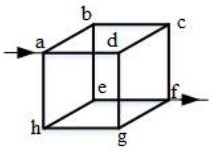
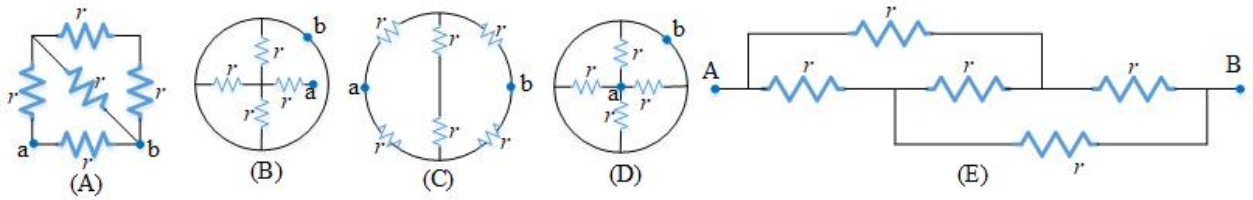
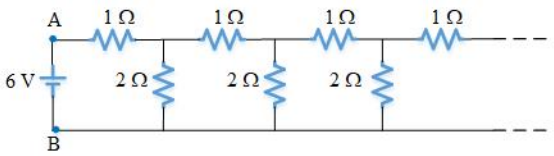
	(a) Each of A and B is correct (b) A is correct but B is wrong (c) B is correct but A is wrong (d) Each of A and B is wrong
Q-29	Two identical batteries are connected in series. Consider the following two statements – (A) The equivalent emf is larger than either of the two emfs. (B) The equivalent internal resistance is smaller than either of the two internal resistances. (a) Both A and B are correct (b) A is correct but B is wrong (c) B is correct but A is wrong (d) Both A and B are wrong
Q-30	Two identical batteries are connected in parallel. Consider the following two statements – (C) The equivalent emf is larger than either of the two emfs. (D) The equivalent internal resistance is smaller than either of the two internal resistances. (a) Both A and B are correct (b) A is correct but B is wrong (c) B is correct but A is wrong (d) Both A and B are wrong
Q-31	The net resistance of an ammeter should be small to ensure that – (a) It does not get overheated. (b) It does not draw excessive current (c) It can measure large current (d) It does not appreciably change the current to be measured.
Q-32	The net resistance of a voltmeter should be large to ensure that – (a) It does not get overheated. (b) It does not draw excessive current (c) It can measure large current (d) It does not appreciably change the voltage to be measured.
Q-33	Consider a capacitor-charging circuit. Let Q_1 be the charge given to the capacitor in a time interval of 10 μs and Q_2 be the charge given in the next time interval of 10 μs. Let 10 μC charge be deposited in a time interval t_1 and the next 10 μC charge is deposited in the next time interval t_2. (a) $Q_1 > Q_2, t_1 > t_2$ (b) $Q_1 > Q_2, t_1 < t_2$ (c) $Q_1 < Q_2, t_1 > t_2$ (d) $Q_1 < Q_2, t_1 < t_2$
Q-34	Electrons are emitted by a hot filament and are accelerated by an electric field as shown in the figure. The two stops at the left ensure that the electron beam has a uniform cross-section. (a) The speed of electron is more at B than at A (b) Electric current is from left to right (c) Magnitude of current is larger at B than at A (d) The current density is more at B than at A. 
Q-35	A capacitor with no dielectric is connected to a battery at $t = 0$ Consider a point A in the connecting wires and a point B in between the plates. (a) There is no current through A. (b) There is no current through B. (c) There is a current through A as long as the charging is not complete. (d) There is a current through B as long as the charging is not complete.
Q-36	When no current is passed through a conductor – (a) The free electrons do not move (b) The average speed of a free electron over a large time is zero. (c) The average velocity of a free electron over a large time is zero. (d) The average of the velocities of all the free electrons at an instant is zero

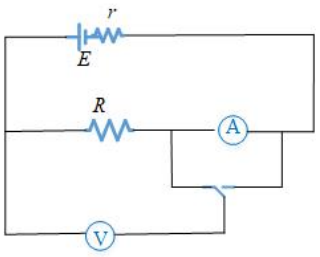
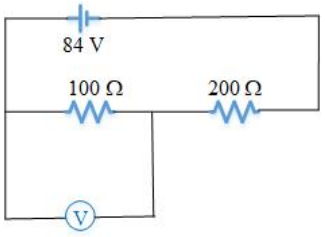
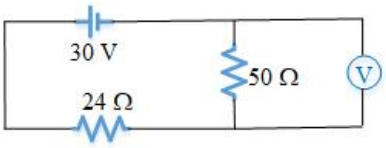
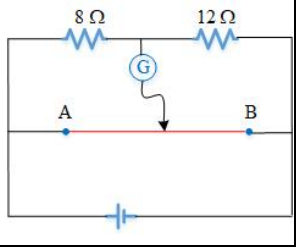
Q-37	Which of the following quantities do not change when a resistor connected to a battery is heated due to the current? (a) Drift speed (b) Resistivity (c) Resistance (d) Number of free electrons
Q-38	As the temperature of a conductor increases, its resistivity and conductivity change. The ratio of resistivity to conductivity – (a) Increases (b) Decreases (c) Remains constant (d) May increase or decrease depending on the actual temperature
Q-39	A current passes through a wire of non-uniform cross-section. Which of the following quantities are independent of the cross-section? (a) The charge crossing in a given time interval (b) Drift speed (c) Current density (d) Free-electron density
Q-40	Mark out the correct options – (a) An ammeter should have small resistance (b) An ammeter should have large resistance (c) A voltmeter should have small resistance (d) A voltmeter should have large resistance
Q-41	A capacitor of capacitance 500 μF is connected to a battery through a 10 Ω resistor. The charge stored on the capacitor in the first 5 s is larger than the charge stored in the next (a) 5 s (b) 50 s (c) 500 s (d) 5000 s
Q-42	A capacitor C_1 of capacitance 1 μF and another capacitor C_2 of capacitance 2 μF are separately charged by a common battery for a long time. Two capacitors are then separately discharged through equal resistors. Both the discharge circuit are connected at $t = 0$. (a) The current in each of the two discharging circuit is zero at $t = 0$. (b) The current in the two discharging circuits at $t = 0$ are equal but not zero. (c) The current in the two discharging circuits at $t = 0$ are unequal. (d) C_1 loses 50% of its initial charge sooner than C_2 loses 50% of initial charge.
Q-43	The amount of charge passed in time t through a cross-section of a wire is $Q(t) = At^2 + Bt + C$. (a) Write dimensional formulae for A, B and C (b) If the numerical values of A , B and C are 5, 3, and 1 respectively in SI units find value of current at $t = 5$ s.
Q-44	An electron gun emits 2.0×10^{16} electrons per second. What current does this correspond to?
Q-45	The electric current existing in a discharge tube is 2.0 μA. How much charge is transferred across cross-section of the tube in 5 minutes?
Q-46	The current through a wire depends on time as $i = i_0 + \alpha t$, where $i_0 = 10$ A and $\alpha = 4$ A/s. Find charge crossed through a cross-section of wire in 10 seconds.
Q-47	A current of 1.0 A exists in a copper wire of cross-section 1.00 mm^2. Assuming one free electron per atom calculate the drift speed of the free electrons in the wire. The density of copper wire is 9000 kg/m^3.
Q-48	A wire of length 1 m and radius 0.1 mm has a resistance of 100 Ω. Find resistivity of the material.

Q-49	A uniform wire of resistance 100 Ω is melted and recast in a wire of length double that of the original. What would be the resistance of the wire?
Q-50	Consider a wire of length 4 m and a cross-sectional area 1mm^2 carrying a current of 2A. If each cubic meter of material contains 10^{29} free electrons, find average time taken by an electron to cross the length of the wire.
Q-51	What length of a copper wire of cross-sectional area 0.01 mm^2 will be needed to prepare a resistance of 1 k Ω. Resistivity of copper is 1.7×10^{-8} Ωm.
Q-52	Figure shows a conductor of length l having a circular cross-section. The radius of cross-section varies linearly from a to b. The resistivity of the material is ρ. Assuming that $b - a \ll l$, find resistance of the conductor. 
Q-53	A copper wire of radius 0.1 mm and resistance 1kΩ is connected across a power supply of 20 V. (a) How many electrons are transferred per seconds between the supply and the wire at one end? (b) Write down the current density in the wire.
Q-54	Calculate the electric field in a copper wire of cross-sectional area 2.0 mm^2 carrying a current of 1 A. The resistivity of copper is 1.7×10^{-8} Ωm.
Q-55	A wire has a length of 2.0 m and a resistance of 5.0 Ω. Find electric field existing inside the wire if it carries a current of 10 A.
Q-56	The resistances of an iron wire and a copper wire at 20^{0}C are 3.9 Ω and 4.1 Ω respectively. At what temperature will the resistances be equal? Temperature coefficient of resistivity for iron is 5.0×10^{-3} K^{-1} and 4.0×10^{-3} K^{-1}. Neglect any thermal expansion.
Q-57	The current in a conductor and potential difference across its ends are measured by an ammeter and a voltmeter. The meter draws negligible currents. The ammeter is accurate but the voltmeter has a zero error (that is, it does not read zero when no potential difference is applied. Calculate the zero error if the readings for two different conditions are 1.75 A, 14.4 V and 2.75 A, 22.4 V.
Q-58	Figure shows an arrangement to measure the emf E and internal resistance r of a battery. The voltmeter has a very high resistance and the ammeter also has some resistance. The voltmeter reads 1.52 V when switch is open. When the switch is closed the voltmeter reading drops to 1.45 V and ammeter reads 1.0 A. Find emf and internal resistance of the battery. 
Q-59	The potential difference between the terminal of a battery of emf 6.0 V and internal resistance 1 Ω drops to 5.8 V when connected across an external resistor. Find the resistance of the external resistor.
Q-60	The potential difference between the terminals of a 6.0 V battery is 7.2 V when it is being charged by a current of 2.0 A. What is the internal resistance of the battery?
Q-61	The internal resistance of an accumulator battery of emf 6 V is 10 Ω when it is fully discharged. As the battery gets charged up, its internal resistance decreases to 1 Ω. The battery in its completely discharged state is connected to a charger which maintains a constant potential difference 9 V. Find the current through the battery – (a) Just after connections are made, (b) After a long time when it is completely charged.
Q-62	Find the value of $\frac{i_1}{i_2}$ in figure if (a) $R = 0.1\ \Omega$, (b) $R = 1\ \Omega$, (c) $R = 10\ \Omega$. Note from your answer that in order to get more current from a combination of two batteries they should be joined in parallel if the external resistance is small and in series if external resistance is large as compared to the internal resistances. 

Q-63	Consider $N = n_1 n_2$ identical cells, each of emf E and internal resistance r. Suppose n_1 cells are joined in series to forma line and n_2 such lines are connected in parallel. The combination drives a current in the external resistance R. (a) Find the current in the external resistance. (b) Assuming that n_1 and n_2 can be continuously varied, find the relation between n_1, n_2 , R and r for which the current in R is maximum.
Q-64	A battery of emf 100 V and a resistor of resistance 10 kΩ are joined in series. This system is used as a source to supply current to an external resistance R. If R is not greater than 100 Ω, the current through it is constant up to two significant digits. Find its value. This is the basic principle of a *constant-current source.*
Q-65	If the reading of ammeter A_1 in figure is 2.4 A what will the ammeters A_2 and A_3 will read? Neglect the resistances of the ammeters. 
Q-66	The resistance of the rheostat shown in the figure is 30 Ω. Neglecting the meter resistance, find the minimum and maximum current through the ammeter as the rheostat is varied. 
Q-67	Three bulbs, each having a resistance of 180 Ω are connected in parallel to an ideal battery of emf 60 V. Find the current delivered by the battery when – (a) All the bulbs a switched on, (b) Two of the bulbs are switched on, (c) Only one bulb is switched on.
Q-68	Suppose you have three resistors of 20 Ω, 50 Ω and 100 Ω. What minimum and maximum resistances can you obtain from these resistor?
Q-69	A bulb is made using two filaments. A switch selects whether the filaments are used individually or in parallel. When used with a 15 V battery, the bulb can be operated at 5 W, 10 W and 15 W. What should be resistances of the filaments?
Q-70	Figure shows a part of a circuit. If a current of 12 mA exists in the 5 Ω resistor, find the currents in the other three resistors. What is the potential difference between the points A and B? 
Q-71	An ideal battery sends a current of 5A in a resistor. When another resistor of value of 10 Ω is connected in parallel, the current through the battery is increased to 6 A. Find the resistor of the first resistor.
Q-72	Find the equivalent resistance of the network shown in the figure between the points a and b. 
Q-73	A wire of resistance 15.0 is bent to form a regular hexagon ABCDEFA. Find the equivalent resistance of the loop between the points – (a) A and B, (b) A and C, (c) A and D

Q-74	Consider the circuit shown in figure. Find the current through the 10 Ω resistor when the switch S is (a) open and (b) closed.	
Q-75	Find the current through the three resistors shown in the figure.	
Q-76	Figure shows a part of an electric circuit. The potential at the points a, b and c are 30 V, 12 V and 2 V respectively. Find currents through the three resistors.	
Q-77	Each of the resistors shown in the figure has a resistance of 10 Ω and each of the battery has an emf of 10 V. Find the currents through the resistors a and b in the two circuits.	
Q-78	Find the potential difference $V_a - V_b$ in the circuits shown.	
Q-79	In the circuit shown in the figure $E_1 = 3$ V, $E_2 = 2$ V, and $E_3 = 1$ V and $r_1 = r_2 = r_3 = 1\Omega$. Find potential difference between the points A and B and the current through each branch.	
Q-80	Find the current through the 10 Ω resistor shown in figure.	
Q-81	Find the current in the three resistors shown in figure.	

Q-82	What should be the value of R in figure for which the current in it is zero? 
Q-83	Find equivalent resistance of the circuit shown in figure between points a and b. Each resistor has a resistance r. 
Q-84	Find the current measured by ammeter in the circuit shown in figure. 
Q-85	Consider the circuit shown in figure (A). Find – (a) The current in the circuit. (b) The potential drop across the 5 Ω resistor. (c) The potential drop across the 10 Ω resistor. (d) Answer the parts (a), (b) and (c) with reference to figure (B)  (A)  (B)
Q-86	Twelve wires, each having equal resistance r are joined to form a cube as shown in the figure. Find the equivalent resistance between the diagonally opposite points a and f. 
Q-87	Find the equivalent resistances of the networks shown in figure between points a and b. 
Q-88	An infinite ladder is constructed with 1Ω and 2 Ω resistors as shown in figure. (a) Find the effective resistance between the points A and B. (b) Find the current that passes through the 2 Ω resistor nearest to the battery. 
Q-89	Q-47, HCV-II, Ch-32, Ex, pp. 201

Q-89	The emf E and the internal resistance r of the battery shown in the figure are 4.3 V and 1.0 Ω respectively. The external resistance R is 50 Ω. The resistances of the ammeter and voltmeter are 2.0 Ω and 200 Ω respectively. (a) Find the reading of the two meters. (b) The switch is thrown to the other side. What will be the reading of the two meters now ? 
Q-90	A voltmeter of resistance 400 Ω is used to measure the potential difference across 100 Ω resistor in the circuit shown in the figure. (a) What will be the reading of the voltmeter? (b) What was the potential difference across 100 Ω before the voltmeter was connected? 
Q-91	The voltmeter shown in figure reads 18 V across the 50 Ω resistor. Find the resistance of the voltmeter. 
Q-92	A voltmeter consists of a 25 Ω coil connected in series with a 575 Ω resistor. The coil takes 10 mA for full-scale deflection. What maximum potential difference can be measured on this voltmeter?
Q-93	An ammeter is to be constructed which can read currents upto 2.0 A. If the coil has a resistance of 25 Ω and takes 1 mA for full-scale deflection, what should be the resistance of the shunt used?
Q-94	A voltmeter coil has resistance 50.0 Ω and a resistor of 1.15 kΩ is connected in series. It can read potential difference upto 12 volts. If this same coil is used to construct an ammeter which measure current upto 2.0 A, what should be the resistance of the shunt used?
Q-95	The potentiometer wire AB shown in figure is 40 cm long. Where should the free end of the galvanometer be connected on AB so that the galvanometer may show zero deflection? 

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