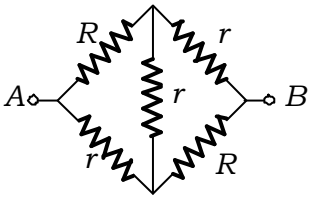
ELECTRICAL CONDUCTION & CURRENT ELECTRICITY

1. Find the equivalent resistance of the resistive network between terminals A and B in the following diagram.



Answer: $R_{eq} = \dfrac{r(3R+r)}{(R+3r)}$

2. The potential difference across a cell is 1.8 V when a current of 0.5 amp is drawn from it. The potential difference falls to 1.6 volt when a current of 1.0 amp is drawn. Find the emf and the internal resistance of the cell.

Answer: E = 2.0 V, r = 0.4 Ω

3. Two cells connected in series have emf of 1.5 V each. Their internal resistances are 0.5 Ω and 0.25 Ω respectively. This combination is connected to a resistance of 2.25 Ω. Calculate the current flowing in the circuit and the potential difference across the terminals of each cell.

Answer: 1.0 amp, 1.0 V and 1.25 V

4. In hydrogen atom, an electron moves in an orbit of radius 5×10^{-11} m with a speed of 2.2×10^{6} ms^{-1}. Find the equivalent current. ($e = 1.6 \times 10^{-19}$ C)

Answer: 1.12 m A

5. A current of 5 A is passing through a copper wire of cross-sectional area 4×10^{-6} m^2. Assuming that there is one free electron per atom in copper determine the drift speed of electrons. Given density of copper 8.9×10^{3} kg m^{-3} and atomic weight 63.5. (Avogadro number = 6.02×10^{26} atoms per kg-mole, $e = 1.6 \times 10^{-19}$ C)

Answer: 92.8×10^{-6} m s^{-1}

6. The resistance of a wire is R ohm. What will be its new resistance if it is stretched to n times its original length?

Answer: n^2R

7. A uniform copper wire of mass 2.23×10^{-3} kg carries a current of 1 A when 1.7 V is applied across it. Calculate its length l and area of cross-section A. If the wire is uniformly stretched to double its length, calculate the new resistance. Density of copper is 8.92×10^{3} kg m^{-3} and resistivity is 1.7×10^{-8} Ω-m.

Answer: l = 5 m, $A = 5 \times 10^{-8}$ m^2, R' = 6.8 Ω

8. On applying the same potential difference between the ends of wires of iron and copper of the same length, same current flows in them. Find the ratio of their radii. Specific resistance of iron and copper are ρ_1 and ρ_2 respectively. Also find the ratio of their current densities.

Answer: $r_1/r_2 = \sqrt{\rho_1/\rho_2}$, $j_1/j_2 = \rho_2/\rho_1$

9. 1 m long metallic wire is broken into two unequal parts P and Q. The part P is uniformly extended into another wire R. The length of R is twice the length of P and the resistance of R is equal to that of Q. Find the ratio of the resistances of P and R and also the ratio of the lengths of P and Q.

Answer: $R_P/R_R = 1/4$, $l_P/l_Q = 1/4$

10. A metal piece of width 4×10^{-3} m, thickness 25×10^{-5} m and length 6×10^{-2} m caries a current of 4.8 m A when a constant potential difference is applied across it. Find the current density. If number of free electrons per unit volume in the conductor is 10^{26}, find the time taken by the electron to travel the full length of the conductor.

Answer: 4.8×10^3 A m^{-2}, 200 s.

11. A long uniformly charged cylinder of radius R is moving along its axis with a constant velocity v. If the strength of electric field on the surface of cylinder due to charge distribution is E then find the electric current due mechanical transfer of charge.

Answer: $2\pi \in_o ERv$

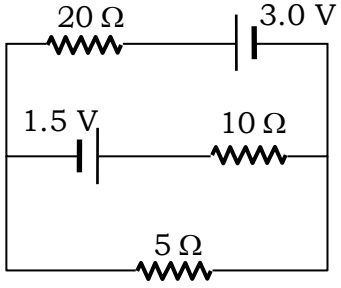
12. Two resistances, R and ηR have temperature coefficients $\eta\alpha$ and α respectively. Find the equivalent temperature coefficient of their series and parallel combinations.

Answer: $\dfrac{2\eta\alpha}{\eta+1}, \dfrac{(\eta^2+1)\alpha}{(\eta+1)}$

13. A material of resistivity ρ is filled between the two thin concentric conducting shells of radius a and b ($a < b$). Find the resistance of medium between the two shells.

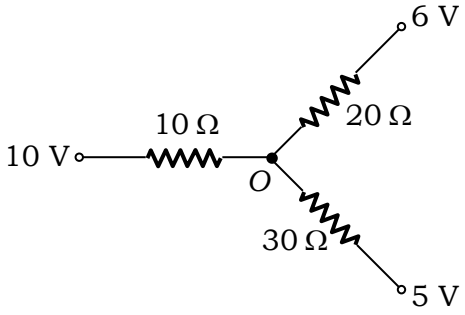
Answer: $\dfrac{\rho}{4\pi}\dfrac{(b-a)}{ab}$

14. Find the magnitude and direction of the current flowing in the 5 Ω resistance in the following figure.



Answer: 0 amp.

15. Find the potential of point O and the current flowing through 10 Ω resistance in the following figure.

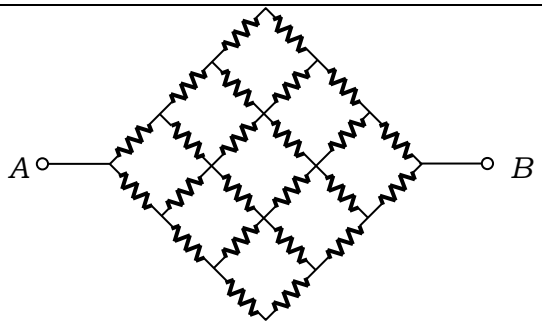


Answer: V_O = 8 V, i = 0.2 amp

16. 12 cells each having same e.m.f are connected in series with some cells wrongly connected. The arrangement is connected in series with an ammeter and two cells which are in series. Current is 3 A when cells and battery aid each other and is 2 A when cells and battery oppose each other. Find the number of cells wrongly connected.

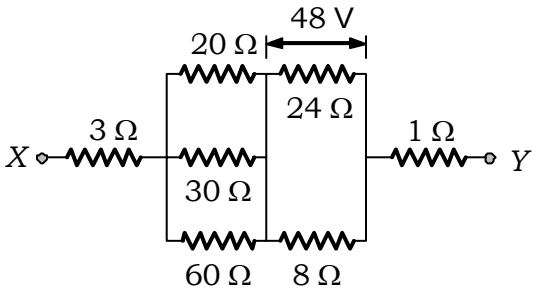
Answer: 1

17. Find the equivalent resistance of the following resistive network consisting of 24 resistors of identical resistances r each between terminals A and B.



Answer: $\frac{13}{7}r$

18. The potential difference across 8 Ω resistance is 48 V as sown in figure. The value of the potential difference across X and Y points will be

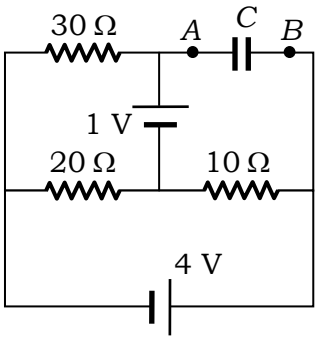


Answer: 160 V

19. Two resistances 300 Ω and 400 Ω are connected in series with a battery of e.m.f. 60 V and negligible internal resistance. A non ideal voltmeter reads 30 V when connected across 400 Ω resistor. If the same voltmeter is connected across 300 Ω resistor find the reading of same voltmeter.

Answer: 22.5 V

20. Find the potential difference ($V_A - V_B$) between the plates of the capacitor C in the following circuit.



Answer: -1 V

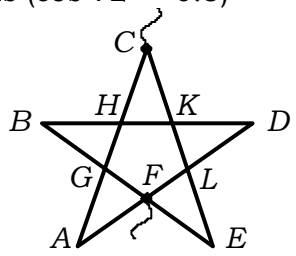
21. In a potentiometer experiment a cell balances at 240 cm length of potentiometer wire. On shunting the cell with a resistance of 2 Ω, the balancing length reduces to 120 cm. Find the internal resistance of the cell.

Answer: 2 Ω

22. An ammeter and a voltmeter are connected in series to a battery with an emf E = 9 V. When a certain resistance is connected parallel to voltmeter the reading of voltmeter decreases by a factor η = 2 where as the reading of ammeter increases by same factor. Find the voltmeter reading after connecting resistance parallel to voltmeter.

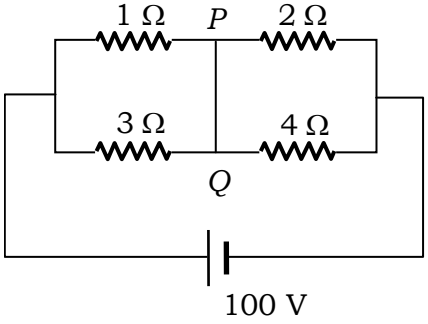
Answer: $V = \frac{E}{(\eta+1)} = 3$ V

23. A five pointed regular star has been soldered together from a uniform wire. The resistance of the section *EL* is *r*. The star is connected to the circuit at points *F* and *C*. The equivalent resistance is (cos 72° = 0.3)



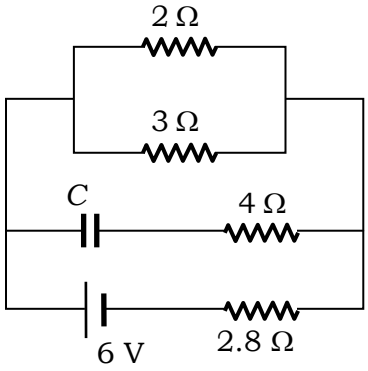
Answer: $\frac{25}{26}r$

24. Find the current flowing through the wire segment *PQ* in the following circuit.



Answer: 4 amp

25. Calculate the steady-state current in the 2 Ω resistor shown in figure. The internal resistance of the battery is negligible and the capacitance of the capacitor is 0.2 μF.

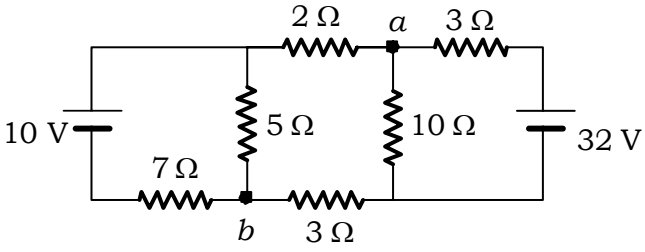


Answer : 0.9 A

26. Find the resistance of a truncated right circular solid cone of length ℓ with radii of two ends r_1 and r_2. Given resistivity of the material = ρ.

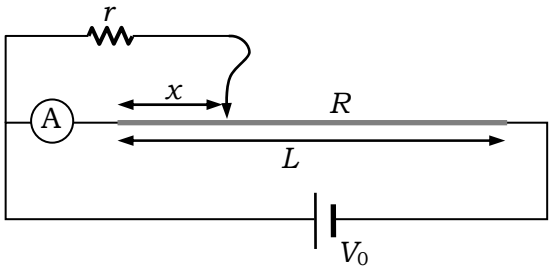
Answer: $\frac{\rho\ell}{\pi r_1 r_2}$

27. Six resistors and two sources of e.m.f. of negligible internal resistance are connected as shown in the figure. Find the potential difference between the points *a* and *b*.



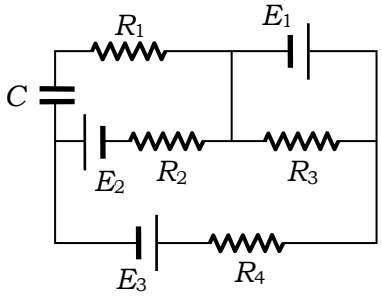
Answer: $V_a - V_b = 14$ V

28. Figure shows a potentiometer of resistance R with a source of constant emf V_0 and negligible internal resistance. The sliding contact J has a resistance r. Determine the ammeter reading as function of length x from left end. Also find the minimum and maximum value of it.



Answer: $i_{(x)} = \dfrac{V_0 rL^2}{R\left(RxL - Rx^2 + rL^2\right)}$, $i_{\min} = \dfrac{4V_0 r}{R(4r+R)}$, $i_{\max} = \dfrac{V_0}{R}$

29. In the given circuit

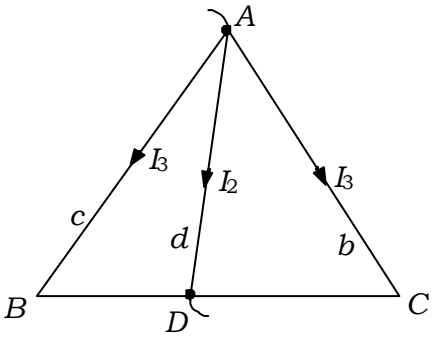


$E_1 = 3E_2 = 2E_3 = 6$ Volt
$R_1 = 2R_4 = 6\Omega$
$R_3 = 2R_2 = 4\Omega$
$C = 5\ \mu F$
Find the current in R_3 and the energy stored in the capacitor.

Answer: 1.5 amp, 14.4 μJ

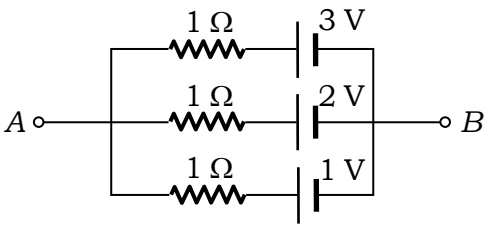
30. The resistance of three wires BC, CA, and AB of same material and uniform cross section are a, b and c respectively. Another wire from A of constant resistance d can make a sliding contact with BC. If a current enters at A and leaves at the point of contact with BC, show that the maximum resistance of network is

$$\frac{(a+b+c)d}{a+b+c+4d}.$$



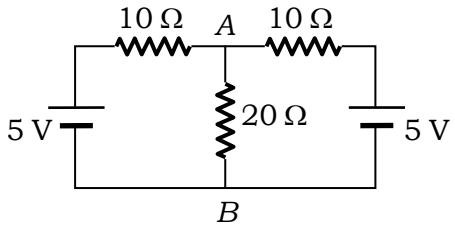
31. A battery of N cells is such that when they are arranged in m rows each of n cells in series the current is maximum for a given external circuit. Instead if the cells are arranged in n parallel sets containing m cells in series, show that the current through the same external circuit is given $I' = \dfrac{I}{\dfrac{(m+n)^2}{2N} - 1}$ where I is the maximum current in the first case.

32. In the circuit shown in figure find the potential difference between the points A and B



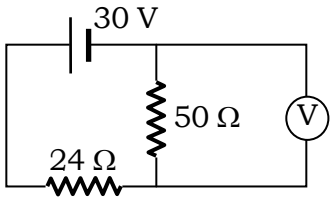
Answer: 2 V

33. Find the current in the 20 Ω resistor shown in figure. If a capacitor of capacitance 4 μF is joined between the points A and B, find the electrostatic energy stored in it in steady state.



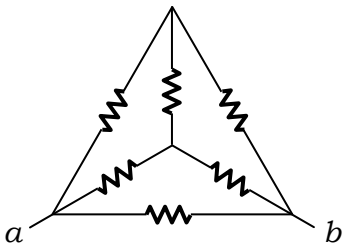
Answer: 0.2 A, 32 μJ

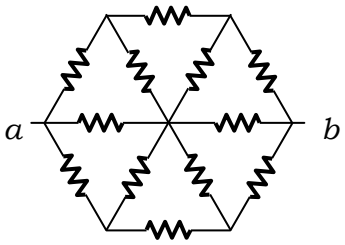
34. The voltmeter shown in the figure reads 18 V across the 50 Ω resistor. Find the resistance of the voltmeter.



Answer: 130 Ω

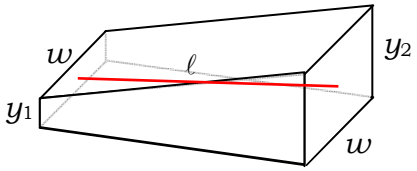
35. Find equivalent resistance of the resistive network with each resistance r between points a and b.





Answer: $r/2$, $\left(4/5\right)r$

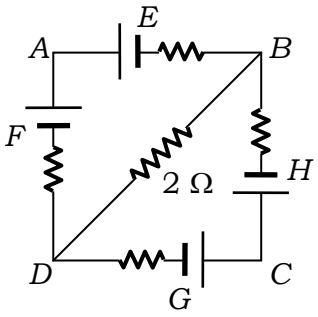
36. Material with uniform resistivity ρ is formed into a wedge as shown in figure. Find the resistance of wedge between faces A and B of the figure.



Answer: $\dfrac{\rho\ell}{w(y_2-y_1)}\ln\left(y_2/y_1\right)$

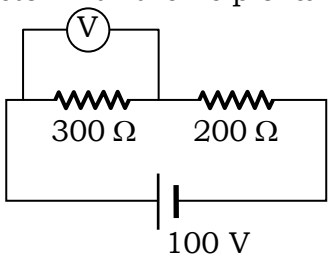
37. In the circuit shown in figure E, F, G and H are cells of emf 2, 1, 3 and 1 V respectively. Their internal resistances are 2, 1, 3 and 1 Ω respectively. Find the

potential difference between points B and D and the potential difference across the terminals of cell G.



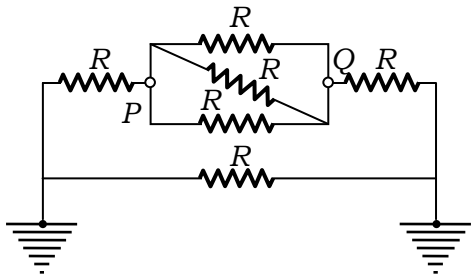
Answer: $\frac{2}{13}$ V, $\frac{21}{13}$ V

38. Two resistors of 300 Ω and 200 Ω are connected in series with a cell of emf 100 V and negligible internal resistance. Calculate the %age error in finding potential difference across 300 Ω resistor with the help of a voltmeter of resistance 600 Ω.



Answer: 16.7%

39. Find the equivalent resistance of the following circuit between points *P* and *Q*. All resistances are of *R* Ω each.



Answer: $\left(\frac{2}{7}\right)R$

40. Two cylindrical conductors of equal cross-section and different resistivity ρ_1 and ρ_2 are put end to end. Find the charge at the boundary of the conductors if a current i flows from conductor 1 to conductor 2.

Answer: $\in_o (\rho_2 - \rho_1) I$