Basic Electronics

Assessed Problems 1

For online completion before your week 2 deadline.

APS1.1 A wire carries a DC current of 1 mA. How many electrons will pass any point in the wire during 1 minute? [1 mark]

(a) None
(b) 6.25×10^{15}
(c) 3.75×10^{17}
(d) 6.25×10^{18}

APS1.2 The wire in the question above is made of copper [carrier electron number density $n = 8.45 \times 10^{28}\,\mathrm{m}^{-3}$] and has a circular cross-section of diameter of 0.97 mm. What is the average speed of the electrons? [1 mark]

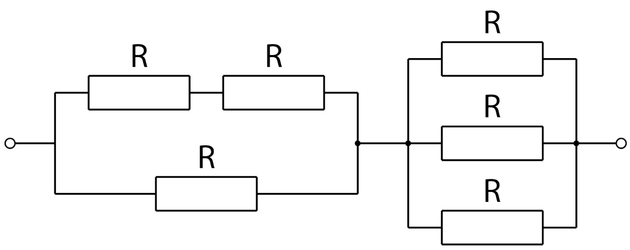
(a) 10^{-4} mm/s
(b) 10^{-2} mm/s
(c) 1 mm/s
(d) About one-third light-speed

APS1.3 What will be the potential difference across a 10 cm length of the wire? [Resistivity of copper is $\rho = 1.72 \times 10^{-8}\,\Omega$ m at room temperature]. [1 mark]

(a) 0 V
(b) 0.58 μV
(c) 2.3 μV
(d) 0.23 V

APS1.4 In the circuit shown below, the wires used are 'ideal' - they have zero resistance[1].What is the equivalent resistance between the terminals? [1 mark]

(a) $R/3$
(b) R
(c) $3R$
(d) $6R$



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[1] Note that all such circuit diagrams are assumed to use ideal wires, unless specifically stated otherwise

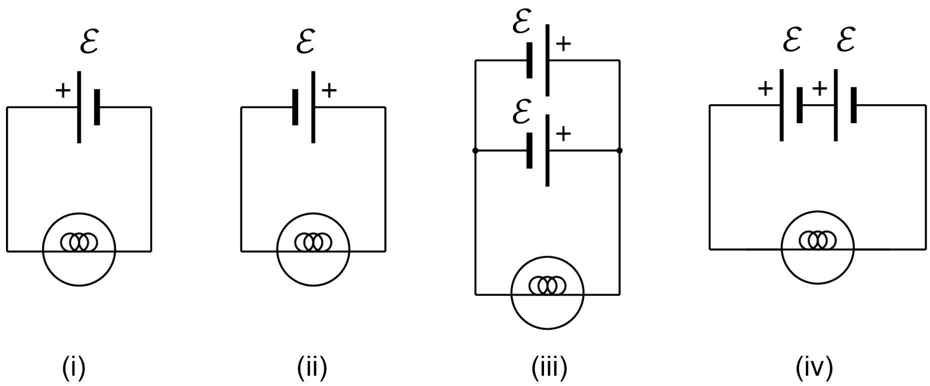
APS1.5 In the circuits below all the bulbs are identical and the EMF sources ($\mathcal{E}$) are ideal[2]. Which is the correct statement? [1 mark]

(a) Identical bulbs are always equally bright

(b) (i) and (ii) are equally bright, (iii) and (iv) are the same but brighter

(c) (iv) is the brightest and - assuming the sources are identical batteries - (iii) will last longest

(d) (iv) is brighter than (iii), which is brighter than (i) and (ii)



APS1.6 Considering figure (iv) above, which of the following statements is most true? [1 mark]

(a) Conventional current flows anticlockwise, and each coulomb of charge gains energy $\mathcal{E}$ each complete loop of the circuit

(b) Electrons flow clockwise and each coulomb gains energy $2\mathcal{E}$ each complete loop of the circuit

(c) Conventional current flows anticlockwise, and each coulomb gains no net energy each complete loop of the circuit

(d) Electrons flow clockwise and each coulomb gains energy $\mathcal{E}$ each complete loop of the circuit

APS1.7 An alkaline AA battery with an EMF (electromotive force) $\mathcal{E} = 1.5\,\text{V}$ is described as having a capacity of 1800 mA h (milli-amp hours). How much potential energy does it store? [1 mark]

(a) 9720 J

(b) 97.2 kJ

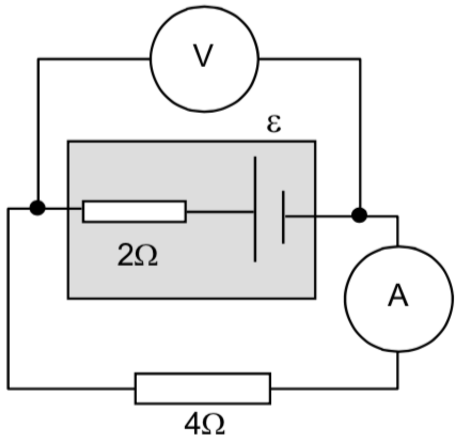
(c) 6.48 kJ

(d) None

[2] Zero internal resistance. This can always be assumed when you see a voltage source, unless specifically stated otherwise

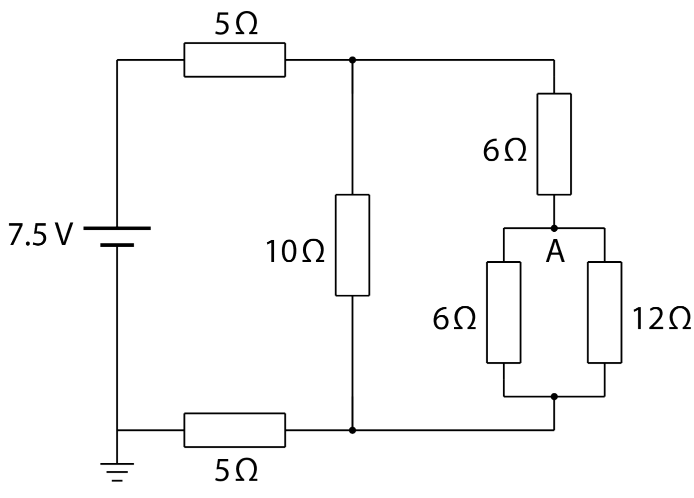
APS1.8 The circuit shows a battery with an EMF $\mathcal{E} = 12\,\text{V}$ and an internal resistance $2\,\Omega$. The ammeter and voltmeter are assumed to be ideal. Choose the best answer [1 mark]

(a) The ammeter reads 2 A
(b) The voltmeter reads 8 V
(c) Each second, the battery uses 24 J stored potential energy
(d) All of the above are true



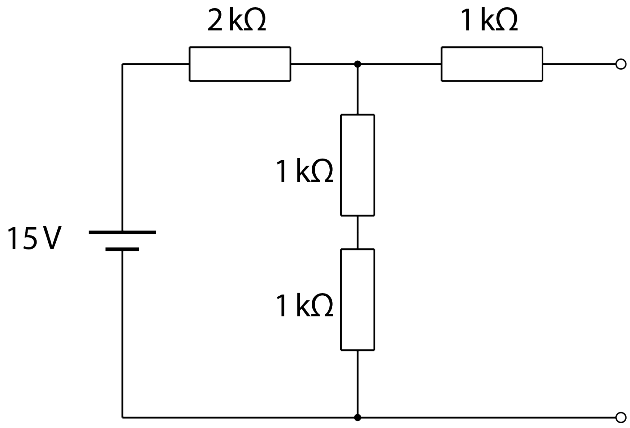
APS1.9 For the circuit below, which of the following statements are true? [1 mark]
Hint: First combine the resistances to find the total current flowing through the voltage source. Then use Kirchhoff's laws to find the currents into and out of each junction in the circuit (labelled with solid circles)

(a) The current through the $5\,\Omega$ resistor is $\frac{1}{2}$ A and the potential at point A is 1 V
(b) The current through the $12\,\Omega$ resistor is $\frac{1}{12}$ A and the potential at point A is 2.5 V
(c) The current through the $12\,\Omega$ resistor is $\frac{1}{12}$ A and the potential at point A is 3.5 V
(d) The current through the $10\,\Omega$ resistor is $\frac{1}{4}$ A and the potential at point A is 7.5 V



APS1.10 The Thévenin equivalent of the circuit shown in the figure is represented by [1 mark]

(a) 5 V in series with 1 kΩ
(b) 7.5 V in series with 1.25 kΩ
(c) 7.5 V in series with 2 kΩ
(d) 15 V in series with 1 kΩ



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2-Jan-18

Basic Electronics

Tutorial Problems 1

These problems are for your week 2 tutorial.

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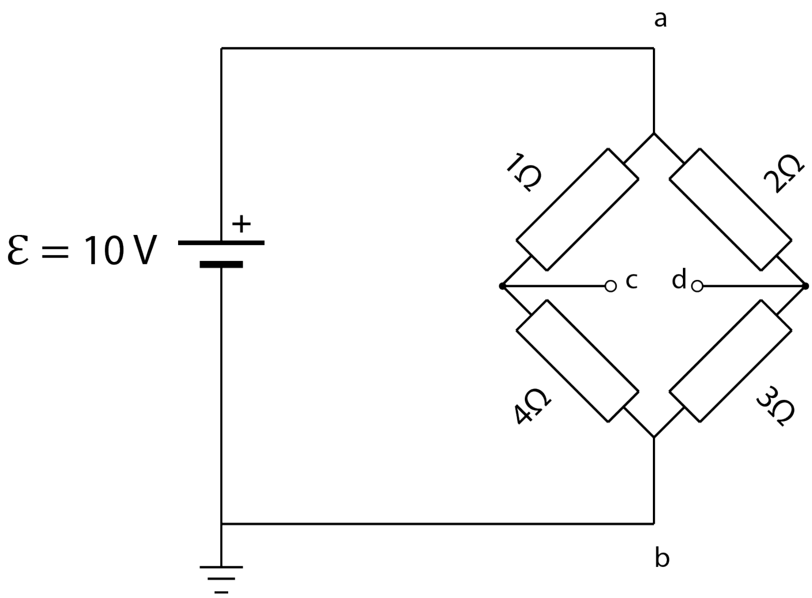
1. The circuit shown below is called the resistive (or Wheatstone) bridge[1]. Typically, a voltage is measured between points c and d.



   (a) What is the potential difference V_{cd}?

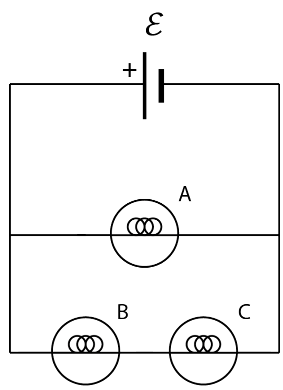
   (b) If a $5\,\Omega$ resistor is connected between points c and d, does this change the voltage V_{cd}? If so, by how much, and why does this happen?

[Hint: use Kirchhoff's Laws. Start by labelling the currents through the resistors. How many distinct circuit loops are there?]

[1] In this problem, we'll look at the general behaviour of the circuit. However, if you do the Advanced Electronics course then you'll see this circuit again in one of the projects, where it is used to measure very small resistance changes in a bridge made of strain sensors (measuring mechanical deformation in a structure).

Discussion Problems

2. A cylindrical metal rod has resistance R. If we make a second rod from the same metal but with triple the length and diameter, what is its resistance, in terms of R?
3. The two rods are joined end-to-end and a current passed through them both. At the junction, does the electron drift speed change?
4. Make a quick estimate of the force between two 1 C charges placed 1 m apart. Explain why a current of 1 A [1 C/s] can quite easily be passed through a wire without it being torn apart.
5. The diagram shows three identical lightbulbs connected to an ideal battery of EMF $\mathcal{E}$. How do the brightnesses of the bulbs compare? Why? What happens if bulb A is removed? What happens if bulb A is put back in place and bulb C is removed, and then replaced with a wire (short-circuit)?



6. Explain why car headlamp bulbs are connected in parallel not series.

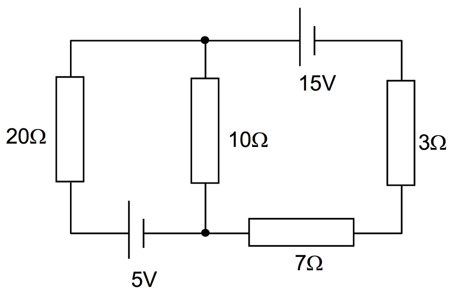
Basic Electronics

Further Problems 1

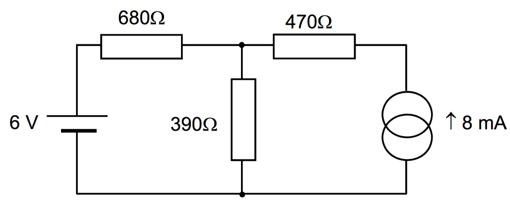
1. The density of copper (Cu) is 8.92 g/cm^3 and a mole of Cu atoms weighs 63.54 g. Estimate the electron carrier density for copper, assuming that each atom contributes one free electron. [Avogadro's number is 6.02×10^{23}]

2. Tungsten (W) is commonly used coiled-up as a filament material in incandescent light bulbs. The room temperature resistivity of W is 5.6×10^{-8} Ωm. Calculate the resistance of a 50 cm long W filament having a cross sectional area of 2×10^{-9}m^{-2} at
   (a) room temperature and
   (b) at its operating temperature of 2000 K [the temperature coefficient of resistivity, α, for W is 0.0045].

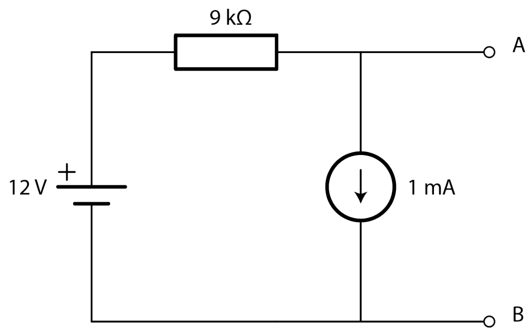
3. For the circuit shown below, use Kirchhoff's laws to calculate the current flowing through each of the resistors.



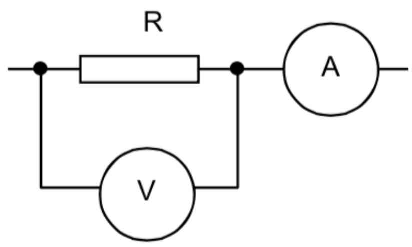
4. Using the principle of superposition, calculate the current in the 390 Ω resistor in the circuit shown below.



5. The circuit shown below consists of an ideal voltage source of 12 V, an ideal current source of 1 mA, and a resistance of 9 kΩ .
   (a) Find the open-circuit voltage across the output terminals A and B
   (b) Find the short-circuit current through AB
   (c) Hence give the Thévenin equivalent of the circuit



6. You are required to measure the unknown resistance R in the circuit shown below, using 'real-world' ammeter (resistance of $2\,\Omega$) and voltmeter (resistance of $10\,k\Omega$) devices[1]. The voltmeter reads 12 V while the ammeter reads 100 mA. What is the value of R and the power dissipated in R?



Numerical solutions and hints

1. $8.45 \times 10^{28} m^{-3}$
2. (a) $14\,\Omega$, (b) $121\,\Omega$
3. $I_{20} = 0.1\,A$, $I_{10} = 0.7\,A$, $I_3 = I_7 = 0.8\,A$
4. 10.7 mA
5.
6. $121.5\,\Omega$, 1.17 W

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15-Dec-17

[1] Note: non-ideal meters are not examinable.