Cube of Resistors

A Level

Imagine a cube of resistors, where each edge of the cube is a resistor of resistance $1\,\Omega$. In this question we will find the equivalent resistance between different vertices.

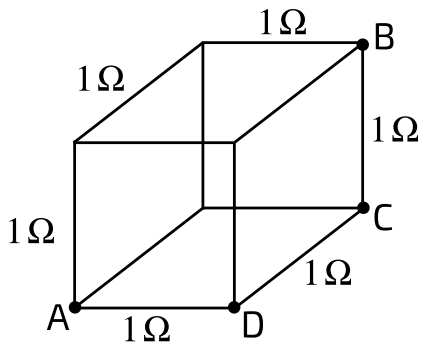

Figure 1: A cube of $1\,\Omega$ resistors. Six of the twelve edges are labelled; all have the same resistance. Four of the vertices are labelled.

Part A Resistance across main diagonal

What is the equivalent resistance between two vertices on the main diagonal, e.g. between points A and B in **Figure 1**? Give your answer to 3 s.f.

Part B Resistance across diagonal of a face

What is the equivalent resistance between two vertices on the diagonal of a face, e.g. between points A and C in **Figure 1**? Give your answer to 3 s.f.

Part C Resistance between adjacent vertices

What is the equivalent resistance between two adjacent vertices, e.g. between points A and D in **Figure 1**? Give your answer to 3 s.f.

Power in a Potential Divider 10.8

A Level

A $\varepsilon = 5.4\,\mathrm{V}$ power supply (with $r = 8.0\,\Omega$) powers a $50\,\Omega$ phone. A voltmeter (with resistance $200\,\Omega$) is connected to measure V.

Part A Voltage V

How much voltage V is measured across the phone?

Part B Power delivered

Calculate the power delivered to the phone.

Potential dividers with LEDs 8.1

A Level

Quantities:

ε e.m.f. (V)
V p.d. across fixed resistor (V)
V_{LED} p.d. across LED (V)
I current through circuit (A)
R fixed resistor resistance (Ω)
E photon energy (J)
λ wavelength of emitted light (m)

Equations:

$$V = IR \qquad \varepsilon = V_{\mathrm{LED}} + V \qquad V_{\mathrm{LED}} = \frac{E}{e} \qquad E = \frac{hc}{\lambda}$$

Use the equations above to derive expressions for:

Part A The resistance of the fixed resistor R

the resistance of the fixed resistor R in terms of the e.m.f. ε, the p.d. across the LED V_{LED} and the current I.

The following symbols may be useful: `I, R, V_LED, epsilon`

Part B The resistance of the fixed resistor R, using λ

the resistance of the fixed resistor R in terms of the e.m.f. ε, the wavelength of the LED λ, the current I and the physical constants h, c and e.

The following symbols may be useful: `I, R, c, e, epsilon, h, lambda`

Potential Dividers with LEDs 8.3

A Level

A blue LED produces light of wavelength $480\,\text{nm}$. It is powered using a $9.00\,\text{V}$ battery using the circuit design shown below. Assume that there is no internal resistance in the power supply.

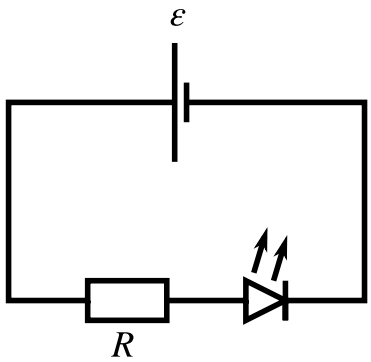

Figure 1: A circuit with a single cell in series with a resistor and an LED.

Part A The p.d. across the LED

Calculate the p.d. across the LED.

Part B The minimum value of R

Calculate the minimum value of R to ensure the current through the LED does not exceed $50.0\,\text{mA}$.

Part C The resistance of the LED

Calculate the resistance of the LED.

Transforming Resistors

A Level

The two resistor networks below can be called equivalent if they have the same electrical properties when viewed between any two of the terminals A, B or C. R_a, R_b and R_c can be given values based on the values of R_x, R_y and R_z in order to make the two networks equivalent.

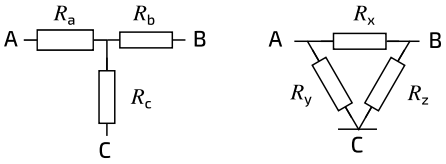

Figure 1: Two resistor networks.

Part A Expression for R_a

If the two resistor networks of **Figure 1** are equivalent, find an expression for R_a in terms of R_x, R_y and R_z.

The following symbols may be useful: `R_a, R_x, R_y, R_z`

Part B A circuit

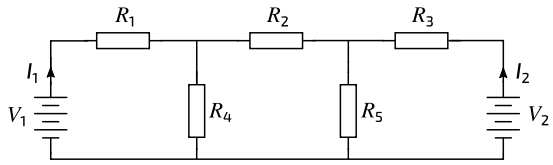

Figure 2: A circuit with two cells and five resistors.

Using the transformation and your result from Part A, or otherwise, work out the value of the current I_1 in the circuit of **Figure 2**. You are given that $R_1 = 1.0\,\Omega$, $R_2 = R_4 = R_5 = 3.0\,\Omega$, $R_3 = 2.0\,\Omega$, $V_1 = 22\,\text{V}$ and $V_2 = 11\,\text{V}$.

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Rambunctious Resistors

A Level

The circuit diagram below shows a combination of resistors with equivalent resistance $R_{eq} = 37.0\,\Omega$.

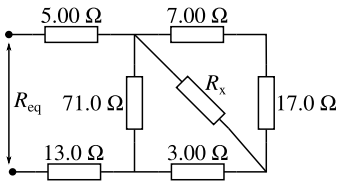

Figure 1: Circuit diagram showing how the resistors are arranged and the values of the resistances. The unknown resistor has resistance R_x.

What value of resistance R_x for the unknown resistor satisfies this value for the equivalent resistance?

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Non-linear I-V

GCSE A Level

The circuit below contains a metal oxide rod, represented by a dashed line. The potential difference (in volts) across the rod is given by $V = 0.200I^2$ where I is the current (in amps) through the rod. This relationship is only valid for $I > 0$.

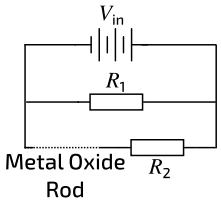

Figure 1: Circuit diagram showing how the rod, resistors and cell are connected to each other.

Given that $R_1 = 3.00\,\Omega$, $R_2 = 2.00\,\Omega$ and $V_{in} = 6.00\,\text{V}$ what is the total current drawn from the cell?

Adapted with permission from UCLES, A Level Physics, June 1961, Paper 3, Question 8

Current Division 9.4

A Level

I am going to connect two resistors in parallel to share a $13\ \mathrm{A}$ current so that $5.0\ \mathrm{A}$ flows through one resistor. The resistor with the larger resistance is a $2.2\ \Omega$ resistor. Calculate the resistance of the other resistor.

Current Division 9.2

A Level

A $9.0\,\Omega$ resistor is connected in parallel with a $81\,\Omega$ resistor. What fraction of the total current flows through the $81\,\Omega$ resistor?

Power in a Potential Divider 10.2

A Level

Calculate the load power P for an $\varepsilon = 240\,\mathrm{V}$ generator with internal resistance $2.5\,\Omega$ when it is supplying $4.2\,\mathrm{A}$.