2.4 Series and parallel circuits

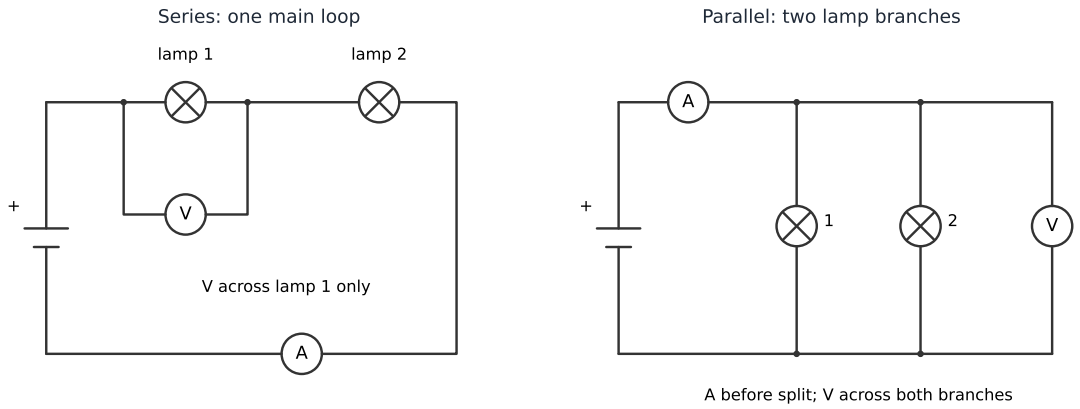
Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS potential difference

Objective

Apply the series and parallel rules for current, potential difference and resistance, calculate series totals, and explain both resistance trends. Original questions for spec statement 4.2.2.

1 Key knowledge and worked examples



One loop versus branches.

Rule	Series	Parallel
current	same through every component	total = sum of branch currents
potential difference	shared between components	same across each component
resistance	$R_{total} = R_1 + R_2$ (sum)	less than the smallest single resistor

Not required: calculating the combined resistance of two parallel resistors. You compare and explain instead.

Explain the trends:

- **Series adds resistance**: the charge has one path through every resistor in turn, so the total opposition is the sum.
- **Parallel lowers resistance**: each branch is an extra path for charge, so more total current flows at the same potential difference – the same V with larger I means smaller R.

Worked example. A 6.0 V battery drives a lamp in series with a 6.0 Ω resistor. The lamp resistance is 12 Ω at this operating point.

- Known: series supply and two resistances. In series they add.

$$R_{total} = 12 + 6.0 = 18\ \Omega$$

- Why $I = V/R_{total}$: one loop, so the supply drives the current through the total resistance.

$$I = \frac{6.0\ \text{V}}{18\ \Omega} = 0.33\ \text{A}$$

- The lamp's share: $V_{lamp} = IR_{lamp} = (6.0/18) \times 12 = 4.0$ V, using unrounded current. Check: $4.0 + 2.0 = 6.0$ V ✓.

Worked example (parallel reading). Two identical lamps in parallel each carry 0.21 A from the same supply.

- Branch rule: the supply current is the sum.

$$I_{total} = 0.21 + 0.21 = 0.42\ \text{A}$$

- Each lamp has the full supply potential difference across it, so for a suitable fixed-pd supply each has its normal brightness at that pd. Identical filament lamps across this supply are brighter than when in series.

Common exam shapes: explain why a lamp is dimmer in series (shares the potential difference → smaller current); explain why adding a lamp in parallel does not dim the others (each branch keeps the full supply potential difference; the total current grows).

2 Practice

2.1 A series circuit contains 4.0 Ω, 6.0 Ω and 10 Ω resistors. Calculate the total resistance, and the current when a 12 V supply is connected. [3]

2.2 Two ammeters in the two branches of a parallel circuit read 0.30 A and 0.45 A. State the supply current and the rule used. [2]

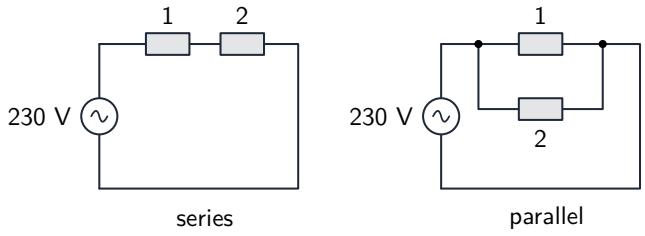
2.3 Explain why the total resistance of two resistors in parallel is less than the resistance of either one alone. [2]

3 Exam-style questions

3.1 Hair straighteners contain two heating elements (resistors). A switch arrangement can connect them in series or in parallel.

(a) The straighteners do not heat at all when only the switch that completes the *inner loop* through one element is closed – no current flows in either element. Explain why. [2]

(b) With both elements connected, explain whether the series or the parallel arrangement gives the higher power output. [3]



3.2 A 12 V battery drives two identical lamps, first in series, then in parallel. For this calculation, model each lamp as a fixed 8.0 Ω resistance in both connections; real filament-lamp resistance changes with temperature.

(a) Series: calculate the current and the potential difference across each lamp. [3]

(b) Parallel: state the potential difference across each lamp and calculate the total current drawn from the battery. [3]

(c) Explain why each lamp is brighter in parallel. [2]

3.3 A vending machine's heater uses a 230 V supply. Its circuit has a 46 Ω heating element in series with a control resistor.

(a) The control resistor is set to 44 Ω. Calculate the current. [2]

(b) Calculate the potential difference across the heating element. [2]

(c) The control resistor is replaced by two 22 Ω resistors connected in parallel with each other, in the same position. Explain what happens to the current and to the heating element's power. [4]