

Circuit rules, power and mains safety

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer shows the formula, the substitution and the result with its unit. Final results are in bold. If your numbers differ slightly, check your rounding: intermediate values are kept unrounded and only the final result is rounded.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE P2, HS-PS3-3

Problem 1 Series or parallel?

1. **Series** (one loop, one current).
2. **Parallel** (each branch is across the supply).
3. **Parallel:** the other branches still form complete loops.
4. **Series:** the resistances add, so the total is larger than any one. In parallel it would be smaller.

Problem 2 Phone charger power

1. $P = IV = 5.0 \times 2.0 = \mathbf{10\ W}$.
2. $t = 30 \times 60 = 1800\ \text{s}$. $E = Pt = 10 \times 1800 = \mathbf{18\ 000\ J}$.
3. $E = 10\ \text{W} \times 0.5\ \text{h} = \mathbf{5.0\ Wh}$ ($18\ 000\ \text{J} \div 3600 = 5.0\ \text{Wh}$).

Problem 3 Three resistors in series

1. $R = 15 + 25 + 10 = \mathbf{50\ \Omega}$.
2. $I = V \div R = 9.0 \div 50 = \mathbf{0.18\ A}$.
3. $V = IR = 0.18 \times 25 = \mathbf{4.5\ V}$.

Problem 4 Reading labels

1. $2.5 \times 1000 = \mathbf{2500\ W}$.
2. $450 \div 1000 = \mathbf{0.45\ W}$.
3. $90 \div 60 = \mathbf{1.5\ h}$.
4. $1\ \text{kWh} = 3.6\ \text{MJ}$, so $3.6\ \text{MJ} = \mathbf{1.0\ kWh}$.

Problem 5 Voltage in a series loop

1. The voltages add to $6.0\ \text{V}$: $V_2 = 6.0 - 2.2 = \mathbf{3.8\ V}$.
2. $I = V \div R = 2.2 \div 11 = \mathbf{0.20\ A}$.
3. The same $0.20\ \text{A}$ flows through B: $R = 3.8 \div 0.20 = \mathbf{19\ \Omega}$.
4. $P = VI = 3.8 \times 0.20 = \mathbf{0.76\ W}$. (Check: $11 + 19 = 30\ \Omega$ and $6.0 \div 30 = 0.20\ \text{A}$.)

Problem 6 Currents in branches

1. A_1 measures the total: $0.80 + 1.50 = \mathbf{2.30\ A}$.
2. Both lamps are across the cell: $\mathbf{9.0\ V}$.
3. $R_2 = 9.0 \div 0.80 = 11.25$, so $\mathbf{11\ \Omega}$; $R_3 = 9.0 \div 1.50 = \mathbf{6.0\ \Omega}$.
4. $P = VI = 9.0 \times 2.30 = 20.7\ \text{W} = \mathbf{21\ W}$ (2 s.f.).

Problem 7 Toaster fuse

1. $I = P \div V = 800 \div 240 = \mathbf{3.3\ A}$.
2. A 3 A fuse would blow in normal use, and 13 A is too big to protect the flex, so choose $\mathbf{5\ A}$: just above the working current.
3. $t = 4 \times 60 = 240\ \text{s}$. $E = Pt = 800 \times 240 = \mathbf{192\ 000\ J}$.

Problem 8 Night fan costs

1. $E = 0.060\ \text{kW} \times 8\ \text{h} = \mathbf{0.48\ kWh}$.
2. $0.48 \times 30 = \mathbf{14.4\ kWh}$.
3. Cost = $14.4 \times 1.50 = \mathbf{21.60\ cedis}$.

Problem 9 Two resistors in parallel

1. $1/R = 1/12 + 1/4 = 1/12 + 3/12 = 4/12 = 1/3$, so $R = \mathbf{3.0\ \Omega}$.
2. $I = 9.0 \div 3.0 = \mathbf{3.0\ A}$.
3. $I_1 = 9.0 \div 12 = \mathbf{0.75\ A}$; $I_2 = 9.0 \div 4 = \mathbf{2.25\ A}$. They add up to 3.0 A.

Problem 10 Heating coil

1. $P = I^2 R = 5.0^2 \times 46 = 25 \times 46 = \mathbf{1150\ W}$.
2. $V = IR = 5.0 \times 46 = \mathbf{230\ V}$.
3. $t = 120\ \text{s}$. $E = Pt = 1150 \times 120 = \mathbf{138\ 000\ J}$.

Problem 11 Resistance of an iron

1. $R = V^2 \div P = 220^2 \div 1000 = 48\ 400 \div 1000 = \mathbf{48.4\ \Omega}$.
2. $I = P \div V = 1000 \div 220 = \mathbf{4.5\ A}$.
3. The normal current 4.5 A is larger than 3 A, so a 3 A fuse would melt every time the iron is switched on; a $\mathbf{5\ A}$ or $\mathbf{13\ A}$ fuse is needed.

Problem 12 Why parallel at home?

1. Each lamp gets the full mains voltage so it shines at its rated brightness, and each lamp can be switched on or off separately.
2. In series the circuit would be broken, so **all the lamps would go out**.
3. In parallel the lamps already lit keep the same voltage and the same brightness: **no**

change. In series the voltage is shared among more lamps, so each gets less and **all become dimmer.**

Problem 13 Power against current squared

1. Since $P = I^2 R$, the gradient of P against I^2 is the **resistance R** .
2. Gradient = $36 \div 4.0 = \mathbf{9.0 \Omega}$.
3. $P = 9.0 \times 2.5 = \mathbf{22.5 W}$ (about 22 W to 23 W from the graph).
4. $I^2 = 18 \div 9.0 = 2.0 \text{ A}^2$, so $I = \sqrt{2.0} = \mathbf{1.4 A}$.

Problem 14 Which bulb is brighter?

1. $R = V^2 \div P$. Lamp X: $144 \div 24 = \mathbf{6.0 \Omega}$. Lamp Y: $144 \div 6.0 = \mathbf{24 \Omega}$.
2. $R_{\text{total}} = 30 \Omega$, so $I = 12 \div 30 = \mathbf{0.40 A}$.
3. $P = I^2 R$. X: $0.16 \times 6.0 = \mathbf{0.96 W}$. Y: $0.16 \times 24 = \mathbf{3.84 W}$.
4. **Lamp Y**, the lower-rated one, is brighter. In series the current is the same, so the lamp with the larger resistance gets more power.

Problem 15 Overloaded extension lead

1. Kettle: $2200 \div 230 = 9.57 \text{ A}$. Toaster: $900 \div 230 = 3.91 \text{ A}$. Lamp: $100 \div 230 = 0.43 \text{ A}$.
2. Total power 3200 W, so $I = 3200 \div 230 = \mathbf{13.9 A}$ ($9.57 + 3.91 + 0.43$).
3. 13.9 A is more than the 13 A rating, so the **fuse will melt** and cut the supply.
4. Use the kettle and toaster from separate sockets, or not at the same time, so no lead carries more than 13 A.

Problem 16 Farm lighting

1. $P = 6.0 + 9.0 + 15 = \mathbf{30 W}$.
2. $I = P \div V = 30 \div 12 = \mathbf{2.5 A}$.
3. $6.0 \div 12 = \mathbf{0.50 A}$; $9.0 \div 12 = \mathbf{0.75 A}$; $15 \div 12 = \mathbf{1.25 A}$ (sum 2.5 A).
4. $R = V \div I = 12 \div 2.5 = \mathbf{4.8 \Omega}$.
5. $E = 0.030 \text{ kW} \times 5 \text{ h} = \mathbf{0.15 kWh}$; $E = 30 \times 18\,000 \text{ s} = \mathbf{540\,000 J}$.

Problem 17 Series-parallel network

1. $1/R = 1/12 + 1/4 = 4/12$, so $R = \mathbf{3.0 \Omega}$.
2. $R_{\text{total}} = 6.0 + 3.0 = \mathbf{9.0 \Omega}$; $I = 18 \div 9.0 = \mathbf{2.0 A}$.
3. V across $6.0 \Omega = 2.0 \times 6.0 = \mathbf{12 V}$; across the pair = $2.0 \times 3.0 = \mathbf{6.0 V}$.
4. I (12Ω) = $6.0 \div 12 = \mathbf{0.50 A}$; I (4.0Ω) = $6.0 \div 4.0 = \mathbf{1.5 A}$.
5. $P = I^2 R$ or $V I$: 6.0Ω : 24 W; 12Ω : 3.0 W; 4.0Ω : 9.0 W. Sum = $\mathbf{36 W}$, equal to the supply power $18 \times 2.0 = 36 \text{ W}$.

Problem 18 Spot the errors

1. Resistances only add in *series*. In parallel $1/R = 1/5 + 1/20 = 5/20$, so $R = \mathbf{4.0\ \Omega}$, smaller than $5\ \Omega$.
2. The formula is $I = P \div V$, not $P \times V$: $I = 1200 \div 230 = \mathbf{5.2\ A}$.
3. Power is I^2R , not $I \times R$. $P = 3.0^2 \times 10 = \mathbf{90\ W}$ (30 would be a voltage in volts, not a power).

Problem 19 Losing power in cables

1. $I = P \div V = 2000 \div 200 = \mathbf{10\ A}$.
2. $P(\text{lost}) = I^2R = 10^2 \times 0.50 = \mathbf{50\ W}$.
3. $I = 2000 \div 2000 = \mathbf{1.0\ A}$.
4. $P(\text{lost}) = 1.0^2 \times 0.50 = \mathbf{0.50\ W}$.
5. The same power needs ten times less current at ten times the voltage. Since the loss is I^2R , ten times less current gives **100 times less waste**.

Problem 20 Design a lamp circuit

1. $I = P \div V = 3.0 \div 6.0 = \mathbf{0.50\ A}$.
2. $R = V \div I = 6.0 \div 0.50 = \mathbf{12\ \Omega}$.
3. In series $R_{\text{total}} = 24\ \Omega$, so $I = 12 \div 24 = 0.50\ \text{A}$, the rated current. Each lamp has $0.50 \times 12 = 6.0\ \text{V}$, so **both are at full brightness**.
4. Energy = $12 \times 2.0 = 24\ \text{W}\cdot\text{h}$. Power = $6.0\ \text{W}$. Time = $24 \div 6.0 = \mathbf{4.0\ h}$.
5. The resistor must take $12 - 6.0 = 6.0\ \text{V}$ at $0.50\ \text{A}$: $R = 6.0 \div 0.50 = \mathbf{12\ \Omega}$. Power wasted = $I^2R = 0.25 \times 12 = \mathbf{3.0\ W}$.