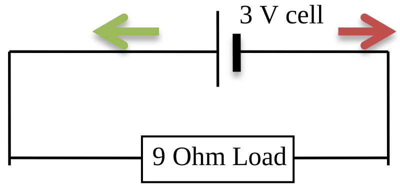
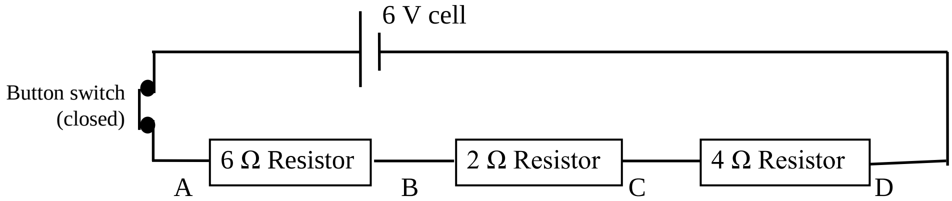
05 Electric currents review answers

1. Simple circuit.



(a) Draw the circuit.
(b) Draw arrows showing the direction of the **current flow** and the direction of the **electron flow**.
(c) State the value of the potential difference across the 9 Ohm load. **V = 3 Volts**
(d) Calculate the current flowing through the circuit. **I = V/R = 0.33A**
(e) By considering the definition of potential difference and that current is a flow rate of charge explain why the power dissipated in the resistor is equal to 1 Watts.
p.d. = energy per unit charge and current is charge per unit time so
p.d. x current = energy per unit time = 3 x 0.33 = 1Watt
(f) Derive a formula for power dissipated based on the values of current and resistance only.
P = VI and V = IR so by substitution P = IxRxI = I^2R.
(g) How long would it take before 60 Joules of energy had been transferred to the load from the cell?
1 Watt = 1 Joule per second………60 seconds
(h) How much energy does each individual electron supply to the load?
i) in eV 1eV is the energy gained when 1 electron accelerates over one volt. **3eV**
ii) in Joules **1e = 1.6×10^{-19}C 3eV = $3\times1.6\times10^{-19}$ = 4.8×10^{-19} Joules**
(g) How many electrons will have flowed through the resistor to transfer the 60 Joules of energy?
0.33 coulombs per second x 60 seconds ÷ 1.6×10^{-19}C =
Easier…… 60 ÷ 4.8×10^{-19} = 1.25×10^{20}

2. In line (series) circuit.



(a) Calculate the total resistance of the circuit. **12 Ω**
(b) Calculate the current flowing around the circuit. **0.5A**
(c) Calculate the potential differences between:
(i) A and B **3V** (ii) B and C **1V** (iii) C and D **2V** (iv) A and C 4V (v) A and D **6V**
(d) Calculate the power being dissipated at each of the loads **A: 1.5W, B: 0.5W, C: 1W, D: 3W**

3. Parallel circuit

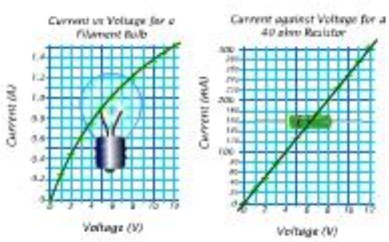
(a) Redraw the circuit as a parallel circuit with a button switch for each load. Explain what the advantages of parallel circuits are. Each component receives the supply voltage and can be switch on/off independently.
(b) Calculate the combined resistance of the three parallel loads and hence the total current.
1/R = 1/6 + ½ + ¼ = 2/12 + 6/12 + 3/12 = 11/12 so R = 12/11 = 1.09 Ω
I = 6/1.09 = 5.5 A
(c) Show that this total current is consistent with calculating the current though each of the three resistors independently and adding the result.
6 Ω : I = 6/6 = 1A, 2 Ω: I=6/2 = 3A, 4 Ω: I=6/4 = 1.5A These sum to 5.5A

4. Additional observations.

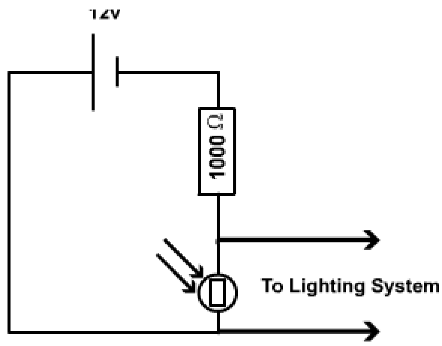
(a) In questions 2 which resistor has the most power dissipated across it and in questions 3 which resistor has the most power dissipated across it. **Most power in series is the highest value resistor ($P=I^2R$, I is the same for all resistors, Most power in parallel is lowest value resistor ($P=V^2/R$)**

(b) Measuring the values of current and resistance will affect the values. Explain this statement. Voltmeters do not have infinite resistance and ammeters do not have zero resistance so they will affect the current flow.
(c) The 6V cell in questions 3 and 4 will in reality have internal resistance. Will this affect the answers to question 3 or 4 the most? **This will affect the answers to 4 the most as $V_s = V_{emf} - Ir$ and I is higher in 4.**

5. Resistivity and Ohms law
(a) A wire of diameter 0.5mm and length 0.8m has a resistance of 8 Ohms. Calculate the resistivity of the wire.
$R = \rho L/A$ so $\rho = RA/L = 8 \times 2\pi(0.5\times10^{-3}/2)^2/0.8 = 3.9\times10^{-6}\ \Omega m$
(b) Potential difference does not affect resistivity but if the temperature of the wire increases the resistivity of the wire increases. Explain whether or not the wire obeys Ohm's law. **The wire does obey Ohms law if resistivity does not change.**
(c) Sketch a graph of Current against voltage for a perfect resistor, this wire and a filament lamp.

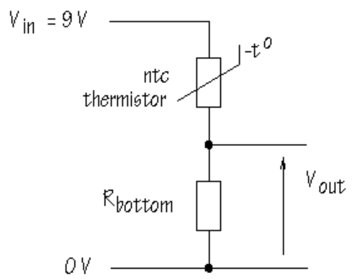


6. Specialized circuits
(a) The circuit opposite is used to control a lighting circuit.
In the day time the LDR has a resistance of 200Ω. At night the LDR has a resistance of 5000Ω. The lighting system needs at least 8 V to operate. Show that the lighting circuit will be activated in the night but not in the day.



Day:
Rtotal = 1200 Ω so I = 12/1200 = 0.01A
V across LDR = 0.01x200 = 2V (lighting system off)
Day:
Rtotal = 6000 Ω so I = 12/1200 = 0.002A
V across LDR = 0.002x5000 = 10V (lighting system on)

(b) A similar circuit shown below can be used to control a heating system using a NTC thermistor.



In this circuit when it is cold resistance of the thermistor is high.
(i) At cold temperature a higher proportion of the 9V P.D. will be across the thermistor so Vout will be low.
The heating system therefore activates at lowVout P.D.
(ii) R_{total} = 220kΩ
I = V/R = 9/220k
V_{out} = IR = (9/220k)x100k = 4.1V

The system should activate when it is cold. Explain whether the heating system will be activated by a low or high potential difference at V_{out}.

(c) In the strain gauge circuit below R1, R2, R3 and the strain gauge all have the same resistance when the gauge is not under strain. A very sensitive Voltmeter can therefore be used as the voltage measured is always small. If the strain guage resistance increases slightly which side of the voltmeter will have a positive voltage compared to the other side? **Strain gauge p.d. will increase so RHS will be positive.**

Quarter-bridge strain gauge circuit