2024 Sec 4 Physics Assignment 16A
D.C Circuit (Sample Solutions)

Reminders:

1. Use subscripts for similar quantities belonging to different components, e.g. R_1, R_2.
2. Write down the **basic formulae** before substitution.
   - Component: $V = I R$
   - Entire circuit: e.m.f. = $I_{main} R_{eff}$
3. Show all key mathematical steps clearly.
4. **Redraw & rearrange** circuit components and wiring to **simplify** circuit diagrams
   - Note short-circuits, switches open/closed, junctions, etc.
5. Evaluate your final answer! (2 or 3 s.f.)

1 **(a)** Find resistance of the two resistors in parallel:
1/(1/10) + (1/10) = 5.0 Ω
Hence total resistance = R_T = 3.0 + 5.0 = 8.0 Ω

(b) $I = V / R$ = 4.0 V / 8.0 Ω = 0.50 A

(wrong method: 4.0 V divided by 3.0 Ω)

(c) Each resistor gets 0.50 A ÷ 2 = 0.25 A of current.
$Q = I t$ = (0.25 A) (2.0 s) = 0.50 C

2 **(a)** I = 1.0 A Note: Redraw and simplify the circuits!

(b) I = 0.50 A

3 **(a)** Find resistance of the two resistors 12 Ω and 6.0 Ω in parallel:
1/(1/12) + (1/6.0) = 4.0 Ω

Find resistance of the two resistors 3.0 Ω and 6.0 Ω in parallel:
1/(1/3.0) + (1/6.0) = 2.0 Ω

Find resistance of the two resistors 4.0 Ω and 2.0 Ω in series:
R_T = 6.0 Ω

(b) I = 12 / (4.0 + 2.0) = 2.0 A

(c) I = 12 / (4.0 + 3.0) = 1.7 A

4 **(a)** V_x = 12 / 2 = 6 V; V_y = 0 V

Why is V_y = 0 V?
When there is no current, both terminals of the appliance are at the same electric potential, hence the potential difference across that appliance is zero.

(b) same p.d. and resistance across each branch,
so both have same current = 0.30 A
hence new ammeter reading = 0.30 A × 2 = 0.60 A

OR
2 lamps in series: R = 12 V / 0.30 A = 40 Ω
2 branches in parallel: effective resistance, R_e = 40 / 2 = 20 Ω
Main current = e.m.f. / R_e = 12 V / 20 Ω = 0.60 A

5 Rearrange the circuit to see that the 3 resistors are in parallel.
R_e = 5.0 Ω / 3
e.m.f. = I R_e = 3.0 A × 5.0 Ω / 3 = 5.0 V

6 (a) In 2nd branch, current = V / R = 12 V / 5.0 Ω = 2.4 A

(b) In 1st branch, current = 5.0 A – 2.4 A = 2.6 A

$R = V / I$ ➔ X + 3.0 Ω = 12 V / 2.6 A

X = 1.62 Ω = 1.6 Ω (1.d.p.)

(c) All 3 branches are in parallel with the battery.

The current flowing through the 5.0 Ω resistor is unchanged (still 2.4 A) as the voltage across the 5.0 Ω is unchanged at 12 V even with the addition of the 2.0 Ω resistor.

7 (a) $I = V / R$ = 4.0 V / 10 Ω = 0.40 A

(b) 0 A since S acts as a short-circuit across the 4.0 Ω

[*Note*: answer for question (b) is not 4.0 V / 6.0 Ω = 0.67 A, since question did not ask for current through that 6.0 Ω resistor.]

8 **Note**: May use potential divider method, treat resistance wire as 2 variable resistors in series as the jockey moves!

- The p.d. across the wire is proportional to its resistance when current through it is constant. $V = I R$ ➔ $V \propto R$
- Resistance of that wire is proportional to its length.
- When S is at A, voltmeter reading is zero as the resistance across it is zero.
- As S moves from A towards B, the p.d. across the length of wire AS increases with increasing resistance, based on potential divider concept. Hence the voltmeter reading V increases.
- When S is at B, the voltmeter reading is 4.0 V as the voltmeter is across the maximum length of the resistance wire AB.

Need to specify the minimum and maximum voltmeter readings.

Language Notes:

- **DO NOT** write: *voltage flows through* a component
- You may write: current (flows) through a component
  OR p.d. or voltage (established) across a component

9 **(a)** Let resistance of each lamp be R.

L_2 and L_3 are in parallel, so effective resistance is found to be $R/2$

Ratio of resistance of L1: L2 and L3 (in parallel)
= $R : R / 2$
= 2 : 1

So ratio of p.d.s is also = 2 : 1 = 4 V : 2 V

$V_{L2} = V_{L3} = 2.0$ V
Lamps L2 and L3 will be equally dim as the p.d. across each of them is lower than the rated value of 3.0 V.

$V_{L1} = 4.0$ V
Lamp L1 will be brighter than normal as the p.d across it is higher than the rated value of 3.0 V.

Note:
- Rating of 3.0 V means when a p.d. of 3.0 V is applied across the lamp, it has normal brightness.
- Redraw the circuit and simplify if it helps you to understand the circuit better.
- Brightness is *not* directly proportional to current or p.d.: **NOT twice as bright**!

(b) The two lamps are in series.

$V_{L1} = V_{L3} = 3.0$ V
Lamp L3 and lamp L1 will both be operating at normal brightness as the p.d. across each of them is equal to the rated value of 3.0 V.

Note:
When a lamp is removed, the wires next to it are NOT reconnected unless stated!

(c) The two lamps are in parallel.

$V_{L2} = V_{L3} = 6.0$ V
Lamps L2 and L3 will both be very bright (and likely to fuse) as the p.d. across each of them is doubled the rated value of 3.0 V.

10 **(a)** $I = V / R_{total} = 0.020$ A

(b)(i) $V = 6.0$ V

(ii) $V = 3.0$ V

(iii) $V = 0.0$ V

Note: Brightness of lamp is not directly proportional to V or I.